THE SYSTEMATICS OF THE GENUS AUGOCHLORELLA (HYMENOPTERA,
HALICTIDAE) NORTH OF MEXICO AND THE BIONOMICS OF A. STRIATA AND
A. PERSIMILIS IN EASTERN KANSAS

by

Ellen Ordway
B. A., Wheaton College, Mass., 1950
M.S., Cornell University, N. Y., 1955

Submitted to the Department of
Entomology and the Faculty of the
Graduate School of The University
of Kansas in partial fulfillment
of the requirements for the degree
of Doctor of Philosophy.

Dissertation Committee:

Redacted Signature
Chairman
Redacted Signature

Redacted Signature
CONTENTS

INTRODUCTION.............................................................................. 1

PART I. SYSTEMATICS

GENUS AUGOCHELRELLA................................................................. 3
  Introduction.......................................................................... 3
  Some Diagnostic Characters............................................. 7
  Key to the Genera of Green Halictines of the United
  States.................................................................................. 10

TERMINOLOGY.................................................................................. 12

METHODS......................................................................................... 14
  Equipment............................................................................. 14
  Synonymies.......................................................................... 14
  Types.................................................................................... 14
  Descriptions......................................................................... 15
  Variations............................................................................. 15
  Distributions......................................................................... 16
  Seasonal Activity................................................................. 16
  Flower Records...................................................................... 16

SPECIFIC CHARACTERS.................................................................. 18
  Body Color............................................................................ 18
  Size....................................................................................... 19
  Clypeus................................................................................ 21
  Supraclypeal Area................................................................. 21
  Tegula.................................................................................. 21
  Propodeum.......................................................................... 21
  Metasoma............................................................................. 23
PART II. THE BIONOMICS OF AUGOCHLORELLA STRIATA AND PERSIMILIS

INTRODUCTION

METHODS

GENERAL ACCOUNT

NATURAL ENEMIES

AGGREGATIONS

Locations

Size

Survival

NEST STRUCTURE

The Entrance

The Turret

The Main Burrow

Supplementary Burrows

The Cluster Cavity

The Cell Cluster

Cells

Other Species

NEST CONSTRUCTION

NEST CONTENTS AND POPULATIONS

Provisions and Immature Stages

Cells

Adults
INTRODUCTION

Although bees of the genus Augochlorella (Halictidae) are common over much of the United States, the interspecific relationships and biologies of the species are little understood. In an attempt to clarify some of the problems in this group, a taxonomic study was made of all species occurring north of Mexico and the biological and behavioral differences between the two species occurring in Kansas were investigated.

This study is divided into two parts. Part I, a systematic account, concerns the species occurring in the United States. Those northern species ranging into Mexico and their close relatives are also treated. Part II is an account of observations on the biology and behavior of the two species, A. striata and A. persimilis, occurring in Kansas.
PART I

THE SYSTEMATICS OF THE GENUS AUGOCHLORELLA (Hymenoptera, Halictidae)

NORTH OF MEXICO
PART I. SYSTEMATICS

This section originated from a study of interspecific relationships of the two species of Augochlorella occurring in the vicinity of Lawrence, Kansas. Females of the two species, persimilis and striata, could not be satisfactorially distinguished and preliminary biological observations indicated little or no difference between them. In order to understand the nature of the variations and intergradations occurring between these two species, all species occurring within the United States were examined. They are redefined and illustrated, keys for their identification are provided, and variations within species analyzed.

For those investigators who are interested chiefly in the species occurring in a certain area, primary use should be made of the Regional Account of the Species. Other sections to be consulted include the discussion of the genus, the section on terminology, the keys to the species and under the Species Accounts, parts on comparisons with other species and seasonal activity.

For those interested primarily in studies of variation, special attention should be given to sections on Specific and Other Characters, Terminology, Species Groups and under the Species Accounts, parts on comparisons and variation. The regional account should also be of value.
Augochlorella is a genus of bright metallic blue or green bees. As in most halictines, the species are morphologically variable and are in many cases difficult to distinguish. Therefore, special attention is given to the nature and extent of variations within and among species. Since other species, not being considered in this work, occur in Mexico, Central and South America, a complete analysis cannot be attempted until all species have been studied, preferably both biologically and morphologically. Eight species are treated here; seven occur north of Mexico, the other is from Mexico and Central America.

The more than 14,000 specimens examined in this study were obtained from a total of 50 private and institutional collections (Table 1). In addition to the pinned material, 414 specimens were examined from 134 nests excavated near Lawrence, Kansas, and the variation compared with that of populations throughout the country.

The genus Augochlorella was proposed (with the type species Augochlora gratiosa Smith) by Sandhouse (1937) in a revision of an assemblage of forms that had previously been lumped together in the genus Augochlora. Prior to the revision by Sandhouse, all green halictines except the Agapostemon were commonly referred to Augochlora, including forms now placed in Augochlora, Augochloropsis and Augochlorella. [For synonyms of these genera, see Sandhouse (op. cit.).] I am not certain of the status of Pereirapis Moure, which was synonymized with Augochlorella by Michener (1954). Since the included species except for edentata (see Species Groups) are distinctly different from those of the north and are separated from each other by entirely different
<table>
<thead>
<tr>
<th>Code No.</th>
<th>Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>University of Arizona, Tucson.</td>
</tr>
<tr>
<td>2</td>
<td>University of Arkansas, Fayetteville.</td>
</tr>
<tr>
<td>3</td>
<td>California Academy of Sciences, San Francisco.</td>
</tr>
<tr>
<td>4</td>
<td>University of California, Berkeley.</td>
</tr>
<tr>
<td>5</td>
<td>Los Angeles County Museum, Los Angeles, California.</td>
</tr>
<tr>
<td>6</td>
<td>P. H. Timberlake Collection, Riverside, California.</td>
</tr>
<tr>
<td>7</td>
<td>University of Colorado Museum, Boulder.</td>
</tr>
<tr>
<td>8</td>
<td>Colorado State University, Ft. Collins.</td>
</tr>
<tr>
<td>9</td>
<td>United States National Museum, Washington, D.C.</td>
</tr>
<tr>
<td>10</td>
<td>State Department of Agriculture, Gainesville, Florida.</td>
</tr>
<tr>
<td>11</td>
<td>University of Georgia, Athens.</td>
</tr>
<tr>
<td>12</td>
<td>Fattig Collection, University of Georgia, Athens.</td>
</tr>
<tr>
<td>13</td>
<td>Chicago Natural History Museum, Chicago, Illinois.</td>
</tr>
<tr>
<td>14</td>
<td>Illinois Natural History Survey, Urbana.</td>
</tr>
<tr>
<td>15</td>
<td>Robertson Collection, Illinois Natural History Survey, Urbana.</td>
</tr>
<tr>
<td>16</td>
<td>Purdue University, Lafayette, Indiana.</td>
</tr>
<tr>
<td>17</td>
<td>Indiana University, Bloomington.</td>
</tr>
<tr>
<td>18</td>
<td>Iowa State University, Ames.</td>
</tr>
<tr>
<td>19</td>
<td>Kansas State University, Manhattan.</td>
</tr>
<tr>
<td>20</td>
<td>University of Kansas, Lawrence.</td>
</tr>
<tr>
<td>21</td>
<td>Carl W. Rettenmeyer Collection, Kansas State University, Manhattan.</td>
</tr>
<tr>
<td>Code No.</td>
<td>Collection</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>22</td>
<td>Museum of Comparative Zoology, Cambridge, Massachusetts.</td>
</tr>
<tr>
<td>23</td>
<td>University of Massachusetts, Amherst.</td>
</tr>
<tr>
<td>24</td>
<td>R. R. Dreisbach Collection, Michigan State University, East Lansing.</td>
</tr>
<tr>
<td>25</td>
<td>Michigan State University, East Lansing.</td>
</tr>
<tr>
<td>26</td>
<td>University of Minnesota, St. Paul.</td>
</tr>
<tr>
<td>27</td>
<td>University of Missouri, Columbia.</td>
</tr>
<tr>
<td>28</td>
<td>University of Nebraska, Lincoln.</td>
</tr>
<tr>
<td>29</td>
<td>David W. Ribble Collection, University of Nebraska, Lincoln.</td>
</tr>
<tr>
<td>30</td>
<td>Rutgers, The State University, New Brunswick, New Jersey.</td>
</tr>
<tr>
<td>31</td>
<td>Cornell University, Ithaca, New York.</td>
</tr>
<tr>
<td>32</td>
<td>American Museum of Natural History, New York City, New York.</td>
</tr>
<tr>
<td>33</td>
<td>North Carolina State, Raleigh.</td>
</tr>
<tr>
<td>34</td>
<td>North Dakota Agricultural College, Fargo.</td>
</tr>
<tr>
<td>35</td>
<td>University of North Dakota, Grand Forks.</td>
</tr>
<tr>
<td>36</td>
<td>Ohio State University, Columbus.</td>
</tr>
<tr>
<td>37</td>
<td>Oklahoma State University, Stillwater.</td>
</tr>
<tr>
<td>40</td>
<td>South Dakota State College, Brookings.</td>
</tr>
<tr>
<td>41</td>
<td>University of Tennessee, Knoxville.</td>
</tr>
<tr>
<td>42</td>
<td>Alvin F. Shinn Collection, Oak Ridge, Tennessee.</td>
</tr>
<tr>
<td>Code No.</td>
<td>Collection</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>43</td>
<td>Utah State University, Logan.</td>
</tr>
<tr>
<td>44</td>
<td>George E. Bohart Collection, Utah State University, Logan.</td>
</tr>
<tr>
<td>45</td>
<td>Brigham Young University, Provo, Utah.</td>
</tr>
<tr>
<td>46</td>
<td>Milwaukee Public Museum, Milwaukee, Wisconsin.</td>
</tr>
<tr>
<td>47</td>
<td>University of Wisconsin, Madison.</td>
</tr>
<tr>
<td>48</td>
<td>British Museum (Natural History), London.</td>
</tr>
<tr>
<td>49</td>
<td>Canadian National Collection, Ottawa.</td>
</tr>
<tr>
<td>50</td>
<td>Naturhistorisches Museum, Wien, Austria.</td>
</tr>
</tbody>
</table>
characters, I feel that they form a legitimate group which should perhaps be recognized at the subgeneric level.

Moure (personal communication, 1961) has included the following species in the *Pereirapis* group: *A. bidentata* Michener, *A. cerasis* (Vachal), *A. chrysaspis* (Vachal), *A. edentata* Michener, *A. phoenicis* (Vachal), *A. semiauratus* (Spinola) = *A. titania* (Smith), *A. hypixis* (Vachal), *A. seminigra* (Cockerell) (= *P. rhysophila* Moure) and *A. simotes* (Vachal). He has also indicated that the following Central and South American species are to be placed in *Augochlorella*: *A. cladopyga* (Cockerell), *A. comis* (Vachal), *A. ephyra* (Schrothky) = *A. traumatias* (Vachal), *A. ictis* (Vachal) and *Oxystoglossidia uraniella* Moure, *A. iophoeila* Moure, *A. iphigenia* (Holmberg), *A. michaelis* (Vachal) (= *Oxystoglossidia uranioides* Moure), *A. tredecim* (Vachal), *A. urania* (Smith).

Some Diagnostic Characters

The genus can be distinguished from the other genera of green halictines occurring north of Mexico by the key below. A detailed description was given by Sandhouse (1937) and modified by Michener (1954). The following account, therefore, is brief and presents only the most diagnostic and readily visible characters by which *Augochlorella* can be distinguished from the other nearctic halictines of similar appearance.

**HEAD:** The epistomal suture (Fig. 2, es.) in *Augochlorella* and *Augochloropsis* extends ventrolaterally on each side of the clypeus to the level of the mandibular base where it angles abruptly laterally. In *Augochlora* and most *Agapostemon* it loops below the level of the mandibular
base into the clypeal area, thus forming a lobate extension of the paraocular area (Fig. 1).

The clypeus is flattened in Augochlorella but with the apical half beveled or at a slight angle to the upper half. Females have the beveled portion brown or black with large, coarse, well separated punctures. The upper half is metallic green or blue with smaller punctures of varying sizes. In Augochlora the clypeus is flat, or the beveling is not noticeable since the entire surface is green except for a narrowly black apical edge. In Augochloropsis the clypeus is protuberant and rounded, sometimes slightly darkened medially at the apex. The clypeus of Agapostemon is similar to that of Augochlorella except for the ventrolateral or lobate extensions of the epistomal suture.

The vertex in Augochlorella is short, about equal to the oculo-ocellar distance, and abruptly angled or declivitous between the posterior ocelli and the occipital carina (Fig. 5). In Augochlora this area is broadly rounded and longer than the oculo-ocellar distance (Fig. 3). In Augochloropsis the vertex is long and sharply angled so that the occipital carina is usually hidden from above except when the head is strongly depressed (Fig. 4). In Agapostemon the vertex is similar to that of Augochlorella.

THORAX: The posterior vertical surface of the propodeum of Agapostemon may be distinguished from that of all the other genera by the key character given below.

The marginal cell of the forewing in Augochlorella is pointed at the wing margin (Fig. 6), whereas in the other three genera it is narrowly
Figs. 1-2. Front view of head. Fig. 1, Augochlora; Fig. 2, Augochlorella; epistomal suture.

Figs. 3-5. Side view of head. Fig. 3, Augochlora; Fig. 4, Augochloropsis; Fig. 5, Augochlorella.

Figs. 6-9. Forewings. Fig. 6, Augochlorella; Fig. 7, Augochlora; Fig. 8, Augochloropsis; Fig. 9, Agapostemon.

Figs. 10-11. Body measurements; Fig. 10, a: width of head; b: length of clypeus; c: width of clypeus; Fig. 11, a: length of metanotum; b: length of propodeum.
truncate at the tip or bent away from the margin of the wing. In Augochlora and some Agapostemon and Augochloropsis the lower vein of the marginal cell (Fig. 7) extends beyond the tip of the cell.

Key to Genera of Green Halictines of the United States

1. Body surface strongly sclerotized with large deep punctures similar to that of chrysidids; female without scopa——Temnosoma
   -- Body surface not as above; females with scopa on hind legs-----------------------------------------------2

2. Posterior vertical surface of propodeum enclosed by a strong carina; first recurrent vein (1st m-cu) basad of 1st r-m (Fig. 8)-----------------------------------------------Agapostemon
   -- Posterior vertical face of propodeum not enclosed by a carina; first recurrent vein interstitial with 1st r-m (Fig. 6)-------3

3. Epistomal suture forming deep loop into clypeal area, extending below level of base of mandible (Fig. 1)----------------Augochlora
   -- Epistomal suture forming right angle bending laterally at level of mandibular base (Fig. 2)-----------------------------4

4. Marginal cell pointed on margin of wing (Fig. 6); metasomal terga without fringe of long apical hair; inner hind tibial spur of female serrate--------------------------------Augochlorella
   -- Marginal cell either truncate and appendiculate apically or pointed below margin of wing (Fig. 9); inner hind tibial spur of female pectinate--------------------------------5

5. Tegula with inner posterior angle lobate; pronotum with dorsal edge carinate or lamellate; apical margins of metasomal terga green, usually with fringe of apical hairs----------------Augochloropsis
-- Tegula oblong, not lobate posteriorly; pronotum with dorsal edge rounded or angulate; apical margins on metasomal terga black without fringe of apical hairs---------Pseudaugochloropsis
TERMINOLOGY

Terminology for all morphological structures follows that of Michener (1944) unless otherwise stated. In the interests of simplicity and conservation of space, certain terms have been used in the descriptions and discussions of variation which may seem vague; they have been used, however, in precise ways in the sections that follow, as explained below:

The body surface: the integument or a sclerite in general or the areas between punctures, striations or other specifically mentioned conformations when present; its degree of shininess and roughening are often significant characters.

Shininess: polished, absolutely smooth at magnifications used and highly reflective; shiny, reflective but not brilliant and not necessarily smooth; dull, not shining although sometimes appearing smooth at magnifications used.

Roughness: smooth, without obvious irregularities or unevenness; granular, with very small, round pits, usually regularly distributed giving the illusion of raised bumps as on fine sand paper; rough or roughened, with a slightly irregular or uneven surface but without any obvious pattern to the unevenness; rugose, deeply roughened or wrinkled, often forming a regular pattern with the elevations and ridges occupying an area as large as or larger than the depressions; areolate, deeply rugose, forming a network of ridges with depressions occupying greater areas than the elevations or ridges.

The degree of roughening or punctation is described by the following adverbs in sequence starting with the least amount of roughening:
minutely, weakly, finely and coarsely. An adjective when used by itself (i.e., "rough") describes a condition between fine and coarse.

**Punctures distinct:** This expression is used if each puncture is separated from every other puncture, with the outlines easily discernable. Punctures may be very close together but nevertheless easily recognizable as individual punctures.

**Punctures indistinct:** This expression is used if the punctures are not easily recognizable as distinct entities and may be either shallow or minute and vaguely defined or may merge together.

**Disc** refers to the dorsal area of the propodeum only. **The edge of the disc** refers to the angle formed between the dorsal and vertical surfaces of the propodeum. It grades from sharp or weakly carinate to gradually rounded. The **shape or outline of the disc** is the pattern formed by the edge of the disc when viewed from above.

**Form** refers only to particular variants in the species *striata*. 
METHODS

Equipment. All specimens were examined under 40X magnification of a dissecting microscope. A 100 watt incandescent bulb was used when recording body sculpturing. An American Optical Company microscope light with rheostat transformer and blue filter was used to view the color of body and pubescence.

All photographs were taken at the same magnification and those appearing in any one plate are reproduced at the same magnification.

Measurements were made by means of an ocular micrometer at 40X magnification. In all cases, the specimen was aligned so that both extremities of the structure being measured were in focus and a maximum measurement obtained of the distance between them.

Synonymies. In the synonymy of each species all known references are given, with annotations indicating the content as follows: descriptions or descriptive comparisons with other species (descr.), distribution records (distr.), flower records (fl.), keys (key), annotated or unannotated lists of species such as catalogues or regional compendia (list), and taxonomic treatments usually including keys, distributions, descriptions, etc. (tax.). Secondary references to synonymies in catalogues or taxonomic treatments are not included. Certain authors (Rau, 1922) have confused species of Augochlorella with Augochlora pura. References published under specific names of Augochlorella (e.g., striata) but known to refer to Augochlora pura are of course omitted from the synonymies.

Types. The type (holotype or lectotype) has been seen for all species unless otherwise noted.
**Descriptions.** With the exception of *persimilis* and *striata*, all specimens of a species were examined for all characters. During the course of the study all but those characters finally used in the descriptions were eliminated, usually because they were found to have little or no diagnostic value. The genitalia of about 50% of the males of each species, from localities throughout the range, were examined.

Because of the large number of specimens of *striata* and *persimilis*, the descriptions and detailed examinations of these species were made from a sample of about 50 specimens, mostly from one state. Samples from all other states were then compared with the description, and corrections and variations noted. Every specimen in both species, both male and female, was critically examined with regard to all propodeal characters and metasomal punctures and for the basitarsal hair of males. Other characters received attention commensurate with their diagnostic value. For variable characters in *persimilis*, enough specimens were examined to determine the extent of the variation and the distribution of the variants. For *striata*, variation was studied by recognizing several lettered "forms." The details are indicated in the discussion of that species.

**Variations.** An attempt has been made to indicate as closely as possible the range of variation of each character in each species. Whenever practical, particular specimens have been cited to illustrate certain variational features, or percentages are given if large numbers of individuals are involved. Particular specimens are identified by
their label data followed by the code numbers, in parentheses, of the collections in which they are located (see Table I).

In the section on regional variation all species occurring within each geographical area are compared.

Although much attention has been paid to the problem of variation in this group, this is not primarily a study of variation and at least in one species, striata, a considerable amount of work, both analytical and statistical, still needs to be done before a complete understanding can be achieved.

**Distributions.** Although a complete list of all label data has been made, localities are listed in this paper only by counties except where the counties are large with widely varying habitats (all western and southwestern states), are rarely used (Canada) or do not exist (Mexico). Only those specimens that have been examined are listed (unless otherwise specified). Records from the literature are omitted due to the unreliability of specific determinations.

**Seasonal activity.** The data on this topic were obtained from pinned material unless otherwise noted. Dates given for seasonal activity are those on which collections were made and do not necessarily represent the entire season of the bees' activity.

**Flower records.** Flower records were taken from the literature and from labels on pinned specimens but not from laboratory observations since host plant preferences in the laboratory are shown to have little correlation with those in the field under natural conditions (see Part II). The records listed under each species show the flowers without regard to
sex or to whether the bee was collecting pollen or nectar, since this information is usually not available. All flower names have been checked and the appropriate synonymies made according to the following references: Fernald (1950), Gould and Thomas (1962), Kearney and Peebles (1951), Munz (1959), Smith (1933) and Index Kewensis (1895-1955).
SPECIFIC CHARACTERS

Nearly all of the specific characters vary in a continuous manner, so that it is difficult to categorize the differences within and among species. Many of the characters are self-explanatory but others require explanation and are discussed below. Some of these characters are of no value in distinguishing the North American species from one another but are of value in distinguishing certain neotropical species.

Body color. Coloration throughout the range of the species is extremely variable. The usual color is a bright green, but specimens may range from bronzy or yellowish green to a deep violet-blue. Blue specimens are found only in Florida. The part of the body with the greatest color variation is the metasoma where coloration is often incomplete, allowing various amounts of brown to show through, so that in some specimens this area looks brown with metallic reflections. Of the species considered in this paper, only the males of edentata have the metasoma consistently and naturally brown. It was found that in dried specimens, normally testaceous colored (pale yellow-white) structures may in some specimens turn orange due to ageing or other factors. This condition has not been found in live or freshly killed bees.

The metallic color is structural and can be altered artificially by various environmental conditions or chemicals. Limited tests have shown that dried bright green bees turn blue-green to blue within five minutes in ethyl acetate (liquid) and that on drying, the bees stay blue-green. If they are then put into water the bright green color slowly returns.
Bees preserved in alcohol or in Dietrich's or Carnoy's solutions remain green, but dry, bright green or yellow-green bees turn coppery-green to reddish in an atmosphere containing phenol (as in a relaxing chamber). Depending on the concentration and exposure time, the altered color may remain after the specimen has redried.

Chemicals may affect the coloration of insects found in collections. The color of live bees may be determined or influenced during the pupal stage by atmospheric or soil moisture. Specimens of Augochlorella found in Florida are uniformly darker green than they are to the north but it is not known whether the bright blue individuals, frequently found in collections from Florida, actually are this color in nature. Many of the blue specimens were collected by Graenicher. It is possible that he and some other collectors in Florida used acetate killing jars, thus changing the color of the bees. Some persimilis were reared in the laboratory in wet soil. Emerging females were usually a dark green but one blue individual was produced. The males produced were mostly the yellow-green color typical of both sexes of this species in Kansas. The blue reflections found on the frontal area of the head in some species appear to be a natural phenomenon with variation only in the intensity.

Size. Total body length, although inexact, gives a rough indication of the overall length and is given for comparison with species described by earlier workers. When a wide variation of lengths occurs the extremes are given. All measurements are made on individuals with bodies in extended positions. Width of the head is a more standard and reproducible measurement and has been shown (Michener and Lange, 1958), at least for Lasioglossum rhytidophorum, to be highly correlated with other body
measurements such as wing length and thoracic size. Both in *A. striata* and *persimilis* a high correlation (r values significant at < .01) was also found between the width of the head and length of the wing with r values of .65 and .55 in *striata* and *persimilis* respectively (see Part II for full discussion of variation). Head width was measured across the widest part of the face, at about the level of the ocular emargination (Fig. 10). When available, at least 50 males and 100 females of each species were measured from throughout its geographic range, representing as wide a span of collecting dates as possible. An effort was made to include all size extremes. In *striata*, all "forms" were lumped together. Wing length was not used, as it is a difficult and unreliable measurement on dried material. The width-to-length relationship of the head is given as an indication of the shape of the face. Bees in which the length of the head is greater than the width have a face that appears long (Fig. 52); when the length is equal to the width (± 0.4 mm), it appears round (Fig. 53), and when the width is greater than the length, the face appears wide (Fig. 54). In some species the shape of the face is relatively constant; in others it is variable. The length of the face was measured from the apex of the clypeus to the vertex, with the head positioned so as to give a maximum measurement and with the distance being determined when both extremities were in focus. It is a poor measurement to use by itself, as it is frequently inexact or cannot be reproduced exactly on the same specimen. However, as a comparison with the width (greater than, equal to or less than), it is quite usable, and the same proportions may be obtained after multiple readings.
Clypeus. The clypeus in all species studied is largely green or similar in color to the rest of the head. In males, the apex is narrowly testaceous medially, slightly more extensively so at the lateral corners. In females the apex of the clypeus is nonmetallic brown or black, the extent of the nonmetallic area being variable within and among species. The length (Fig. 10b) is usually equal to or slightly greater than the width (Fig. 10c) in both sexes. The size and spacing of the punctures on the clypeus usually varies within species although some species have a more uniform pattern than others.

Supraclypeal area. This area is slightly convex and looks protuberant in all species except edentata. This protuberance is due more to depression of the epistomal suture and antennal sockets than to an elevation of the area itself. In edentata and some other neotropical species, there are scarcely any depressed areas so that the entire face looks broadly and evenly convex.

Tegula. The length to width ratio of the tegula differs among species. In all species unless otherwise noted, this structure is oval, shiny and smooth, transparent to pale yellowish anteriorly, becoming darker posteriorly and dark brown, usually with metallic reflections, along the proximal edge. The anterior part is usually minutely pilose.

Propodeum. The characters of the propodeum are highly variable. All variation is more or less continuous so that there are rarely distinct gaps separating species, and yet these characters are still the most diagnostic for distinguishing species, especially in the females. The length of the disc (the dorsal area) is measured along the median line
from the anterior carina separating the metanotum and propodeum, to the posterior margin of the disc. When the posterior margin forms a sharp V medially, the posterior edge is assumed to be evenly rounded and the tip of the V is omitted from the measurement (Fig. 11b).

The outline or shape of the disc is classified into four categories, although all gradations occur among these categories. The "bracket" shape ( ) is perhaps the most distinctive (Figs. 12-14, 57, 58) and is characteristic of gratiosa, aurata and some striata. The posterior edge comes to a point or V medially, slopes laterally to the posterolateral corners of the propodeum, then angles abruptly anterolaterally. The V-shape is similar but without the distinctive angulation at the posterolateral corners. The V may be deep, so that the length of the disc is considerably longer medially than at any other point, as in some striata b (Figs. 15, 63), or it may be shallow or "obtuse" with the length of the disc essentially equal throughout (Fig. 59). In addition, the posterior edge may be sharply pointed medially (Fig. 12) or blunt and rounded (Fig. 14), or may extend posteriorly in the plane of the rest of the disc or be depressed onto the posterior vertical propodeal surface (Fig. 63). The U-shape (Figs. 16, 62) lacks the medial V and is evenly rounded posteriorly. The length of the disc is greater medially than laterally. The semicircular shape is similar to the U-shape but is shorter in relation to its width, with shorter, more rounded posterolateral corners (Figs. 18, 64). Gradations among all shapes occur (Figs. 17, 65). Relationships of the different shapes are diagrammed in Figure 19.

The sharpness of the edge and the flatness of the disc is indicated by the profile type. In type 1 (Figs. 20, 21), the edge of the disc is
weakly or sharply angulate to carinate and slightly elevated, giving the
disc a concave appearance in profile. In type 2 (Fig. 22), the edge is
abruptly rounded, not elevated, and distinct when viewed from the top.
The surface of the disc is flat. In type 3 (Fig. 23), the edge is
rounded but slightly prominent or thickened, so that although the edge
is definite when viewed from above it is not as distinct as in type 2.
Type 4 has a gradually and smoothly rounded edge (Fig. 24) without any
demarcation between the dorsal and vertical surfaces. Type 5 (Fig. 25)
includes only *pomoniella* and combines characteristics of types 3 and 4.
The edge of the disc, although gradually and smoothly rounded, is at the
same time prominent and somewhat elevated. The dorsal surface of the
disc is therefore slightly concave, a feature that is evident both from
the top and from the side.

When the striae do not reach the posterior edge of the disc or the
de edge is unclear as in profile type 4, the surface of the disc beyond the
striae may be variously marked with granulations (Fig. 62), fine ridges
(Fig. 66) or minute transverse lines or reticulations (Figs. 67, 69, 70);
each type of surface is characteristic of certain species.

The posterior vertical surface of the propodeum is also variously
sculptured in the different species, grading from smooth and shiny with
minute punctures (Fig. 73) to smoothly granular (Fig. 74) to roughened
and rugose (Fig. 75). There is some variation within species, particularly
among the forms of *striata*, but in general each species is characterized
by a certain type of sculpturing.

*Metasoma*. Because the first abdominal segment is incorporated into
the thorax, segments of the apparent abdomen are numbered from one on
Figs. 12-18. Diagrams showing shapes of propodeal disc. Figs. 12-14, bracket-shaped, Fig. 12, A. gratiosa; Fig. 13, striata a; Fig. 14, aurata; Fig. 15, V-shaped, striata d; Fig. 16, U-shaped, pomoniella; Fig. 17, U-shaped, edentata; Fig. 18, semicircular, bracteata.

Fig. 19. Relationship of disc shapes; v: V-shaped; s: semicircular; u: U-shaped.

Figs. 20-25. Diagrams showing profiles of thorax. Fig. 20, A. striata a, type 1; Fig. 21, gratiosa, type 1; Fig. 22, aurata, persimilis, bracteata, type 2; Fig. 23, striata b, d, neglectula, type 3; Fig. 24, striata c, edentata, type 4; Fig. 25, pomoniella, type 5.
and are called metasomal segments. Numbered terga and sterna always refer to these metasomal segments.

The size and density of punctures on the first and second tergum are variable within and among species in both males and females, sometimes varying geographically. The punctures may be distinct and regular or they may be indistinct, irregular or variable in size and spacing. The third and following terga in all species studied are densely and minutely punctured, with the punctures inconspicuous and blending together giving the surfaces of the terga a minutely reticulate appearance. The apices of the terga are narrowly margined with brown in all species. The sterna of both males and females are brown, with long hair on at least the apical halves. In females this hair is longer than in males and is frequently used by the bee as part of the scopa. In addition to color variations noted in a previous paragraph, the first and second terga may show dull, discolored areas on the dorsal median surface. This is due to a waxlike secretion from this area (Fig. 56) that leaves the otherwise shiny surface dull. The nature and function of this secretion is not known, but it occurs in females (but not males) of all species of Augochlora and Augochlorella examined. It is not found on fresh, young (entirely unworn) specimens but the discoloration, if not the waxlike substance itself, may be found on most older specimens.

**Pubescence.** Over most of the dorsal part of the body there are two types of pubescence, the long, simple or branched hairs usually referred to as the pubescence or hairs and exceedingly short, fine, highly plumose pubescence not visible except when the longer hairs have been worn away and the surface is seen in profile. This latter pubescence is
white in *Augochlorella* and may be rather dense in unworn specimens, especially on the head, posterior surface of the propodeum and metasoma. The longer hairs are white to golden-white, depending on the region of the body and on the individual specimen.

**Male genitalia.** The male genital capsule (Figs. 26-28) is basically similar for all Nearctic species but differs significantly in structure from that of *A. seminigra* of the *Pereirapis* group (Figs. 29-30). The only specifically variable structure on the capsule is the inner lobe of the gonostylus (Fig. 27). This lobe is essentially similar in all the eastern species (*aurata, striata, gratiosa, persimilis* and *bracteata*) (type 1, Figs. 31-34) but is distinctive for each of the remaining western and Mexican species (types 2-4, Figs. 35-39). In type 1, considerable variation occurs within species in the length of the attenuated, finger-like projection, the number of long setae, and the roundness and slope of the apical portion of the lobe. There are average differences in shape among the species, as seen in Figs. 31-36, but these differences are not constant and cannot be used as diagnostic characters. The number of setae is not constant but averages about 10 on the rounded portion of the lobe and 2 to 3 on the attenuation. The outer lobe (Fig. 27) is similar for all type 1 species and varies little except for the number of long, unbranched setae. The genitalia of the remaining (western and Mexican) species are described under those species.

**Hidden sterna.** Only three structural types are recognized among the eight species studied (Figs. 40-42), with all eastern species and *neglectula* belonging to type 1. Slight individual variations occur in
Figs. 26-28. Male genital capsule of *Augochlorella striata*. Fig. 26, dorsal view; Fig. 27, ventral view (*l₁*: inner lobe of gonostylus; *l₂*: outer lobe of gonostylus; *gn*: gonostylus); Fig. 28, side view of genital capsule.

Figs. 29-30. Male genital capsule of *Augochlorella seminigra*. Fig. 29, dorsal view; Fig. 30, ventral view.

Figs. 31-36. Lobes of the gonostylus. Fig. 31, *A. bracteata*; Fig. 32, *striata*; Fig. 33, *persimilis*; Fig. 34, *gratiosa*; Fig. 35, *pomoniella*; Fig. 36, *edentata*. 
type 1 (Fig. 40) that involve the degree of sclerotization, the shape of
the apex, and the number and position of setae on the seventh sternum.
The central thickening appears to be absent in *neglectula*. In *pomoniella*
(Fig. 41), the sterna differ by the presence of a variably shaped knob-
like median projection on the eighth sternum, by the minute setose
projections on the distal arms, by the apparent lack of central thickening
and the consistent lack of apical setae on the seventh sternum. In
*edentata* (Fig. 42) the structure of the eighth sternum is similar to
that of the eastern species, but the seventh sternum is elongate and
truncated apically.

**Eighth tergum.** This tergum is hidden, mostly membranous, internal,
usually closely adherent to the seventh tergum and attached by weakly
sclerotized arms to the eighth sternum. There is a row of spiculate,
finger-like projections along the anterior (inner) edge when the
sclerite is in its normal inverted position (Fig. 43). However, this whole
structure may be everted, in which case the projections extend posteriorly
to the outside (Figs. 44, 45). There are differences among species in
the number, shape and spacing of the finger-like projections. All the
eastern species as well as *pomoniella* belong to type 1 (Fig. 43)
characterized by 10 to 14 closely arranged, densely setose projections
with the entire tergum minutely setose. The projections are sometimes
branched at the tips in *gratiosa*. In *neglectula* (Fig. 46) there are 8 to
9 short, thin, widely separated, and sparsely, minutely and inconspicuously
pubescent projections. The membrane appears finely pubescent laterally
but bare medially. In *edentata* (Fig. 47) the projections number 12 to 14,
Figs. 37-39. Lobes of the gonostylus of *A. neglectula*. Figs. 37-38, *n. neglectula*; Fig. 39, *n. maritima*.

Figs. 40-42. Hidden metasomal sterna, a: sternum 7, b: sternum 8.

Fig. 40, type 1, *A. striata*; Fig. 41, type 2, *pomoniella*; Fig. 42, type 3, *edentata*. 
are long, thin and very sparsely setose. The arms are minutely pubescent, but the transverse part appears bare. The differences noted here are easily observable under 200X magnification of a compound microscope. Differences in the shape of the tergum, length and shape of the lateral arms, presence and location of punctures and arrangement and pattern of the pubescence are not considered of diagnostic value because of the fragile nature and eversibility of the entire structure. The eighth tergum is most easily removed with the genital capsule and seventh and eighth sterna to which it is attached.
Figs. 43-47. Hidden eighth metasomal tergum. Fig. 43, A. striata (normal inverted position); Fig. 44, gratiosa (semi-everted);
Fig. 45, gratiosa (everted position); Fig. 46, neglectula; Fig. 47, edentata.

Figs. 48-51. Male hind basitarsus, inner view. Fig. 48, A. striata; Fig. 49, neglectula; Fig. 50, persimilis; Fig. 51, gratiosa.
OTHER CHARACTERS

Other characters were studied and rejected because the characters were identical in all species, because they were too variable intra-symmetrically to have any meaning, or because the measurements or definitions were not precise or reproduceable. A total of 20 characters, most with multiple character states, were used in a factor analysis of differences between females of *persimilis* and *striata*. Although none of the characters was rejected on the basis of this study, it was shown that those characters deemed most useful in species recognition were indeed most highly correlated with the species (used in the analysis as one of the characters). These most useful characters were located in the propodeal area.

Characters studied but seldom or not found useful among the Nearctic species are:

**Head**: Ratio of clypeal length to width; protuberance of clypeus and supraclypeal area, color and shape of labrum; degree of rugosity of frontal area; roughening of vertex; relations between upper interocular, the interocellar and the ocellocular distances; smoothness, color and length of pubescence of genal area; antennal contrasts in color of different segments.

**Thorax**: The angle between the dorsum of the scutum and the slope of the propodeal disc; wing length; color, size, shape of the tegula; precise measurements and comparisons of size and spacing of punctures anteriorly, centrally, laterally and at anterolateral angles of the scutum; sculpture, color and smoothness of the scutellum; sculpture, color and smoothness of each part of the pleuron; size and spacing of
propodeal striations; ratio of dark to light areas on the femora and
tibiae of the male; length to width ratios of the hind tibia and tarsal
segments; color of the basitibial plate.

**Metasoma:** Detailed color variations of the terga; descriptions,
measurements and comparisons of size and spacing of punctures and surface
markings on all terga; punctures and lineations or other markings on the
sterna; depth of emargination of fourth sternum in males; comparisons
of certain structures of the genital capsule of males—length of the
attenuation of the inner lobe; roundness and height of the apex or
crown of the inner lobe; spacing and number of setae on the inner lobe;
shape, location and area of fusion of other lobes and processes on the
gonostylus; comparison of profiles (side view) of capsule.
SPECIES GROUPS

The Nearctic group of species (i.e., Augochlorella s. str., not Pereirapis) includes both Neotropical and Nearctic species although only the Nearctic species are considered at this time. This group is divisible into eastern, western and southern subgroups, each showing certain distributional and morphological affinities. The only species included in this work from the southern subgroup is edentata, but there are undoubtedly other species to the south. The western or "pomoniella subgroup" contains pomoniella and neglectula. The eastern or "striata subgroup" consists of aurata, striata, persimilis, gratiosa and bracteata.

The pomoniella subgroup ranges from northern California southeast into Arizona and New Mexico in the United States and at least as far south as Costa Rica and Panama. The striata subgroup is found from south central and southeastern Canada through the eastern, midwestern and southern United States and as far west as Colorado and New Mexico. Except for bracteata, none of the included species ranges into Mexico.

Morphological characters separating the striata and pomoniella subgroups involve the shape of the fourth metasomal sternum of males (margin straight in pomoniella subgroup, emarginate in striata subgroup) and the shape of the inner lobe of the gonostylus of the male genital capsule. The degree of morphological variation occurring within the two groups is also significant. These characters and their relationships among the species are discussed under each species. It is quite probable that significant biological differences may be found between the subgroups, but as yet only the biologies of persimilis and striata are known (see Part II).
The species of the eastern subgroup seem more closely related to each other than are the two species of the western subgroup. In the striata subgroup there is greater morphological variation and intergradation among the species and the male genitalia are all essentially alike. In the pomoniella subgroup the male genitalia differ, and there is comparatively little variation and virtually no intergradation between the two species.

The relationship of edentata to the northern Augochlorella and to the Pereirapis group is not clearly understood. The female appears to belong to Pereirapis and has been placed in that group by Moure. The male, however (previously undescribed), has clypeal and genitalic characteristics of the northern species but in other respects looks similar to Pereirapis.
SPECIES ACCOUNT

Key to the species of Augochlorella

This key must be used in conjunction with the regional keys and the section Regional Discussion because of the wide variability within species and the continuous or intergrading nature of all characters. It will not work for all specimens since intermediates are found among many of the species and forms. The term "disc" in all cases refers to the dorsal area of the propodeum.

Females

1. Striae of disc reaching edge posteriorly, i.e., with little or no unstriated area between ends of striae and edge of disc (Figs. 57-63)----------------------------------------------- 2

2. Striae of disc not reaching edge posteriorly, with distinct unstriated region between ends of striae and edge of disc (Figs. 64, 67, 69)----------------------------------------------- 11

2. Scutum coarsely punctate and strongly rugose anteriorly (Fig. 77)----------------------------------------------- 3

3. Scutum with small, distinctly separated punctures, finely roughened to weakly rugose anteriorly (Fig. 78)-------------------------- 9

3. Striae of disc fine and close together; disc at least weakly bracket-shaped (Figs. 57, 58) length less than or only slightly longer than metanotum--------------------------------------------------------

------------------------ aurata, gratiosa, striata a (see regional keys)
4. Posterior edge of disc sharply angulate (Fig. 21) or abruptly rounded (Fig. 22); disc sharply pointed medially; length of disc less than 1.5 times that of metanotum (Fig. 60) — striata a

--- Posterior edge of disc gradually rounded or at most abruptly rounded, not sharply pointed medially, or if so, length more than 1.5 times as long as metanotum------------------- 5

5. Disc at least weakly bracket-shaped, length equal to or only slightly longer than metanotum (Fig. 71)----------------- striata d

--- Disc V-shaped, U-shaped or semicircular (Figs. 16-19)--------- 6

6. Disc obtusely and bluntly V-shaped (Figs. 15, 63), length 1.5 to 2 times that of metanotum------------------------ striata b

--- Disc U-shaped or semicircular, or if V-shaped then less than 1.5 times length of metanotum------------------- 7

7. Shape of disc semicircular or U-shaped; edge smoothly and gradually rounded posteriorly (Figs. 24, 62) without distinct difference in sculpture between dorsal and vertical surfaces------------------- striata c

--- Shape of disc variable, posterior edge slightly roughened, abruptly angulate (Figs. 22, 23) or with distinct contrast in sculpture between dorsal and vertical surfaces------------------- 8

8. Disc roundly V-shaped with medial striae ending abruptly at posterior edge-------------------------- striata d
Disc semicircular with striae ending gradually near posterior edge------------- striata c

9. Shape of disc semicircular (Fig. 66); scutum with small, distinctly separated punctures, space between punctures smooth and shiny (Fig. 78) (Texas and Mexico only)---------- bracteata

Shape of disc at least weakly bracket-shaped (Figs. 57, 58); scutum with punctures irregular in size and shape, very close or contiguous with little or no smooth shiny space between (Fig. 81), giving scutum a slightly roughened appearance-------- 10

10. Posterior vertical surface of propodeum finely and evenly granular or smooth (Fig. 74), length of disc equal to or slightly greater than length of metanotum--------------- aurata

Posterior vertical surface of propodeum irregularly or coarsely granular with minute irregular ridges (Fig. 76), length of disc equal to or less than metanotum---------------- gratiosa

11. Scutum with small distinct punctures, surface between punctures smooth, or minutely roughened and without distinct punctures. (Figs. 78, 79)----------------------------------------------- 12

Scutum with surface rough, coarsely punctate or rugose, at least anteriorly----------------------------------------------- persimilis, striata c, neglectula, pomoniella (see regional keys)

12. Antenna with yellow tip; scutum without distinct punctures (Fig. 79); propodeal disc more than 1.5 times as long as metanotum----------------------------------------------- edentata
Antenna with dark tip; scutum with close, distinct punctures (Figs. 78, 80); propodeal disc 1.5 times as long as metanotum or less------------------------------- 13

13. Striae occupying three-quarters the length of the disc or less as in Figure 69, with posterior edge of disc smooth and shiny---
----------------------------------------------- pomoniella

Striae occupying more than three-quarters the length of the disc, posterior edge roughened and dull------------------- 14

14. Posterior vertical surface of propodeum finely and evenly granular or smooth; tegula shiny without distinct punctures------ bracteata

Posterior vertical surface of propodeum roughened with horizontal rugae extending across posterolateral corners; tegula dull, with small but distinct punctures---------------------- neglectula maritima

Males

No attempt is made to separate males of striata into forms a to d, since only a few can be so classified. Differences among these forms, when present, are explained at the end of the description of striata.

1. Fourth metasomal sternum with apical margin straight------------ 2

--- Fourth metasomal sternum with apical emargination------------ 4

2. Metasomal terga green or blue; first sternum with metallic reflections----------------------------------------------- 3

--- Metasomal terga brown; first sternum without metallic reflections-------------------------------- edentata
3. Posterolateral corner and lateral vertical surface of propodeum smooth with punctures; frons without bluish reflections—pomoniella
   Posterolateral corner and lateral vertical surface of propodeum rough or rugose, not punctate; frons with bluish reflections----
   -------------------------------------------------------------- neglectula

4. Hind basitarsus with erect hairs of two distinctly different lengths (exclusive of basal tuft), longest hairs at least twice as long as width of segment, usually curved at tips (Figs. 50-51)------------------------ 5
   Hind basitarsus with erect hairs of similar lengths (exclusive of basal tuft), 1.5 times as long as width of segment or less; all hairs straight (Figs. 48-49)--------------------------------
   -------------------------------- aurata, striata, bracteata (see regional keys)

5. Basal third of hind basitarsus without long erect hairs; longest hairs on apical two-thirds about twice as long as width of segment (Fig. 50); last antennal segment similar in color to preceding segment, not entirely dark brown; fifth metasomal sternum without greenish reflections----------------- persimilis
   Basal third of hind basitarsus bearing long curved hairs, four times as long as width of segment (Fig. 51); last antennal segment entirely dark brown; fifth metasomal sternum with greenish reflections-------------------------------- gratiosa
Regional Keys

If the user of the keys is directed to the Regional Keys by the main keys he should select the region to which his specimens belong and continue keying at the appropriate couplet.

Northeast (Canada, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Pennsylvania, New York, New Jersey.)

Females

From couplet 3: all specimens are striata a.

From couplet 11: all specimens are striata c.

Males

From couplet 4: all specimens are striata.

North Central (Ohio, Indiana, Michigan, Illinois, Kentucky, Kansas, Colorado, Wyoming, Nebraska, Iowa, Wisconsin, Minnesota, North Dakota, South Dakota, Montana.)

Females

From couplet 3: all specimens are striata a.

From couplet 11: intergrades occur throughout the region but particularly in Illinois, Indiana, Missouri, Nebraska and Kansas. Check regional discussion for description of variations.

Surface of disc beyond striae smooth; striae extending almost to posterior edge of disc (Fig. 68)--- striata c
Surface of disc beyond striae usually linearly roughened; striae extending about four-fifths or less the length of disc (Fig. 64)----------*persimilis*

**Males**

From couplet 4: all specimens are *striata*.

Southeast (Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia, Maryland, Delaware.)

**Females**

From couplet 3:

A. Posterior vertical surface of propodeum finely and evenly granular or smooth (Fig. 74); length of disc equal to or slightly greater than length of metanotum----------------------------- B

-- Posterior vertical surface of propodeum irregularly or coarsely granular (Fig. 76); length of disc equal to or shorter than metanotum------------------------ *gratiosa*

B. Striae of disc thick, regular, straight or slightly wavy (Fig. 60)----------------------------- *striata a*

-- Striae of disc fine, close, irregular (Fig. 57)--------*aurata*

From couplet 11: nearly all specimens are *persimilis* from this area as *striata c* is not common and is usually large (more than 6 mm long) with characters not usually confused with those of *persimilis*. Neither one has been seen from Florida.
Striae of disc almost reaching posterior edge; surface beyond striae smooth and shiny or at most minutely reticulated (Fig. 68)------------------------ striata c

Striae extending about three-fourths the length of the disc medially, the area beyond striae usually finely and linearly roughened parallel to edge of disc (Fig. 64)---
----------------------------- persimilis

Males

From couplet 4:

Striae of disc fine and close together (Fig. 57); scutum with small, distinct but crowded punctures, weakly rugose anteriorly------------------------ aurata

Striae of disc coarse, widely or closely spaced (Figs. 59, 60, 63); scutum smooth with large, widely spaced punctures or rough and coarsely punctate, coarsely rugose anteriorly------------------------- striata

South Central (Texas, Louisiana, Mississippi, Alabama.)

Females

From couplet 3:

Posterior vertical surface of propodeum uniformly and finely granular (Fig. 74); length of disc equal to or longer than metanotum medially, striae straight or irregular and indistinct; apex of clypeus less than one-third brown; in Texas, first metasomal tergum strongly punctate (Fig. 82)-------------------------- aurata
Posterior vertical surface of propodeum roughly or irregularly granular (Fig. 76); length of propodeal disc equal to or shorter than metanotum, striae straight and regular (Fig. 58); clypeal apex more than or less than one-third brown; in Texas, first metasomal tergum finely punctate (Fig. 83)------------------ gratiosa

From couplet 11:

A. Posterior vertical surface of propodeum and posterolateral corners finely and transversely rugose; southwestern Texas----------------------------- neglectula
-- Posterior vertical surface of propodeum and posterolateral corners smooth and shiny or finely granular-- B

B. Striae extending almost to posterior edge of disc; surface beyond striae smooth or slightly irregular or roughened----------------------------- striata d
-- Striae extending about three-fourths the length of disc; surface beyond striae usually linearly roughened----------------------------- persimilis

Males

From couplet 4:

Scutum finely roughened anteriorly; posterolateral corners and lateral vertical face of propodeum punctate to weakly punctorugose------------------ bracteata
(Texas only)
Scutum with anterior margin coarsely rugose to areolate; posterolateral corners and lateral vertical surface of propodeum rough to rugose--------- stríata (throughout the area)

West (California, Nevada, Utah, Arizona, New Mexico, Mexico.)

Females

From couplet 3: none of these species range into these regions.

From couplet 11:

A. Scutum with large, distinct, but close punctures; surface between punctures smooth; posterolateral corners of propodeum prominent, smooth and shiny (Fig. 69); posterior vertical surface of propodeum smooth, finely punctate (Fig. 73); striae of disc short, rarely extending more than two-thirds the length of the disc medially, surface beyond striae smooth and minutely reticulated (Fig. 69)----------------- pomoniella

-- Scutum coarsely punctate; posterolateral corners of propodeum rough, dull, not prominent (Fig. 70); posterior vertical surface of propodeum finely roughened to weakly rugose (Fig. 75); striae of disc reaching about three-fourths length of disc medially, surface beyond striae dull and granular----------------- B

B. Tegula shiny, oval, smooth, without distinct punctures----------------- neglectula neglectula
-- Tegula dull, oblong, distinctly and roughly punctate
(Mexico only)------------------- neglectula maritima

Males
From couplet 4: all Mexican specimens are bracteata; all
western specimens are striata.

Augochlorella pomoniella (Cockerell)

9:99 (list); Sandhouse and Cockerell. 1924. Proc. California
Nat. Hist. (9)18:624 (distr.); Cockerell. 1927. Pan-Pacific
Ent. 3:162 (distr., descr.); Michener. 1936. Pan-Pacific
Ent. 12:172 (distr.); Cockerell. 1937. Amer. Mus. Novitates
Congr. 4:289 (distr.); Linsley, MacSwain, Raven. 1963. Univ.
California Publ. Ent. 33:44 (fl.).

Augochlora (Augochlorella) pomoniella pomoniella Michener. 1951. In
Figs. 52-54. Shapes of heads of *Augochlorella*. Fig. 52, *neglectula*, longer than wide; Fig. 53, *persimilis* as long as wide; Fig. 54, *pomoniella*, wider than long.

Fig. 55. Front view of head of *A. edentata*.

Fig. 56. First and second metasomal terga with waxlike exudate.
Fig. 57. Propodeal disc of *A. aurata*.

Fig. 58. Propodeal disc of *A. gratiosa*. 
Fig. 59. Propodeal disc of *A. striata* a from Florida.

Fig. 60. Propodeal disc of *A. striata* a from east coast (standard).
Fig. 61. Propodeal disc of *A. striata c.*

Fig. 62. Propodeal disc of *A. striata c* (standard).
Fig. 63. Propodeal disc of *A. striata* b (standard).

Fig. 64. Propodeal disc of *A. persimilis*.

Fig. 65. Propodeal disc of *A. striata* b-c intermediate.
Fig. 66. Propodeal disc of *A. bracteata*.

Fig. 67. Propodeal disc of *A. edentata*.

Fig. 68. Propodeal disc of *A. striata c-persimilis intermediate*. 
Fig. 69. Propodeal disc of *A. pomoniella*.

Fig. 70. Propodeal disc of *A. neglectula*. 
Fig. 71. Propodeal disc of *A. striata* d (standard).

Fig. 72. Propodeal disc of *A. striata* b–d intermediate.
Fig. 73. Posterior vertical surface of propodeum, *A. pomoniiella*.

Fig. 74. Posterior vertical surface of propodeum, *A. persimilis*.

Fig. 75. Posterior vertical surface of propodeum, *A. neglectula*.

Fig. 76. Posterior vertical surface of propodeum, *A. gratiosa*.
Fig. 77. Mesocutum, *A. striata*.

Fig. 78. Mesoscutum, *A. bracteata*.

Fig. 79. Mesoscutum *A. edentata*.
Fig. 80. Mesoscutum, *A. pomonella*.

Fig. 81. Mesoscutum, *A. gratiosa*. 
Fig. 82. Metasomal punctures, *A. aurata*.

Fig. 83. Metasomal punctures, *A. gratiosa*. 


Types. Augochlora pomoniella, holotype female, from Aliso Canyon (2 miles from Laguna Beach) [Orange County], California (R. LaFollette) is in the collection of the U.S. National Museum. Augochlora utahensis, holotype female, from Rockville [Washington County], Utah, May 7, 1931 (I. Wilson), on Datura, and one paratype female are in the Snow Entomological Museum, The University of Kansas.

Description. Female: 1. Length 7 to 9 mm; head width 1.8 to 2.6 mm, averaging 1.90 mm, usually wider than long (rarely as wide as long).

2. Color bright green to blue-green; frons often with slight bluish reflections; metasoma similar in color to head and thorax or darker or browner in Mexican specimens.

3. Mandible usually with basal half dark brown, lighter brown becoming ferruginous apically, with or without metallic reflections basally.
4. Clypeus about twice as wide as long; basal half green with large, widely spaced punctures, closer basally; apical half dark brown or black and slightly beveled, with large elongate punctures; surface between punctures usually smooth and shiny, sometimes minutely roughened.

5. Supraclypeal area shiny and irregularly punctured; surface smooth or sometimes minutely roughened.

6. Paraocular area punctorugose to finely rugose below level of antennae, more coarsely rugose above.

7. Antenna entirely dark brown; flagellum often slightly lighter below than above; pedicel as long as broad; first flagellar segment almost twice as wide as long.

8. Scutum regularly and densely punctate; punctures small, deep and close; anterior margin roughened medially, becoming weakly rugose at anterolateral angles.

9. Tegula less than twice as long as wide.

10. Scutellum with small, deep, close punctures.

11. Pleuron rugose, more coarsely so anteriorly.

12. Propodeum with disc 1.5 times as long as metanotum; outline of disc U-shaped, profile type 5, posterior edge abruptly rounded, shiny and smooth; disc extending slightly onto posterior surface of propodeum and particularly onto posterolateral corners; striae wavy, irregular, moderately coarse, extending about two-thirds the length of disc medially, usually attaining edge at extreme lateral corner; surface beyond striae minutely reticulate; posterior vertical surface smooth and shiny,
sparsely and minutely punctured; posterolateral corners prominent, shiny, smooth, with few widely spaced punctures; lateral surface finely and linearly rugose anteriorly, weakly punctate toward posterior angles.

13. Legs brown, fore and hind coxae and trochanters with strong metallic reflections, femora usually with weak metallic reflections.

14. First metasomal tergum polished and brilliant, punctures fine and widely spaced anteriorly, smooth and shiny dorsally with punctures small, distinct, numerous, closely and regularly spaced; other terga with minute, often indistinct punctures close together; first sternum without metallic reflections.

15. Pubescence white on head, pale, golden to white on vertex, thorax, metasoma and legs; pubescence short and sparse on genal area, denser and coarser in Mexican specimens.

Male: 1. Length 9 mm; head width 1.75 to 2.25 mm, averaging 2.18 mm, width equal to length.

2. Color bright green to blue-green; frons without blue reflections on green specimens; metasoma dark green, usually darker than rest of body.

3. Mandible usually with metallic reflections basally.

4. Clypeus with punctures large, widely and irregularly spaced, surface between punctures usually smooth and shiny.

5. Supraclypeal area punctate to punctorugose below antennae, usually smooth, shiny and sparsely punctate basally.

6. Paraocular area with small distinct punctures below level of antennae, finely rugose above.
7. Flagellum dark brown above, yellow-brown below; scape, pedicel and usually first flagellar segment dark brown in the United States and some Mexican specimens, last one or two flagellar segments often slightly darker than preceding segments; pedicel and first flagellar segment about equal in size, each about 1.5 times as wide as long.

8. Scutum shiny and smooth, uniformly punctured; punctures distinct, separated by less than a puncture width medially, more crowded at periphery than at center in specimens from areas outside of California; anterior margin roughened or finely rugose, becoming slightly more coarsely so at lateral angles.

9. Tegula twice as long as wide, entirely pale yellow in some Mexican specimens.

10. Scutellum shiny, roughened and punctate; punctations generally irregular in size and spacing.

11. Pleuron rugose to punctorugose, becoming areolate anteriorly.

12. Propodeum with disc 1.5 times as long as metanotum; outline of disc truncately to obtusely U-shaped; disc nearly horizontal and slightly concave, slightly lower at posterolateral corners than posteromedially; posterior edge abruptly rounded, smooth and shiny; striae rather coarse, distinct, wavy, extending about two-thirds length of disc medially or nearly to margin when median striae depressed, reaching edge laterally, often extending onto lateral surfaces of propodeum; surface of disc beyond striae shiny, smooth, minutely reticulate, smooth area extending onto posterior surface; posterior surface of propodeum shiny, usually slightly roughened with shallow, widely spaced punctures of variable
size and density, distinct to indistinct; posterolateral corners closely and shallowly punctate; lateral surface regularly and distinctly punctate with surface between punctures smooth and shiny.

13. Legs brown, coxae, trochanters, femora and tibiae with metallic reflections; hind basitarsi with erect hairs of uniform length and density from base to apex, about as long as width of segment; basal tuft absent.

14. Metasomal terga dark green with apical margins slightly depressed, narrowly brown. First tergum polished anteriorly with numerous widely spaced punctures, smooth, usually dull dorsally, punctures small and close; second and third terga dull, punctures small and close; sterna light brown, minutely pubescent, hairs often longer and denser at apical margins than elsewhere, less so medially than laterally; first sternum usually with feeble metallic reflections; apical margins of all sterna straight or slightly convex.

15. Pubescence white.

16. Genital capsule as in Figures 26, 27, 35, type 2; inner lobe of gonostylus "fan-shaped," bearing variable number (usually about 8) of large heavy setae, inner portion divided to form finger-like section with two to five setae (usually 2 or 3); separation deep or shallow (so that "finger" may appear long or short, but always evident); sterna 7 and 8 without setae, variable in shape, 8 with broadly rounded basal edge medially, not truncate (Fig. 41b); 7 produced into knob-shaped lump medially, each arm with minute setose protuberance on distal inner angle (Fig. 41a); tergum 8 of type 1 (Fig. 43).
Comparisons: *A. pomoniella* is perhaps, the most distinctive of all the North American Augochlorella. It is the largest, smoothest and most brilliant of the species and the least variable. It seems most closely related to *neglectula*, although the male genitalia show closer affinities with those of the eastern species. Both male and female can be distinguished from *neglectula* by the more widely separated and larger scutal punctures and the generally smooth body surface, the greener legs, the polished posterior part of the propodeal disc and postero-lateral corners, the smooth posterior propodeal surface, and in the males by the genitalia (distinguishable from all other North American species) and the sternal punctures and setae.

No *pomoniella* were found that would be confused with any other species.

Variation: Californian specimens, together with those from Nevada, both male and female, are the most morphologically stable of any species. Variability in size and color increases in Arizona and Mexico, where specimens tend to be smaller with the brown areas paler.

Specimens are larger in California (mean head width = 2.33 mm) than in Mexico or Arizona (mean head width = 2.07 mm) (Fig. 84) while females from Utah are about the same size as in California. Differences noted by Michener (1937) represent normal variations found not only among individuals from Utah but also in Californian material.

The metasoma of both males and females is noticeably darker in Mexican specimens than in specimens from the United States, with a greater tendency for the brown to dominate the green in males or brown to become
black in females. Other brown structures, such as the mandibles, tarsi and tegulae, are paler in males from Mexico than in those from the United States, so that on the mandible, the dark brown area is restricted to the basal portion, and the tarsi of most specimens are lighter in color than other parts of the legs, contrasting with the uniformly dark brown legs of specimens from the United States. One series of nine specimens from Yucatan (13*) had both tibiae and tarsi pale although the tibiae were normal in the two other Yucatan males examined. All male specimens from Yucatan and Sonora had pale testaceous tegulae, although specimens from other parts of Mexico were normal. None of the females showed these variations in color.

Thoracic punctation is uniform both in size and spacing in males from California, but in Arizona and Mexico the punctures are closer together and irregular in size at the periphery of the scutum. Females vary little in this respect.

The surfaces of the head and thorax are dull and finely roughened by minute reticulations in many female specimens from Mexico. This roughening is most apparent on the supraclypeal area, clypeus, scutum and scutellum. In addition, the clypeus is entirely brown or black or the brown area extends medially to the base. Such variants were not found in Baja California; only one of 28 specimens from Sonora showed such characters, but all 27 specimens from other Mexican states showed them in varying degrees.

* See Table 1.
As with other species of *Augochlorella*, the propodeal area shows the greatest amount of variation but even this is less than in other species and there is no geographical trend or seasonal pattern in the variation. The striae of the disc are distinct in all males but in females there are occasional individuals in which the striae are fine, weak, or barely recognizable. The striae normally extend half the length of the disc, although in about one-third of the specimens they are longer medially and almost attain the edge of the disc. Such length is more noticeable in the males where the median area is slightly depressed when this condition occurs.

**Distribution.** From northern California just north of San Francisco and western Nevada, southward through central and southern California; Washington Co., Utah, throughout the western half and southern part of Arizona, Baja California; the west coast of Mexico to Chiapas and eastward to Yucatan, southward into Guatemala and Costa Rica (Map; Fig. 85).

A total of 118 males and 631 females have been seen.

**ARIZONA:** Cochise Co., 5 ♀️ (Huachuca Mts.: Mouth of Carr Canyon; 7 mi. SW. Wilcox; Benson) (July, September); Coconino Co., 2 ♂♂, 26 ♀️ (Grand Canyon: Indian Garden ca. 3800 ft., Phantom Ranch ca. 2500 ft., South Rim 6800 ft.; Supai; Havasu Canyon 3500 ft.) (June-August); Maricopa Co., 1 ♂, 7 ♀️ (Granite Reef Dam; 25 mi. E. Gila Bend; 20.7 mi. S. Gila Bend; Tempe) (March, July, September); Mohave Co., 1 ♀ (Grand Canyon, mi. 179.2 at Lava Falls) (June); Pima Co., 22 ♂♂, 78 ♀️ (Tucson;
Sta. Catalina Mts.: Pepper Sauce Canyon, Sabino Canyon, Sabino Basin 3800 ft., Ventana Canyon, Cape Canyon, Hitchcock Highway mile posts No. 5, 6, 8, 9, 5500 ft.; Saguara Nat. Mon.; 18 mi. W. Sells; 5 mi. N. Tucson; 20 mi. E. Tucson; Lowell Ranger Sta. 2700 ft.; Sahuarita; Baboquivari Mts., Kits Peak Rincon; Sierritas 31°51' N. 111°16' W.; Black Dike Prspt. ca. 3750 ft.; Tanque Verde; Continental; Quitobaquito, Organ Pipe Nat. Pk.) (March-November); Pinal Co., 4 ‰, 8 ‰ (Superior; 20 mi. W. Casa Grande; Florence Jct.; Coolidge; Río Aravaipa 2500 ft.) (February-March, June-July); Santa Cruz Co., 3 ‰ (Coyote Mts. 31°58' N. 111°29' W., ca. 3500 ft.; Sonoita) (July-August); Yavapai Co., 2 ‰ (Seligman; 3 mi. N. Rock Spr.) (July). CALIFORNIA: Alameda Co., 5 ‰ (Tesla) (October); Calaveras Co., 2 ‰ (Murphys 2500 ft.); Contra Costa Co., 2 ‰ (Mt. Diablo) (July); Fresno Co., 2 ‰ (Coalinga; Orange Cove) (April-May); Inyo Co., 3 ″, 63 ‰ (Lone Pine; Darwin Falls; Mazourka Canyon; Panamint Mts., Surprise Canyon; 7 mi. W. Westgard Pass; Death Valley; 5 mi. W. Lone Pine; Big Pine; Independence; Payson, 39°19' N. 118°08' W.; Inyo Mts. 7000-9000 ft.; Antelope Spr., 8 mi. SW. Deep Spr.) (April-August); Kern Co., 5 ‰ (Arvin; Democrat Spr.; 6 mi. W. Inyokern, Short Canyon; Caliente) (March, June); Kings Co., 2 ‰ (12 mi. SW. Avenal) (August); Los Angeles Co., 13 ″, 43 ‰ (Sta. Catalina Is.: Avalon, Cape Canyon, Pebbly Beach, Rancho Escondito; Newton; Clairmont; 5 mi. S. Pearblossum; Acton; Eagle Rock; Altadena; Whittier; 6 mi. W. Palmdale; Pasadina) (February-September, December); Mariposa Co., 1 ‡ (1500 ft.) (May); Mendocino Co., 1 ‡ (Ryan Cr.) (July); Mono Co., 2 ‰ (Oasis) (May); Monterey Co., 8 ″, 15 ′ (Paraiso Spr.; Jamesburg; Sta.
Lucia Mts., Hastings Nat. Hist. Res. 1900-2700 ft.) (April-May, August-September, November); Napa Co., 14 ♀♂ (Pope Valley; Mt. St. Helena; Conn Lake; Chiles) (March, May, September); Orange Co., 3 ♀♂ (Newport Bay; Serra; Aliso Canyon nr. Laguna Beach; Laguna Beach) (July-August); Riverside Co., 4 ♀♂, 32 ♀♂ (Palm Spr.; Riverside; San Jacinto; San Jacinto Mts.: Idyllwild Keen Camp; 10 mi. W. Perris; Henshaw; The Gavilan; Whitewater; Corona; Palm Springs; Cathedral City; 2 mi. E. Anza; Elsinor; Murrieta; Andreas Canyon, Palm Spr.) (March-May, July, October); San Bernardino Co., 1 ♂, 13 ♀♂ (Mill Cr.; Crestline; 5 mi. SE. Hesperia; 12 mi. SE. Ivanpah; E. Highlands; Morongo; Chino Canyon; Argus Range, Indian Joe Spr. 2600 ft.; Colton) (March-May, August-September); San Diego Co., 3 ♀♂, 32 ♀♂ (Jacumba; Poway; Vista; Borego; 2 mi. N. Warner Spr.; 3 mi. S. Oak Grove; Barrett Spr.; El Cajon; San Diego; Campo; Descanso; Torry Pine Pk.; Warren) (March-April, July-September); San Joaquin Co., 1 ♀ (Tracy) (July); San Luis Obispo Co., 2 ♀♂ (Paso Robles; 2.5 mi. S. Creston) (April, September); San Mateo Co., 1 ♀ (Jasper Ridge) (September); Santa Barbara Co., 1 ♀ (Sta. Cruz Is.) (May); Santa Clara Co., 2 ♀♂, 9 ♀♂ (Alum Rock Canyon; Stanford, Palo Alto; San Jose; Mt. Hamilton; Uvas Cr.) (July-August, October); Sonoma Co., 5 ♀♂ (Guerneville; Preston) (May, July); Stanislaus Co., 1 ♀ (del Puerto Canyon) (April); Tulare Co., 1 ♀♂, 8 ♀♂ (Lindsay; Lemon Cove 500 ft.; 3-Rivers 600-800 ft.; Porterville; Kaweah) (June-July, November); Tuolumne Co., 5 ♀♂ (Jamestown; 18 mi. SW. Sonora; 13 mi. SW. Sonora) (April, July); Ventura Co., 54 ♀♂ (Quantal Canyon; 5 mi. S. Gorman, Hungary Valley) (May). NEVADA: Douglas Co., 1 ♀♂, 1 ♀ (3 mi. S. Genoa) (August); Washoe

GUATEMALA: Petalhuleu, 2 ♀ (Champerico) (April).

COSTA RICA: Guanacaste, 3♂ (El Coco) (August).

A. pomoniella appears to be most abundant in California with smaller populations occurring from Baja California down the west coast of Mexico into Central America. Small and possibly isolated populations of pomoniella exist in Utah and possibly in New Mexico. The one specimen from New Mexico is without question pomoniella but does seem to be out of place. Whether this is due to mislabelling or to a lack of collecting cannot be determined from the available information. Specimens from the most southwestern county of Utah, Washington Co., are little different from those in California and seem to be a part of the main Californian stock. Specimens have been taken from near sea level to 7000 feet elevation in California and Arizona and from 200 to 6000 feet in Mexico. Specimens were found near sea level in Costa Rica.

The only species of Augochlorella with which pomoniella is in contact in the United States is neglectula, a species found chiefly on the Mexican Plateau and in the mountains of southern New Mexico and Arizona. Although the ranges of the two species broadly overlap in southern Arizona, they are apparently somewhat different ecologically, judging by random collections made in the Santa Catalina Mountains near Tucson, Arizona. These collections show pomoniella occurring from the Sonoran desert near Tucson, a saguaro-mesquite habitat at about 2800 feet near the base of the mountains, to about 5200 feet in oak-juniper association. A. neglectula has been collected at about 3800 feet and ranges well into the pines near the tops of the mountain at about 8100
feet elevation. A. neglectula has not been collected in the desert area around Tucson. This comparison is based only on the label data of 73 pomoniella and 64 neglectula from this one area.

Seasonal activity. Females have been collected between February 28 and December 27 and males between May 3 and December 17, with little difference in dates throughout the range. Females were collected with pollen in their scopas from early March until the beginning of October in California, with similar dates being recorded from other areas as well. The wide variation in size (Fig. 84) is due to geographical differences rather than to seasonal or caste differences.

Fig. 84. Measurements of head widths of females of *A. pomoniella*.

A. From California and Utah. B. From Arizona and Mexico.
Fig. 85. Distribution of *A. pomoniella* (solid dots) and *bracteata* (rings).
Fig. 86. Histograms showing head widths of field caught females throughout the range of each species, sampled from throughout the season.
Augochlorella neglectula neglectula (Cockerell)


**Augochlorella aurata:** Sandhouse. 1937. Jour. Washington Acad. Sci. 27:71 (in part). (Since 1937, when Sandhouse erroneously synonymized neglectula with aurata, various authors have repeated this synonymy, but additional data pertaining neglectula does not appear to have been given.)

**Types.** Augochlorella neglectula, holotype male, from Filmore Canyon [Dona Ana Co.], New Mexico, August 29 (Townsend), in the collection of P. H. Timberlake, University of California at Riverside, California.
Cotype (paratype) female, Filmore Canyon, New Mexico, August 24 (Townsend), No. 4345, in the collection of the U.S. National Museum. In 1906, Cockerell listed the type locality as Organ Mountains, New Mexico; probably Filmore Canyon is merely a more specific statement of the same locality. The species was recognized as new on the basis of male characters, and the holotype is well marked with "type" labels, although not in Cockerell's usual hand. *Augochlora dimissa*, holotype female, from Victoria [Tamaulipas], Mexico, March 16, is in the collection of the U.S. National Museum, No. 25582.

**Description.** Female: 1. Length 6 to 7 mm; head width 1.68 to 2.21 mm, averaging 1.97 mm; head usually wider than long.

2. Color bright green to dark blue; frons usually with blue reflections; metasoma often darker than head and thorax and suffused with brown.

3. Mandible with basal third dark brown, reddish brown centrally, rufous apically, without metallic reflections basally.

4. Clypeus slightly wider than long; basal half green with rather large punctures about a puncture width apart; apical half dark brown and slightly beveled, with about three to five large, often elongate punctures; surface between punctures smooth and shiny or finely reticulated at base and laterally.

5. Supraclypeal area irregularly punctate, sparsely so medially; surface between punctures usually shiny and smooth, sometimes minutely roughened and dull.
6. Paraocular area closely punctorugose below level of antennae, coarsely rugose above.

7. Antenna dark brown, flagellum slightly lighter below than above; pedicel as broad as long; first flagellar segment less than twice as wide as long.

8. Scutum with punctures variable in size and spacing, grading from distinctly and closely punctate to punctorugose, usually closer together laterally than medially; anterior margin finely roughened medially, becoming finely to coarsely rugose at anterolateral angles.

9. Tegula with length slightly greater than width, shiny, without conspicuous punctures.

10. Scutellum with small, close, irregular sized punctures, becoming indistinct in Mexican specimens.

11. Pleuron coarsely rugose, areolate anteriorly.

12. Propodeum with disc usually less than 1.5 times as long as metanotum; outline of disc broadly semicircular, profile type 3, posterior edge abruptly rounded medially, becoming gradually rounded laterally; striae variable, usually regular, fine and radiating from medial area, medially extending about three-fourths length of disc and ending gradually, laterally nearly reaching edge or extending onto vertical surface; surface beyond striae dull and granular to edge; posterior and lateral vertical surfaces finely roughened, usually with fine horizontal rugae extending from lateral to posterior surface across rounded postero-lateral corners.
13. Legs brown; fore and hind coxae with strong metallic reflections; fore femur sometimes weakly metallic.

14. First metasomal tergum with anterior surface polished, sparsely and finely punctate, dull to shiny dorsally, with fine, distinct, close punctures; second tergum with fine, close punctures, surface between punctures smooth, shiny to dull; first sternum with or without metallic reflections.

15. Pubescence white on head and ventrally on thorax and metasoma, white to pale golden or dorsal parts of thorax and metasoma and on legs, golden on thorax of most Mexican specimens.

Male: 1. Length 7 to 8 mm; head width 1.66 to 2.04 mm, averaging 1.85 mm, greater than, equal to or less than length.

2. Color bright green to blue, frons with bluish reflections in all specimens; usually variably blue-green over entire body.

3. Mandible with or without metallic reflections basally.

4. Clypeus with punctures large, widely spaced, surface between punctures minutely roughened to smooth and shiny.

5. Supraclypeal area variably punctate, surface between punctures smooth and shiny or sometimes minutely reticulate and dull.

6. Paraocular area closely punctate to finely rugose.

7. Flagellum dark brown above, yellowish brown below; scape and pedicel entirely dark brown or black; last one or two flagellar segments usually slightly darker below than preceding segments; pedical as broad as long; first flagellar segment about twice as wide as long.
8. Scutum shiny with punctures distinct, variably spaced medially to parapsidal lines, closer laterally; becoming weakly rugose at lateral anterior margin.

9. Tegula less than 1.5 times as long as wide, shiny, with punctures inconspicuous or lacking.

10. Scutellum shiny, distinctly punctate, more densely so posteromedially than elsewhere.

11. Pleuron areolate anteriorly and laterally.

12. Propodeum with disc slightly longer than, to 1.5 times as long as metanotum; outline of disc semicircular, posterior edge abruptly rounded; striae coarse, irregular, wavy, not reaching edge medially, extending onto vertical surface laterally; surface of disc beyond striae narrowly smooth and shiny or slightly roughened; posterior vertical surface shiny, finely roughened or rugose; posterolateral corners with lineate, horizontal rugae extending from lateral to posterior surfaces; lateral vertical surface finely rugose with horizontal lineate rugae anteriorly.

13. Legs brown, fore and hind coxae and trochanters with strong metallic reflections; femora and fore tibia weakly metallic; middle and hind tibiae and all tarsi brown; hind basitarsus with straight, erect hairs of uniform length along entire segment; these hairs almost 1.5 times as long as width of segment; basal tuft reduced to inconspicuous.

14. Metasomal terga green with apical margins brown; first tergum polished with fine, widely scattered punctures anteriorly, smooth but less shiny dorsally with punctures small and close together; second
tergum minutely to indistinctly punctate; sterna brown, occasionally suffused with black, pubescence short and fine, evenly distributed; first sternum with weak metallic reflections; second through sixth sterna with apical margins straight.

15. Pubescence white over entire body to golden in some Mexican specimens.

16. Genital capsule of type 4 (Figs. 37-38); inner lobe of gonostylus long and thin with blunt apex, bearing 3 to 5 stout setae; posterior edge of lobe with setae variable in size and number; setae on outer lobe (12 Fig. 27) usually branched; seventh tergum type 2 (Fig. 46); seventh and eighth sterna type 1 as figured (Fig. 40).

**Comparisons.** Most *neglectula* can be distinguished from all other North American species of *Augochlorella* by the fine radiating striae that extend only about three-quarters of the way across the propodeal disc, by the rugose nature of the posterior propodeal surface, by the blue areas on the frons, and by the shape of the inner lobe of the male gonostylus. In addition, to these characters, it differs from *pomoniiella* by the usually close, deep, often contiguous scutal punctures giving the scutum a rough or even rugose appearance. In *pomoniiella* the scutum is smooth with distinct, widely spaced punctures. The legs, especially the trochanters and femora, are more uniformly brown in *neglectula* than in *pomoniiella*. In most specimens there are no distinct posterolateral corners to the propodeum (Fig. 70) or if there are, they are weak. The corners are rarely polished and shiny as in *pomoniiella* but usually are traversed by horizontal rugae extending from the lateral to posterior
surfaces. This character will also distinguish *neglectula* from *striata* when the striae of the disc of *neglectula* become coarser and less strongly radiating than usual. Males can be easily distinguished from *striata* on the basis of the fourth sternum and genitalia.

A truer picture of the relationships of *neglectula* to the other North American species of *Augochlorella* must necessarily wait until a study is made of the Mexican, Central and South American species of the genus with which it is possibly more closely related. It has no close affinities with *Pereirapis* and among the species from the United States is most similar to *pomoniella*. *A. neglectula* and *pomoniella* may look similar in areas where their ranges overlap but there is no evidence of genic exchange since the features of each species are maintained. There is a similar resemblance in a few individuals to *striata* but in all such cases also, *neglectula* maintains its identity.

**Variation.** Populations of *neglectula* in Arizona show the greatest amount of variation, particularly in the degree of thoracic roughness. Females are more variable than males.

There is not much difference in size among individuals from different areas of the range although the mean head width of females is largest in Mexico (1.99 mm) and smallest in Texas (1.85 mm). The width of the head is less variable in males, but no trends can be described due to the meager samples available from most areas.

The supraclypeal area is shiny in most males and females from the United States but is rarely polished or brilliant. It may be entirely punctate or more frequently sparsely punctate medially, more densely so
laterally. In many of the Mexican females, as in some Mexican *pomoniella*, the supraclypeal area is dull due to minute reticulations on the integumental surface. This dullness extends onto the basal area of the clypeus and over the scutum, and the brown color on the apex of the clypeus extends in a narrow medial line to the base of the clypeus. In no case is the clypeus entirely brown. But unlike *pomoniella*, other less dull or even shiny *neglectula* sometimes show this same variation of clypeal coloration. The dull specimens may be found throughout the range of Mexican *neglectula* from March to September. The supraclypeal area of the males is rarely dull even though it may be coarsely punctured. The minute fine reticulations were found on only three out of 42 males from Arizona (from Yuma, Cochise and Pima Counties) and on four out of 18 Mexican individuals (from Chihuahua, San Luis Potosi, Durango and Guerrero). Although the roughening may extend onto the clypeus, it does not appear on the scutum and the dullness is considerably less striking than on the females. The female holotype of *Augochlora dimissa* from Victoria, Mexico, shows this dull condition although in every other respect appears to be a normal Mexican *neglectula*. Since there is no apparent morphological difference associated with this condition and no geographical pattern or even distinct population of dull individuals, there is no basis for recognizing this variant either as a species or subspecies.

Although the blue patch on the frons is characteristic of this species, in many Mexican females the blue area is obscure and can only
be found with difficulty. It is not found at all in the Mexican subspecies *maritima*.

The punctures of the scutum are distinct with their diameters about equal to the spaces between them in about half the males (40 specimens) from all parts of the range, but are close, deep, and contiguous or forming a rugose surface in the other half (37 specimens). The scutum is coarsely and closely punctured in females (except for six females from Arizona which have the punctures more widely spaced).

There is considerable variation in the nature of the propodeal area, especially in specimens from Arizona. In the females, the Mexican specimens show the typical *neglectula* pattern with fine, straight, radiating striae on the disc, often reaching the posterior medial edge of the disc. The horizontal rugae are rarely present on the posterior and lateral surfaces of the propodeum but these surfaces are rough and dull. When the striae are larger or less fine the rugae are present posterolaterally. "Typical" *neglectula* are also found in Arizona but individuals occasionally may resemble either *pomoniella* or *striata*. Those similar to *pomoniella* /10 out of 57 specimens from the Santa Catalina Mts. (1*), and two out of five specimens from Globe (9/) have short striae that are finer than found on the usual *pomoniella*. The posterolateral corners are weak and the edge of the disc is shinier than usual, but the polished surface does not extend onto the vertical sides. All these specimens have horizontal rugae on the posterior

*See Table 1.*
surface. Those that resemble *striata* have coarser striae than normal, often reaching almost to the posterior margin of the disc, but in all cases the vertical surfaces are rough with well defined horizontal rugae. Such specimens were found commonly in New Mexico and Texas although the rugae are often less distinct in Texan specimens. None of the specimens from New Mexico or Texas resembles *pomoniella*.

In males, the striae of the disc are variable in thickness but generally rather coarse. In 10 of the 42 males from Arizona and 3 of the 18 Mexican males (Zacatecas, Chihuahua and "Guadalupe"), the propodeum resembled that of *pomoniella*, having shiny, smooth postero-lateral corners and smoother vertical surfaces than is normal for *neglectula*, with the horizontal rugae indistinct or absent. Punctures on the propodeum were distinct although close and coarse so that the roughened character of *neglectula* is maintained in these specimens.

The inner lobe of the gonostylus of the male genitalia is rather constant in shape but variable in the number and character of the setae it bears on its outer edge. These setae may number two or three and be short, very thin and flaccid (Fig. 37), but may vary to long, thick, heavily sclerotized and up to 14 in number. When the larger number are present the series is continuous with the setae at the apex of the lobe, with one or two weaker setae between those on the posterior and apical margins (Fig. 39). If the setae are weak, there is usually a space between those of the two series (Fig. 38). As the setae become longer and thicker the lobe itself becomes shorter and broader. All intermediate conditions occur between the two extremes, and all forms apparently occur.
throughout the range. No correlation has been found between these
genitalic differences and external morphological variation. In no case
does the inner lobe look similar to that of any other species here
considered.

The outer lobe of the gonostylus bears long, fine, branched or
unbranched setae. Branched hairs cannot be correlated with either
locality or external morphological variation.

The Guatemalan and Panamanian specimens look like those from
Mexico.

**Distribution.** From the southern half of Arizona and southwestern
New Mexico into the Big Bend area of Texas, southward through all of
central Mexico, with specimens also from Guatemala and Panama (Map:
Fig. 87).

A total of 79 males and 279 females have been seen: ARIZONA:
Apache Co., 1 ♀ (White Mts.) (June); Cochise Co., 7 ♂♂, 23 ♀♀ (Huachuca
Mts.: Ramsey Canyon; Chiricahua Mts.: Southwest Research Station 5400
ft., Rustlers Park 8784 ft., Portal 5000 ft.; Douglas; 6 mi. NE.
Douglas) (March-August); Coconino Co., 1 ♀ (Oak Creek Canyon 3500 ft.)
(August); Gila Co., 7 ♀♀ (Bott fly Canyon, Pinal Mts. 3500 ft.; Globe;
Payson) (May, July, September); Graham Co., 3 ♂♂, 2 ♀♀ (Graham Mts.:
6-7000 ft., Wet Canyon) (July); Maricopa Co., 1 ♀ (Reef); Navajo Co., 1 ♀
(Carrizo Cr.) (June); Pima Co., 24 ♂♂, 72 ♀♀ (Santa Catalina Mts.:
mile posts Nos. 9, 10, 23 Hitchcock Highway, Pepper & Sauce Canyon,
Sabino Canyon, Sabino Basin ca. 3800 ft., Ventana Canyon, Catalina
Springs, Molino Basin; Santa Rita Mts. 4-8000 ft.; Baboquivari Mts.;
Kits Peak Rincon ca. 1050 ft., Brown's Canyon) (February, April-November); Pinal Co., 1 ♂, 1 ♀ (Superior) (February, July); Santa Cruz Co., 2 ♂♂, 5 ♀♀ (Ruby, Sycamore Canyon; Patagonia; 17 mi. W. Nogales) (March-May, August, November); Yavapai Co., 1 ♀ (4 mi. S. Jerome) (July); Yuma Co., 5 ♂♂, 1 ♀ (Parker Creek; Sierra Ancha Exper. Sta.) (May, August). NEW MEXICO: Catron Co., 1 ♀ (Mogollon Mts.) (August); Dona Ana Co., 2 ♂♂, 28 ♀♀ (Las Cruces; Organ Mts.: La Cueva ca. 5300 ft., 5100 ft., Riley's Ranch, Filmore Canyon 5700 ft., Dripping Springs) (April, June, August-September); Grant Co., 2 ♂♂, 1 ♀ (6 mi. N. Silver City; 14 mi. N. Silver City; Pinos Altos) (June-July); Otero Co., 1 ♀ (Almogordo) (May). TEXAS: Brewster Co., 1 ♂, 6 ♀♀ (65 mi. S. Marathon; Basin 5000 ft., Big Bend Nat. Pk.; Chisos Mts.) (June-July); Jeff Davis Co., 11 ♂♂, 7 ♀♀ (Davis Mts.; Ft. Davis; 23 mi. W. Ft. Davis) (April-July); Val Verde Co., 1 ♂, 6 ♀♀ (Devil's River) (May).

MICHOACAN: 1 ♂, 3 ♀ (Quiroga 6300 ft.; Morelia) (February, July).
MORELOS: 1 ♂, 5 ♀ (Cuernavaca 5500 ft.; 5 mi. S. Cuernavaca 4000 ft.; 3 mi. W. Cuernavaca 6500 ft.; Yautepec 4000 ft.) (March-May). NUEVO LEON: 1 ♂, 7 ♀ (4 mi. W. El Cercado 2100 ft.; 12 mi. S. Linares; China) (June, August, December). OAXACA: 3 ♂♂, 6 ♀♀ (7 mi. SE. El Cameron; Tehuantepec; 5 mi. E. Oaxaca; 10 mi. NE. Oaxaca; Oaxaca; 23 mi. NE. Nochixtlan 7000 ft.; 12 mi. SE. Nochixtlan 7100 ft.) (April, June, July, December). PUEBLA: 3 ♀♀ (2 mi. NW. Petlalcingo 4600 ft.; 8 mi. SE. Tehuitzingo 4100 ft.; 13 mi. E. Villa Juarez 1300 ft.) (June).
QUERETARO: 3 ♀♀ (Queretaro) (June). SAN LUIS POTOSI: 2 ♂♂, 30 ♀♀ (El Salto 1500-1800 ft.; 5 mi. E. Ciudad Maiz 4700 ft.; 3.4 mi. NE. El Naranjo 800 ft.; 5 mi. W. Xilitla; 14 mi. W. Xilitla 4200 ft.; 8 mi. W. Xilitla 3500 ft.; 4.3 mi. NW. Nuevo Morelos; El Huizache; 10 mi. NE. San Luis Potosi 6200 ft.; 29 mi. SW. San Luis Potosi 6800 ft.) (June-September).
TAMAULIPAS: 2 ♀♀ (Llera; Victoria) (March, June). TLAXCALA: 1 ♀ (8 mi. W. Apizaco 8500 ft.) (June). VERACRUZ: 3 ♀♀ (4 mi. NW. Rinconada Antigua 1350 ft.) (June). ZACATECAS: 1 ♂, 4 ♀♀ (15 km E. Sombrerete; 2 mi. S. Fresnillo; 9 mi. S. Fresnillo; Fresnillo 7000 ft.) (July-August). "Guadalupe (Bilimek)" 1 ♂, 1 ♀; "Rio Blanco" 1 ♂ (November).

GUATAMALA. Alta Verapaz, 1 ♀ (Trece Aguas).

PANAMA. Canal Zone, 1 ♂ (Fort Clayton) (May).

This species is widespread in the central plateau area of Mexico. The range extends northward through the Chihuahua desert to New Mexico and Arizona. It also extends southward at least as far as Panama. A.
Augochlorella n. neglectula is not known from along the coasts of Mexico, although it approaches them in Oaxaca and Veracruz. It has been taken at elevations from 800 to 8500 feet in Mexico and from 1050 to 8100 feet in Arizona and New Mexico. (See also discussion under pomoniella.)

Titus (1901) reported two female specimens of neglectula from Ft. Collins and Greeley, Colorado. One specimen from each locality (8), has been examined with dates matching those given by Titus but both specimens were normal Colorado striata d. All other specimens examined from Colorado have also been A. striata and therefore it is assumed that Titus was mistaken in his identification and that neglectula extends only as far north as Catron Co., New Mexico, and Yavapai Co., Arizona.

Dreisbach (1945) reports neglectula from Michigan, but this is clearly a case of confusion in synonymy. (See distribution of Persimilis.)

Seasonal Activity. Females have been collected from mid-February to the end of November in Arizona and to the end of December in Mexico. Males have been taken from March through November in the United States and all through the year in Mexico. Females with pollen in their scopas were collected from April through August in the United States and from February through December in Mexico.

It seems probable that there is little or no activity during December and January in the United States and that nesting takes place from the middle of April into September or October, depending on the elevation. In Mexico, the bees are apparently active and nesting throughout the year, at least at the lower elevations.

*Augochlorella neglectula maritima* new subspecies


Holotype, allotype and 31 ♀♀ and 19 ♂♂ paratypes are in the Snow Entomological Museum, The University of Kansas. Two ♂♂ and two ♀♀ paratypes are in each of the following collections: Michigan State University, American Museum of Natural History, U.S. National Museum and the California Academy of Sciences.
Description. This subspecies, known only from the Pacific Coast of Mexico, differs from the true neglectula only as follows:

Female: 1. Length of head greater than width (width 1.66 to 1.96 mm, averaging 1.81 mm).
2. Frons without bluish reflections.
3. Mandible with basal half brown.
4. Clypeus as long as broad with apical third brown.
8. Scutum finely and very closely punctured, punctures becoming indistinct on extreme anterolateral angles.
9. Tegula oblong, twice as long as wide; surface coarsely punctate and dull on dark brown area.
12. Edge of propodeal disc more angulate than in typical neglectula.
13. Legs dark brown with weak greenish reflections usually on fore and hind coxae, fore trochanter, fore and middle femora and fore tibia.

Male: 1. Length of head greater than width (width 1.52 to 1.84 mm, averaging 1.70 mm).
2. Color bright green, metasoma suffused with black; frons without bluish reflections.
7. Antenna with first flagellar segment entirely dark brown.
9. Tegula oblong, more than twice as long as wide, with distinct, close punctures on dark brown area; surface dull.
11. Pleuron coarsely punctured, becoming rugose laterally.
16. Genital capsule with inner lobe of gonostylus heavily sclerotized with straight outer edge and thick, coarse, long bristles to apex, with-
out gap or finer bristles separating outer and apical series of setae (Fig. 39).

Comparisons. *A. n. maritima* looks similar to *neglectula* but can be readily distinguished by the size, shape, punctations and dullness of the tegulae. In addition, it lacks the blue areas on the frons and is less rugose on the face, thorax and posterior surface of the propodeum. The general appearance of the propodeum is smoother than in *n. neglectula* but otherwise little different. The first flagellar segment of the male is entirely dark in *maritima* and the inner lobe of the gonostylus of the male genitalia is more heavily sclerotized and bears stronger setae than most *n. neglectula*, although intergradations exist. The oculo-ocellar ratios show that the top of the head is slightly narrower than that of *neglectula* and the head is longer in relation to the width. The overall impression is of a longer head with the eyes narrower and less emarginate, and the clypeus longer than in *n. neglectula*. The habitat of *maritima* appears to be distinct from that of *n. neglectula*; the former has so far only been found on the sand dune areas along beaches of the west coast of Mexico.

**Augochlorella edentata** Michener


**Types.** Holotype female, from Panama, Coclé Province, El Valle de Antón, April 1, 1945 (Michener), is in the American Museum of Natural History. One female paratype each at: type locality, January, 1947
Fig. 87. Distribution of *A. neglectula*. 
(Krauss), at The University of Kansas; Canal Zone, Summit, November, 1946 (Krauss), Balboa, May 25, 1914, in shady jungle (Hallinan).

**Description.** Female: 1. Length 6 to 7 mm; head width 1.55 to 1.87 mm, averaging 1.66 mm, width greater than length.

2. Color yellow-green to dark green with silky sheen or luster; frons without blue reflections; metasoma usually similar in color to head and thorax.

3. Mandible dark brown, becoming yellow-brown just before rufous tip, without greenish reflections at base.

4. Clypeus about as long as wide, almost flat; basal half green with distinct but shallow punctures, widely but uniformly spaced, usually finely and closely punctured or roughened along basal suture; apical half brown, very slightly beveled, with elongate, shallow, groove-like punctures separated by about their own diameters; surface between punctures shiny and smooth.

5. Face broadly convex from apex of clypeus to vertex; supra-clypeal area flat to weakly rounded, smooth and shiny to minutely roughened with or without punctures.

6. Paraocular area finely and uniformly roughened throughout by widely scattered minute granules.

7. Antenna dark brown, becoming yellow-brown at tip; last flagellar segment entirely yellow-brown; flagellum lighter below than above; pedicel width subequal to length, first flagellar segment almost
twice as wide as long; pedicel longer than and about as wide as first flagellar segment.

8. Scutum without distinct punctures, surface finely and irregularly roughened throughout (Fig. 79); anterior margin smooth medially to anterolateral angles, except for minute reticulations on surface.

9. Tegula about 1.33 times as long as wide.

10. Scutellum finely and irregularly roughened, without punctures.

11. Pleuron finely rugose, weakly areolate anteriorly.

12. Propodeum with disc almost twice as long as metanotum; outline of disc semicircular to broadly U-shaped, profile type 4; posterior edge of disc smoothly and gradually rounded medially and laterally; striae fine and close, irregular and branching medially, straight and distinct laterally, occupying basal half to two-thirds of disc medially, sometimes attaining edge laterally; area beyond striae minutely reticulated; horizontal area of propodeum only partially occupied by disc laterally and at posterolateral corners; posterior vertical surface exceedingly finely and evenly granular in larger specimens, smooth and shiny with widely spaced minute punctures in smaller specimens; posterolateral corners finely roughened to nearly smooth; lateral vertical surface weakly roughened.

13. Legs brown with slight metallic reflections on hind coxa only.

14. Metasomal terga dark green to golden-green, suffused with brownish in some specimens; first tergum with anterior surface polished with widely scattered punctures laterally; dorsal surface with minute
punctures evenly spaced; second tergum with minute punctures, more crowded than on first; first sternum without metallic reflections.

15. Pubescence white to golden-white dorsally on head and thorax, dorsally and ventrally on metasoma; white ventrally on head, thorax and basal parts of legs; golden on tibiae and tarsi.

Male: 1. Length 6 mm; head width 1.48 to 1.63 mm, averaging 1.56 mm, width slightly greater than length.

2. Color olive-green with yellow-green sheen, varying to yellow-green with golden sheen in some specimens; frons without bluish reflections; metasoma dark brown.

3. Mandible yellow-brown, only slightly rufous at tip, basal condyles usually dark brown; basal metallic reflections absent.

4. Clypeus with punctures shallow and widely spaced, sometimes closer basally; surface between punctures brightly polished.

5. Face broadly convex from apex of clypeus to vertex; supraclypeal area scarcely protuberant, impunctate but variably roughened.

6. Paraocular area smooth and polished below level of antenna with a few, widely spaced, minute punctures, becoming rougher toward frons; frons with dense mat of short white pubescence extending from antennal sockets to vertex.

7. Flagellum slightly darker above than below; scape and pedicel dark brown; last one and a half to two flagellar segments uniformly dark brown; pedicel and first segment each less than twice as wide as long.
8. Scutum shiny with satiny luster; punctures very weak, sparse and widely spaced (wider than own diameters), minute centrally, larger and closer laterally, becoming slightly deeper and contiguous to weakly and finely punctorugose anterolaterally; anterior margin smoothest medially, becoming rougher laterally; sculpturing exceedingly fine, shallow and indistinct (Fig. 79).

9. Tegula twice as long as wide.

10. Scutellum shiny, slightly roughened and punctate, punctures weak and widely spaced.

11. Pleuron shallowly and irregularly punctorugose, shallowly areolate anteriorly; surface between impressions minutely roughened, dull.

12. Propodeum with disc about 1.75 times as long as metanotum; outline of disc U-shaped, posterior edge indistinct, smoothly and gradually rounded and shiny; striae distinct, fine, close, irregular, often branched, extending about three-fourths length of disc medially, reaching edge laterally; surface of disc beyond striae smooth, minutely reticulated, irregularly and minutely wrinkled; posterior vertical surface of propodeum and posterolateral corners shiny and smooth with widely spaced, minute punctures; lateral vertical surface of propodeum finely but regularly roughened becoming distinctly but shallowly punctate dorsally.

13. Legs dark brown; fore and hind coxae and femora with slight greenish reflections; tibiae and tarsi lighter brown at bases; hind
basitarsus with erect hairs short, uniform in length, dense, slightly longer than width of segment; basal tuft indistinct.

14. Metasomal terga dark brown with slight bluish highlights and broad, reddish brown apical margins; first tergum polished anteriorly, with slight olive-green metallic reflections, smooth but less shiny dorsally, sparsely and minutely punctate; second and following terga smooth, dull, essentially impunctate but with widely scattered minute punctures; all sterna brown, finely and uniformly pubescent, without metallic reflections, with apical margins straight; surfaces smooth without reticulations or punctures.

15. Pubescence golden dorsally, white ventrally; face with mat of short dense white hair from antennae to vertex and longer, fine golden hair dispersed over entire face; pubescence golden dorsally on thorax, entire metasoma and legs, white ventrally on head and thorax.

16. Genital capsule, seventh and eighth sterna and eighth tergum type 3 (Figs. 36, 42, 47).

Comparisons. This species has certain affinities with both the species of the north and those of the Pereirapis group. It is small, has the convex face and the similar fine, smooth sculpturing and discal shape, and has the straight margin of the fourth sternum in the male, all as in Pereirapis. But the genital capsule and the white apex of the clypeus of the male are more similar to those of the North American species than to Pereirapis. A. edentata is characterized by its round, convex face, comparatively smooth, fine and very shallow body sculpturing,
and usually by the yellow tipped antennae in the female. The clypeus is also flatter than in other North American species but comparative material is necessary to recognize this character.

**Variation.** The body color in both males and females varies from dark green to yellow-green. Although the bee is shiny, the color is dull, with olive-green tones. In females, the metasoma is green or only slightly suffused with brown in some of the darker specimens, or yellower green in lighter colored individuals. The metasoma is consistently brown in males.

There is greater variation of the head width to length ratio in females than in males. (However, the available males are nearly all from the same population.) Both the length and width are variable in females.

The clypeal punctures are generally rather uniform in males but variable in size, number and spacing in females. The basal punctures range from absent to crowded in both sexes.

The tips of the antennae of females are brownish yellow in all specimens examined from Mexico and Costa Rica, the intensity of the yellow varying only slightly. However, in the holotype the antennal tips are brown, only inconspicuously paler than the rest of the flagellum. The one paratype seen, also from the type locality, has the antennal tips yellower than the holotype but darker than those from Mexico and Costa Rica. More specimens should be examined to see if this is individual or geographical variation.
There is slight variation in the quality of the roughening of the scutum among females. On about half the specimens the smoothness of the anteromedial edge extends down each side of the median suture, creating a transverse gradient in degree of roughness from the center line to the parapsidal lines. However, the anterolateral angles are no more roughened than other parts of the scutum in either sex.

The punctures on the scutellum are variable in size, number, spacing and depth among males.

There is little variation in the propodeal area of males, but in females the length of the striae is variable, extending more than two-thirds the length of the disc in only one specimen "Pra Antonio" (9*). In this specimen, only a small area is unstriated medially, and the lateral striae are strong, ending abruptly at the edge. Although lateral striae usually reach the edge, they may be shorter in the larger specimens. The sloping horizontal area of the propodeum is usually only partially occupied by the disc laterally, the rest of the horizontal area being characterized by sculpturing similar to that of the vertical surface (Fig. 67). The posterior vertical surface in females varies from very smooth, broken only by widely scattered minute punctures, to weakly uneven or slightly roughened. There is also some variation in amount of roughening of posterolateral angles. There is little variation in the lateral vertical surface.

* (See Table 1.)
The metasomal punctures are similar in all specimens; however, in females they may vary somewhat in depth and are barely detectable in some individuals.

The color of the pubescence is difficult to determine in most specimens of both sexes, usually because of wear or dirt. Some appear lighter than others so that the dorsal pubescence appears to range from all white to golden. The short, dense facial pubescence is matted and gummy in most specimens, giving the face a yellowish cast. This facial hair is worn away on some specimens.

**Distribution.** This species has been taken only as far north as southern San Luis Potosí in Mexico. It ranges at least as far south as Panama and has been taken at elevations from 200 to 4500 feet (Map: Fig. 88). The following specimens have been seen:

**MEXICO. MORELOS:** 1 ♂, 2 ♀ (3 mi. N. Alpuyeka 3400 ft.; S. end Cuernavaca 4500 ft.) (March-April); OAXACA: 1 ♀ (Rin Antonio); SAN LUIS POTOSI: 12 ♀♂, 4 ♀♀ (Huichihuayan; Xilitla 1450 ft.; 5 mi. E. Xilitla) (July, September); VERACRUZ: 1 ♂, 6 ♀♀ (17 mi. NW. San Andres Tuxtla 900 ft.; 6 mi. N. Jesús Carranza, Isthmus of Tehuantepec 200 ft.; 1.4 mi. N. Santiago Tuxtla 1150 ft.; Córdoba) (January, June).

**GUATEMALA.** *Alta Verapaz,* 2 ♀♀ (Trece Aguas) (June).

**EL SALVADOR.** *La Libertad,* 6 ♀♀ (5 mi. W. Quezaltepeque) (June-August).

**COSTA RICA.** *CARTAGO:* 3 ♀♂, 1 ♀ (Turrialba) (August); *LIMÓN:* 2 ♀♂, 12 ♀♀ (Pandora) (August); *PUNTARENAS:* 1 ♂, 14 ♀♀ (6 mi. NE. Esparta;
Gromaco 34 km. SE. Potrero Grande, Río Coto Brus. 1000 ft.; Playon, 8
mi. N. Parrita 30 m) (June-July, December); SAN JOSE: 2 ♂♂, 5 ♀♀
(Pozo Azul, junc. Ríos Parrita and Candelaria 85 m) (August).

Seasonal Activity. Females of edentata are apparently active
throughout the year; males have been collected from March through
August but are probably active in other months as well. Pollen collectors
have been found during June and July in Mexico and in August and
December (1 specimen) in Costa Rica.

Augochlorella bracteata new species

27:70 (in part) (taxon.).

Types. Holotype female, Southmost, Cameron Co., Texas, March 27,
1951 (R. H. Beamer) taken on Prosopis; allotype male, same locality,
April 13, 1950 (Beamer, Stephen, Michener, Rozen); 45 female paratypes,
same locality, March 27, 1951 (Beamer); 26 female paratypes, same
locality and date (Michener); 4 male paratypes, Brownsville, Texas,
June; 2 male paratypes, Cameron Co., Texas, August 3, 1928 (J. G. Shaw);
1 male paratype, Brownsville, Texas, April 17, 1952 (Michener, Beamer,
Wille, LaBerge).

Holotype, allotype, 55 female and 3 male paratypes are in the
Snow Entomological Museum of The University of Kansas; one male and
four female paratypes are in each of the following: the American
Museum of Natural History, the U.S. National Museum, the University
of Nebraska and the California Academy of Sciences. I have seen 14
Fig. 88. Distribution of *A. aurata* (solid dots) and *edentata* (rings).
males and 137 females from other localities in Texas and Mexico, not included in the type series. The holotype and female paratypes represent a series of large and uniformly similar bees, probably spring queens. Not included in this series are smaller and more morphologically diverse specimens, including probable worker forms.

**Description.** Female: 1. Length 5 to 6 mm; head width 1.47 to 1.79 mm (holotype = 1.79 mm), averaging 1.63 mm, width equal to, or slightly greater than length.

2. Color yellow-green to dark green (bright green in holotype); frons without bluish reflection; metasoma often slightly browner than rest of body.

3. Mandible with basal third dark brown, yellowish brown centrally, rufous at tip, without green basal reflection.

4. Clypeal width equal to or subequal to length (length slightly greater than width in holotype), basal two-thirds green, punctures variable, irregularly spaced, smaller basally than apically; apical third brown and slightly beveled with large deep punctures; surface between punctures shiny and smooth.

5. Supraclypeal area sparsely punctured medially, becoming densely punctured peripherally; surface smooth to minutely reticulated.

6. Paraocular area with large contiguous punctures below antenna, finely rugose above antenna.

7. Antenna dark brown; flagellum usually lighter below than above; pedicel longer than wide; first flagellar segment slightly wider than long; pedicel longer and narrower than first segment.
8. Scutum smooth, finely and uniformly punctured throughout, punctures small, close, distinct, extending almost to anterior edge; anterior edge with surface slightly roughened medially as on vertex becoming slightly rougher laterally to very finely rugose at antero-lateral angles.

9. Tegula 1.5 to 2.0 times as long as wide.

10. Scutellum rough with fine, shallow, irregular to indistinct punctures.

11. Pleuron punctorugose to shallowly and finely rugose (finely punctorugose in holotype), areolate anteriorly.

12. Propodeum with disc equal to or slightly longer or shorter than metanotum (slightly longer in holotype); outline of disc semi-circular, profile type 2, posterior edge of disc abruptly rounded, indistinct, more gradually rounded laterally; striae irregular, vermiciform or straight (rather straight in holotype), fine and close together, usually ending almost at edge of disc medially, straight and reaching edge but not crossing it laterally; surface at ends of striae minutely roughened, narrowly shiny; posterior vertical surface and posterolateral corners shiny but surface uneven, without punctures or coarse roughening, often weakly granular posteriorly and finely granular at posterolateral corners; lateral surface moderately roughened to weakly rugose (weakly rugose in holotype), without basal subhorizontal rugae.

13. Legs brown, fore and hind coxae with strong green reflections, femora and hind trochanter with weak metallic reflections.
14. Metasomal terga green, suffused with brownish; apical margins narrowly pale brown; first tergum shiny, polished, with numerous, fine, distinct punctures anteriorly, almost impunctate along narrow median longitudinal area, smooth and shiny dorsally with numerous, small, close, distinct, regularly spaced punctures; second tergum with punctures more numerous and smaller; first sternum without metallic reflections.

15. Pubescence golden-white dorsally, white ventrally on head, thorax and basal parts of legs, golden on leg extremities and ventral part of metasoma.

   Male: 1. Length 5 to 6 mm; head width 1.53 to 1.76 mm, averaging 1.63 mm, width less than, equal to, or greater than length (width equal to length in allotype).

   2. Color yellowish green to dark green; frons without bluish reflections; metasoma variably suffused with brownish.

   3. Mandible without metallic reflections basally.

   4. Clypeus with punctures large medially, small and close basally and laterally; surface between punctures usually smooth and shiny.

   5. Supraclypeal area finely punctate laterally; surface shiny basally, usually minutely roughened above.

   6. Paraocular area finely and weakly rugosopunctate.

   7. Antenna dark brown above, dark yellow below; scape usually narrowly yellow below; last flagellar segment entirely pale brown to dark brown, pedicel and first flagellar segment each less than 1.5 times as wide as long.
8. Scutum shiny and smooth with punctures small, distinct, usually separated by at least the width of a puncture medially, closer laterally and anteromedially; anterior margin weakly roughened as on vertex, becoming weakly rugose at extreme anterolateral angles.

9. Tegula slightly more than 1.5 times as long as wide.

10. Scutellum shiny and punctate; punctures distinct, closer posteriorly than elsewhere.

11. Pleuron rugosely punctate, areolate anteriorly.

12. Propodeum with disc slightly longer than metanotum; outline of disc obtusely V- or U-shaped to semicircular (semicircular in allotype), posterior edge sharply angulate to gradually rounded (abruptly rounded in allotype); striae fine to coarse, regular to irregular (fine and irregular in allotype), reaching edge medially, crossing edge laterally; marginal surface narrowly shiny and slightly roughened posteriorly, shiny posterolaterally; posterior vertical surface either with widely separated shallow punctures and surface between punctures shiny, or weakly roughened and impunctate; posterolateral corners evenly punctate; lateral vertical surface more closely punctate with punctures usually distinct, regular, separated by about the width of a puncture; surface between punctures finely roughened or entire surface weakly rugosopunctate (punctate in type).

13. Legs light brown; fore and hind coxae, trochanters and femora with metallic reflections; tibiae light brown, yellow-brown at apices; tarsi uniformly pale yellow-brown; hind basitarsus with erect hairs of
uniform length, about as long as width of basitarsus, basal tuft slightly shorter.

14. Metasomal terga dark green, usually suffused with brownish, yellowish or reddish with apical margins brownish, scarcely contrasting in color with rest of tergum; first tergum polished anteriorly with small, widely spaced punctures throughout; smooth but less shiny dorsally, with punctures variable, usually large, distinct and irregularly spaced; second tergum with punctures of same size but very closely spaced; sterna dark brown, smooth, with short inconspicuous white pubescence; first sternum with weak metallic reflections; fourth sternum broadly and shallowly emarginate.

15. Pubescence short and white over entire body.

16. Genital capsule, seventh and eighth sterna and eighth tergum of type 1 (Figs. 31, 40, 43).

Comparisons. The females of this species look most like persimilis or the striata-persimilis intergrades. The size is small, at most the size of persimilis. The female can be distinguished from the other species found in the United States by its small size, the small but distinctly separated punctures on the scutum, and the lack of coarse roughening or rugosity anteriorly on the scutum (Fig. 78). It is further separated from gratiosa and neglectula by the very smooth posterior surface of the propodeum. Although this is also consistently smoother than aurata, persimilis or striata, the differences among these species in the posterior surface of propodeum are usually too slight to be recognized without comparative material.
The male is about the size and color of the male of *persimilis* but has the characteristics of a small *striata* with an emarginate fourth sternum, short basitarsal hair, and with the last segment of the antenna dark. The male genitalia are not perceptibly different from those of other members of the eastern species group, although there is a tendency for the process of the inner lobe of the gonostylus to be shorter and blunter than in other species (Fig. 31). Like the female, the male can be distinguished from all forms of *striata* by both its small size and its smooth but distinctly punctured scutum.

**Variation.** The greatest variation in *bracteata* is found in the characters of the propodeum. Males are in general more variable than females, the females varying chiefly in connection with differences in size. There is little geographical variation, probably due to the limited range and to the few specimens available outside of Texas.

As with most of the eastern species of *Augochlorella*, there is considerably more size variation in females than in males. This may be due to caste differences. In females the width of the head is usually greater than the length, but sometimes the width and length are equal. No such general pattern can be established for the males since the length-width ratio is highly variable, even though the overall variation in size is not great.

Color varies from dark green to yellow-green in both males and females, with no apparent correlation between size, date or location. There seems to be an unusual amount of discoloration, fading or bleaching in many of the specimens, especially on the metasoma. In males, many of
the specimens are coppery or reddish (see section on Specific Characters). In spite of the large proportion of specimens thus discolored, freshly caught specimens are probably normally green.

The number and size of punctures on the clypeus of the female is variable. When the punctures are sparse, the clypeus looks smooth, shiny and gently rounded, with the apex also smooth. This condition is apparent especially in the smaller (worker?) individuals. There is little variation in the size and density of punctures in males.

The supraclypeal area in both males and females is usually punctate, with the surface between punctures variably roughened. A female with a sparsely punctate clypeus will usually have a sparsely punctate supraclypeal area, with the central portion smooth and shiny. In the male the supraclypeal area may be shiny with few punctures (14% of the specimens) or with the upper half rough and lower half shiny (67%) or entirely rough (19%).

There is little variation in the punctation of the thorax except as related to the size of the individual bee. On particularly small females the punctures are exceedingly small and close and may give the scutum the appearance of being granular rather than punctate.

The rugosity of the mesepisternum also becomes very fine on small females so that the surface may look similar to that of the metepisternum.

The disc is the most variable structure in this species. Although the edge is rounded in both males and females, it may be smooth and
shiny, minutely or weakly roughened, or smooth with minute reticulations. In males the punctures of the posterior vertical surface of the propodeum may reach the dorsal part of the edge on some shiny specimens, and the edge may be more or less sharply defined (but never carinate) with shininess often associated with a rounded edge and dullness with a more distinct edge. A V-shaped depression is rarely apparent but may be indicated on those specimens with a relatively defined edge.

The shape of the disc shows little variation in females. In all cases it is semicircular, like that found in *persimilis* or in the *persimilis-striata* intermediates. There is somewhat more variation in males, with the outline varying from semicircular to roundly V-shaped, but not bracket-shaped as in *striata* form 3. The striae may be of any thickness from very fine to coarse, especially in males, and may vary from straight to vermiciform or, as in some small females, may be so irregular as to be unrecognizable as striae. Striae usually reach the edge of the disc, at least medially, where they are usually branched or irregular. In both sexes they are frequently slightly shorter on each side of the median line, where the edge then becomes thicker (see Fig. 66). The striae are straighter and more regular in the larger females than in smaller ones. There is as much variation in the characters of the disc as in *persimilis* and its intermediates, with some specimens resembling the small *striata* form 3 and others resembling *persimilis*.

The posterior surface of the propodeum is smoother in some females than others but never equals the smoothness of the anterior part of the
first tergum. The roughening takes the form of fine granulations or irregularities on an otherwise smooth surface.

The lateral vertical surface of the propodeum ranges from rugose to finely roughened in the females and distinctly and evenly punctured to weakly roughened, largely punctorugose or finely reticulate, in the males.

The metasomal punctures are variable in both sexes, although the type series of 72 females, all collected at the same time and place, are similar in this feature. The punctures on the first tergum in females may be absent in some small specimens or small and irregularly spaced to large, distinct, and closely spaced. There is little indication of regional variation, although most specimens with large, close punctures are from southern Texas. The four specimens from Mexico have small to minute punctures. In males the punctures of the first tergum vary from very small to large, close to widely spaced, with no regional pattern evident. The second tergum of females usually has very small punctures regardless of the size of those of the first tergum. In males both the size and the spacing of punctures of second tergum are variable, but usually the punctures are smaller than on the first. The third tergum in males sometimes has small but distinct punctures.

There are a few females with all white pubescence over the body. These are usually discolored individuals with brown metasoma (Victoria, Kingsville, etc.).

**Distribution.** From northeastern to southern Texas, southward through eastern Mexico to Hidalgo (Map: Fig. 85).
In addition to the type series, 14 males and 137 females were seen:

TEXAS: Bexar Co., 5 ♀♀ (March, July-August); Blanco Co., 2 ♀♀; Cameron Co., 6 ♂♂, 33 ♀♀ (January-August, September); Comal Co., 1 ♀ (May); Dallas Co., 8 ♀♀ (March-May); Hidalgo Co., 1 ♂, 4 ♀♀ (April-June); Jackson Co., 2 ♀♀ (March); Karnes Co., 6 ♀♀ (March, September); Kleberg Co., 1 ♀ (June); Lee Co., 2 ♂♂, 20 ♀♀ (February-June, September); Maverick Co., 3 ♀♀ (April); Nacogdoches Co., 1 ♀ (June); Nueces Co., 1 ♀ (April); Refugio Co., 1 ♀ (April); Robertson Co., 15 ♀♀ (April); San Patricio Co., 3 ♀♀ (June-July); Travis Co., 1 ♀; Val Verde Co., 1 ♂, 1 ♀ (May-June); Victoria Co., 1 ♂, 20 ♀♀ (March-April, September, November); Webb Co., 6 ♀♀ (December); Wilson Co., 1 ♀ (October).

HIDALGO: 1 ♂, 3 ♀♀ (18 mi. NE. Jacala 4750 ft.) (June). NUEVO LEÓN: 1 ♀ (General Terán) (July).

Seasonal Activity. The females are apparently active throughout the year, and the males are present at least from March through November. None of the 30 females taken between October and February was collecting pollen, and most of these specimens were clean and unworn, although both larger and smaller individuals were represented. Of the 90 specimens taken in March, the only five collecting pollen were captured on or after the 24th of the month. From April through September many specimens have pollen in the scopa; one was taken with a pollen load as late as September 29.

From these data it would seem that although the bees are active throughout the year, nesting takes place only from early spring into September. From variations in size of females it also seems that
this species probably does have a worker caste, as do striata and persimilis.


Augochlorella gratiosa (Smith)


Types. *Augochlora gratiosa*, holotype female, from Georgia, is in the British Museum (Natural History). Although labels on the holotype agree with those indicated by Smith's published description of *gratiosa*, the description agrees better with the holotype of *aurata*. Conversely, his description of *aurata* fits best the type of *gratiosa*. All recent descriptions and most determinations of *gratiosa* agree with the *gratiosa* type and not with Smith's description. Since Smith himself probably mixed labels and descriptions, since his descriptions are scarcely decisive, and since utmost confusion would result from reversing the application of the names in a group already so difficult taxonomically, it seems best to follow usage and the labeled types, which bear the proper locality data, and ignore the inconsistencies in the descriptions. I have not seen the types, but Dr. C. D. Michener took detailed notes on them and compared them with submitted specimens.

Description. Female: 1. Length 6 to 7 mm; head width 1.68 to 2.13 mm, averaging 1.92 mm; head length to width ratio variable.

2. Color yellowish green to blue; frons often with slight bluish reflections; metasoma usually more yellow or brownish than head and thorax.

3. Mandible without metallic coloration basally.

4. Clypeal width about equal to length, basal two-thirds shiny green with punctures irregular in size and shape, smaller and closer at margins of clypeus than centrally; apical third brown and slightly beveled with punctures large, elongate; surface between punctures smooth and shiny.
5. Supraclypeal area usually impunctate medially, lateral punctures variable in size, surface between punctures minutely roughened laterally.

6. Paraocular area punctorugose below level of antennae, coarsely rugose above.

7. Antenna dark brown; flagellum slightly lighter below than above; first segment of flagellum less than 1.5 times as wide as long, pedicel slightly longer and narrower than first flagellar segment with ratio of length to width variable.

8. Scutum roughly punctate to rugosopunctate; punctures small and contiguous; anterior margin rugose, becoming areolate at anterolateral corners.

9. Tegula almost 1.5 times as long as wide.

10. Scutellum coarsely roughened and granular, punctures indistinct or absent.

11. Pleuron coarsely rugose, areolate anteriorly.

12. Propodeum with disc equal to or shorter than metanotum; outline of disc bracket-shaped, profile type 1; posterior edge of disc sharply angulate posteriorly, rounded laterally; striae fine, straight, close together, extending full length of disc; posterior vertical surface finely, unevenly roughened or granular, usually dull, occasionally with very fine, indistinct, irregular, subhorizontal rugae; posterolateral corners coarsely and often linearly roughened; lateral vertical surface weakly rugose, rugae usually lineate along anterior and ventral edge, reticulate centrally.
13. Legs brown; fore and hind coxae and outer surface of fore femur with metallic reflections.

14. First metasomal tergum with anterior surface minutely and sparsely punctured, polished and finely pubescent; surface less shiny dorsally with close, minute punctures; second tergum with surface minutely reticulated, similar to following terga; sternum without metallic reflections.

15. Pubescence white ventrally on head and thorax, golden elsewhere; short and dense on genal area.

Male: 1. Length 6 to 8 mm; head width 1.72 to 2.00 mm, averaging 1.86 mm, greater than, equal to or less than length.

2. Color yellow-green to royal blue, usually bright, shiny green; frons without blue reflections on green specimens; metasoma usually slightly redder than rest of body or color uniform over entire body.

3. Mandible usually with metallic reflections basally.

4. Clypeus with large, irregularly shaped punctures separated by less than their diameters; surface between punctures smooth and shiny.

5. Suprachylopel area with punctures large, shallow and close; surface between punctures minutely roughened.

6. Paraocular area with punctures small, deep and crowded.

7. Flagellum brown above, yellow-brown below; scape dark brown except for narrow light area below; pedicel usually all yellow; last flagellar segment entirely dark; pedicel and first flagellar segment each less than 1.5 times as wide as long.
8. Scutum rough, with punctures deep and distinct medially, deep and contiguous at parapsidal lines, becoming rugose anteriorly; anterior margin variably roughened medially, rugose to areolate laterally.

9. Tegula 1.5 times as long as wide.

10. Scutellum shiny, coarsely punctate, punctures irregular in size and spacing.

11. Pleuron rugose, more coarsely so anteriorly.

12. Propodeum with disc equal or subequal in length to metanotum; outline of disc weakly bracket-shaped, dorsal surface slightly concave, posterior edge sharply to weakly angulate, well defined, rounded laterally; striae usually straight, regular, fine, widely to narrowly spaced, reaching edge posteriorly and laterally; posterior vertical surface coarsely rugose, usually without punctures; posterolateral corners rounded with posterior rugosity extending onto lateral surface; lateral vertical surface less coarsely rugose than posterior surface, rugae lineate, perpendicular to anterior and ventral edges.

13. Legs brown, fore and hind coxae brightly metallic anteriorly; trochanters and femora with at least slight metallic reflections; tibiae dark yellow, usually brownish centrally; basitarsi pale yellow with following segments slightly darker; posterior basitarsus with erect hairs very long on basal third of segment, four times as long as width of basitarsus, curved at tips, becoming shorter on apical two-thirds of segment; basal tuft reduced, often inconspicuous.

14. Metasomal terga green, sometimes lighter or browner than thorax; first tergum polished anteriorly with punctures separated by slightly
more than their diameters medially, closer laterally, surface smooth but less shiny dorsally, with punctures slightly larger, more distinct and denser; second tergum with punctures similar to first; first sternum strongly metallic, fifth and sometimes fourth sterna with feeble metallic reflections; fourth sternum deeply and broadly emarginate apically.

15. Pubescence white to golden-white over entire body, yellowish on tarsi.

16. Genital capsule, seventh and eighth sterna and eighth tergum of type 1 (Figs. 34, 40, 44).

Comparisons. A. gratiosa is not a very common species. It has been collected during all months of the year and most frequently from Georgia and Florida. It comes in contact with persimilis, aurata, striata and bracteata, and apparently intergrades morphologically with both aurata and striata. Although the males of gratiosa are distinct and can usually be identified by the key characters (see exception below), females are more difficult to distinguish and the subtle differences can be difficult to recognize unless samples of each are available.

A. gratiosa is characterized chiefly by the propodeal characters in the females. The disc is as short as or shorter than the metanotum (Fig. 58). Its posterior border is usually well delineated, sometimes by a weak carina but more usually by its abruptly declivitous edge which has a weak, medial, V-shaped depression (Figs. 12, 20). The striae are fine, straight, and distinct, extending the full length of the disc; the posterior vertical surface is dull and granular, usually with short
subhorizontal lineate irregularities (Fig. 76). The second metasomal tergum is granulose and similar to the following terga rather than minutely punctulate as is the first tergum.

Females of gratiosa differ from aurata by the distinct, clear-cut features of the propodeal disc, by the complete, straight striae and the nature of the posterior face and second metasomal tergum. Although aurata may also have striae as fine and close together as those of gratiosa, they are rarely as straight or regular, nor do they extend onto the posterior margin of the disc (Fig. 57). Also, in aurata, the edge of the disc is less sharp posteriorly, usually without the medial V-shaped depression, and the posterior surface is smoother, shinier and lacks the lineate irregularities. In Texas the two species are easily distinguished by the above characters and in addition, the first metasomal tergum is strongly punctate in aurata (Fig. 82) but finely punctate as usual in gratiosa (Fig. 83). In striata the striae usually extend the full length of the disc, the disc in form a is frequently as well delineated posteriorly as in gratiosa, possesses the V-shaped depression and may approximate the bracket-shaped outline of gratiosa. However, if the striae are as straight and regular as those of gratiosa they usually are considerably coarser (fewer in number with greater space between them). If they are as fine as those of gratiosa they rarely are as straight, regular or well defined. In addition, the posterior vertical surface of the propodeum in striata is smoother, shinier, with minute punctures and without the lineate granular
irregularities found in *gratiosa*, and the second tergum is similar to the first rather than the third or fourth terga.

*A. gratiosa* is apparently more closely related to *striata* or *aurata* than to any other group. There is comparatively little variation and variation attributed to it in the past is seemingly partly due to misidentification based chiefly, if not exclusively, on the nature of the propodeal disc. When other characters are also used, identification becomes easier. The strict definition of *gratiosa* is based chiefly on the distinct and unvarying characters in the male, as opposed to the high degree of variability found in males as well as females of *striata*.

**Variation.** The few variations that exist are associated chiefly with size and color. There is a wide variation in head size (Fig. 86) with the largest individuals being found in Louisiana and Alabama. A sample of 22 female specimens was measured from Florida, and all females from other states were measured. There is some indication that there may be caste differences in size although there is no correlation between width of head and season (i.e., large, small or average individuals may be found at any time of the year). Males show similar variations in size. The width of the head, with only a few exceptions is regularly greater than the length.

Body color is rather uniformly yellowish green except in Florida where it varies from dark green to deep violet-blue. Most males (14 out of 18) and about 40% of the females are blue in Florida. In these specimens there are weak metallic reflections at the bases of the mandibles in females and on the hind tibiae of males, variations rarely found in
green specimens. Only one out of 20 females from Georgia [Tifton, Ga.,
6-13-96, Lot 209 (38*)] showed such reflections on the mandibles and
two green Floridian males had slight reflections on the hind tibiae
[Jacksonville 9-3-11 (9); Levy Co., Fla., 9-10-55 (10)].

The extent of brown on the clypeus of females is variable from
specimen to specimen with no apparent regional trend, but it does not
exceed one-third of the total length.

The degree of roughness and amount of punctation on the supra-
clypeal area is also variable throughout the range. The frons shows
very weak bluish reflections in most green specimens when the light is
properly reflected from the surface but usually there are no readily
visible spots of blue such as are found in neglectula. All blue-green
specimens from Florida showed differential coloring on the various parts
of the body with the head usually darker (bluer) than the thorax, and
the metasoma lightest (greenest) in color.

In females from Louisiana the antennae are lighter below than
above as usual, but the apical third of the flagellum is lighter above
than the preceding segments.

The scutum in females is roughly and closely punctured throughout
the range but is less so than that of striata. Punctures are usually
distinct but are very close or become indeterminate or rugose anteriorly
and laterally. This rugosity is not correlated with size, color or

*See Table 1.
distribution, although in Florida rugosity occurs with higher frequency in blue specimens than in green ones (in 45% of the blue and 9% of the green).

The characters of the propodeum are remarkably stable in *gratiosa*, compared with the variability in the other eastern species. The sharply delineated disc is usually bracket-shaped and narrow in females, somewhat less distinctly so in males. Three of the seven females from Louisiana [2] from 8.5 a-l. ms. New Roads, 6-22-60 (20); Olivier, 5-04 (9) [7]; 2 of the 146 from Florida [Homestead 8-31-27 (9)] [7] and one from Summerville, S.C. [5-10- (20)] out of seven seen, were found with a more rounded outline although it is difficult to draw the line between one type and the other. When the posterior margin is subbracket-shaped, the medial V-shaped depression is not evident and the sharply angulate edge becomes abruptly rounded. The size of the striae varies little and only in the males do the spaces between striae vary. On the lateral sides of the propodeum of females there may or may not be very fine lineate rugae perpendicular to the anterior and ventral margins. They are present in all males seen with the exceptions noted below in Texas. Again, this seems to be a variation within populations and not correlated with season or distribution.

The first sternum of the metasoma is variously metallic in females, strongly blue or blue-green in many darker specimens to brown with faint metallic reflections in others, especially the paler specimens.
The amount of metallic coloration on the legs of females is relatively constant although any or all trochanters and femora may be slightly colored in addition to the always colored fore and hind coxae.

All Floridian females have deep golden pubescence over all the body including the ventral parts of head and thorax, whereas in Texas, pubescence is paler with hairs whitish on the upper parts of the head and basal parts of the legs, in addition to the venter. The males do not vary in this character.

Male genitalia have the inner lobe of the gonostylus as shown in Fig. 34. The fingerlike projection averages slightly longer than in the other eastern species but enough variation occurs in each of the eastern species that distinctions cannot usually be made. The outer lobe has long, unbranched hair as in other eastern species.

The two males from Texas /Nacogdoches, X-3-60 (42) and Victoria, VI-10-07 (9)/ are divergent individuals falling between gratiosa and persimilis, not fitting either group well but appearing to be most like gratiosa. On the basis of characters 1, 3 and 7, the specimen from Nacogdoches is most like gratiosa (the specimen from Victoria is without a head). The thoracic and metasomal characters of both specimens resemble those of either persimilis or gratiosa, and the hind basitarsus of each specimen is intermediate between the two species although more similar to gratiosa than to persimilis.

Distribution. From New Jersey and Washington, D.C. southward to the keys of Florida, along the Gulf Coast states into southeastern Texas, extending inland as far as northern Georgia and eastern Tennessee (Map: Fig. 87).
A total of 29 males and 199 females have been seen:

ALABAMA: Mobile Co., 1 ♀; Washington Co., 1 ♀ (June). FLORIDA:
Alachua Co., 1 ♂, 8 ♀♀ (February-May, August, October, December);
Bradford Co., 1 ♂, 1 ♀ (April); Brevard Co., 1 ♂, 1 ♀ (April, November);
Broward Co., 2 ♀♀ (February, October); Collier Co., 1 ♂, 5 ♀♀ (April);
Dade Co., 13 ♂♂, 49 ♀♀ (January-April, June-December); Duval Co., 1 ♂,
2 ♀♀ (April, August, November); Gadsden Co., 1 ♀ (April); Hendry Co.,
2 ♀♀ (July, October); Hernando Co., 1 ♀ (December); Highlands Co., 6 ♀♀
(April-June, August); Hillsborough Co., 3 ♀♀ (April, August); Lake Co.,
8 ♀♀ (January-February, April); Lee Co., 1 ♀ (March); Levy Co., 1 ♂,
19 ♀♀ (February, April, June, September); Manatee Co., 2 ♀♀ (February,
April); Marion Co., 4 ♀♀ (February, April); Martin Co., 1 ♀ (March);
Monroe Co., 4 ♀♀ (January, May); Nassau Co., 4 ♀♀ (July-August); Orange
Co., 4 ♀♀ (February-April, December); Palm Beach Co., 2 ♀♀ (March,
September); Pasco Co., 3 ♀♀ (January, August); Polk Co., 2 ♀♀ (May,
September); Putnam Co., 6 ♀♀ (May); Seminole Co., 1 ♀; St. Lucie Co.,
1 ♀ (April); Volusia Co., 1 ♀. DISTRICT OF COLUMBIA: 1 ♂ (May).

GEORGIA: Haralson Co., 1 ♀ (June); Lowndes Co., 2 ♀♀ (July); Thomas
Co., 2 ♀♀ (April); Tift Co., 5 ♂♂, 14 ♀♀ (June); Townes Co., 1 ♂
(August); Walker Co., 1 ♀ (June); Ware Co., 1 ♂, 2 ♀♀ (July).

LOUISIANA: East Baton Rouge Parish, 2 ♀♀ (July); Iberia Parish, 1 ♀
(May); Pointe Coupée Parish, 3 ♀♀ (June); Tangipahoa Parish, 1 ♀
(June). MISSISSIPPI: Forrest Co., 3 ♀♀ (August-September). NEW JERSEY:
1 ♀. NORTH CAROLINA: Columbus Co., 1 ♀ (August); Moore Co., 1 ♀
(November); Tyrrell Co., 1 ♀ (July); Wake Co., 3 ♀♀ (April-May). SOUTH
CAROLINA: Dillon Co., 3 ♀ (April); Dorchester Co., 1 ♀ (May).

TENNESSEE: 1 ♀. TEXAS: Colorado Co., 1 ♀ (March); Jackson Co., 3 ♀ (March); Nacogdoches Co., 1 ♂ (October); Victoria Co., 1 ♂ (June).

A single male (9) from Washington, D.C. and one female labeled "N. J. 1786" (9) were examined, although no specimens of this species have otherwise been taken north of North Carolina. One female [Chickamauga, Ga. VI-24-98 (38)] taken in the northwest corner of Georgia in Walker Co. and one female labeled "E. Tenn." (38) represent the most inland records. Although specimens are scarce and widely scattered in this region, they do not differ from others except that the individual from Walker County is somewhat paler with more brown on the metasoma than usual.

Lovell (1942) records this species from Jefferson Co., Kentucky, in the north central part of the state. I have not seen any of his specimens but it seems unlikely that gratiosa ranges that far inland.

Seasonal Activity. Females of gratiosa are active throughout the year in Florida and have been taken from April through September in other states. Males have been collected from March through December in Florida and June through October elsewhere. Pollen collectors are found from mid-April at least through July and probably well into the fall throughout the range and from the end of February to September in Florida.

Flower Records. Aster, Ampelopsis arborea, Asclepias syriaca, Berteroa, Bidens bipinnata, Bidens mitis, Bidens pilosa, Callicarpa americana, Cassia aspera, Chrysobalanus icaco, Chrysopsis microcephala,

**Augochlorella aurata** (Smith)


Fig. 89. Distribution of *A. gratiosa*.
Types. Augochlora aurata, holotype female, from St. John's Bluff [St. Johns Co.], Eastern Florida, is in the British Museum (Natural History). Although labels on the holotype agree with those in Smith's published description of aurata, the description agrees best with the holotype of gratiosa. Conversely, his description of gratiosa better fits the type of aurata. For further discussion of this problem, see Augochorella gratiosa. I have not seen the type but Dr. C. D. Michener took detailed notes on it and compared it with submitted specimens. Augochlora australis, holotype female, No. 12859 [Robertson's number], from Inverness [Citrus Co.], Florida, 1892, is in the Robertson Collection at the Illinois Natural History Survey. For the most part the aurata of Sandhouse (1937) and Mitchell (1960) is persimilis.

Description. Female: 1. Body length 7 mm; head width 1.58 to 1.98 mm, averaging 1.84 mm, width to length ratio variable.

2. Color yellow-green to blue-green; frons without bluish reflections on green specimens, metasoma similar in color to other body regions.

3. Mandible with basal third dark brown, yellow-brown centrally, rufous at tip, rarely with metallic reflection at base.

4. Clypeal width subequal to length; basal part green with large, irregularly spaced punctures; apical fifth or less, brown, brown area not exceeding one-third, slightly beveled; punctures in brown area round, or slightly elongate when brown area exceeds diameter of puncture; surface between punctures usually shiny and smooth.

5. Supraclypeal area variably punctate, surface between punctures shiny and smooth or finely roughened.
6. Paraocular area punctorugose to rugose below antenna, more
coarsely rugose above.

7. Antenna dark brown, often slightly lighter below than above;
pedicel with length subequal to width, first flagellar segment wider
than long.

8. Scutum coarsely punctate; punctures close to contiguous over
entire dorsum, similar to frons; anterior margin and anterolateral
corners finely rugose to finely areolate.

9. Tegula almost twice as long as wide.

10. Scutellum roughened or shallowly and irregularly punctate.

11. Pleuron finely rugose, becoming areolate anteriorly.

12. Propodeum with disc equal to or slightly longer than metanotum;
outline of disc bracket-shaped to semicircular, usually weakly bracket-
shaped, forming blunt point medially, profile type 2; posterior edge of
disc distinct, abruptly rounded to sharp, gradually rounded laterally;
striae fine, close, wavy, usually irregular, ending just before edge
or at edge medially, often leaving edge slightly raised, roughened
and dull, reaching or crossing edge laterally; posterior vertical
surface evenly and finely granular; not rough; posterolateral corners
not prominent, usually slightly more roughened than posterior surface;
lateral vertical surface weakly rugose.

13. Legs brown, fore and hind coxae, mid and hind trochanters and
femora with metallic reflections.
14. First metasomal tergum with anterior surface shiny but not polished, with numerous widely spaced punctures; dorsal punctures minute and close, or large, close and distinct (Texas); first sternum without metallic reflections.

15. Pubescence golden-white on dorsum and legs and ventrally on metasoma; white ventrally on head and thorax; pubescence short and thick but not dense on genal area.

Male: 1. Length 7 mm; head width 1.81 to 1.91 mm, averaging 1.86 mm, width to length ratio variable.

2. Color bright green; often with bluish reflections on frons; metasoma often slightly redder or browner above than on other parts of body.

3. Mandible with dark metallic reflections basally.

4. Clypeus with punctures variable in size and spacing; surface between punctures shiny and smooth.

5. Supraclypeal area variably punctured with surface smooth and shiny or irregularly roughened.

6. Paraocular area finely punctorugose.

7. Flagellum dark brown above, yellowish brown below; scape dark brown; pedicel partially light brown above, dark brown below; last flagellar segment entirely dark brown; pedicel and first flagellar segment each about 1.5 times wider than long.

8. Scutum with punctures distinct but crowded medially, separated by less than their diameters, becoming contiguous at parapsidal lines; anterior margin rugose, becoming areolate laterally.
9. Tegula twice as long as wide.

10. Scutellum shiny, punctate to punctorugose.

11. Pleuron rugose, becoming areolate anteriorly.

12. Propodeum with disc equal to or slightly longer than metanotum; outline of disc weakly bracket-shaped to obtusely V-shaped, posterior edge abruptly rounded; striae fine, wavy and irregular, reaching edge posteriorly, crossing edge laterally; posterior vertical surface and posterolateral corners finely rugose or roughened; lateral vertical surface rugose.

13. Legs brown, with fore and hind coxae, trochanters and femora reflecting green; tibiae reflecting green medially, testaceous at extremities; tarsi testaceous; hind basitarsus with erect hairs uniform in length, up to 1.5 times as long as width of segment, variable among individuals, pale yellow in color; basal tuft distinct.

14. Metasomal terga green; first tergum polished, with widely scattered fine punctures anteriorly, smooth but less shiny dorsally, punctures small and close; sterna brown, pubescence short, fine over entire sterna; first sternum with weak metallic reflections, fourth sternum shallowly emarginate.

15. Pubescence white on head, white to golden dorsally on thorax, golden on metasoma and legs.

16. Genital capsule, seventh and eighth sterna and eighth tergum all of type 1 (similar to Figs. 32, 40, 43).

Comparisons. Very few specimens of aurata have been collected outside of Florida and Texas although nine specimens are available from
Alabama, Georgia and North Carolina. The females are most similar in appearance to those of gratiosa and the males to striata, the range of variation in Florida overlapping those of both striata and gratiosa.

The females can usually be distinguished from gratiosa by the slightly longer propodeal disc, the flatter bracket-shape (Figs. 57, 58) and less acutely angulate posterior edge of the disc and the smoother posterior vertical surface of the propodeum. In Texas they can be additionally distinguished by the deep, crowded, distinct punctures on the first and second metasomal terga (Figs. 82, 83).

They can be distinguished from striata in North Carolina and Georgia by the flatter bracket-shaped disc with a less acutely angulate posterior edge and the finer, more irregular striae, and in Florida usually by finer more irregular striae and the less rugose sculpturing on the thorax. There are no striata females in the south with which this species could be confused.

The males are similar to striata with short basitarsal hairs of more or less uniform length, shallowly emarginate fourth metasomal sternum and dark tipped antennal flagellum. The range of variation is not known since only five males from Georgia have been positively identified and these were similar to one another. Ten males from Florida are also tentatively included. These look very similar to variants of striata. The males from Georgia differ from all striata males in the flatter, more finely striate, propodeal disc. The difference in scutal punctures will also separate what are believed to be Floridian aurata from Floridian striata.
I believe that *aurata* is more closely related to *striata* than to *gratiosa* although it is more difficult to distinguish the females from those of *gratiosa*. The paucity of males may reflect limited collecting at the proper time of year or their occurrence in locations other than where the females were taken or it may be that they have not been distinguished from *striata* males since the nature of the variation in *striata* has not been fully evaluated.

**Variation.** There is comparatively little variation in size although particularly large or small individuals may occasionally be found in Florida. The color, usually a yellow-green to bright green, is often blue-green in Floridian specimens although yellow-green individuals may also be found.

The clypeus is apically brown, usually for one-sixth to one-fourth its length in females, but is one-third brown in some specimens from Florida and one-half brown in some specimens from Georgia. The face looks long (Fig. 52) in all Texan and some Floridian specimens but round in the rest (Fig. 53).

The propodeal disc of the female is usually slightly longer than the metanotum, or it may be equal to the metanotum but is not shorter. The disc is nearly always at least weakly bracket-shaped and bluntly pointed medially (Fig. 57). The edge is usually abruptly rounded and distinct although it may be either sharply angulate or rounded and indistinct in some specimens from Texas and Florida. There is more variability among Floridian specimens in this character than elsewhere in the range; the four specimens from Georgia are all
similar to Figure 57. The striae are rarely as straight and well defined as in *gratiosa* (except for a few from Florida) but are very fine, irregular or vermiciform, with no definite spaces between them. The posterior edge is usually minutely roughened when rounded and the striae end gradually in this roughened area. The most striking variation occurs in the metasomal punctures of specimens from Texas. Throughout the rest of the range the punctures are small, close, shallow, and almost inconspicuous as in *gratiosa* (Fig. 83). In Texas, the punctures, although also close, are slightly larger, much deeper, and more conspicuous (Fig. 82), giving the tergum a coarse or roughened appearance.

Males have been seen only from Georgia and Florida. Those from Georgia have the disc resembling that of the females, widely bracket-shaped, with fine irregular striae ending in a minutely roughened area at the edge. None of the presumed *aurata* males from Florida have discs similar to this or to that of the females. The shape of the disc in Florida varies from weakly bracket-shaped and narrow to long and roundly V-shaped. The striae are usually rather thin and close, and the posterior edge is usually abruptly rounded; the posterior surface may be weakly roughened as in the Georgian specimens or rugose as in many male *striata*. These specimens are all different from one another, resembling males of *striata* but are unlike the *striata* from Florida. There is considerable variation in the characters of the disc of females in Florida; perhaps the variability is as great
in males. Due to the uncertainty in identification of the Floridian males, the above description of the male is based solely on the specimens of *aurata* from Georgia.

Throughout Florida, occasional female specimens are found that are brilliantly shiny, very finely punctured, with a body surface finely roughened or at most, weakly rugose on the thorax. These individuals are always dark blue-green in color but in all other respects are similar to other Floridian *aurata*. Eleven such specimens have been seen. They do not form an isolated population nor have corresponding males been found and therefore it seems improbable that these few specimens represent a different species. Such specimens are from: W. Palm Beach, IX-3-27 (Graenicher) (32*); Highlands Co., VI-6-60 (Weems) (10); Pasco Co., III-2-57 (Weems) (10); Port Sewell, II-24-29-44 (Sanford) (32); Jacksonville Beach, VIII-5-36 (Mitchell) (33); Archibald Res. Sta., Lake Placid, IV-6-61 (Dietrich) (32)*.

**Distribution.** This species is found from Florida along the Gulf coast into Texas and northward along the east coast as far as North Carolina (Map: Fig. 88).

A total of 15 males and 163 females have been seen:

- **Alabama:** Houston Co., 1 ♀ (July).

- **Florida:** Alachua Co., 1 ♂, 8 ♀♀ (March-May, October, December); Brevard Co., 1 ♂, 10 ♀♀ (March-April, July, November); Broward Co., 2 ♀♀ (February); Collier Co., 1 ♀ (April); Dixie Co., 1 ♂ (August); Duval Co., 1 ♂, 16 ♀♀ (May, August-September);

*See Table 1.*
Flagler Co., 2 ♀ (February, December); Glades Co., 1 ♀ (March);
Hendry Co., 1 ♂ (July); Highlands Co., 5 ♀ (April, June); Hillsborough Co., 3 ♀ (April); Indian River Co., 1 ♀ (March); Jackson Co., 1 ♀ (August); Levy Co., 1 ♀ (September); Marion Co., 1 ♀ (March); Martin Co., 1 ♀ (February); Nassau Co., 2 ♀ (July); Okeechobee Co., 1 ♀ (April); Orange Co., 1 ♂, 9 ♀ (March-June); Palm Beach Co., 2 ♂♂, 5 ♀ (September); Pasco Co., 1 ♀ (March); Pinellas Co., 1 ♀ (April); Polk Co., 3 ♀ (March-April); St. Lucie Co., 1 ♀ (April); St. Johns Co., 2 ♀ (April); Seminole Co., 4 ♀ (May, July); Volusia Co., 2 ♂♂, 6 ♀ (June-September). GEORGIA: Brooks Co., 1 ♀ (March); Dougherty Co., 1 ♂ (June); Lowndes Co., 4 ♂♂ (July); Pike Co., 1 ♀ (April); Thomas Co., 1 ♀ (April). NORTH CAROLINA: "N.C." 1 ♀. TEXAS: Aransas Co., 4 ♀ (July-August); Bastrop Co., 2 ♀ (May); Bee Co., 1 ♀ (May); Calhoun Co., 2 ♀ (April); Cameron Co., 4 ♀ (June); Colorado Co., 1 ♀ (April); Fayette Co., 3 ♀ (March); Goliad Co., 5 ♀ (May); Jackson Co., 4 ♀ (March, July); Kenedy Co., 2 ♀ (April); Lee Co., 20 ♀ (March-June); Nacogdoches Co., 3 ♀ (April, September); Refugio Co., 1 ♀ (April); Victoria Co., 16 ♀ (February-May, August, October); Waller Co., 1 ♀ (April).

Seasonal Activity. Females of aurata are apparently active throughout the year and have been collected from early February through December. Males are active from early June through November. Pollen collectors have been found from early February to the beginning of September although nesting activities may continue later into the fall.
Flower Records. Aster, Cirsium, Citrus sinensis, Crataegus, Lythrum alatum, Opuntia, Polygonum hydropiperoides, Rubus, Viburnum rufidulum.

Augochlorella persimilis (Viereck) (n. comb.)

Halictus (Oxystoglossa) persimilis Viereck. 1910. In Smith. Ann. Rept. New Jersey State Mus. for 1909, p. 688 (list) (new name for Augochlorella similis Robertson, preoccupied in Halictus; Viereck's identification was in error but his new name stands for similis Robertson).


Augochlorella persimilis: Ordway. 1964. J. Kansas Ent. Soc. 37: 139-152 (biol.).


Types. Augochlorella similis, lectotype female here designated, No. 1104, from Carlinville, Macoupin Co., Illinois, 1891, is in the Robertson Collection at the Illinois Natural History Survey. This specimen has been selected from among 19 syntype females. It agrees with the original description and may be considered "typical" of the species. There are eight male syntypes in the Robertson Collection, one (No. 474, Robertson's number) being a large striata and 18 syntype females all from Carlinville, Macoupin Co., Illinois, with dates from
1885-1887 and 1890-1892. *Halictus xystris* Vachal, lectotype female and two syntypes each labeled "xystris \[sic\] ? Vach." are located in the Vachal collection at the Museum National d'Histoire Naturelle, Paris. I have designated as lectotype one of the three syntypes that best fits the description and the only one with a locality label. The handwritten label reads "Augochlora pura, from *Potentilla*, S. Ill. June..." The label has been cropped closely, obliterating the rest of the date. It is probable that Vachal mistook the handwritten "S. Ill." for "S.W." and published the locality as "southwestern United States." Two of the three specimens including the lectotype resemble *persimilis* from southern Illinois. The third is a *persimilis-striata* intermediate that might be a small *striata* form. It does not agree as well with the original diagnosis as the propodeal striae are regular and almost reach the edge of the rounded disc so that there is scarcely any smooth shiny area beyond the striations. I was able to see these specimens thanks to the generosity and cooperation of Mademoiselle S. Kelner-Pillault of the Muséum National de Paris who lent them to me.

Although Sandhouse (1937) synonymized this species with *aurata* Smith 1853, the type of *aurata* is different from Robertson's *similis*.

**Description.** Female: 1. Length 5 to 6 mm; head width 1.44 to 1.91 mm, averaging 1.69 mm; head width greater than length.

2. Color bright green to yellow- or coppery-green; frons without bluish reflections; metasoma usually more golden, coppery or brownish than head and thorax.
3. Mandible with basal third dark brown, yellow-brown centrally, rufous at tip, without green basal reflections.
4. Clypeal length equal to width or slightly longer; basal part green with punctures variable in size, smallest and closest near basal angles, becoming larger apically and separated by about twice their diameters or more; apical third to two-thirds of clypeus brown and slightly beveled, with elongate punctures becoming shallow and indistinct at apex, giving apex roughened appearance; surface between punctures smooth and shiny.
5. Supracylpeal area with surface weakly roughened, punctures small just below antennae and along subantennal sutures, sometimes with few scattered punctures centrally.
6. Paraocular area usually closely punctate below antenna, finely rugose above antenna.
7. Antenna brown, flagellum lighter below than above; first flagellar segment wider than long; pedicel slightly longer and narrower than first flagellar segment, ratio of length to width variable.
8. Scutum coarsely and irregularly punctured, punctures close, usually with little or no space between them, rarely separated by as much as a puncture width centrally, becoming closer and coarser laterally; surface between punctures, when present, smooth and shiny centrally; anterior margin roughened with surface finely lineolate and dull medially, becoming rugose laterally and at anterolateral angles.
9. Tegula twice as long as wide.

10. Scutellum shiny and roughened, irregularly punctate or rugose.

11. Pleuron irregularly rugose, becoming coarsely areolate anteriorly.

12. Propodeum with disc slightly longer than to a little more than 1.5 times as long as metanotum; outline of disc roundly semi-circular, profile type 2, posterior edge indistinct and gradually rounded; striae variable, usually irregular, branched, vermiform, occupying 60 to 80 percent the length of disc medially, reaching edge laterally; surface beyond striae smooth but minutely lineate or finely roughened; posterior vertical surface shiny and smooth with sparsely scattered minute punctures, or surface finely granular with granular texture extending across upper part of posterolateral corner to lateral surface; lateral vertical surface weakly rugose or coarsely roughened with widely separated or reticulated rugae.

13. Legs brown; fore and hind coxae strongly metallic; trochanters and femora with feeble metallic reflections.

14. First metasomal tergum with anterior surface brilliantly polished with a few widely spaced fine punctures; punctures more numerous and surface less brilliant dorsally; second tergum with numerous fine punctures separated by about twice their diameters; surface usually dull; first sternum sometimes darker than others, often greenish but not metallic.
15. Pubescence golden-white dorsally on head, thorax, apical segments of legs, and on dorsal and last two ventral metasomal segments; white ventrally on head and thorax; white or golden on basal segments of legs and ventral part of metasoma.

Male: 1. Length 7 mm; head width 1.45 to 1.80 mm, averaging 1.66 mm; head width equal to, greater than or less than length with no regional or seasonal pattern.

2. Color yellow-green to coppery-green; frons without blue reflections; metasoma usually more golden or reddish than rest of body.

3. Mandible with or without metallic reflections basally.

4. Clypeal surface shiny between rather large punctures; punctures irregular in size, shape and spacing, smallest along basal edge.

5. Supraclypeal area with small scattered punctures; surface between punctures minutely roughened, dull; rougher immediately below antennae than just above clypeus, or shiny and smooth.

6. Paraocular area finely and closely punctate to rugosopunctate.

7. Flagellum dark brown above, yellow below; scape entirely dark brown except for small apical yellow area on underside; pedicel dark brown and yellow; last flagellar segment rarely darker below than preceding segments, but if so, then only partially dark apically; pedicel and first flagellar segment about 1.5 times as wide as long.

8. Scutum shiny with punctures distinct, separated by less than their own diameters medially, slightly closer laterally, smaller
and closer posteriorly; anterior margin roughened to finely rugose medially to rugose laterally.

9. Tegula more than 1.5 times as long as wide.

10. Scutellum shiny, coarsely punctate, punctures distinct but irregular in size and spacing.

11. Pleuron rugose to rugosopunctate, coarsely areolate anteriorly.

12. Disc of propodeum longer than metanotum; outline of disc semicircular, posterior edge prominent, abruptly rounded medially, gradually rounded laterally; striae variable, usually moderately coarse, irregular or wavy, not quite reaching edge medially, attaining edge laterally; surface of disc beyond median striae coarsely roughened to smooth and shiny with minute reticulations; posterior vertical surface usually smooth and brilliant, or only weakly and irregularly roughened, upper part of posterolateral corners minutely punctate to weakly roughened; lateral vertical surfaces roughened to rugose or finely areolate with weak horizontal rugae along anterior and ventral margins.

13. Legs with fore and hind coxae, trochanters and femora bright green, tibiae yellow-brown, usually darker centrally, hind tibia sometimes weakly reflecting green on inner surface; tarsi pale yellow; hind basitarsus with erect hairs along apical two-thirds of segment only, longer basally than apically; longest hairs about twice as long as width of segment, usually slightly curved at tips; basal third of segment without erect hairs; basal tuft short and sparse.
14. Metasomal terga green with apical margins usually narrowly brown; first tergum polished anteriorly with few, widely scattered fine punctures, smooth but less shiny dorsally, punctures denser, minute, separated by 1.5 times their diameters or less; sterna brown, first sternum with green reflections; fourth sternum emarginate apically.

15. Pubescence short, thick and white between antennae and on paraocular areas, white on cheeks, venter of thorax and basal segments of legs; white to golden-white on clypeus, frons and vertex, dorsum of thorax, on tibiae and tarsi and metasoma.

16. Genital capsule, seventh and eighth sterna and eighth tergum of type 1 (Figs. 33, 40, 43).

Comparisons. Although the range of persimilis overlaps that of four other species of Augochlorella, females intergrade only with form c of striata. There is no sure way of separating females of the two species where intermediates occur although the key will distinguish a majority. Males of the two species remain distinct and are readily distinguishable by the key characters.

Both males and females of persimilis may superficially resemble bracteata in size, coloration and often in characters of the propodeal disc. There is however, only slight overlap in ranges and the consistantly rougher thorax of persimilis effectively serves to distinguish the two species.

Apart from bracteata and striata c, persimilis can be distinguished from the eastern species by its generally smaller size, smoother body
and propodeal disc with rounded posterior edge and short medial striae. The males are distinguishable by the long hind basitarsal hairs (Fig. 50) although in Texas two male specimens of gratiosa were found that looked very similar to those of persimilis (see variation under gratiosa). The fourth metasomal sternum of the males is about as emarginate as that of gratiosa, so that any distinction is difficult to make, especially when the segments are telescoped.

**Variation.** Body color varies in persimilis from blue-green to golden or coppery-yellow. The metasoma is usually lighter in color than the head and thorax (it may be browner or yellower). The males are predominantly yellowish green throughout the range except in Arkansas, Virginia and Georgia where all individuals seen are coppery in color. In Kansas, where a large sample was available, 85% of the females are bright green, 14% yellow-green or coppery and 1% blue-green. More than half the specimens are yellow-green or coppery-green in Tennessee, North Carolina, Maryland, Texas, Arkansas, Indiana, Missouri, Minnesota and Virginia, but populations are predominantly bright green in Illinois, Kansas, Nebraska and Wisconsin. About half the specimens are bright green in Louisiana and Oklahoma.

In both males and females, the width of the head varies widely within any one area. When measurements were pooled for each sex, however, normal distributions were obtained with only a slightly skewed distribution in the case of males. The head width may be greater than, equal to or less than the length in the case of the males with only slight differences between width and length. In
females the width is consistently greater than the length. Little
difference in size was found between populations from different
areas. In females, the average head width of field caught bees is
greater during the spring (March, April, May) (Fig. 89) than during
other months; at least throughout much of the range only queens are
present in spring. During the rest of the season, both queens and
workers are present. (See Part II for discussion of size and caste
data.)

The length of the clypeus in females is about equal to the width
giving the face a round appearance, especially in smaller individuals.
The spacing and number of punctures on the clypeus are variable among
individuals. Also, the extent of the brown color on the apical
portion varies from about one-third to one-half the length. No
regional trends were observed for either character.

The supracylpeal area is always roughened in females and at
least partially so in males. The amount of punctation in this area
is variable as is the degree of roughness. The paraocular areas are
usually punctate near the lower ends of the eyes and finely rugose
elsewhere. However, in about one percent of the females from throughout
the range the rugoseness extends to the bases of the mandibles.

The antennae of some males have the last flagellar segment
slightly darker below than the preceding segments but the segment
is only partially dark and the darkening is slight.

The punctures of the scutum in females are rather constant in
size but vary in respect to their spacing. The punctures are always
distinct centrally but are closer toward the edges and the scutum may become rugose laterally and anteriorly. The amount of space between the central punctures varies; usually the punctures are close together with little space between, giving the surface a rather rough appearance. The surface looks smoother when the punctures are more widely spaced as in many of the specimens from Arkansas and a few from Virginia. The anteromedial surface is finely lineolate or roughened. This roughening extends for varying distances along the median suture but is always evident at least at the anterior end of the suture. There is little variability in scuta of males.

The scutellum in males and many females has punctures of various sizes and unequal spacing. In the females the scutellum may have distinct punctures or the punctures may run together or the surface may be entirely rugose, with all conditions occurring in populations throughout the range. When the punctures are distinct in females, they are closer and smaller at the edges, becoming rugose along the posterior margin and along the medial line, usually being shallower and smaller than those on the scutum. In males the punctures may vary from widely spaced to crowded.

There is little variation in the pleural region. Although the sculpturing of the mesepisternum and metepisternum is about equally coarse, the rugose patterns of the two areas are different.

As in other eastern species the propodeal area is highly variable, yet in females, it remains the most diagnostic character available.
The disc is longer than the metanotum in both sexes. Only one male out of about 50 measured was found with disc and metanotum equal in length \( \text{Illinois, 566, Hart Coll. (14*)} \). In males the metanotum showed greater variation in length than the propodeum; in females, both structures varied in length.

The shape of the margin of the disc and the lack of a V-shaped midapical depression is unvarying in all males. In two males out of about 300 examined, the usually thick posterior margin was thin, abruptly angulate and almost carinate \( \text{Indiana, Warren Co., VII-25-50 (16)}; \text{Missouri, Tecumseh, VI-9-60 (25)} \). In females the shape of the margin varies little and there is no V-shaped depression. Although the smooth, lineate, posterior part of the disc does extend onto the posterior surface in the shape of a V, there is no median depression as is found in *gratiosa* or some *striata*. The posterior edge in females usually is thickened as in males, but may be very narrow, flat, or in certain cases completely rounded so that there is no clear demarkation of the margin \( \text{Illinois, 16966 (14)}; \text{Nebraska, Nebraska City, VII-23-01 (28)} \). The striae are extremely variable in both sexes although more so in females. Variation in males is limited chiefly to the thickness of the striae and to the amount of their separation. The striae in both males and females may be regular and straight or, more usually, at least partially wavy, branched or irregular. All grades of irregularity occur in the striae of

*See Table 1.*
females, but rarely are the striae straight and distinct in the central area, and in no case was a specimen found in which the striae were both thick and straight, and widely spaced as in the large striata c or Floridan striata a. Although the striae rarely exceed 80% of the length of the disc centrally, specimens may be found where they reach into the lineate region medially in Texas (38); Kansas, Douglas Co. (20) etc. The lateral striae are nearly always rather straight and distinct in both males and females. Various types of "extreme" conditions appear periodically in females of various populations. It is not feasible to cite them all, but they include forms without striae and with only fine roughening along the basal half of the disc in Kansas, Lawrence, VIII-3-58 (20); Wisconsin, Oshkosh, VIII-7-16 (47), or with fine rugae running transversely and joining with lateral striae in Kansas, Douglas Co., IX-5-53 (28); Missouri, Buffalo, VI-8-52 (20) or with striae so irregular that there is no linear quality at all in Illinois, Algonquin, VI-4-09 (14); Missouri, Big Spring St. Pk. (20) etc. The posterior surface of the propodeum of females may be shiny and smooth or slightly less brilliant and granular in nature. No specimen was seen with rugae on this area. Specimens from the east (Maryland, Georgia, North Carolina, Virginia) are predominantly shiny and smooth; in other areas both conditions occur in about equal proportions. Three specimens were found in which the propodeal area was somewhat misshappen with the result that the posterior surface was "wrinkled looking," shiny and without the usual minute punctures in Arkansas, Jonesboro, VI-29-52 (20); Wisconsin,
In males the posterior surface is usually very shiny and only slightly but variously roughened. This roughening may be in the form of shallow punctures which may or may not be distinct or may be merely unevenness of the surface. Two specimens, however, were found with very rough and somewhat duller posterior surfaces in Illinois, 32408 (14); Illinois, Willow Spr., VIII-12-05 (14).

There is little variation in coloration of the legs in either males or females except for the intensity of green. This coloration seems to be correlated with the darkness of body coloration, the paler (yellower) individuals having less strongly green legs. Such variation occurs throughout the range. The length of the hairs on the hind basitarsus of the male is rather constant. Only one male was found where the long hairs were as short as one-half the width of the basitarsal segment and in this case they originated close to the basal tuft with somewhat less space separating the tuft and the hairs than is normal in Arkansas, Malvern, VI-15-58 (25).

The metasoma shows the usual color variation of other body regions. The first sternum of the male is variously tinted with green. Some specimens have the metallic nature barely visible in Louisiana, 2392 (9); several Minnesota specimens whereas others are bright green or intermediate. In females the first sternum is not green although it may vary from light brown to dark brown and may be shiny and greenish but never metallic.
One male was found in which the second tergum is granulose and similar to the third rather than punctate as is the first. Missouri, Buffalo, VI-8-52 (20). The third tergum is frequently punctate like the first in females. In females the second tergum may be similar either to the first or third or even occasionally intermediate. Indiana, Tippecanoe Co., VI-16-53 (16). Again, this variation appears to be individual rather than regional in nature.

The color of pubescence in females varies regionally to a slight extent. In the eastern states (Georgia, Maryland, North Carolina, Virginia, Tennessee, Louisiana) the ventral part of the metasoma and basal segments of the legs have golden rather than white hair. In the midwest (Oklahoma, Wisconsin, Minnesota, Nebraska, Kansas, Missouri, Texas, Arkansas) most specimens are paler below with the hairs on the basal leg segments white and on the venter white or golden-white, although, in Iowa, Indiana, Oklahoma and Arkansas, individuals are variable so that all combinations can be found. One male was found that had all white pubescence. Illinois, "Airport Region" Peoria, VII-20-41 (14).

On the male genital capsule, the inner lobe is variable and usually similar to that of striata. There is a tendency for the rounded portion to slope off sooner at each side of the apex, whereas in striata it is more broadly rounded. The finger-like process is variable in length although it is rarely as long as in gratiosa or striata.
Distribution. From the eastern Appalachian Mountains, Maryland to Georgia, westward to about the 97th parallel, from southeastern Minnesota and Wisconsin southward to northeastern Texas and Arkansas (Map: Fig. 90).

More than 300 males and 2300 females were seen: ALABAMA:

Cullman Co., 1 ♂ (July); Jefferson Co., 1 ♂ (August). ARKANSAS:

Boone Co., 1 ♀ (August); Carroll Co., 3 ♀♀ (August-October);

Craighead Co., 32 ♀♀ (April, June); Faulkner Co., 2 ♀♀ (June); Garland Co., 1 ♂, 21 ♀♀ (September-October); Hempstead Co., 1 ♂, 8 ♀♀ (June);

Hot Springs Co., 3 ♂♂, 14 ♀♀ (May-June); Polk Co., 1 ♂, 4 ♀♀ (August);

Pulaski Co., 4 ♀♀ (June); Scott Co., 3 ♀♀ (May); Searcy Co., 2 ♂♂,

1 ♀ (August); Sebastian Co., 2 ♀♀ (May); Sevier Co., 6 ♂♂, 28 ♀♀

(June); Washington Co., 10 ♂♂, 17 ♀♀ (May, August); White Co., 1 ♀

(April). GEORGIA: Clark Co., 1 ♂, 1 ♀ (June); Cobb Co., 1 ♀ (July);

Fulton Co., 3 ♂♂ (June); McDuffie Co., 1 ♀; Meriwether Co., 1 ♀ (July);

Polk Co., 1 ♀ (May); Rabun Co., 1 ♂, 1 ♀ (June-July); "Head River"

1 ♀ (July). ILLINOIS: Champaign Co., 5 ♂♂, 4 ♀♀ (May-July); Cook Co.,

2 ♂♂, 8 ♀♀ (May-August); Du Page Co., 4 ♀♀ (May, August); Jackson Co.,

4 ♂♂ (June, August); Jefferson Co., 30 ♀♀ (May); Johnson Co., 1 ♀

(May); McHenry Co., 4 ♂♂, 13 ♀♀ (May-July, September); Macoupin Co.,

10 ♂♂, 22 ♀♀; Peoria Co., 1 ♂ (July); Piatt Co., 2 ♂♂, 1 ♀ (June);

Union Co., 1 ♂ (August); Vermilion Co., 2 ♀♀ (June); Warren Co., 1 ♂

(August). INDIANA: Harrison Co., 1 ♀ (July); Lake Co., 1 ♀ (August);

Spencer Co., 1 ♀ (September); Tippecanoe Co., 6 ♂♂, 102 ♀♀ (April-

September); Warren Co., 1 ♂, 2 ♀♀ (July-August). IOWA: Fremont Co.,
1 ♀ (July); Louisa Co., 1 ♀ (June); Story Co., 5 ♀♀ (May). KANSAS:
Allen Co., 16 ♀♀ (April, June); Anderson Co., 40 ♀♀ (May, September);
Atchison Co., 2 ♂♂, 2 ♀♀ (May, July); Bourbon Co., 1 ♂, 2 ♀♀; Butler
Co., 2 ♀♀ (June); Chautauqua Co., 1 ♂, 11 ♀♀ (August); Cherokee Co.,
2 ♂♂, 5 ♀♀ (June, August); Cowley Co., 1 ♂, 2 ♀♀; Doniphan Co., 8 ♀♀
(May, July-August); Douglas Co., 131 ♂♂, 1271 ♀♀ (March-October);
Franklin Co., 13 ♀♀ (May-June); Greenwood Co., 2 ♀♀ (August); Jefferson
Co., 1 ♀ (May); Johnson Co., 3 ♂♂, 6 ♀♀ (July-August); Labette Co.,
5 ♀♀ (May-June); Leavenworth Co., 1 ♂, 43 ♀♀ (May-June); Marshall Co.,
2 ♂♂, 40 ♀♀ (May, September-October); Miami Co., 20 ♀♀ (May-June);
Montgomery Co., 1 ♂, 1 ♀ (June, September); Neosho Co., 37 ♀♀ (April);
Osage Co., 2 ♀♀ (June); Pottawatomie Co., 1 ♂, 7 ♀♀ (May, July);
Republic Co., 1 ♀ (July); Riley Co., 10 ♂♂, 56 ♀♀ (April-October);
Wilson Co., 3 ♂♂ (June); Woodson Co., 2 ♀♀ (June). KENTUCKY: Graves
Co., 1 ♂ (June). LOUISIANA: St. Landry Parish, 1 ♂, 5 ♀♀. MARYLAND:
MINNESOTA: Fillmore Co., 2 ♀♀ (May); Houston Co., 25 ♀♀ (May); Le
Sueur Co., 1 ♀ (August); Olmsted Co., 1 ♂ (July); Ramsey Co., 1 ♀
(May). MISSOURI: Andrew Co., 1 ♀ (May); Boone Co., 1 ♂, 6 ♀♀ (May-
July, October); Carter Co., 1 ♂ (June); Cooper Co., 1 ♀ (June);
Dallas Co., 1 ♂, 30 ♀♀ (June); Jasper Co., 2 ♂♂, 3 ♀♀ (June); Laclede
Co., 22 ♀♀ (June, August); Livingston Co., 1 ♀ (July); Miller Co., 4 ♀♀
(June, September, October); Ozark Co., 1 ♂, 1 ♀ (June-July); St. Louis
Co., 4 ♀♀ (July, November); Taney Co., 1 ♂, 5 ♀♀ (May, September).
NEBRASKA: Cass Co., 13 ♀♀ (May-July); Douglas Co., 1 ♀ (August);
Lancaster Co., 1 ♀ (July); Otoe Co., 4 ♀♀ (May, August); Richardson Co., 1 ♀ (July); Saunders Co., 5 ♀♀ (May); "Child's Point" 2 ♀♀ (July). NORTH CAROLINA: Haywood Co., 1 ♂, 5 ♀♀ (May, July-August); Rutherford Co., 1 ♀ (June); Swain Co., 4 ♀♀ (April, June). OHIO: Lawrence Co., 1 ♂, 1 ♀ (August); Washington Co., 1 ♀ (June).

OKLAHOMA: Atoka Co., 1 ♀ (April); Bryan Co., 1 ♀ (June); Carter Co., 1 ♂, 8 ♀♀ (April-July, November); Choctaw Co., 2 ♂♂ (June); Latimer Co., 2 ♀♀ (June); Le Flore Co., 3 ♂♂, 1 ♀ (June); McCurtain Co., 4 ♂♂, 4 ♀♀ (June); Murray Co., 1 ♀ (June); Noble Co., 1 ♀ (August); Osage Co., 1 ♀ (August); Pawnee Co., 1 ♂, 6 ♀♀ (June-July); Payne Co., 2 ♂♂, 14 ♀♀ (April-July); Pittsburg Co., 3 ♂♂, 15 ♀♀ (April, June); Pushmataha Co., 1 ♀ (June); Wagoner Co., 2 ♀♀ (July). PENNSYLVANIA: Delaware Co., 1 ♀ (June). SOUTH CAROLINA: Greenville Co., 1 ♀ (August). TENNESSEE: Knox Co., 1 ♂, 2 ♀♀ (May, August); Lincoln Co., 1 ♀ (April); Montgomery Co., 1 ♀ (July); Sevier Co., 7 ♀♀ (July); Shelby Co., 2 ♂♂, 7 ♀♀ (June). TEXAS: Bowie Co., 3 ♀♀ (March); Fannin Co., 2 ♀♀ (May); Hunt Co., 7 ♀♀ (March-June); Lamar Co., 1 ♂, 1 ♀ (June); Nacogdoches Co., 2 ♂♂ (October); Red River Co., 1 ♀ (April); Tarrant Co., 1 ♂ (June). VIRGINIA: Botetourt Co., 4 ♂♂, 3 ♀♀ (June); Fairfax Co., 1 ♂, 14 ♀♀ (March, May-August); Fauquier Co., 1 ♂, 2 ♀♀ (July); Fredrick Co., 2 ♀♀ (May); Prince William Co., 1 ♀ (July); "Barcroft" 11 ♀♀ (May-July, September). WISCONSIN: Dane Co., 1 ♂, 12 ♀♀ (May-August); Grant Co., 2 ♂♂ (July); La Crosse Co., 1 ♀ (August); Pierce Co., 1 ♂, 4 ♀♀ (July-August); Vernon Co., 5 ♂♂, 3 ♀♀ (July-August); Winnebago Co., 1 ♀ (August).
This species seems to be most common in eastern Oklahoma and Kansas, and throughout Arkansas, Missouri and Illinois. Although it does range east of the Mississippi River as far as the eastern slopes of the Appalachian chain, the populations apparently decrease in numbers. This is not entirely due to lack of collecting since ample specimens of *striata* have been obtained from many of these areas, but rather seems to reflect an actual thinning out of the species. One male was taken on the southern border of Michigan but specimens have not been taken further north in this state in spite of intensive collecting. South of Michigan the apparent gap could be due to inadequate collecting in northeastern Indiana and northwestern Ohio. In the West, the abrupt line at about the 97th parallel reflects the decrease in rainfall and therefore corresponding changes in edaphic and vegetational conditions in this region.

Sandhouse (1937) limited the range of the species (using the name *aurata*) to south of 42 degrees north latitude even though she saw specimens from Minnesota, north of this line. Specimens recorded by her and others from Colorado and New Mexico are now recognized to be *striata* and *neglectula*. The Floridian specimens recorded by Sandhouse as *aurata* are the true *aurata* of Smith, 1853.

The distribution given by Mitchell (1960) was largely taken from the literature and reflects the complex errors in identification and synonymy that have been recorded. For example, J. B. Smith (1910) and Viereck (1916) record "*aurata*" and "*persimilis (= similis Robt.*)" from New York, New Jersey and Connecticut. It is uncertain what they
were regarding as *aurata*, but their *persimilis* was undoubtedly the small *striata* form that is occasionally found in these states or small individuals of other forms of *striata*.

The report by Rau (1922) concerning the nests of *A. similis* in a log refers to *Augochlora pura*. But perhaps the most complex error was made by Dreisbach (1945) who refers to "*Augochlorella neglectula (= A. aurata Sm.)*" as occurring in Michigan and gives as his reference Titus 1901, who referred to this species under the name *A. similis*. These specimens are not *aurata*, *neglectula* or *similis* (= *persimilis*) but are undoubtedly *striata*, essentially the only *Augochlorella* found in Michigan.

**Seasonal Activity.** *A. persimilis* is active from early April to about mid-October although nesting takes place only from the end of April to about the middle of August. Males start appearing with the emergence of the first brood at the end of May and can be found on flowers until the first frost in the fall. Although there is division of labor in colonies of this species, morphological castes cannot be distinguished. For details of the biology of *persimilis*, see Part II.

**Flower Records.** *Achillea*, *Agastache foeniculum*, *Ailanthus*, *Alisma subcordatum*, *Althaea*, *Ammannia coccinea*, *Amorpha canescens*, *Amorpha fruticosa*, *Antennaria plantaginifolia*, *Anthemis cotula*, *Aphanes skirrobasia*, *Apocynum androsaemifolium*, *Arabis perstellata*, *Arabis virginicus*, *Asclepias incarnata*, *Asclepias purpurascens*, *Asparagus officinalis*, *Aster ericoides villosus*, *Aster lateriflorus*,
reptans, Polygonum, Polytaenia nuttallii, Potentilla canadensis, Potentilla norvegica, Prunus serotina, Psoralea psoralicoides glandulosa, Psoralea tenuiflora floribunda, Pycnanthemum flexuosum, Ranunculus abortivus, Ranunculus recurvatus, Raphanus, Rhus copallina, Rhus glabra, Rorippa obtusa, Rorippa sinuata, Rosa, Rubus canadensis, Rubus flagellaris, Rudbeckia triloba, Sabatia, Sagittaria latifolia, Salix humilis, Salix nigra, Salix purpurea, Salvia officinalis, Salvia pratensis, Senecio plattensis, Sida spinosa, Silphium speciosum, Sisyrinchium angustifolium, Smilacina stellata, Smilax herbacea, Solidago missouriensis, Solidago nemoralis, Specularia perfoliata, Stellaria longifolia, Stellaria media, Symphoricarpos orbiculatus, Taenidia integerrima, Taraxacum officinale, Thaspium trifoliatum, Tradescantia longipes, Trifolium hybridum, Trifolium repens, Valerianella radiata, Verbena simplex, Verbena stricta, Verbena urticifolia, Verbesina helianthoides, Vernonia baldwinii, Veronica arvensis, Veronica peregrina, Viburnum dentatum, Zigadenus, Zizia aptera, Zizia aurea.

**Augochlorella striata** (Provancher)

Fig. 90. Distribution of *A. persimilis*.


**Types.** *Augochlora striata*, female lectotype, male lectoallotype, from Quebec, Canada, are in the collection of Laval University, Department of Biology, Ste. Foy, Quebec, Canada. These specimens have been carefully compared by Dr. René Beique, Curator of Entomology at Laval University, with specimens I submitted. Dr. Beique's careful examination and illustration clearly show that these specimens are typical of *striata* of eastern Canada and typify form a of the discussion below. According to Dr. Beique (personal communication), these types are the only two specimens of this species in the Provancher collection, although the original series contained two females and four males. The lectotypes were labeled (but not published) by Mr. Noel Comeau, the former curator of the Provancher collection, in 1941, and are labeled as follows: female specimen No. 119: with a small yellow label marked 1475 (Provancher number), a white label with red border bearing the identification in Provancher's handwriting, a red label marked lectotype with the identification, Comeau's signature, dated 1941 and No. 119; male specimen No. 120: with a small white label with ♂ sign, a yellow label with Provancher's number 1475 A, and a purple label marked Allotype, No. 120, with
Comeau's signature and dated 1941. The lectotype designation is here published for the first time. The location of the rest of the syntype series is not known.

*Augochlora confusa*, lectotype female No. 927 (Robertson's number) is from Carlinville, Macoupin Co., Illinois, 1886, and is in the Robertson Collection at the Illinois Natural History Survey. This specimen was selected from among 33 females of *Augochlorella striata* in the syntype series. Eighteen other females in the series are *Augochlora pura*. I have also seen seven male syntypes, all *striata*, and similar in appearance. I have not seen one female and four males of the original series. It seems certain that Robertson's description was based upon the *Augochlorella striata* and not the *Augochlora pura*. This lectotype designation is also published here for the first time.

*Augochlora coloradensis*, lectotype female, Ft. Collins [Larimer Co.], Colorado, June 13, 1899, is at the U. S. National Museum. It has a red U. S. National Museum cotype label No. 19459, and an identification label by Titus. I have selected this specimen as the lectotype because it agrees as well as any with the description, is in good condition, and will be located at the same museum as other Titus types. Other known female syntypes are located at the Museum of Comparative Zoology (1 specimen), U. S. National Museum (1 other specimen), Purdue University (2 specimens), University of Kansas (1 specimen), and Colorado State University (6 specimens). This species was originally described from numerous females and two males. I have not seen the males or other females, if any.
Augochlora matilda, lectotype female, No. 12247 (Robertson's number), from Inverness, Citrus Co., Florida, 1892, is in the Robertson Collection at the Illinois Natural History Survey. I have seen only one of the two syntypes and here designate it as the lectotype.

Augochlora pseudopurella Strand was proposed for Halictus purus Vachal (not Say). It does not seem likely that Strand designated a holotype from among the "numerous" specimens which Vachal misidentified as H. purus Say. I have not seen these specimens which are in the Museum National d'Histoire Naturelle de Paris, but Pe. J. S. Moure (personal communication) has verified that they are Augochlorella and not Augochlora. The specimens from Canada, the northeastern United States and possibly Louisiana would be striata; those from Orizaba and Oaxaca, Mexico are probably neglectula.

This species consists of highly variable, intergrading groups of individuals. In order to describe and discuss the variation, four forms (a-d) have been recognized. The variability is such over most of the range that no definite line can be drawn between the four groups and therefore it is not always possible to assign certain specimens to any of the groups. These unplaced individuals are called "s." Although detailed studies were made of variations among males, it seemed impractical in the time available to segregate all males into forms and many are therefore assigned to group s. The following discussions of the forms concern only females unless specific reference is made to males. Biological information from
Kansas (see Part II) indicates that there may be at least two populations or species, but until further ecological and behavioral data are obtained, there is little justification for recognizing more than one species. However, when possible, I have kept the information concerning the four groups separated in the following discussion and records in the event that further biological work substantiates the hints that there may be sibling species involved.

In discussing regional variation among the different forms, the specimens are compared with a "standard." This is a specimen of each form chosen from an area where the form is usually distinct, where there are few, if any, intergrades, and where the majority of specimens look alike. The term "standard" refers only to these specimens in the following discussions. The standard of form a is from Philadelphia, Pennsylvania, IX-24-14 (38); that of form b is from Alleghany Co., North Carolina, along Little River, nr. Eunice, VII-26-28-57 (R. Baileys & C. F. Walker) (25); that of form c is from Lee Co., Iowa, VI-28-29-(Parks) (6); and that of form d is from Colorado Springs, Colorado, VI-6-52 (W. E. LaBerge) (20).

The type of striata is form a. Robertson's matilda is also form a but is too coarsely sculptured to be typical except in Florida. The type of Robertson's confusa is typical of form c. Form b is morphologically between a and c. In some areas it intergrades with form a, in other areas with form c. Occasionally there is a continuum from a to c but usually b is entirely separable from both a and c. The type of coloradensis Titus is a representative of form d. In
some areas this form appears to be a variable intergrade between \texttt{a}, \texttt{b} and \texttt{c} but in other areas it is quite distinct.

The following descriptions apply to all forms of \texttt{striata} except as noted.

\textbf{Description.} Female: 1. Length 5 to 8 mm; head width 1.55 to 2.82 mm, averaging 1.96 mm, width greater than length.

2. Color varying regionally from blue-green to yellow-green; frons without bluish reflections in green specimens; metasoma similar in color to head and thorax.

3. Mandible with basal third dark brown, reddish brown centrally, rufous at tip; without green reflections basally.

4. Clypeal length equal to, or slightly greater than width; basal part green with large, irregularly spaced punctures, smaller and closer basally; apical one-fourth to one-half brown, slightly beveled, with elongate punctures or irregularities; surface between punctures smooth and shiny.

5. Supraclypeal area variously punctate with surface between punctures smooth or roughened.

6. Paraocular area punctorugose to rugose below antennae, coarsely rugose above antennae.

7. Antenna dark brown, flagellum slightly lighter below than above, pedicel as long as broad, first flagellar segment slightly wider than long; pedicel longer than but equal in width to first flagellar segment.
8. Scutum coarsely punctate to rugose (some form \( \frac{a}{a} \) only) medially, becoming more coarsely rugose between parapsidal lines; anterior margin smoothly roughened at midline, becoming coarsely areolate laterally.

9. Tegula about 1.5 times as long as wide.

10. Scutellum finely and irregularly roughened, without distinct punctures.

11. Pleuron rugose, becoming areolate anteriorly.

12. Propodeum with disc variable in size, shape and sculpturing; length equal to metanotum (some form \( \frac{a}{a} \)) or more usually, longer than metanotum, rarely more than twice metanotal length; outline of disc sharply to roundly bracket-shaped (forms \( \frac{a}{a}, \frac{d}{d} \)) to deeply roundly or obtusely V-shaped (forms \( \frac{a}{a}, \frac{b}{b} \)) to broadly U-shaped or semicircular (form \( \frac{c}{c} \)), profile types 1-4; posterior edge sharp or weakly carinate (form \( \frac{a}{a} \)), abruptly rounded and thickened (forms \( \frac{b}{b}, \frac{d}{d} \)) to smoothly and gradually rounded and indistinct (form \( \frac{c}{c} \)); striae usually distinct, slightly irregular or straight, usually reaching edge posteriorly; posterior vertical surface coarsely and deeply roughened (some form \( \frac{a}{a} \) only) to smooth, shiny and granular; posterolateral corners finely granular to finely roughened (forms \( \frac{b}{b}, \frac{c}{c}, \frac{d}{d} \)), to strongly roughened (forms \( \frac{a}{a}, \frac{b}{b} \)) or rugose (form \( \frac{a}{a} \)); lateral vertical surface finely to coarsely (some form \( \frac{a}{a} \) only) rugose or reticulated.

13. Legs brown; coxae bright green, trochanters and femora usually with weak metallic reflections.
14. Metasomal terga with apical margins narrowly, often inconspicuously margined with brown; first tergum with anterior portion polished, sparsely and finely punctate, dorsal surface variously punctate with punctures minute and inconspicuous to large, and widely to closely, regularly to irregularly spaced; second tergum with punctures similar to first but with punctures closer; first metasomal sternum with or without weak metallic reflections.

15. Pubescence golden on dorsum and legs and ventrally on metasoma; golden to white ventrally on thorax and head.

Male: 1. Length 6 to 8 mm; head width 1.63 to 2.13 mm, averaging 1.85 mm, usually equal to or less than length, rarely wider than long.

2. Color yellow-green to dark blue-green, usually bright shiny green, frons without blue reflections on green specimens, usually uniformly colored over entire body.

3. Mandible with or without metallic reflections basally.

4. Clypeus with punctures variable in size and number, separated by about their own diameters, surface between punctures usually smooth and shiny.

5. Supraclypeal area protuberant, variably punctate, with surface between punctures roughened or sometimes smooth and shiny at least basally.

6. Paraocular area with small close punctures below level of antennae, minutely but deeply punctorugose above level of antennae.
7. Flagellum dark brown above, yellow-brown below; scape and pedicel dark brown with yellow apical area below; width of pedicel and first flagellar segments variable, each averaging 1.5 times as wide as long.

8. Scutum shiny with punctures variable in size and spacing; anterior margin and anterolateral angles areolate, smoother anteromedially.

9. Tegula about two times longer than wide.

10. Scutellum with surface irregular, punctate to rugose; punctures, when present, distinct to indistinct, irregular in size and spacing.

11. Pleuron punctate to rugose, becoming areolate anteriorly.

12. Propodeum with disc equal to or slightly longer than metanotum; outline of disc varying from distinctly bracket-shaped to obtusely U-shaped or semicircular, posterior edge varying from sharply angulate and prominent to gradually rounded; striae fine to coarse, regular to irregular or branched, straight to wavy, widely separated to close together, usually reaching edge posteriorly, or slightly before when edge of disc gradually rounded, reaching edge laterally; posterior vertical surface minutely to finely rough; posterolateral corners with or without subhorizontal rugae extending from lateral to posterior faces; lateral vertical surface irregular, rugose with weak lineate rugae perpendicular to anterior and ventral edges.
13. Legs brown, fore and hind coxae, trochanters and femora green, tibiae dark brown, with greenish reflections at least on anterior side of hind leg, usually yellow-brown apically and basally; tarsi brown; hind basitarsus with erect hairs of uniform length, equal to or longer than basal hairs, length variable, not exceeding 1.5 times width of segment; basal tuft present.

14. Metasomal terga green with brown apical margins; first tergum polished with widely scattered, fine punctures anteriorly, smooth but less shiny dorsally, punctures variable in size and spacing; second tergum with punctures variable in size, denser than those of first, indistinct on third and following terga, surface minutely reticulated in appearance, pubescence fine, short to long depending on wear; first sternum usually with metallic reflections variable in intensity; fourth sternum distinctly but weakly emarginate.

15. Pubescence white to golden, usually golden dorsally, white ventrally with long golden hairs and short white hairs on head and ventral part of abdomen; golden on tibiae and tarsi, white on coxae, trochanters and femora.

16. Genital capsule, sterna 7 and 8 and tergum 8 of type 1 (Figs. 32, 40, 43).

Forms

The following accounts describe the "standard" individual of each form and a series from the same locality. They do not include total variation of the form or attempt to describe intergrades among
the forms. The males were described only from specimens that could be definitely placed as to form and were usually from the same areas as the females.

**A. striata form a**

Female: Disc sharply bracket-shaped to obtusely V-shaped (Figs. 59, 60), shorter to slightly longer than metanotum, these sclerites usually about equal in length; length of disc at postero-lateral corners as long as length posteromedially; edge of disc weakly carinate to sharply defined posteriorly (Fig. 21), becoming rounded laterally; disc pointed or sharply V-shaped medially and depressed onto posterior vertical surface. Striae variable, straight, thick and well defined to irregular, branched and close, or thin, fine and very close; always reaching well defined edge. Posterior vertical surface of propodeum smoothly granular to coarsely roughened or rugose.

Male: Disc usually as long as metanotum or only slightly longer, with distinct, usually sharp edge, often bracket-shaped; striae well defined, regular but wavy, reaching edge; posterior surface of propodeum variable, usually uneven, may be rather smooth to rough. Hind basitarsus with hairs appearing short and sparse, only slightly longer than width of basitarsus, contrasting only slightly in length with basal tuft.

All *striata* with sharp bracket-shaped discal areas belong in this group. As the bracket-shape and edge become rounded it is less easy to recognize this form. This form grades gradually into forms b,
$g$ and $d$ as the disc becomes more rounded in shape and rounded along its edge. The outline of the disc is similar to that of *gratiosa* and females may look similar to *gratiosa* and *aurata* when the striae are fine.

**A. striata form b**

**Female:** Disc longer than metanotum, up to twice as long, obtusely V-shaped, longer medially than laterally, with medial portion of V rounded and sometimes extending onto posterior vertical surface (Fig. 63), edge distinct, often thickened, rough and abrupt but rounded (Fig. 23), not ridged or carinate. Striae large, irregular and branched, reaching edge at all points; posterior vertical surface of propodeum finely and regularly granular (Fig. 74), lateral vertical surface rugose.

**Male:** Disc long medially, obtusely V-shaped, up to twice as long as metanotum, with edge thickened but rounded and often roughened; striae wavy but regular, reaching edge; posterior surface of propodeum usually shiny but rough to smooth, punctured or finely rugose, variable throughout range; hind basitarsal hair dense, usually of more or less uniform length, about twice as long as basal tuft; hind basitarsus usually appearing large, with long, dense hair.

These bees are usually large and light green. They grade into forms $a$, $c$ and $d$ in certain areas but are predominant and most similar to the standard in the southeastern part of the range.
A. striata form C

Female: Disc large, up to twice length of metanotum, broadly U-shaped (Fig. 62); edge of disc indistinct, smoothly and gradually rounded from vertical to horizontal plane; striae large and distinct, straight or irregular, wavy and branched, sometimes widely separated; striae ending gradually at indistinct edge of disc; surface between striae shiny and smooth or minutely reticulated or minutely roughened; posterior vertical surface of propodeum evenly granular (Fig 74), lateral vertical surface rugose.

Male: Disc broadly and deeply U-shaped, longer than metanotum; edge of disc smoothly rounded, shiny; striae straight, often widely separated with surface shiny between, usually reaching edge or ending gradually just before edge; posterior surface of the propodeum shiny but uneven or roughened and irregularly and minutely punctured, often rough; hind basitarsus with hairs long but sparse, distinctly longer than basal tuft.

There is wide variation in size in this form but the most distinctive or characteristic bees of this group are large. Small individuals look similar to A. persimilis, especially if the striae fade out before the edge of the disc leaving a shiny area between the striae and the edge. These bees are most prevalent in the northern part of the range and are most similar to the standard in Iowa and Illinois.
A. striata form d

Female: Propodeal disc equal to or usually slightly longer than metanotum, obtusely U-shaped to weakly bracket-shaped (Fig. 71), edge distinct, often slightly thickened and rough or uneven, sometimes extending medially onto posterior surface as indistinct or rounded V; striae large, irregular or vermiform, usually reaching edge posteriorly; posterior vertical surface of propodeum smooth and finely granular (Fig. 74); lateral vertical surface coarsely reticulate to rugose.

Male: Disc similar to that of female but with smoother, rounder posterior edge and often straighter striae; edge slightly extended medially but rounded rather than V-shaped; posterior vertical surface of propodeum shiny, shallowly punctured to weakly rugose, finely and linearly rugose or punctorugose over posterolateral corners and on lateral vertical surface; hairs of hind basitarsus less than twice as long as width of segment but appearing long, rather dense and distinctly longer than basal tuft.

These bees are usually bright green to dark green. They intergrade with forms a, b and occasionally with e. They are predominant and most similar to the standard in the western part of the range from Texas to the Dakotas.

Comparisons. A. striata is the most widely distributed and morphologically diverse of all the North American species of Augochlorella. It overlaps the ranges of all the species north of
Mexico except *pomoniella* and intergrades morphologically, at least in the females, with these species. It frequently is the largest and most coarsely sculptured of the eastern species but due to the wide variability in size, cannot always be distinguished by these features.

In the southeastern region most specimens of *striata* are distinctive although gradations toward *aurata* and *persimilis* do exist. Males of *striata* a, in particular, are easily confused with those of *aurata*, and although the key separates the two, without biological information I am uncertain whether the separation represents a valid difference between populations or merely an artificial or arbitrary dichotomy. Females of *striata* a may be separated from *aurata* and *gratiosa* where ranges overlap by their generally coarser striae, the rougher sculpturing and other key characters.

A few specimens in the south and southeast and many in the central region that are small individuals of *striata* c or possibly d, intergrade completely with *persimilis*, so that differentiation of females cannot always be certain. In these individuals the body size, the characters of the disc, and the body sculpturing all resemble those of *persimilis*.

In Texas, some *striata* d may resemble *bracteata* in the characters of the disc but in this region most *striata* are larger and more rugose than *bracteata*, and the two species should not be confused. There seems to be little if any intergradation with *neglectula* where the ranges overlap in southeastern New Mexico. A *striata*
are usually less rough on the posterior vertical surface of the propodeum than **neglectula** and can be easily separated by the key characters.

**Variation** (all forms). Body size and head width in both males and females varies considerably throughout the range (Fig. 86), with the largest specimens (8 mm) occurring among Floridian specimens of form $a$ and the smallest (6 mm) among New Mexican specimens of form $d$. Small workerlike individuals were found in all forms usually during summer months, the small individuals of form $c$ usually intergrading with, or becoming indistinguishable from, **persimilis**.

Body color varies regionally in both sexes with dark blue-green individuals found chiefly in Florida and New Mexico. Elsewhere, throughout the range, most specimens are a bright green but may range from yellow-green to blue-green. The different regions of the body of any one specimen are similar in coloration, so that **striata** is more uniform in color than other eastern species. The mandibles of females are usually brown as described; however some Floridian specimens do have weak greenish reflections at the bases.

The supraclypeal area in both sexes is variously punctate. In females, the surface between punctures is usually shiny and smooth but may be minutely roughened or weakly rugose as in some Floridian specimens. In males, the supraclypeal area is roughened but may be smoother basally than just below the antennae.

The punctuation patterns on the scutum of males can be divided into four groups, all groups occurring throughout the range but with
one pattern often regionally predominant. This character appears to be more geographically variable than it is variable among forms and cannot be correlated with any of the other major characters. The following puncture patterns can be recognized: a) punctures distinct and widely spaced centrally, separated by distances equal to or greater than one diameter; closer laterally, distinct to almost contiguous at the parapsidal lines. b) evenly and widely spaced (separated by two times their diameters) over entire scutum. c) evenly and closely spaced (separated by distances, equal to or less than their own diameters) over entire scutum. d) distinct but unevenly spaced medially, becoming very close and rugose just medial of the parapsidal lines. No such variation is found in females.

Males are less easily separated into forms than females on the basis of propodeal characters and show a wider range of variation so that in certain areas each of a number of individuals has a different combination of characters (Florida, Kansas, Nebraska, etc.). Deviations from the descriptions of the four forms occur among the intergrades between different forms and among intergrades of *striata* and other species but it is not feasible to describe all the variations found in the continuum.

The legs show little color variation; paler specimens show less metallic coloration than darker ones. In males, the extent of metallic coloration on the outer surface of the hind tibia is individually variable. The hairs on the hind basitarsus of males, although similar in length for all forms, look longer and denser in
form $b$ with the hairs of the basal tuft appearing proportionally shorter than in forms $a$, $c$ and $d$. Although differences do exist in these characters, they form a continuum and cannot be correlated with other characters.

The metasomal punctures are variable in size and spacing in both sexes, but like scutal punctures can be divided into groups. Any one group may be regionally predominant (Ind., Ill., Mich., etc.) or the punctation may vary among individuals within any one region (Nebr., Minn., Tex., Conn., etc.). In males the punctures are always distinct, although regularly or irregularly spaced and separated by more than to less than their own diameters. In the females the punctures are frequently very small or inconspicuous but may also become large. Spacing varies from very close to widely scattered and regularly or irregularly spaced. Not all specimens show the greenish reflections on the first sternum, and in those that do, the amount or intensity of reflection is variable. This coloration occurs more often in males than in females, and there seems to be no correlation between this character and the form or region.

**Distribution.** From southern Canada to southern Florida, westward to the Rocky Mountains (Map: Fig. 91).

The forms occurring in each county are indicated, including those specimens not placed as to form ("g"); most of the latter are males.

More than 6700 females and 1400 males were seen: **ALABAMA:** Clay Co., 2 ♀ $\left(\text{a, b}\right)$; Houston Co., 2 ♀ (July-August) $\left(\text{a, g}\right)$; Jefferson
Co., 1 ♀ (August) (♀); Mobile Co., 5 ♀, 6 ♀♀ (June-November) (♂, ♀, ♀); Washington Co., 1 ♀ (June) (♀). ARKANSAS: Ashley Co., 1 ♀ (July) (♀); Benton Co., 2 ♀♀ (April, August) (♂); Boone Co., 3 ♀♀ (August) (♂); Carroll Co., 1 ♂, 1 ♀ (September) (♀); Craighead Co., 7 ♀♀ (April) (♂, ♀); Garland Co., 1 ♂, 7 ♀♀ (September-October) (♂, ♀); Hempstead Co., 3 ♀♀ (June) (♂, ♀); Hot Spring Co., 3 ♂♂, 19 ♀♀ (June) (♂, ♀, ♀); Marion Co., 5 ♀♀ (July) (♂, ♀); Mississippi Co., 1 ♂ (August) (♀); Polk Co., 1 ♀ (July) (♂); St. Francis Co., 1 ♀ (April) (♂); Sebastian Co., 2 ♀♀ (August) (♂, ♀); Sevier Co., 3 ♀♀ (June) (♂, ♀); Van Buren Co., 3 ♀♀ (August-September) (♂, ♀); Washington Co., 3 ♂♂, 9 ♀♀ (August-September) (♀, ♀). COLORADO: Archuleta Co., 2 ♀♀ (♂); Bent Co., 4 ♂♂ (August) (♀); Bovard Co., 17 ♂♂, 82 ♀♀ (April-November) (♂, ♀, ♀); Cheyenne Co., 22 ♀♀ (June-July) (♀); Denver Co., 1 ♂, 16 ♀♀ (May-June, September) (♀, ♀); Elbert Co., 2 ♀♀ (June) (♂); El Paso Co., 1 ♀ (June) (♂); Jefferson Co., 1 ♂, 14 ♀♀ (May-June, October) (♀, ♂, ♀); Larimer Co., 28 ♀♀ (May-July, September-October) (♀, ♂, ♀); Logan Co., 1 ♂, 14 ♀♀ (June-September) (♀, ♂, ♀); Otero Co., 4 ♀♀ (June, August) (♀); Sedgwick Co., 8 ♀♀ (June) (♂); Weld Co., 6 ♀♀ (June-August) (♂); Yuma Co., 1 ♂, 2 ♀♀ (August) (♂, ♀); "Lindemeyer's Lake" 1 ♀ (May) (♂); "Berkley" 14 ♀♀ (April-May) (♀). CONNECTICUT: Fairfield Co., 2 ♂♂, 95 ♀♀ (May-September) (♂, ♀, ♀); Hartford Co., 3 ♂♂, 23 ♀♀ (April-August) (♂, ♀, ♀); Litchfield Co., 3 ♂♂, 10 ♀♀ (May-August) (♂, ♀, ♀); New Haven Co., 2 ♂♂, 5 ♀♀ (April, August-September) (♂); Tolland Co., 1 ♀ (September) (♀); Windham Co., 4 ♀♀ (July-August) (♀). DELAWARE: Kent Co., 2 ♀♀ (July) (♂).
DISTRICT OF COLUMBIA: 7 & 15 (April-May, July-September) (a, b).

FLORIDA: Alachua Co., 8 & 105 (March-November) (a); Bradford Co., 1 (April) (a); Brevard Co., 10 (March-April, July) (a); Broward Co., 8 & 6 (March-April, June-July, November) (a); Citrus Co., 1 (December) (a); Collier Co., 1 (April) (a); Duval Co., 7 (May-June, August-September) (a); Flagler Co., 1 (December) (a); Gadsden Co., 1 (August) (a); Glades Co., 1 (March) (a); Hendry Co., 1 (April) (a); Hernando Co., 1 (August) (a); Highlands Co., 3 (March, June) (a); Hillsborough Co., 2 (August) (a); Indian River Co., 1 (March) (a); Jackson Co., 5 (April, August) (a); Jefferson Co., 3 (May, August, October) (a); Lake Co., 1 & 6 (March, September) (a); Leon Co., 4 (March-April, June, November); Levy Co., 4 & 42 (April, June, September-November) (a); Liberty Co., 2 (April, September) (a); Manatee Co., 1 (January) (a); Marion Co., 1 & 3 (May) (a); Martin Co., 1 (February) (a); Nassau Co., 2 (August) (a); Okeechobee Co., 2 (April) (a); Orange Co., 4 (March, May-June) (a); Osceola Co., 2 (July) (a); Palm Beach Co., 1 (September) (a); Pasco Co., 1 (August) (a); Pinellas Co., 1 (April) (a); Polk Co., 1 & 1 (August) (a); Putnam Co., 6 (April, July) (a); St. Johns Co., 3 (March-April) (a); St. Lucie Co., 1 (April) (a); Sarasota Co., 2 (April, June) (a); Seminole Co., 2 & 7 (April-May, July) (a); Suwannee Co., 1 & 5 (July) (a); Taylor Co., 1 (October) (a); Volusia Co., 1 & 14 (March-August) (a). GEORGIA: Bartow Co., 2 & 1 (June-July) (b); Burke Co., 3 (July) (a, b, c); Calhoun Co., 2 (June)
(a); Chattooga Co., 1 ♀ (July) (b); Cobb Co., 18 ♀ (March, June-August) (a, b); Crawford Co., 1 ♀ (June) (a); Dade Co., 3 ♀ (July) (b); DeKalb Co., 2 ♀ (March, July) (a, b); Dougherty Co., 2 ♀ (June) (a, d); Fannin Co., 1 ♀ (September) (c); Fulton Co., 3 ♀ (March, June-August) (a, b, c); Glynn Co., 1 ♀ (July) (a); Harris Co., 1 ♀, 1 ♀ (June-July) (b, c); Lowndes Co., 3 ♀ (June) (b, s); Lumpkin Co., 3 ♀ (July) (a, c); Meriwether Co., 1 ♀ (July) (b); Murray Co., 2 ♀ (July) (c); Paulding Co., 5 ♀, 1 ♀ (July-October) (a, b); Pike Co., 7 ♀ (April, June) (a, b); Rabun Co., 4 ♀, 9 ♀ (May, June-September) (a, b, c); Sumter Co., 1 ♀ (April) (a); Thomas Co., 3 ♀; 3 ♀ (February-March, July) (a, b, s); Towns Co., 1 ♀, 1 ♀ (August) (a, b); Union Co., 4 ♀, 15 ♀ (May-November) (a, b, c, s); Walker Co., 3 ♀ (June) (b, c); Ware Co., 1 ♀ (July) (a); White Co., 1 ♀ (June) (a). ILLINOIS: Adams Co., 1 ♀, 1 ♀ (May, July) (b, s); Bureau Co., 2 ♀ (June) (c); Cass Co., 1 ♀ (June) (d); Champaign Co., 4 ♀, 19 ♀ (April-June, August-September) (a, b, c, d, s); Coles Co., 1 ♀ (May) (c); Cook Co., 3 ♀, 18 ♀ (May-September) (b, c, e); DuPage Co., 16 ♀ (May-June) (b, c, d); Jackson Co., 1 ♀ (May) (c); Kankakee Co., 1 ♀ (July) (d); Lake Co., 8 ♀ (June) (a); McHenry Co., 15 ♀ (April-July) (a, c); McLean Co., 1 ♀ (June) (c); Macoupin Co., 8 ♀, 34 ♀ (June) (c, s); Marion Co., 1 ♀ (May) (a); Morgan Co., 2 ♀ (August) (a); Peoria Co., 1 ♀, 1 ♀ (July-August) (c); Piatt Co., 2 ♀, 4 ♀ (April-July) (b, c, d); Saint Clair Co., 1 ♀ (April) (s); Union Co., 1 ♀ (July) (c); Vermilion Co., 2 ♀, 12 ♀ (May-June, August) (b, c); Washington Co., 1 ♀ (August) (b); Will Co.,
1 ♀ (June) (c); Winnebago Co., 1 ♀ (June) (s). INDIANA: Benton Co.,
2 ♀ (May) (d, s); Clark Co., 19 ♀ (June-August) (a, b, c, d, s);
Clay Co., 1 ♀ (May) (a); Clinton Co., 3 ♀ (March, July) (a, c, d);
Decatur Co., 2 ♀ (July) (b, d); Gibson Co., 1 ♀ (June) (d);
Harrison Co., 6 ♀ (May) (a, d); Henry Co., 1 ♀ (July) (b); Johnson
Co., 1 ♀ (May) (s); Kosciusko Co., 6 ♀ (May) (a, c, s); LaGrange Co.,
1 ♀ (June) (d); Lake Co., 1 ♀, 3 ♀ (May, July-August) (a, b, s); La
Porte Co., 1 ♀ (September) (a); Lawrence Co., 1 ♀ (July) (g); Marshall
Co., 2 ♀ (June, August) (a, b); Monroe Co., 31 ♀ (April-July) (a,
b, d, s); Orange Co., 2 ♀ (July) (b); Porter Co., 7 ♀ (July) (b, c,
d); Posey Co., 1 ♀ (May) (a); Putnam Co., 1 ♀ (June) (b); Ripley Co.,
1 ♀, 2 ♀ (April, June-July); Spencer Co., 2 ♀, 1 ♀ (May, September);
Tippecanoe Co., 2 ♀, 60 ♀ (April-September) (a, b, c, s); Warren
Co., 3 ♀ (June, August) (c); Wayne Co., 1 ♀ (June) (b). IOWA:
Benton Co., 1 ♀ (June) (c); Boone Co., 1 ♀, 6 ♀ (May-June, September-
October) (c, s); Decatur Co., 2 ♀ (May-June) (d, s); Dickinson Co.,
2 ♀ (July) (a, s); Henry Co., 1 ♀ (October) (s); Iowa Co., 1 ♀ (July)
(a); Johnson Co., 1 ♀ (August) (d); Kossuth Co., 2 ♀ (May) (a); Lee
Co., 2 ♀ (May-June) (a, c); Monona Co., 2 ♀ (July) (c, d); Page Co.,
3 ♀ (June-July) (a); Story Co., 6 ♀, 81 ♀ (April-August, October-
November) (a, c, d, s); Winnebago Co., 2 ♀ (June-July) (a);
Winnesheik Co., 1 ♀ (July) (g); Woodbury Co., 2 ♀, 16 ♀ (April-
October). KANSAS: Allen Co., 17 ♀ (April) (a, d, s); Anderson Co.,
23 ♀ (May-June) (a, c, d, s); Atchison Co., 1 ♀, 3 ♀ (May, July)
(b, s); Barber Co., 1 ♀, 18 ♀ (May-June, September) (b, d, s);
Bourbon Co., 3 ♀♀ (June-July) (♀, ♂); Butler Co., 1 ♂ (♀); Chase Co., 1 ♀ (June) (♂); Chautauqua Co., 1 ♂, 3 ♀♀ (♀, ♂); Cherokee Co., 3 ♀♂, 20 ♀♀ (June-August) (♂, ♀, ♂, ♀); Cloud Co., 9 ♀♂ (September) (♂, ♀, ♀); Cowley Co., 1 ♂ (♀); Dickinson Co., 1 ♀ (August) (♂); Doniphan Co., 1 ♂, 2 ♀♀ (May, August) (♀, ♂); Douglas Co., 116 ♀♂, 518 ♀♀ (April-October) (♀, ♂, ♀, ♂, ♀); Ellis Co., 3 ♀♀ (June) (♂, ♀, ♂); Finney Co., 2 ♀♀ (June) (♀, ♂); Franklin Co., 2 ♀♂, 8 ♀♀ (June-August) (♂, ♀, ♂, ♀); Geary Co., 1 ♀ (July) (♀); Greenwood Co., 17 ♀♀ (May, September) (♀, ♂); Hamilton Co., 6 ♀♀ (♂); Jewell Co., 2 ♀♀ (July) (♂, ♂); Johnson Co., 2 ♀♂, 1 ♀ (June, August) (♂, ♀, ♂); Kearny Co., 1 ♀ (August) (♂); Kingman Co., 2 ♀♀ (July) (♀, ♂); Labette Co., 1 ♀ (June) (♀); Leavenworth Co., 18 ♀♀ (May-June) (♂, ♀, ♂); Marion Co., 4 ♀♀ (June-July) (♂); Miami Co., 1 ♂, 21 ♀♀ (May-June) (♀, ♂, ♀, ♂); Montgomery Co., 2 ♀♀ (September) (♂, ♀); Neosho Co., 19 ♀♀ (April) (♀, ♂, ♀); Norton Co., 2 ♀♀ (August) (♂, ♂); Osage Co., 3 ♀♀ (June) (♂); Osborne Co., 8 ♀♀ (May) (♂, ♀); Phillips Co., 1 ♀ (June) (♂); Pottawatomie Co., 1 ♂, 7 ♀♀ (May-June) (♂, ♀, ♂); Pratt Co., 1 ♂, 1 ♀ (June) (♂); Reno Co., 2 ♀♀ (July, September) (♂); Riley Co., 13 ♀♂, 84 ♀♀ (May-October) (♀, ♂, ♀, ♂, ♀); Scott Co., 1 ♀ (August) (♂); Shawnee Co., 2 ♀♂ (August) (♀); Sheridan Co., 1 ♀ (June) (♀); Stafford Co., 2 ♀♀ (April) (♂); Sumner Co., 1 ♀ (June) (♀); Thomas Co., 3 ♀♀ (November) (♀, ♂); Woodson Co., 3 ♀♀ (April-August) (♀, ♂). KENTUCKY: Bell Co., 2 ♀♂, 1 ♀ (June) (♂, ♀);
Bullitt Co., 3 ? (June) (d); Floyd Co., 1 d (June) (g); Nelson Co., 3 ? (May-June) (a, b). LOUISIANA: Ascension Parish, 1 ? (June) (a); Cameron Parish, 2 dd, 21 ? (June-July) (a, b, d, g); De Soto Parish, 2 dd, 1 ? (June) (b); East Baton Rouge Parish, 9 dd, 59 ? (March-August, October, December) (a, b, c, d, g); Lafayette Parish, 1 ? (April) (b); Madison Parish, 6 dd, 13 ? (March-May, September-November) (a, b, d, g); Natchitoches Parish, 1 ? (June) (d); Orleans Parish, 1 d, 6 ? (March, May-June) (a, b, g); Pointe Coupée Parish, 3 dd, 5 ? (May-June) (a, b, d, g); Red River Parish, 1 ? (October) (a); St. Landry Parish, 3 dd, 30 ? (a, b, d, g); St. Tammany Parish, 4 ? (June) (b, g). MAINE: Aroostook Co., 1 ? (August) (a); Cumberland Co., 1 ? (August) (g); Franklin Co., 1 d, 1 ? (August-September) (a, g); Hancock Co., 1 d, 6 ? (July-August) (a, g); Kennebec Co., 1 d (August) (a); Knox Co., 3 ? (June-July) (a, b, g); Lincoln Co., 6 dd, 6 ? (June-August) (a, b, g); Oxford Co., 1 ? (c); Penobscot Co., 1 d, 8 ? (May-July, September) (a, g); Waldo Co., 2 dd (September) (g); York Co., 1 ? (July) (a); "Indiantown Id." 1 d, 4 ? (May) (a, g); "West Beach" 1 ? (g). MARLAND: Calvert Co., 1 ? (April) (b); Kent Co., 1 ? (August) (b); Montgomery Co., 4 dd, 25 ? (March-September) (a, b, g); Prince Georges Co., 2 ? (July-August) (a, b); "Plummers Is." 10 ?; "Ripley" 1 d (July) (a). MASSACHUSETTS: Barnstable Co., 10 dd, 62 ? (April-September) (a, g, g); Berkshire Co., 1 ? (a); Bristol Co., 2 ? (June) (a); Dukes Co., 1 d, 9 ? (July-September) (a, b, g); Essex Co., 3 dd, 6 ? (June-August) (a, b, d, g); Hampden Co., 4 ? (July-August) (a, b, c); Hampshire Co.,
1 φ, 36 ϑ (May-September) (α, β, γ, δ); Middlesex Co., 3 ϑ, 32 ϑ (May-September) (α, β, γ, δ); Nantucket Co., 4 ϑ, 7 ϑ (June, August-September) (α, β, γ, δ); Norfolk Co., 6 ϑ (May-June, October) (β, γ); Plymouth Co., 2 ϑ, 9 ϑ (June-October) (α, β, γ, δ); Suffolk Co., 8 ϑ, 101 ϑ (May-October) (α, β, γ, δ); Worcester Co., 5 ϑ, 13 ϑ (June-August) (α, β, γ, δ). MICHIGAN: Alcona Co., 1 φ (August) (α); Alpena Co., 1 φ (July) (γ); Antrim Co., 1 φ (July) (β); Arenac Co., 1 φ (August) (γ); Barry Co., 6 ϑ (June-July) (α); Bay Co., 2 ϑ, 3 ϑ (June, September) (α, γ); Benzie Co., 3 ϑ (April, June-July) (α, γ, δ); Berrien Co., 13 ϑ (May-August) (α, β, γ, δ, δ); Calhoun Co., 2 ϑ (June) (α); Charlevoix Co., 2 ϑ (May) (α, γ); Cheboygan Co., 15 ϑ, 33 ϑ (May-August) (α, β, γ, δ, δ); Clare Co., 4 ϑ, 6 ϑ (May-September) (α, γ, δ, δ); Clinton Co., 21 ϑ (May-August) (α, β, γ, δ, δ); Crawford Co., 1 φ, 2 ϑ (May-July) (α, γ); Dickinson Co., 1 φ, 1 φ (June, August) (γ); Eaton Co., 4 ϑ (May-June) (γ); Emmet Co., 6 ϑ, 3 ϑ (May, July-September) (γ); Genesee Co., 1 φ, 1 φ (June-July) (γ, δ); Gladwin Co., 1 φ, 6 ϑ (May-August, September) (γ, δ, δ); Grand Traverse Co., 1 φ, 2 ϑ (June-August) (γ, δ); Gratiot Co., 2 ϑ (May) (α); Hillsdale Co., 2 ϑ (May-June) (γ); Huron Co., 1 φ, 1 φ (June-July) (γ, δ); Ingham Co., 3 ϑ, 11 ϑ (April-May, June, October) (α, γ, δ, δ); Ionia Co., 1 φ, 2 ϑ (May, July) (α, γ, δ); Iosco Co., 1 φ, 2 ϑ (June-July) (γ); Iron Co., 1 φ (June) (γ); Isabella Co., 2 ϑ, 3 ϑ (June, August) (α, β, γ); Jackson Co., 1 φ (June) (γ); Kalamazoo Co., 3 ϑ, 17 ϑ (June-August) (α, β, γ, δ, δ); Kalkaska Co., 2 ϑ (June) (γ, δ); Kent Co., 3 ϑ, 7 ϑ (May, July-
October) (♀, ♂, ♀); Lake Co., 2 ♀♂, 1 ♀ (May, July-August) (♀, ♀); Lapeer Co., 2 ♀♀ (May) (♂, ♀); Lenawee Co., 1 ♀ (June) (♀); Livingston Co., 5 ♀♀ (May-June) (♀, ♀); Mackinac Co., 4 ♂♂, 5 ♀♀ (June, August) (♀); Manistee Co., 2 ♀♀ (July) (♀, ♀); Marquette Co., 2 ♀♀ (June, August) (♀); Mason Co., 3 ♂♂, 1 ♀ (August) (♂); Mecosta Co., 2 ♂♂, 3 ♀♀ (May-July) (♀, ♀, ♀); Menominee Co., 1 ♀ (July) (♀); Midland Co., 2 ♂♂, 6 ♀♀ (May-July, September) (♂, ♂, ♀); Missaukee Co., 3 ♂♂, 9 ♀♀ (May-August) (♀, ♂, ♂, ♀); Monroe Co., 2 ♀♀ (May-June) (♀, ♀); Montcalm Co., 7 ♀♀ (April-May, September) (♀, ♀); Montmorency Co., 1 ♀, 2 ♀♀ (May, September) (♀, ♀); Muskegon Co., 3 ♂♂, 10 ♀♀ (July-August) (♀, ♂, ♂, ♀); Newaygo Co., 2 ♂♂, 5 ♀♀ (May-July) (♀, ♂, ♂, ♀); Oakland Co., 22 ♀♀ (June) (♀, ♀); Oceana Co., 2 ♀♀ (July-August) (♀, ♀); Ogemaw Co., 1 ♀ (August) (♂); Osceola Co., 3 ♀♀ (May-June) (♀, ♂, ♂, ♀); Oscoda Co., 1 ♀ (July) (♀); Otsego Co., 3 ♂♂, 2 ♀♀ (May, July) (♀, ♂, ♂, ♀); Ottawa Co., 1 ♀ (August) (♀); Presque Isle Co., 4 ♀♀ (June-July) (♀, ♀); Roscommon Co., 2 ♀♀ (May) (♀); Saginaw Co., 1 ♀ (June) (♀); Shiawassee Co., 2 ♂♂, 4 ♀♀ (June-September) (♂, ♀, ♂, ♀); Tuscola Co., 1 ♀ (August) (♀); Van Buren Co., 1 ♀ (July) (♀); Washtenaw Co., 1 ♂, 5 ♀♀ (May-July) (♀, ♂, ♂, ♀); Wayne Co., 2 ♀♀ (May) (♀); Wexford Co., 6 ♀♀ (May-July) (♀, ♀). MINNESOTA: Anoka Co., 2 ♀♀ (July) (♀); Beltrami Co., 1 ♂, 1 ♀ (July-August) (♂, ♀); Carver Co., 10 ♀♀ (June-September) (♂, ♀); Chisago Co., 1 ♂, 5 ♀♀ (May, June-July) (♀, ♀); Clearwater Co., 14 ♂♂, 30 ♀♀ (May-September) (♀, ♂, ♂, ♀); Fairbault Co., 2 ♀♀ (June-July) (♀); Fillmore Co.,
5 ♀ (May-July) (a, c); Goodhue Co., 1 ♀ (May) (g); Hennepin Co.,
2 ♀, 10 ♀ (June-August) (a, c, g); Houston Co., 46 ♀ (May-June)
(a, b, c, g); Hubbard Co., 1 ♀ (August) (g); Koochiching Co., 1 ♀
(August) (g); Le Sueur Co., 2 ♀ (June) (g); Lyon Co., 1 ♀ (June)
(a); Mille Lacs Co., 1 ♀, 4 ♀ (May, August, October) (a, b, c, g);
Nicollet Co., 1 ♀ (July) (a); Olmsted Co., 1 ♀, 12 ♀ (May-July,
September) (b, c, d, g); Otter Tail Co., 4 ♀, 2 ♀ (August) (g, g);
Pine Co., 1 ♀ (May) (g); Pope Co., 2 ♀ (July) (g); Ramsey Co., 7 ♀,
21 ♀ (April-October) (a, b, g, g); Red Lake Co., 1 ♀ (September) (g);
Renville Co., 1 ♀ (June) (d); Rice Co., 1 ♀ (July) (a); Swift Co., 1 ♀
(July) (a); Todd Co., 1 ♀ (July) (g); Traverse Co., 1 ♀ (g); Wabasha
Co., 1 ♀ (July) (g); Washington Co., 4 ♀ (May-July) (a, g); Watonwan
Co., 1 ♀ (September) (g). MISSISSIPPI: Adams Co., 1 ♀ (October)
(g); Forrest Co., 15 ♀ (February-March, June-October) (b, d, g);
Harrison Co., 1 ♀ (June) (d); Hinds Co., 1 ♀ (August) (b); Lee Co.,
1 ♀ (April) (a); Marion Co., 1 ♀ (March) (g). MISSOURI: Andrew Co.,
4 ♀ (April-June) (g, d); Boone Co., 2 ♀, 11 ♀ (April-May, July,
August-September) (b, c, g); Buchanan Co., 1 ♀ (July) (g); Camden Co.,
3 ♀ (May-June) (b, d); Carter Co., 1 ♀, 3 ♀ (June) (b, c, g);
Christian Co., 4 ♀ (September) (b, c, d); Dallas Co., 6 ♀, 32 ♀ (June)
(b, g, d, g); Franklin Co., 7 ♀ (June) (b, c); Hickory Co., 1 ♀ (July)
(g); Howell Co., 11 ♀ (June) (b, g); Jackson Co., 3 ♀ (May, July)
(g); Jasper Co., 1 ♀ (June) (g); Laclede Co., 10 ♀, 18 ♀ (June,
August) (b, g, d, g); Ozark Co., 2 ♀ (June, August) (b); Pettis Co.,
6 ♀ (June-August) (g, d, g); St. Louis Co., 3 ♀, 11 ♀ (May-June)
(b, c); Saline Co., 1 ♀ (May) (c); Taney Co., 4 ♀♀, 7 ♀♀ (May, September) (b, c, d, g); "St. Louis City" 1 ♂, 3 ♀♀ (July-August) (c, d). MONTANA: "Montana" 2 ♀♀, 6 ♀♀ (c). NEBRASKA: Adams Co., 3 ♀♀ (August) (g); Antelope Co., 2 ♀♀ (June) (d); Brown Co., 2 ♀♀ (June) (b); Case Co., 35 ♀♀ (May-August) (b, c, d); Chase Co., 7 ♀♂ (September) (g); Cherry Co., 2 ♀♂, 2 ♀♀ (June, September) (d, g); Cuming Co., 7 ♀♂, 49 ♀♀ (May-October) (b, c, d, g); Custer Co., 1 ♀ (June) (d); Dakota Co., 2 ♀♀ (June-July) (c, d); Dawes Co., 24 ♀♀ (May-July) (c, d); Douglas Co., 3 ♀♂, 13 ♀♀ (June-August) (b, c, d); Dundy Co., 1 ♀ (July) (d); Fillmore Co., 2 ♀♀ (July) (d, g); Franklin Co., 1 ♀ (August) (d); Gage Co., 2 ♀♀ (July) (c, d); Keya Paha Co., 13 ♀♂, 52 ♀♀ (June-July) (b, d, g); Knox Co., 1 ♀ (August) (d); Lancaster Co., 12 ♀♂, 240 ♀♀ (April-October) (a, b, c, d, g); Loup Co., 1 ♂ (August) (g); Madison Co., 1 ♂ (g); Nemaha Co., 2 ♀♀ (May) (b); Nuckolls Co., 1 ♀ (September) (d); Otoe Co., 10 ♀♂, 32 ♀♀ (May, August-September) (b, c, d, g); Richardson Co., 2 ♀♀ (June-July) (c, d); Saunders Co., 21 ♀♀ (May, July) (b, c, d, g); Sioux Co., 2 ♀♂, 29 ♀♀ (May-June, August) (b, c, d, g); Thomas Co., 1 ♂, 6 ♀♀ (June-July) (d, g); "Childs Point" 3 ♀♀ (July) (c). NEW HAMPSHIRE: Belknap Co., 39 ♀♂, 65 ♀♀ (May-September) (a, b, c, g); Cheshire Co., 16 ♀♂, 30 ♀♀ (May-September) (a, b, c, g); Coos Co., 1 ♂, 8 ♀♀ (July-August) (a, g); Grafton Co., 2 ♀♂, 3 ♀♀ (August) (a, c); Hillsboro Co., 1 ♂, 5 ♀♀ (May-June, August-September) (a, b, c, g); Merrimack Co., 3 ♀♂, 4 ♀♀ (July-August) (a, b, c, g); Strafford Co., 2 ♀♀ (July) (a). NEW JERSEY: Atlantic Co., 1 ♀ (June) (a); Bergen Co., 7 ♀♀,
92 ♀♀ (May-September) (♀♀); Burlington Co., 7 ♀♀ 10 ♀♀ (May-September) (♀♀); Camden Co., 1 ♀♀ 39 ♀♀ (May-July, October) (♀♀); Cape May Co., 4 ♀♀ (June-July) (♀♀); Cumberland Co., 2 ♀♀ (October) (♀♀); Essex Co., 7 ♀♀ 6 ♀♀ (May, July, September) (♀♀); Glouster Co., 1 ♀♀ 1 ♀♀ (April, July) (♀♀); Hudson Co., 1 ♀♀ (July) (♀♀); Hunterdon Co., 1 ♀♀ (August) (♀♀); Mercer Co., 1 ♀♀ 2 ♀♀ (May, August) (♀♀); Middlesex Co., 1 ♀♀ 12 ♀♀ (April-May, July-August) (♀♀); Monmouth Co., 2 ♀♀ 1 ♀♀ (July) (♀♀); Morris Co., 1 ♀♀ 7 ♀♀ (May-June, August) (♀♀); Ocean Co., 4 ♀♀ 27 ♀♀ (April-September) (♀♀); Passaic Co., 2 ♀♀ 2 ♀♀ (May, July-August) (♀♀); Salem Co., 2 ♀♀ (August) (♀♀); Union Co., 3 ♀♀ 6 ♀♀ (April-August) (♀♀); Warren Co., 2 ♀♀ (May, July) (♀♀). NEW MEXICO: Chaves Co., 5 ♀♀ 24 ♀♀ (June-August) (♀♀); Dona Ana Co., 17 ♀♀, 61 ♀♀ (April-August) (♀♀); Otero Co., 3 ♀♀ (June-July) (♀♀); San Miguel Co., 1 ♀♀ (July) (♀♀); "Trout" 1 ♀♀ (♀♀). NEW YORK: Allegany Co., 7 ♀♀ 3 ♀♀ (August) (♀♀); Broome Co., 11 ♀♀ (June) (♀♀); Cattaraugus Co., 1 ♀♀ (July) (♀♀); Cayuga Co., 1 ♀♀ 6 ♀♀ (July, September) (♀♀); Chautauqua Co., 5 ♀♀ (June-August) (♀♀); Clinton Co., 3 ♀♀ (August) (♀♀); Columbia Co., 4 ♀♀ 5 ♀♀ (August) (♀♀); Delaware Co., 1 ♀♀ (July) (♀♀); Dutchess Co., 1 ♀♀ (July) (♀♀); Erie Co., 5 ♀♀, 9 ♀♀ (May-October) (♀♀); Essex Co., 4 ♀♀, 11 ♀♀ (June-September) (♀♀); Greene Co., 4 ♀♀, 6 ♀♀ (July-August) (♀♀); Hamilton Co., 2 ♀♀ (July) (♀♀); Jefferson Co., 1 ♀♀ (♀♀); Kings Co., 2 ♀♀ 4 ♀♀ (May-September) (♀♀); Madison Co., 1 ♀♀ 13 ♀♀ (July) (♀♀); Monroe Co., 1 ♀♀ 18 ♀♀ (May-July) (♀♀); Nassau Co., 4 ♀♀
(June) (c); New York Co., 2 dd', 7 ff (May, July) (a, s); Oneida Co.,
2 ff (June) (s); Orange Co., 5 dd', 29 ff (May-September) (a, c, s);
Oswego Co., 2 dd', 6 ff (May-August) (a, s); Otsego Co., 1 f (May)
(s); Putnam Co., 2 ff (s); Queens Co., 3 ff (May) (c, s); Rensselaer
Co., 1 f (August) (a); Richmond Co., 2 dd', 2 ff (May, July-August)
(b, s); Rockland Co., 2 dd', 6 ff (May-July, September) (b, c, s);
Schenectady Co., 1 f (September) (a); Schuyler Co., 1 f (c); Suffolk
Co., 10 dd', 37 ff (May-September) (a, b, c, s); Sullivan Co., 2 dd',
1 f (July-August) (a, s); Tioga Co., 16 ff (June-July) (a, c, s);
Tompkins Co., 294 dd', 615 ff (April-September) (a, b, c, s); Ulster
Co., 6 dd', 8 ff (March, June-September) (a, b, c, s); Warren Co.,
3 dd', 4 ff (August-September) (a, b, c, s); Washington Co., 2 ff
(July) (a); Wayne Co., 2 ff (September) (a); Westchester Co., 4 dd',
30 ff (May-August) (a, c, s); Wyoming Co., 7 ff (June-July) (a, s);
"Bolton" 2 ff (August) (s). NORTH CAROLINA: Buncombe Co., 3 dd', 27 ff
(May-August, October) (a, b, c); Dare Co., 7 dd', 35 ff (May-September)
(a); Haywood Co., 2 dd', 6 ff (May, August) (a, b, c); Hyde Co., 1 d'
(June) (a); Jackson Co., 2 ff (August) (b, c); Macon Co., 34 dd', 45 ff
(May-August) (a, b, c, s); Madison Co., 3 ff (June-July) (b, c);
Mitchell Co., 1 f (August) (a); Moore Co., 2 dd', 11 ff (June, August,
November) (b, c); Swain Co., 5 ff (May, July) (a, b, c); Transylvania
Co., 3 ff (July) (c); Tyrrell Co., 3 ff (July) (a); Wake Co., 2 dd',
5 ff (April-June, August) (a, b); Watauga Co., 2 ff (July-August) (b).
NORTH DAKOTA: Cass Co., 5 dd', 30 ff (June-September) (a, d, s);
Richland Co., 1 f (May) (s). OHIO: Ashtabula Co., 6 ff (May-July)
(a, b, g); Cuyahoga Co., 1 d', 1 ♀ (August) (a); Clinton Co., 1 ♀ (August) (b); Delaware Co., 1 ♀ (August) (b); Erie Co., 3 ♀♀ (June) (b); Fairfield Co., 1 d (b); Franklin Co., 15 ♀♀ (May-July) (b, q); Highland Co., 2 dd', 1 ♀ (August-September) (b, s); Hocking Co., 1 ♀ (May) (b); Lawrence Co., 1 ♀ (May) (g); Logan Co., 3 ♀♀ (August-September) (b, g); Ottawa Co., 4 dd', 2 ♀♀ (June, August) (a, g); Shelby Co., 1 ♀ (August) (b); Stark Co., 2 ♀♀ (August) (a, b); Summit Co., 1 ♀ (July) (b). OKLAHOMA: Adair Co., 1 ♀ (June) (q); Alfalfa Co., 2 ♀♀ (June) (d, s); Atoka Co., 1 ♀ (April) (c); Bryan Co., 4 ♀♀ (June) (b, q); Carter Co., 6 ♀♀ (April-May) (b, d, s); Choctaw Co., 1 d', 2 ♀♀ (June) (d, s); Comanche Co., 1 d', 5 ♀♀ (May, July) (c, d, g); Kay Co., 5 ♀♀ (May) (d); Logan Co., 3 ♀♀ (June-July) (d, g); McCurtain Co., 2 dd', 5 ♀♀ (June, August) (b, c, d, s); Nowata Co., 1 ♀ (June) (d); Oklahoma Co., 1 ♀ (August) (g); Okmulgee Co., 1 ♀ (July) (c); Pawnee Co., 3 ♀♀ (June-July) (c); Payne Co., 14 ♀♀ (April-July) (b, c, d, s); Pittsburg Co., 6 ♀♀ (April, June) (b, c, s); Sequoyah Co., 1 ♀ (June) (g); Tulsa Co., 2 ♀♀ (May) (d).

PENNSYLVANIA: Allegheny Co., 5 dd'; 29 ♀♀ (March, May-July, September) (a, b, g, g); Berks Co., 1 d', 1 ♀ (July-August) (c, g); Bucks Co., 2 ♀♀ (July-August) (g, g); Carbon Co., 1 d', 4 ♀♀ (June-July) (a, c, g); Center Co., 3 ♀♀ (May) (a, g); Chester Co., 1 d', 1 ♀ (May) (a, g); Columbia Co., 2 ♀♀ (August) (a); Cumberland Co., 1 d', 15 ♀♀ (May-July, September-October) (a, b, g, g); Dauphin Co., 13 ♀♀ (May, July-August) (a, g); Delaware Co., 1 d', 19 ♀♀ (May-August) (a, b, c); Erie Co., 2 dd', 2 ♀♀ (July-August) (a, g); Fayette Co.,
2 ♀, 2 ♀ (July-August) (a, b, g); Lancaster Co., 2 ♀ (June-July) (a); Luzerne Co., 1 ♀ (September) (g); Monroe Co., 1 ♂, 18 ♀ (May-July) (a, g); Montgomery Co., 3 ♀ (May, July) (a); Philadelphia Co., 2 ♂, 37 ♀ (April-September) (a, b, g, g); Pike Co., 4 ♀ (May-June, September) (a, g); Sullivan Co., 1 ♀ (August) (g); Tioga Co., 2 ♀ (August) (a); Washington Co., 1 ♀ (b); Westmoreland Co., 6 ♂, 9 ♀ (July) (a, b, g, g). SOUTH CAROLINA: Aiken Co., 2 ♀ (June) (a, b); Anderson Co., 1 ♂, 1 ♀ (July-August) (a, g); Beaufort Co., 1 ♀ (April) (a); Charleston Co., 1 ♀ (May) (a); Colleton Co., 1 ♀ (July) (b); Fairfield Co., 1 ♂ (September) (b); Hampton Co., 1 ♂, 1 ♀ (June) (a, b); Lexington Co., 2 ♀ (June) (a, b); Oconee Co., 2 ♀ (June) (a, g); "Paris Mt." 1 ♀ (June) (b). SOUTH DAKOTA: Bonn Homme Co., 1 ♂, 5 ♀ (June, September) (b, d, g); Brule Co., 11 ♀ (June) (c, d); Clay Co., 1 ♀ (June) (d); Custer Co., 11 ♂ (June-July) (c); Fall River Co., 3 ♀ (June-July) (d); Haakon Co., 1 ♂ (August) (a); Lawrence Co., 5 ♀ (June-July) (c); Pennington Co., 1 ♂, 3 ♀ (August) (c, d); Roberts Co., 1 ♀ (July) (d); Shannon Co., 2 ♀ (June) (b, d); Stanley Co., 1 ♂, 2 ♀ (August) (d, s); Union Co., 2 ♀ (May, September) (a, g); Yankton Co., 1 ♀ (June) (d). TENNESSEE: Anderson Co., 1 ♀ (April) (b); Gibson Co., 1 ♀ (a); Haywood Co., 1 ♀ (a); Knox Co., 2 ♂, 25 ♀ (April-August, October) (a, b, c); Lake Co., 1 ♂, 1 ♀ (July, September) (a, c); Lawrence Co., 1 ♀ (April) (c); Morgan Co., 6 ♀ (July, August) (a, c); Roane Co., 1 ♀ (August) (d); Robertson Co., 6 ♀ (May) (a, c); Sevier Co., 2 ♂, 27 ♀ (May, July) (a, b, c, d); Shelby Co., 3 ♀ (June) (a, d); Wayne Co., 1 ♀ (August) (b).
TEXAS: Angelina Co., 3 ♢ (April-June) (a, d); Bowie Co., 4 ♢ (March, May, August, November) (a, d); Brewster Co., 4 ♢ (June) (a, d); Brown Co., 1 ♢ (August) (d); Camp Co., 1 ♢, 2 ♢ (May, October) (d); Colorado Co., 3 ♢ (March-April) (d); Dallas Co., 3 ♢, 4 ♢ (March-June, August-November) (a, b, d, g); Denton Co., 9 ♢ (April) (d); Eastland Co., 2 ♢ (May, August) (d); El Paso Co., 1 ♢, 1 ♢ (July) (d, g); Fannin Co., 8 ♢ (May-June) (a, d); Ft. Bend Co., 1 ♢ (March) (b); Galveston Co., 1 ♢ (May) (g); Gillespie Co., 2 ♢ (May) (d); Gonzales Co., 1 ♢ (April) (b); Grayson Co., 2 ♢ (March, June) (d); Hardeman Co., 1 ♢ (June) (a); Hunt Co., 29 ♢ (April, October-November) (a, d); Houston Co., 3 ♢ (April) (b, d); Kerr Co., 1 ♢ (May) (d); Lamar Co., 3 ♢, 14 ♢ (April, August-November) (a, d, g); Lee Co., 1 ♢, 17 ♢ (March, May) (d, g); Leon Co., 3 ♢ (April) (a, d); Marion Co., 1 ♢ (October) (b); Mason Co., 2 ♢ (April) (d); Matagorda Co., 39 ♢, 53 ♢ (May) (a, b, d, g); Navarick Co., 1 ♢ (April) (d); Montgomery Co., 3 ♢ (April) (b); Nacogdoches Co., 2 ♢, 12 ♢ (April-July, September-October) (a, b, d, g); Navarro Co., 3 ♢ (April) (b, d); Randall Co., 1 ♢ (June) (d); Red River Co., 1 ♢ (April) (b); Robertson Co., 1 ♢, 20 ♢ (April, October) (a, d, g); San Patricio Co., 1 ♢ (July) (g); Taylor Co., 4 ♢ (April) (a, d); Tom Green Co., 1 ♢ (June) (d); Trinity Co., 1 ♢ (April) (b); Victoria Co., 4 ♢ (April-May) (a, d); Waller Co., 1 ♢ (April) (d); "Hetty" 1 ♢, 1 ♢ (October) (d, g). VERMONT: Addison Co., 1 ♢, 2 ♢ (July-August) (a); Bennington Co., 1 ♢, 1 ♢ (June, August) (a, g); Caledonia Co., 1 ♢ (August) (g); Grand Isle Co., 1 ♢ (July) (g); Orange Co., 1 ♢ (July)
(a); Rutland Co., 2 dd', 3 ♀♀ (August) (a, s); Windham Co., 4 dd', 8 ♀♀ (May-August) (a, b, c, s); Windsor Co., 5 ♀♀ (July-September) (a, b, s). VIRGINIA: Albemarle Co., 2 ♀♀ (June) (b); Arlington Co., 1 d', 7 ♀♀ (March-August) (a, b); Augusta Co., 1 ♀ (May) (a); Botetourt Co., 2 ♀♀ (June) (c); Carroll Co., 4 dd' (August) (b, c, s); Dinwiddie Co., 1 ♀ (June) (c); Fairfax Co., 7 dd', 52 ♀♀ (April-August) (a, b, s); Fauquier Co., 1 ♀ (June) (a); Giles Co., 1 d', 12 ♀♀ (May-August) (a, b, c); Henrico Co., 1 ♀ (August) (b); Lee Co., 1 ♀ (b); Nelson Co., 1 ♀ (July) (a); Nottoway Co., 1 ♀ (April) (a); Page Co., 1 ♀ (August) (a); Rockbridge Co., 1 d' (September) (a); Spotsylvania Co., 1 ♀ (May) (b); "Alexandria" 1 ♀ (July) (b). WEST VIRGINIA: Greenbrier Co., 1 d' (July) (c); Lewis Co., 2 dd', 1 ♀ (June) (a, b); Mercer Co., 2 ♀♀ (June) (b, c); Morgan Co., 2 ♀♀ (July) (c); Nicholas Co., 1 ♀ (August) (c); Randolph Co., 5 ♀♀ (June, August) (c); Tucker Co., 1 d' (October) (b); Wood Co., 1 ♀ (June) (c); Wyoming Co., 2 ♀♀ (August) (b, c); "Cheat Mts." 1 d' (June) (b). WISCONSIN: Ashland Co., 1 ♀ (July) (d); Bayfield Co., 1 ♀ (September) (d); Brown Co., 2 dd', 3 dd', 2 ♀♀ (July-August) (g); Buffalo Co., 1 ♀ (August) (g); Burnett Co., 1 ♀ (June, August) (g); Crawford Co., 1 ♀ (September) (g); Dane Co., 2 dd', 48 ♀♀ (May-September) (a, c, d, s); Dodge Co., 1 ♀ (May) (s); Door Co., 1 ♀ (June) (s); Douglas Co., 1 ♀ (July) (a); Eau Claire Co., 2 ♀♀ (June) (a); Grant Co., 2 dd', 11 ♀♀ (June-August) (a, c, s); Iron Co., 1 ♀ (June) (g); Manitowoc Co., 1 d', 5 ♀♀ (June-July, September) (a, b, d, s); Marinette Co., 1 ♀ (June) (c); Milwaukee Co., 1 d', 11 ♀♀ (June-
July, September) (g, s); Monroe Co., 1 q (July) (g); Pierce Co., 2 dd', 13 q (July-August) (a, b, c, d, s); Polk Co., 5 dd (August) (g); St. Croix Co., 1 d', 11 q (July-August) (a, d, s); Sauk Co., 2 q (May) (a, g); Shawano Co., 1 q (June) (c); Vernon Co., 8 dd', 10 q (July) (a, b, c, s); Vilas Co., 2 q (August) (d, s); Walworth Co., 1 d (August) (g); Washington Co., 2 dd', 1 q (August) (s); Waupaca Co., 1 d (August) (c). WYOMING: Goshen Co., 1 q (June) (d); Laramie Co., 1 q (June) (d).

MANITOBA: Winnipeg, 1 q (July) (g); Baldur, 1 q (June) (g); Ninette, 1 q (June) (g). NEW BRUNSWICK: St. Andrews, 1 q (August) (s); St. John, 1 d, 3 q (July, September) (a, s). NOVA SCOTIA: Digby Co., 2 q (June, August) (a); Kings Co., 1 d', 2 q (June, August) (a); Lun Co., 2 q (July) (s); Weymouth, 2 dd', 3 q (August) (a). ONTARIO: Acton, 1 q (June) (g); Ancaster, 1 q (May) (a); Bancroft, 1 q (July) (a); Belleville, 2 dd', 7 q (May-September) (a); Belle Corners, 5 q (May-June) (a, b, s); Bobcaygeon, 1 q (August) (a); Brighton, 1 q (September) (g); Brimley, 1 q (May) (a); Burlington, 1 q (September) (a); Chatham, 2 q (May) (a); Effingham, 1 q (September) (a); Finland, 1 d', 2 q (July) (a, g); Ft. Erie, 1 q (September) (a); Gravenhurst, 1 d, 1 q (July-August) (a); Jordan, 3 dd', 2 q (May, July-September) (a, s); Kinburn, 1 d (August) (c); London, 1 q (April) (a); Madoc, 2 dd', 1 q (July) (c, s); Manotick, 4 q (May) (c, s); Marmora, 3 dd', 42 q (May-July) (a, b, c, s); Merivale, 1 d, 1 q (May, September) (a); Miners Bay, 2 q (May) (s); Nestor Falls, 1 q (June) (a); Niagara Glen, 1 q (June) (a); Normandale,
9 ♀ (May) (a, c, s); North Bay, 1 ♀, 1 ♀ (August) (a, g); Norwood, 1 ♀ (June) (g); One Sided Lake, 8 ♀ (June-July) (a, g); Orillia, 1 ♂ (July) (g); Ottawa, 9 ♀, 17 ♀ (April-September) (a, b, c, g); Pelee Is., 1 ♀ (June) (g); Perth Road, 1 ♂ (August) (g); Petawawa N.P., 1 ♀ (August) (a); Point Pelee, 1 ♂, 3 ♀ (May-July) (a, s); Port Sydney, 2 ♀ (a); Ridgeway, 1 ♀ (August) (g); Robeson's Is., 1 ♀; St. Johns West, 2 ♀ (August) (g); Shannonville, 2 ♀, 1 ♀ (August) (g); South March, 3 ♀ (May, August) (b, g); Spencerville, 3 ♀ (May) (a, c, g); Strathroy, 4 ♀ (May, July-August) (a, s); Tillsonburg, 1 ♀ (July) (g); Toronto, 6 ♀ (May-July) (a, c, s); Trenton, 5 ♀ (May-June, September) (g); Vineland, 5 ♀ (June-July) (a, s); Wellington, 2 ♀ (August) (g). QUEBEC: Abbotsford, 3 ♀, 1 ♀ (June, August) (b, g); Beechgrove, 3 ♀ (May-June) (a); Chambly Co., 1 ♂ (August) (c); Clarenceville, 1 ♀ (July) (g); Covey Hill, 1 ♀ (June) (g); Fairy Lake, 2 ♀, 1 ♀ (July) (b, c, s); Ft. Coulange, 2 ♀, 6 ♀ (June-August) (a, c, s); Gatineau Park, Harrington Lake, 16 ♀ (May-June) (a, b, c, s); Graceville, 1 ♀ (June) (c); Hemmingford, 2 ♀, 6 ♀ (June, August) (a, s); Kazabazua, 1 ♀ (July) (s); Kirks Ferry, 1 ♀ (July) (a); Knowlton, 3 ♀ (June, August) (a); Lac Bernard, 1 ♀ (August) (a); Lac Phillipe, 1 ♂ (July) (g); Laurentians, 1 ♀ (June) (a); Luskville, 4 ♀ (May) (c); Montreal, 1 ♂, 15 ♀ (May-September) (a, c, s); Norway Bay, 5 ♀ (May) (a, s); Old Chelsea, 4 ♀, 1 ♀ (July) (b, c, s); Pinks Lake C.P., 2 ♀ (June) (b, c); Queens Park, Aylmer, 2 ♀, 4 ♀ (July-September) (c, s); Rigaud, 1 ♂, 3 ♀ (May)
(♀, ♂); St. Isadore, 1 ♀ (July) (♀); Wright, 3 ♀♀ (June) (♀, ♂).

**CHIHUAHUA:** Juarez, 1 ♀ (August) (♀).

**Seasonal Activity.** *A. striata* is active from early April to about the middle of October throughout most of its range. Pollen collectors are found from the end of April through middle or late August and males occur from late May to late October. In the North the season is slightly shorter, lasting from the end of April to the end of September, whereas in the South the bees are active throughout the year with pollen collectors being found from early April to early September.

There is considerable variation in size in this species (Fig. 86) within all forms. Usually the small individuals are similar in structure and appearance to the larger females of the same form although somewhat less coarsely sculptured. There is a queen and usually one or more workers (individuals that do not lay eggs) in each nest, but these cannot always be distinguished morphologically. Where both large and small individuals are present in one nest, one of the large females is always the queen and the remaining large and small females are workers. All gradations in size may occur within one colony, or all bees of a colony may be approximately the same size. Small individuals (probably of form ♀) do sometimes found nests in the spring, but then all offspring are as small as the queen or smaller. For further details on the biology of this species, see Part II.
Flower Records. *Achillea millefolium*, *Aesculus glabra sargentii*,
*Aesculus parviflora*, *Agastache foeniculum*, *Agoseris cuspidata*,
*Althaea rosea*, *Amelanchier canadensis*, *Amorpha canescens*, *Amorpha
fruticosa*, *Anemone canadensis*, *Anemone virginiana*, *Anemonella
thalictroides*, *Antennaria neglecta*, *Antennaria plantaginifolia*,
*Apocynum androsaemifolium*, *Apocynum cannabinum*, *Aquilegia canadensis*,
*Arabis laevigata*, *Arabis perstellata*, *Arabis virginicus*, *Aralia
spinosa*, *Argemone intermedia*, *Aruncus dioicus*, *Asclepias purpurascens*,
*Asclepias sullivantii*, *Asclepias syriaca*, *Asclepias tuberosa*, *Aster
ericoides villosus*, *Aster lateriflorus*, *Aster laevis*, *Aster macrophyllus*,
*Aster salicifolius*, *Aster simplex*, *Aster tenuifolius*, *Astragalus*,
*Barbarea vulgaris*, *Berteroa incana*, *Bidens frondosa*, *Bidens mitis*,
*Bidens pilosa*, *Brassica*, *Callirhoe digitata*, *Callirhoe involucrata*,
*Calopogon pulchellus*, *Camassia scilloides*, *Camelina*, *Campanula
americana*, *Campanula rapunculoides*, *Campanula rotundifolia*, *Capsella
bursa-pastoris*, *Cardamine bulbosa*, *Carduus*, *Cassia fasciculata*,
*Cassia marilandica*, *Caulophyllum thalictroides*, *Ceanothus americanus*,
*Ceanothus ovatus*, *Celastrus scandens*, *Centaura jacea*, *Cephalanthus*,
*Cercis canadensis*, *Chaerophyllum procumbens*, *Chrysanthemum leucanthemum*,
*Chrysopsis mariana*, *Chrysopsis microcephala*, *Cichorium intybus*,
*Cicuta maculata*, *Circaea latifolia*, *Cirsium altissimum*, *Cirsium
undulatus*, *Cirsium vulgare*, *Citrullus vulgaris*, *Claytonia caroliniana*,
*Claytonia virginica*, *Clethra alnifolia*, *Convovulus*, *Coreopsis palmata*,
*Coreopsis tinctoria*, *Cornus alternifolia*, *Cornus amomum*, *Cornus florida*,
Lespedeza virginica, Leaguerella, Linum rigidum, Lippia lanceolata, Lobelia cardinalis, Lobelia inflata, Lobelia siphilitica, Lobelia spicata, Lomatium foeniculaceum, Lonicera maackii, Lotus corniculatus, Lycopersicium esculentum, Lycopus americanus, Lythrum alatum, Lythrum lanciolatum, Lythrum salicaria, Malus, Malva rotundifolia, Malva sylvestris, Medicago lupulina, Medicago sativa, Melilotus alba, Melilotus officinalis, Mentha, Mertensia virginica, Mikania batatifolia, Mikania reticulata, Monarda bradburiana, Monarda fistulosa, Monarda pectinata, Monarda punctata, Myosoton verna, Nigella, Nothoscordum, Oenothera fruticosa, Oenothera hartwegi, Oenothera speciosa, Onopordum, Opuntia, Osmorhiza longistylis, Oxalis europaea, Oxalis violacea, Paeonia, Parthenium hysterophoros, Parthenocissus inserta, Paspalum distichum, Pastinaca sativa, Penstemon digitalis, Perideridia americana, Petalostemum candidum, Petalostemum purpureum, Phryma leptostachya, Physalis virginiana, Polemonium reptans, Polygonatum canaliculatum, Polygonum hydropiperoides, Polygonum pensylvanicum, Polymnia laevigata, Polytaenia nuttallii, Pontederia cordata, Potentilla canadensis, Potentilla norvegica, Potentilla recta, Prenanthes crepidinea, Prunella vulgaris, Prunus americanus, Prunus angustifolia, Prunus serotina, Psoralea tenuiflora floribunda, Ptelea trifoliata, Pteridium, Pycnanthemum flexuosum, Pyrrhopappus carolinianus, Pyrrhopappus grandiflora, Pyrus icoenis, Pyrus malus, Pyrus melanocarpa, Ranunculus abortivus, Ranunculus fascicularia, Ranunculus recurvatus, Ranunculus septentrionalis, Ratibida columnaris, Rhamnus lanceolata, Rhus aromatica, Rhus copallina, Rhus glabra, Rhus toxicodendron, Rhus
Fig. 91. Distribution of A. striata.
Fig. 92. Distributions of forms of *A. striata*. (Black - form $A$; dots - form $B$; gray shading - form $C$; cross-hatched - form $D$; white group $E$.)

Each circle includes each state it overlaps except where the state is divided by broken line. Circle No. 117, includes West Virginia, Kentucky, Tennessee only. Circle No. 276 does not include New Mexico. The numbers beside each circle represent the total number of specimens examined from the area represented by the circle.
TABLE 2. PER CENT OCCURRENCE OF SPECIES OF AUGOCHLORELLA FROM EACH AREA

<table>
<thead>
<tr>
<th>AREA</th>
<th>% striata</th>
<th>% gratiosa</th>
<th>% persimilis</th>
<th>% bracteata</th>
<th>% aurata</th>
<th>% neglectula</th>
<th>% pomoniella</th>
<th>% edentata</th>
<th>Total AUGOCHLORELLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTHEAST</td>
<td>99.9</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,889</td>
</tr>
<tr>
<td>SOUTHEAST*</td>
<td>81.2</td>
<td>6.1</td>
<td>11.4</td>
<td>0</td>
<td>1.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>701</td>
</tr>
<tr>
<td>FLORIDA*</td>
<td>54.3</td>
<td>28.6</td>
<td>0</td>
<td>0</td>
<td>17.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>574</td>
</tr>
<tr>
<td>SOUTH</td>
<td>60.0</td>
<td>2.1</td>
<td>3.4</td>
<td>23.8</td>
<td>7.4</td>
<td>3.3</td>
<td>0</td>
<td>0</td>
<td>984</td>
</tr>
<tr>
<td>CENTRAL</td>
<td>58.7</td>
<td>0</td>
<td>41.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,202</td>
</tr>
<tr>
<td>WEST</td>
<td>12.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21.0</td>
<td>66.2</td>
<td>0</td>
<td>0</td>
<td>909</td>
</tr>
<tr>
<td>MEXICO</td>
<td>0.5</td>
<td>0</td>
<td>1.2</td>
<td>0</td>
<td>44.8</td>
<td>37.7</td>
<td>15.8</td>
<td>0</td>
<td>406</td>
</tr>
</tbody>
</table>

*For the purposes of this table this region has been divided into two parts.
<table>
<thead>
<tr>
<th>AREA</th>
<th>% form a</th>
<th>% form b</th>
<th>% form c</th>
<th>% form d</th>
<th>% group s</th>
<th>Total specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTHEAST</td>
<td>40.1</td>
<td>6.8</td>
<td>19.1</td>
<td>0</td>
<td>34.0</td>
<td>2,885</td>
</tr>
<tr>
<td>SOUTHEAST**</td>
<td>46.4</td>
<td>35.3</td>
<td>15.3</td>
<td>0.2</td>
<td>2.8</td>
<td>569</td>
</tr>
<tr>
<td>FLORIDA**</td>
<td>96.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0</td>
<td>3.2*</td>
<td>312</td>
</tr>
<tr>
<td>SOUTH CENTRAL</td>
<td>15.1</td>
<td>20.5</td>
<td>1.0</td>
<td>45.1</td>
<td>18.3</td>
<td>590</td>
</tr>
<tr>
<td>NORTH CENTRAL</td>
<td>7.8</td>
<td>13.8</td>
<td>28.4</td>
<td>28.7</td>
<td>21.3</td>
<td>3,640</td>
</tr>
<tr>
<td>WEST-MEXICO</td>
<td>0</td>
<td>3.4</td>
<td>0</td>
<td>61.0</td>
<td>35.6</td>
<td>118</td>
</tr>
</tbody>
</table>

*These are *aurata-striata* intergrades (probably *striata* form g).

**For this table the southeastern region has been divided into two parts.
BIOSYSTEMATICS OF A. STRIATA AND PERSIMILIS

The biology of *persimilis* and *striata* will be discussed in detail in Part II. Some of the results obtained by excavating 133 nests near Lawrence, Kansas, are of systematic importance and are discussed here since populations from these nests shed some light on the complexities of the interspecific and intraspecific variation. Except as otherwise indicated, the following discussion relates only to females.

About 21\% of the nests contained unquestionable *persimilis*; 54\% were clearly *striata* (s.l.) and 25\% contained apparent mixtures of *persimilis* and *striata* or individuals of uncertain identity intermediate between the two species.

The 72 nests of *striata* contained pure colonies of forms $b$, $c$, or $d$ individuals, or mixed colonies of both $b$ and $d$ individuals, mixed colonies of $b$- or $d$-intermediates or more usually, mixtures of $b$ and $b$-, $b$ and $b$- or $c$ and $c$- individuals. One nest was found to contain $c$-intermediates. There were six nests containing recognizable *striata* of forms $b$, $c$, $d$, or their intermediates, as well as small, *persimilis*-like individuals, but in all cases the small individuals looked more like small *striata* $c$ rather than like *persimilis*. In contrast, two nests were found with small, but clearly *striata*-like females as well as males of *persimilis*.

Of the 25 nests containing *persimilis*-*striata* mixtures or intermediates, 20 contained individuals intermediate between
persimilis and striata and five contained apparent mixtures of both persimilis and striata. None of these nests contained males.

Since males of striata and persimilis are easily distinguished, 30 females intermediate between the two species were brought into the laboratory and allowed to establish nests. Male progeny from these females were examined after they emerged from the nests or as they were leaving. Of the 116 males recovered throughout the summer, 94% were persimilis, indicating that most of the original females belonged to this species. Judging by the frequency and periodic appearance of the striata males, it appeared probable that they were produced by a single female.

Although these data are fragmentary, they do serve to crystallize some of the problems involved. Within the species striata, it seems that forms b and d are not different biologically since both can be regularly found within a single nest population. Form g may be biologically distinct since no nests were found in which both g and another form coexisted, although g-d intermediates occur in nests with form g.

The small specimens, intermediate between striata and persimilis that were found within the striata nests, were probably striata, and those in nests of persimilis were probably persimilis although the possibility that F₁ hybrids exist cannot be ignored. Male (presumably haploid) offspring of both striata and persimilis are produced by the intermediate females but it has not been established if any one female can produce both.
So far, biological, behavioral or ecological differences have not been found between the forms of *striata* as they occur in eastern Kansas and such differences between the two species are only slight if extant. If significant differences are discovered or if methods could be found to keep progeny of various females segregated in the laboratory, it would be worth the time and effort to examine in much greater detail the interspecific and intraspecific variation in an attempt to define or categorize those individuals now being classed as intermediates between the forms or species. We have here an excellent case of very similar, sympatric populations with no apparent ecological segregation.
REGIONAL ACCOUNT OF THE SPECIES

The area under consideration in this paper, including Canada, the United States and Mexico, has been divided into regions in order to discuss and compare variation within and among species. These regions are: NORTHEAST (eastern Canada, Maine, New Hampshire, Vermont, Massachusetts, New York, Connecticut, Rhode Island, Pennsylvania, New Jersey); SOUTHEAST (Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware); NORTH CENTRAL (Ohio, Indiana, Michigan, Illinois, Kentucky, Tennessee, Arkansas, Oklahoma, Missouri, Kansas, Colorado, Wyoming, Nebraska, Iowa, Wisconsin, Minnesota, North Dakota, South Dakota, Montana); SOUTH CENTRAL (Alabama, Mississippi, Louisiana, Texas); WEST (California, Arizona, Utah, Nevada, New Mexico); and MEXICO.

The relative abundance of each species within each area is shown in Table 2, and the relative abundance of each of the forms of *striata* is given in Table 3 and Fig. 92. The regions in the latter are subdivided to give a more accurate indication of the relative frequency of the different forms. Unless otherwise stated, the discussions of *striata* below concern only females.
Species represented: _A. striata_ a, b, g.

_A. striata_ is the only species known to occur widely in this region, although other species have been reported in the literature, presumably erroneously, and occasional specimens of _gratiosa_ or _persimilis_ may occur along the southern borders of this region. The three forms of _striata_ are sometimes difficult to distinguish, especially in this region, and therefore the percentage of group s (unplaced specimens) is comparatively large (Fig. 92).

In the southern part of the region, as far north as New Hampshire and Vermont, form a is distinct and easily separated from b and g, though extremely variable. The disc is seldom bracket-shaped but is characterized by a sharp to carinate posterior edge, at least medially, with the median portion coming to a distinct point. Its length is usually equal throughout and its shape is a broad but well defined V (Fig. 60). The length of the disc and the size and regularity of the striae are variable as is the size of individual specimens. Nearly all specimens of form a are weakly rugose or finely roughened on the posterior vertical surface of the propodeum. Large, coarsely rugose specimens resembling form a from Florida (Fig. 59) are occasionally found as far north as Massachusetts, but they have the light green color of northern specimens. In Massachusetts Revere, VII-28-92 (F. A. Eddy Coll'n) (22), 2 specimens; Needham, V-18-20 (F.X.W.) (22), 1 specimen these large individuals contrast
strikingly with other individuals of form \( a \), but to the south they tend to intergrade with other form \( a \) variants and are less noticeable. In Maine and Canada nearly all specimens differ from the standard of form \( a \) in that the posterior edge of the disc is less sharply angulate, the shape of the disc is more variable, usually somewhat rounder, and the median V is often only weakly indicated.

In Canada and Maine, group \( g \) consists chiefly of individuals that have characteristics of all forms rather than resembling variants of any one form. In the rest of the northeastern region specimens of group \( g \) are mostly variations of form \( a \) that do not agree with the standard either because they lack the median V or the angulate edge of the disc or because the shape of the disc is unlike that of the standard or the usual variants of form \( a \) from this region. A few scattered unplaced specimens resemble form \( g \) and a few may be variations of \( b \) or \( c \).

Form \( g \) is generally more common than \( b \) in the Northeast, especially to the north. Only in Pennsylvania is \( b \) more abundant. Specimens similar to the standards for forms \( b \) (Fig. 63) and \( g \) (Fig. 62) are present throughout the region, but because of modifications of the shape and distinctness of the posterior edge of the disc, complete intergradation occurs making the separation of the two forms difficult (Fig. 65). In Canada and Maine the two forms are more clearly separable, with fewer intergrades.
If form \( \text{g} \) is present in this region it is not common and cannot be recognized as distinct. An occasional specimen resembles form \( \text{d} \), especially some small individuals of form \( \text{b} \), but these are few even in New York State from which more than 900 specimens were examined.

The color of most specimens of all forms is a bright green, although yellow-green or dark green specimens are not uncommon and blue-green individuals are occasionally found. The scutal and metasomal punctuation is variable in both sexes throughout the area. Many males can be segregated into the lettered forms, especially form \( \text{a} \), but individual variation is great and numerous and complex combinations of characters can occur, adding to the confusion rather than clarifying the nature of the variation.
SOUTHEAST

Species present: *A. striata* a, b, g, *aurata*, *gratiosa*, *persimilis*.

In Florida three species occur throughout the state, *striata*, *gratiosa*, and *aurata*. In Georgia, *striata* a, b, and g occur throughout the state, form b being most common. *A. gratiosa* and *aurata* occur chiefly in the southern counties but are also found sporadically in the mountains of the north; *persimilis* is found in the northern part of the state. In the Carolinas, *persimilis* has been taken in the mountains to the west, *gratiosa* appears nearer the coast and the three forms of *striata* occur throughout. The one specimen of *aurata* seen from North Carolina lacked detailed locality data. In Virginia, *striata* a, b, and g occur throughout the state, and *persimilis* ranges along the western border as far as Maryland, apparently its northern limit in the east. *A. gratiosa* probably occurs in Virginia as it has been taken in nearby Maryland, but this appears to be its northern limit also. Except for the few *gratiosa* from Maryland, only *striata* has been found in that state.

*A. striata*. There is comparatively little variation within the three forms of *striata* in this region. Only form a is present in Florida (except for one female of form b from Gainesville and a male of form g simply labeled "Florida "). About 90% of the female specimens are large, dark green to blue-green and very coarsely sculptured, especially on the scutum and propodeum. The other 10% are less rugose and resemble *striata* a from other regions. The disc in both sexes is usually bracket-shaped with a sharply angulate or
carinate posterior edge (Fig. 59), although the disc may become more V-shaped and develop a well defined but less sharply angulate posterior margin in some specimens. The posterior vertical propodeal surface varies from rugose to smooth in females (always rugose in males), and the punctures on the first metasomal tergum are variable but usually small and widely spaced. Small worker-like individuals are rare and always look similar to the larger, rough specimens. All but four of the males from Florida belong to the large, robust and coarsely sculptured form $\alpha$. One of the four is form $\varphi$, the other three, similar to males from outside Florida, cannot be classified as to form. Each differs from the others in the shape and size of the disc and in the type of scutal and metasomal punctures.

Throughout the rest of the southeastern region, form $\varphi$ as a distinct group is not found although $\beta$-$\varphi$ intermediates (Fig. 72) do occur. A few of the coarsely rugose Floridian representatives of form $\alpha$ range into Georgia but most specimens from Georgia and elsewhere in this region are similar to the standard of form $\alpha$. Most such form $\alpha$ specimens are bright green in color although some are yellow-green. They differ from forms $\beta$ and $\varphi$ throughout the region, without intergradation.

Form $\beta$ is usually distinctive although intergrades with $\varphi$ and $\alpha$ are found in both sexes. Most specimens of form $\beta$ have a long, roundly V-shaped disc (Fig. 63) with the edge of the disc well defined. In Georgia, the disc may be slightly shorter and rounder than normal,
resembling that of form $\varphi$ (Fig. 72), or less V-shaped in appearance, thus resembling form $\psi$ (Fig. 65).

Form $\varphi$ is considerably more variable than either $\varrho$ or $\psi$. The shape of the disc varies from semicircular to U-shaped and grades into the V-shape of form $\psi$. The edge is smoothly rounded and shiny, with little differentiation between the disc and the vertical surfaces. A few small females throughout the area resemble persimilis but have the striae reaching or almost reaching the posterior margin of the disc. Both $\psi$ and $\varphi$ are usually yellow-green in the southern part of the region and a yellow-green to bright green in Virginia, Maryland and the District of Columbia. The metasomal punctures in all forms are usually small, close, distinct and regularly spaced in both males and females although other punctation patterns may also occur. Most of the males can be placed as to form even though the size, shape and sculpturing of the disc is variable within any one form.

A. persimilis. There is little variation in persimilis in this region. Specimens are generally a light green to yellowish or coppery-green color and the disc (Fig. 64) and posterior vertical surface of the propodeum (Fig. 74) are similar to those of other specimens throughout the range. The pubescence, however, may be more golden in color than it is to the west. The species is not numerous and occurs chiefly in the western edge of the region. Intermediates between persimilis and small striata $\varrho$ may occasionally be found among the females.
A. *gratiosa*. This species is particularly abundant throughout Florida and probably Georgia but becomes sparse to the north. Specimens are usually dark green to deep blue in Florida but are generally a yellow-green to bright green in the rest of the region. This species shows little morphological variation except in Florida where the propodeal disc is often exceedingly short (Fig. 58) with the posterior edge of the disc more sharply angulate than elsewhere in the range. The characters of females in this species intergrade with those of *aurata* in Florida although most specimens can be distinguished by the key characters.

A. *aurata*. In Florida, the range of variation of *aurata* overlaps that of both *striata* and *gratiosa*. In Georgia, however, the species seems to be distinct. Most female specimens look similar to *gratiosa* with a rather short, weakly bracket-shaped disc (Fig. 57), fine striae and a similar body size. The males are most similar to *striata* with short hair on the hind basitarsus and a narrowly emarginate fourth metasomal sternum. The variation in specimens from Florida mainly involves body color, and the size and sharpness of the posterior edge of the disc in both sexes. The few specimens seen from Georgia were all alike in coloring and characters of the propodeum.
Species present: *A. striata* a, b, c, d, *persimilis*.

In the northern part of this region (Michigan, northern Wisconsin and Minnesota) only *striata* is found, forms a, b, and c occurring to the east and b, c, and d to the west. In the east form a is the most abundant, in the west form d is most abundant, form c being more abundant than b throughout the region (Fig. 92). Further south, *persimilis* is also found, its greatest abundance occurring in the western part of its range, particularly in Kansas, Iowa and Illinois. In the southern part of the region, *striata* c is more abundant than b, with form a decreasing in abundance and form d increasing from east to west. *A. persimilis*, though present, is less abundant than it is farther north.

Throughout this region where *persimilis* and *striata* c are common, intermediates between the females of the two species are found. In all areas, *striata* is more abundant than *persimilis*.

*A. striata*. In the North Central region there is a shift in the proportional abundance of forms from east to west. Form a is distinct from other forms in Ohio, Indiana, Illinois, Tennessee and Kentucky (Fig. 56). There seem to be several variants of this form present, so that the form could be easily divided into a number of subtypes based chiefly on shape of the disc and robustness of the bee. To the north, in Michigan, Minnesota and Wisconsin, the edge of the disc becomes less sharp than in the standard and eastern specimens, and the shape
of the disc is variable so that none of the subtypes are well defined or distinctive. One specimen similar to those from Florida (Fig. 59) was found in Iowa ( Ames, XI-1-59 (D. Eastman) (18)). It contrasts strongly with the other specimens, the usual form \( \text{a} \) being smaller, yellower, less robust and less coarsely rugose. Form \( \text{a} \) becomes less abundant to the west and grades into form \( \text{c} \), although a few rather distinct individuals of form \( \text{a} \) occur in Nebraska, Kansas and Colorado. They are apparently absent in Oklahoma, Arkansas and Missouri although the form may be represented as intergrade types in these areas exhibiting an abrupt, but not sharp, posterior discal edge, with or without a medial V.

Form \( \text{b} \) usually is distinct, most specimens agreeing well with the standard (Fig. 63). The proportional abundance, however, decreases sharply to the west and the form is entirely absent in Colorado. Variants from the standard grade into both \( \text{c} \) and \( \text{d} \). Form \( \text{b-c} \) intergrades (Fig. 65) are found frequently to the north in Michigan and Minnesota, and Ohio to Illinois and possess an elongate disc grading from \( \text{V} \)- to \( \text{U} \)-shaped, usually with a distinct but rounded edge. Form \( \text{b-d} \) intergrades (Fig. 72) are found more frequently to the west in Illinois, Iowa and Kansas where the disc becomes shorter and more semicircular. Form \( \text{c-d} \) intergrades are found throughout the Central region. In Kansas, four nests were found containing both \( \text{b} \) and \( \text{d} \) individuals, but in no case did any of the specimens agree with the standards. Also, there were four nests containing
intergrades, two of the nests also containing at least one specimen distinctly of form \( \text{b} \).

Form \( \text{g} \) is variable and poorly defined in the eastern part of the North Central region but numerous and distinctive to the north and west. There are a number of different subtypes represented, with specimens resembling the standard (Fig. 62) found chiefly in Illinois, although they also occur in varying proportions elsewhere throughout the region: In Ohio, Tennessee, and Indiana there are many individuals resembling \( \text{b-g} \) intermediates (Fig. 65), although in Indiana and lower Wisconsin the majority of the individuals of this form are small and intergrade with \text{persimilis} (Fig. 68). In Kansas, Missouri, Arkansas and Oklahoma about 50% of the form \( \text{g} \) group consists of these small \text{persimilis}-like intermediates. These small specimens also occur sparsely in Minnesota, Iowa and Nebraska. In Michigan, South Dakota and Colorado there are some individuals with \text{persimilis}-like discs but the specimens are large and would not be confused with \text{persimilis}, a smaller species. These larger subtypes also occur in Kansas, Nebraska and Missouri. Other variations from the standard also occur throughout the North Central region (Fig. 61); sometimes they represent intergrades with forms \( \text{b} \) or \( \text{g} \).

Form \( \text{d} \) is not abundant nor distinct as a form in the eastern and northern states, although \( \text{d} \)-like specimens are occasionally found. It intergrades chiefly with form \( \text{a} \) in Michigan and Wisconsin, where the disc is weakly bracket-shaped and the edge of the disc may become
sharper than normal, with a weakly developed medial V. This form intergrades with form \( b \) in South Dakota, where the disc becomes more V-shaped and longer than the standard. Form \( g \) individuals are proportionally more abundant than other forms in the Great Plains states and although variable, the majority are similar to the standard of form \( g \) (Fig. 71). Small worker-like individuals are present, some resembling the larger individuals, others being intermediate between the small form \( g \) and \( \text{persimilis} \). Biological data is scarce, although six nests of this form were found in Kansas, all containing large and rather standard individuals, without worker forms. Four other nests contained both distinct \( b \) and \( d \) individuals.

\textbf{A. persimilis.} There is little variation in size or structure in \( \text{persimilis} \) throughout this region, although specimens tend to be somewhat greener (less yellowish) and the pubescence generally whiter than in the east. Throughout the region the disc of the propodeum is as in Figure 64.

\textbf{A. gratiosa.} \textbf{A. gratiosa} is not known in this region, although it may be found along the southeastern borders. It will look similar to \textit{striata a} but with finer, closer striae (Fig. 58) and a rough or granular posterior vertical propodeal surface (Fig. 76). One specimen has been seen from eastern Tennessee.
SOUTH CENTRAL

Species represented: A. striata a, b, d, persimilis, gratiosa, neglectula, aurata, bracteata.

In the western part of this region, the southwestern portion of Texas along the Mexican border as far east as Val Verde Co. and north into the Davis Mountains, neglectula and occasionally striata have been found. In the southern part of Texas, east of the Edwards Plateau, both bracteata and aurata occur, bracteata occurring as far north as Dallas Co., and aurata into Nacogdoches Co. A. bracteata has also been taken along the Rio Grande west to Val Verde Co., where it meets but probably does not overlap the range of neglectula.

A. striata, gratiosa and persimilis also occur to the east of the Edwards Plateau, gratiosa coming from the east and occurring from south of Galveston to Nacogdoches, persimilis going only as far south as Nacogdoches, and striata ranging south to near Corpus Christi. A. striata is the only species on the Edwards Plateau, and although there seems to be a gap between the eastern populations and those of New Mexico and southwestern Texas, all the bees of this species look similar to one another. In Louisiana, Mississippi and Alabama, gratiosa and probably aurata occur to the south, persimilis is rare, and striata occurs commonly throughout.

A. striata. In the eastern part of this region, form a looks similar to its standard (Fig. 60) but becomes less distinct to the west and all but disappears as a distinct form, grading into form d.
Thus, the posterior edge of the disc becomes less sharply defined than in the standard although abruptly rounded, and the disc becomes less angular and the bracket-shape less well defined.

In the eastern part of the region, most specimens of form \( b \) are large and agree well with the standard. Toward the west the characters of form \( b \) grade into those of form \( g \). The posterior edge of the disc remains abruptly rounded but the length of the disc decreases and the outline gradually changes from the broad V typical of form \( b \) (Fig. 63) to the semicircular shape of \( g \) (Fig. 71). Form \( b \) also decreases in proportional frequency although a few specimens similar to the standard are found in eastern Texas.

In form \( g \) the length of the striae and angulation of the posterior margin of the disc as well as the shape of the disc are variable but in general resemble that in Figure 71. Form \( g \) is not distinct in this region, although occasional specimens may show some resemblances to it.

In Louisiana and Texas, a few small persimilis-like individuals are present that would belong to form \( g \) in other parts of the range, but are probably worker individuals of form \( d \) in this region. These are always distinct striata, however, and except for size do not intergrade with persimilis. To the west the percentage of form \( d \) increases.

Throughout the region both color and punctuation of females are variable. Males are individually variable with only a few specimens
distinctive enough to be placed in one form or another; none of the males in this region seem to intergrade with any other species.

*A. persimilis.* *A. persimilis* occurs very sparsely in this region and appears to differ little from those elsewhere in the range (Fig. 64). Most specimens are a yellow-green or coppery green in color. This species does not intergrade with *striata* or *g* in this region, although there are small individuals of *striata* in Texas and Louisiana.

*A. gratiosa.* Only a few specimens of *gratiosa* have been seen from this area. All are similar, usually bright green or yellow-green in color. The propodeal disc is usually about equal in length to the metanotum, sharply defined but rarely carinate. Some females may be confused with females of *aurata* in this region.

*A. aurata.* Females of this species have been taken from throughout southeastern Texas and, although variable in disc characteristics, can be distinguished from other species by the key characters. The females are most similar to *gratiosa*. No males have been seen, and no specimens of either sex have been taken between southeastern Alabama and Texas, probably due to lack of collecting in this area.

*A. neglectula.* This species is a dark green, roughly sculptured species (Figs. 70, 75) with all specimens similar to one another in this region. Although *striata* and *bracteata* have also been taken in the same area, it is probable that the three species occur in different habitats.
A. bracteata. This species is similar to the small striata c-persimilis intermediate in size and in appearance of the propodeal disc (Fig. 66). Both of these characters show considerable variation, but the thoracic sculpturing (Fig. 78) is distinctive and unvarying and serves to separate this species from persimilis, aurata and striata in Texas.
Species represented: pomoniella, neglectula, striata b, d.

The only species occurring in California, Utah and Nevada is pomoniella. *A. pomoniella* enters Utah only in the extreme south-western corner, in Washington Co. In Arizona, both neglectula and pomoniella are found, pomoniella to the west and neglectula to the east, with their ranges broadly overlapping in the center of the state. In New Mexico, striata comes in from the northeast and ranges southward to the Mexican border through the eastern half of the state. *A. neglectula* ranges across the southern half of the state.

*A. striata*. Most of the individuals of striata are small (6 mm), about the size of large *persimilis*. The scutum is rather finely punctured or finely rugose, and the shape of the disc is somewhat variable, but the striae in all cases fill the discal area and reach the distinct posterior edge. The posterior surface of the propodeum is finely granular or weakly roughened, shiny or dull, and the color of the body varies from dark green to blue-green. Most striata belong to form d in this region, although an occasional form b is found. Individuals weakly a-like and intergrades between b and d are also occasionally found.

*A. neglectula*. There is little overall variation in this species except that the propodeal area varies in the degree of roughness of the posterior and lateral vertical surfaces. The smoother individuals superficially resemble pomoniella in Arizona or striata in New Mexico,
although there is usually little difficulty in distinguishing the species, and the number of specimens showing this similarity is few.

_A. pomoniella_. There is little variation in size, color or morphological characters in specimens from California, Nevada and Utah, but in Arizona, specimens are smaller and more variable in the propodeal characters and in color. _A. pomoniella_ is, however, distinctive throughout the area and does not intergrade with _neglectula_ which it overlaps in Arizona.
Species present: *A. neglectula, pomoniella, bracteata, edentata.*

Other species found only in the Neotropical region and belonging to *Pereirapis* are not included here.

Throughout the central part of Mexico from the northern border into Central America, *A. neglectula* is the most common of the species considered in this paper. It occurs throughout Mexico except along the coasts. Both *edentata* and *bracteata* are also found in the central area but occur only sparsely in the eastern part.

In Baja California and along the western coastal area, *pomoniella* is found, and along some beaches of the west coast, *maritima*, a subspecies of *neglectula* is found. Apparently both *pomoniella* and *neglectula* occur together south of Morelos although they have not been collected simultaneously from any one area. In Chiapas and Yucatan, only *pomoniella* has been collected.

*A. neglectula*. This species shows little variation in Mexico, except for Pacific Coast populations placed in the subspecies *maritima*. Occasional female specimens are dull rather than shiny, with the body surfaces minutely reticulated, especially on head and thorax. The blue patches on the frontal areas are rarely conspicuous on Mexican specimens, and occasional specimens with unusually smooth propodeal areas may look similar to *pomoniella*. Many of the specimens of the subspecies *maritima* are from the same population and therefore show little morphological variation among themselves.
A. pomoniella. This species is rather variable in size, color and sculpturing, especially in southern Mexico. Specimens from Baja California and Sonora are large and much like those from California, but those from further south are small, often with paler brown and darker green coloration. The range of pomoniella overlaps that of neglectula in Guerrero and Oaxaca, and females from these areas may intergrade morphologically.

A. bracteata. Only a few specimens of this species have been taken in Mexico so that the nature of the variation has not been determined. The specimens seen are like those from Texas and are easily differentiated by the key characters from other species of this region discussed in this paper.

A. edentata. This species is somewhat variable in both color and sculpturing, but until more specimens can be seen, the extent of the variation cannot be described. It is distinguished from other Mexican species discussed here by its smaller size, smooth sculpturing (Fig. 79), convex face and other key characters.
PART II

THE BIONOMICS OF AUGOCHELORELLA STIATA AND A. PERSIMILIS IN

EASTERN KANSAS
PART II. THE BIONOMICS OF AUGOCHLORELLA

STRIATA AND PERSIMILIS

INTRODUCTION

Part II concerns the life history and certain aspects of the behavior of the two species of Augochlorella, *A. striata* and *A. persimilis*, that occur in the vicinity of Lawrence, Kansas. It is part of a broader study of the origins and evolution of social organization and behavior in primitively social halictine bees and also is part of a continuing study of the biological and behavioral relationships among species in the genus Augochlorella.

*Augochlorella* is a member of the strictly American group of usually brilliantly metallic Halictinae with distinctly emarginate eyes. An account of its life history, social behavior, and castes is important since it is the only member of that group so far found to regularly have colonies each containing a queen and several workers. Other Halictinae known to have more or less distinct castes are all in the *Halictus-Lasioglossum* group of genera.

Previous work on the biology of *A. striata* and *A. persimilis* has included numerous flower records (see Part I), meager accounts of nesting and nest structure (Hicks, 1931; Ordway, 1961; Knerer and Atwood, 1962) and an account of the relationships of these bees with their natural enemies (Ordway, 1964).
The data on nests, and on social structure and behavior, are based on field observations made in the vicinity of Lawrence, Kansas from 1954 to 1963 and on certain laboratory observations made chiefly during 1964. The data on the two species are presented separately whenever practicable, but since the two species usually cannot be distinguished in the field, separate field notes were not kept, and only when nests were excavated or individuals from the nests collected could positive identifications be made. Indeed, even then, not all females could be identified with certainty. The biology of the two species is similar, and they are discussed together except where differences occur. Where the data permit, organization of this part is similar to that used by Michener and Wille (1962) in order to facilitate comparisons with other species of halictines that have been studied.
METHODS

The field methods used were similar to those described by Linsley, MacSwain and Smith (1952) or by Michener, Gross, Daly, Rettenmeyer and Wille (1955) and by Michener and Wille (1961). Additional techniques or appropriate modifications are described where pertinent throughout the text.

Details of the laboratory procedure and equipment will be published later, with information concerning certain behavioral patterns of the bees. In this paper, laboratory observations are referred to only when they relate to observations made in the field. Briefly, nesting boxes (see below) were placed in a room 1.5 by 3.0 m and 2.0 m high, made of insulated wall board with a cement floor and a ceiling of heavy transparent Clopay Super Clopane plastic and nylon netting. Temperature was regulated by an air conditioner at one end of the room. Lighting, produced by cool white fluorescent tubes, provided a maximum of 1600 foot candles near the ceiling and 800 foot candles at the level of the nest entrances (40 cm above the floor). The observation nest boxes were made by mounting two pieces of window glass, 46 x 30 cm, in a three-sided wooden frame, the fourth (top) side being left open. The panes of glass were spaced about 3 mm apart by small pieces of glass glued between them. A piece of small plastic tubing was inserted between the glasses to the bottom of the nest box and sand was placed around the bottom end of the tube. The space between the panes was then filled with dry, sifted soil from one of the nest
aggregations and a trough of pegboard was fastened across and into the top of the two pieces of glass and partially filled with earth so that burrowing bees could dig down through soil between the two pieces of glass. The glass was kept covered by a curtain of black muslin, which kept light out of the nesting area but which could be lifted when observations were being made. The soil was kept moist chiefly from the bottom by means of the plastic tube so as to maintain a moisture gradient in the nesting area. Bees collected randomly in the field and marked individually were placed in artificially started burrows at night for several nights until they started constructing their own burrows and cell clusters. Fresh flowers were brought into the room from the field every two days, or as needed, and honey was provided on wooden platform feeders that hung from the ceiling. Blocks of wood drilled with 3 to 4 mm holes were also hung from the ceiling and provided the males with sleeping places at night. All laboratory observations were made in this room.

In the field, a total of 239 nests were excavated in 1955 and 1957 to 1963, at eight aggregations (see section on Aggregations) as well as from areas where only one or two nests could be found. Of these, 38 were constructed by *persimilis* and 86 by *striata*. The remaining nests were made by these two species of *Augochlorella* but specific identification was not positive, either because the females in the nests were intermediate between the two species (see Part I) and no males were present, or because no bees were present when the nests were excavated. Most data, therefore, are presented separately
for *striata*, *persimilis* and "total", the totals being greater than the sums for the two species. In discussing the results, all data are considered except when the two species are being compared, and then only the data for known *striata* and *persimilis* colonies are used.
GENERAL ACCOUNT

The two species of *Augochlorella* are bright green sweat bees, 5 to 8 mm in length. *A. striata* is distributed generally throughout the eastern half of the United States as far west as the Rocky Mountains and from southern Canada to the Gulf of Mexico. *A. persimilis* also has an eastern distribution, but ranges only as far west as the Great Plains, northward to the Great Lakes and southward into northeastern Texas and the northern parts of the Gulf Coast states. In the east it is not found north of Maryland or along the coast. It occurs most abundantly from eastern Oklahoma and Kansas into Illinois (see Part I, Distributions).

The nests are located in the ground, usually in groups, and each consists of a burrow extending vertically into the ground and enlarging into a cavity in which a cluster of cells is constructed. There may be a terminal blind burrow below the cluster cavity and a turret or chimney at the entrance. The bees inhabiting one nest comprise a colony, and a group of such colonies comprises an aggregation. Queens overwinter in hibernation burrows below their natal nests and emerge in the spring to found new nests. A new nest may be built by a single queen in a new location or by one or more overwintered females at the same site as in the previous year. In this latter case, old cells and cell clusters are not rebuilt or reused but the remains of old clusters can often be found in the
surrounding soil, and in the spring there is the long hibernation burrow extending below the newly constructed cluster cavity. New cells are built and mass provisioned one at a time by all females in the colony during the spring or by the workers or non-egglaying females during the summer. There may be more than one female capable of laying eggs in spring colonies, but after the first brood emerges in June, only one egglayer or queen per colony is found. The first progeny produced are mostly females, although a few males are also found at this time. The nest populations increase during the summer from 1 to 4 bees in spring nests up to a maximum of about 10 individuals per colony at the end of the summer.

The seasonal cycle of both species is similar. The queens emerge from hibernation, in the area of Lawrence, Kansas, usually during the first week in April, depending on the weather conditions. The earliest date that bees were seen was March 23 (1959) but usual first records were from April 1 to April 19, at a time when *Cercis canadensis* (redbud) and *Prunus* are usually in full bloom. Nest construction is started about one week after emergence from hibernation, and the first cell is provisioned about 2 to 3 weeks later. Eggs were first found in *striata* nests on May 7 and in *persimilis* nests on May 15. The immature stages take about one month to complete so that first brood adults start emerging usually about the first week of June. Throughout this time new nests may be started probably as polygynous colonies break up, i.e. leave the company of other queens. Queens may stop laying eggs
after the first 3 or 4 are laid and become temporarily inactive but in
many colonies there is continual production of new individuals. The
production of males increases during the summer through September.
Males leave the nests after emergence and do not return, spending the
rest of their lives around the flowers, where mating probably takes
place. In the fall they disappear and are probably killed by the first
frost. Although the last eggs of *striata* were found on August 20, few
are produced after the end of July. The last eggs of *persimilis* were
found on August 25, about two weeks after most *striata* had stopped
producing. There are frequently about 40 cells in a cluster in
September, many of which have been used a second time. After the
last broods have emerged, bees continue to fly and feed on nectar
from the fall flowers until the first frost, but they do not collect
pollen. During this time females dig a hibernation burrow deep into
the ground under their nest where they pass the winter, below the
frost line.
NATURAL ENEMIES

The natural enemies have been described in detail in an earlier paper (Ordway, 1964). They include the usual predators such as birds, spiders, phymatids, asilid flies and various species of *Philanthus* (Evans, 1959, 1964). The nest parasites include *Sphecodes pimpinellae* (Robertson), an halictine bee, and *Pseudomethoca frigida frigida* (Smith) and *Myrmilloides grandiceps* (Blake), both mutillids. Adult bees are occasionally parasitized by conopids, but no other internal parasites have been found. Scutacarid mites of the genus *Imparapes* and a laelaptid mite (presently being described by G. Eickwort) occur abundantly in the cells of the nests but seem to cause no damage to the offspring of the bees. The nymphs of the laelaptid mites have been observed with pollen inside of them, but it is not certain what the food of the scutacarids is.
AGGREGATIONS

Nests of *Augochlorella* usually occur in loose groups or aggregations but may be difficult to find because the entrances are frequently hidden under stones or sticks, at the base of clumped vegetation, or under leaf litter and debris. Those that occur in bare spots are probably comparatively rare and yet are the ones most easily found. Isolated nests have also been found, but it is not certain how isolated they actually were since they might have been at the edge of an aggregation or near colonies that were temporarily inactive and therefore not discovered. Colonies of *striata* are more easily discovered than those of *persimilis* because their nest entrances are larger and frequently have turrets. That *persimilis* nests are often widely scattered and that so few were located, even though the species is more common in eastern Kansas than *striata*, suggests that the normal nesting areas for *persimilis* may not have been found. If one nest of either species is found, others in the area can often be located by watching for returning bees flying to the ground. In many cases "new" nests seem to appear during the summer in well observed and thoroughly searched aggregations, yet if these nests are excavated, they are found as fully developed as other nests in the area but perhaps with fewer adult bees in the colony. The known size of the aggregation, therefore, depends in part on how long the colonies have been under observation. The apparently identical nesting sites
of the two species may or may not represent the normal nesting sites of each species and greater specific differences may eventually be found.

Locations. The nests of both species occur in open wooded areas, at the edge of woods, in pastures and fields where the ground cover is not too dense or under leaf litter, among dense clumps of grass and under the edges of stones. In summer, nest entrances were usually shaded part of each day but in spring when nests were started, before leafing of trees and growth of herbaceous plants, nests were fully exposed to the sun. Nests may be found in flat areas or occasionally in steep (not vertical) banks but are usually located in places where the ground is sloping or locally uneven, forming low mounds and hillocks. New nests are usually established at the bases of objects, perhaps in small shadows, but no aggregations have so far been found on north facing slopes. The nesting areas were all well drained and located at levels where the land is not subject to flooding by rivers or ground water. In all localities the soil was of a clay or clay loam sometimes variably interspersed with coarse gravel, stones or roots.

The sites of major aggregations are described below. They were given names for reference purposes and are referred to in the following text by the abbreviations in parentheses. Area names on The University of Kansas Natural History Reservation may be found in the publication by Fitch (in press).
Daly's Place (DP): Located on The University of Kansas Natural History Reservation, six miles northeast of Lawrence, on a wooded hillside, in Skink Woods near Ant Rock, the aggregation included colonies predominantly of *striata* although some *persimilis* were always present. The aggregation was found in 1957 and remained active through 1963, the period of this study.

The woods in this area are mainly of chestnut oak (*Quercus muehlenbergii*), black oak (*Quercus velutina*) and shagbark hickory (*Carya ovata*), interspersed with American elm (*Ulmus americana*), hackberry (*Celtis occidentalis*) and black walnut (*Juglans nigra*). There is a sparse undergrowth in the area surrounding the nest sites, consisting of young saplings of larger trees, greenbriar (*Smilax*), bittersweet (*Celastrus scandens*), and such flowering plants in season as dog's-tooth-violet (*Erythronium albidum*), goosegrass (*Galium aparine*), *Prunella vulgaris recognita*, bellflower (*Campanula americana*), *Stachys palustris*, and white snakeroot (*Eupatorium rugosa*), etc.

The soil is of a Sogn-like Silty Clay Loam. It has a thin covering of leaf litter in some spots but is bare and stony where most of the nests were found. There were three aggregations appearing at different times during the five year period that this area was under observation. The first group of nests was found in 1957 on a low, eroded ridge of rocky soil beside the trail. The bank was about 3 m long, running in a north-south direction, and about 1 m high. It
sloped off gradually to the west but dropped sharply on the east. All nests were found either on the top of this ridge or on the gradual western slope, no nests ever being found in the steep east bank.

The second aggregation, which started in 1958, lay about 25 feet from the first site and was probably populated by bees from the first area. It was much flatter, with fewer stones, and the ground was thinly covered with leaf litter and an occasional large stone or small log. The third aggregation, started in 1960, lay about 50 feet to the west of the first aggregation. Here the ground is very stony, eroded and bare and sloping. In all three places the soil was largely exposed to the sun in spring when nesting begins, but became lightly shaded or with only spots of sun later in the year. The shade was from trees, or for the second aggregation, from small but dense weeds.

State Property (SP): This tract of land, on which a number of small aggregations were found in different years, is about 1.5 miles southwest of The University of Kansas campus. Aggregations contained colonies of both *persimilis* and *striata* from 1953 to 1958. All nests were found on sloping rocky ground. Some were at the edge of a pasture which was regularly cut for hay; others were in areas where the grass, weeds and shrubs were allowed to grow uncut. The nests found were in open spots where there were patches of bare ground and numerous small stones. The vegetation here was sparse, tall grasses mixed with many weeds, including *Solanum*, *Asclepias*, sweet clover
(Melilotus), and various composites. There were various shrubs and small trees including Symphoricarpos orbiculatus, hedge apples (Maclura pomifera) and some sumac (Rhus), but these were generally at the edges of the nesting areas and did not shade them. The soil was Newtonia Silty Clay Loam developed on Oread Limestone.

Rattlesnake Ridge (RR): Ten miles southeast of Lawrence, this area was located on flat ground at the top of a wooded hill where the woods were giving way to fields. The nests were first found in 1958 and were all dug up in 1961. All colonies found belonged to striata. The nest site was surrounded by scattered bushes of dogwood (Cornus drummondi), sumac (Rhus), young black walnut (Juglans nigra) and small bushes of wild plum (Prunus). The leaf litter, sometimes 5 cm deep, consisted chiefly of plant stems of Coreopsis and grasses that grew high in the area during the summer. The nests, therefore, were shaded and hidden from view by these tall herbs or bushes and by the ground cover. They were found when bees were seen flying into the litter. No nests could be found in the woods nearby. Under the humus layer, the ground was loosely packed and crumbly, with many roots, pebbles and stones; a coarse gravel substrate occurred about 15 cm from the surface.

Prairie Place (PP): This aggregation was located approximately 200 yards east of the southwest corner of the Rockefeller tract at its boundary with The University of Kansas Natural History Reservation.
Nests were found beside an occasionally used auto track that ran through and along the edge of a field of native prairie. Second growth woods and thickets, chiefly of dogwood and sumac, occurred nearby on the other side of the track. A few *striata* nests were found in 1958 at the edge of the auto ruts or between them, where the ground was somewhat uneven, but not in the hard packed soil of the ruts themselves. The nests were usually shaded by sumac (*Rhus copallina*) and *Ceanothus ovatus* that were encroaching onto the edge of the prairie and were found either between clumps of grass, among the leaf and stick litter or in patches of bare ground at the bases of plants. The soil in this area is a Newtonia-like Silty Loam developed on Limestone, which becomes dry and cracked at the surface but retains moisture below about 6 cm during normal summers. No more than 10 nests were found here at any one time, and these were usually associated with nests of *Lasioglossum imitatum* (Smith).

Clark Road (CR): About 2 miles southwest of the University campus, a patch of native prairie is bordered on the west by a dirt road and limestone outcropping. The prairie field slopes gradually down to the east to a stream bed. A few nests of *persimilis* were found in 1961 and 1962 in the disturbed earth along the edge of the rock outcrop. The ground surface in this area was mostly bare of vegetation but did have a few *Rhus* and *Ceanothus ovatus* along the edge, and a dense stand of *Melilotus alba* in season. Many *Augochlorella* of both species regularly foraged among the prairie flowers below the nesting site,
but no nests were ever found in the prairie itself. The soil at the
nest sites is a stoney clay talus probably deposited when the road
was being constructed.

Sycamore Slope (SS): This area is located on the northern
upland part of The University of Kansas Natural History Reservation
in an area known as "Road Field" which was cultivated for periods of
years in the nineteen thirties and forties and was severely eroded
but was sown to prairie grasses in 1949 and has been left undisturbed
since then. The area was about 100 feet from woodland bordering
the south edge of the field. Numerous nests were found here in 1955,
of both *persimilis* and *striata*. They were located mostly on the top
and sides of small ridges and mounds formed by erosion in the field.
These ridges had very sparse grass cover so that most nests were in
bare ground with little shade. The soil here was severely eroded
Pawnee Silty Clay Loam derived from glacial drift.

Correa's Quarry (CQ): This large aggregation was located at the
site of an abandoned rock quarry on the property of Mr. O. H. Correa,
about 5.5 miles north of Lawrence. Nests of both *persimilis* and
*striata* were found in 1963 and 1964, but the majority of colonies
consisted of females intermediate between the two species. The soil
where the nests were located was a mixture of yellow clay, stone and
gravel deposited in a large talus mound during the quarrying operations.
The vegetation on this mound was sparse and limited to a few small
saplings and weeds, chiefly *Melilotus*, growing about 3 to 4 feet high.
The soil became hard, dry and deeply fissured, with the surface layer becoming parched and friable during the summer. The cell clusters tended to be deep in this location with burrows that utilized the subsurface crevices.

Lakeview Bank (LB): This aggregation was located about 3 miles ESE of Lecompton in Douglas County at the base of a wooded hillside along the edge of a road. In 1962, it contained colonies of both striata and persimilis, with striata being more abundant than persimilis. All nests found were dug up in the same year. The soil was a clay similar to that found at other aggregations and was very stony along a tractor road leading up the hill. A low embankment (the old road cut) extended beside the main road. Nests were found along the top or issuing from the face of the bank and along the edge or between the tracks of the tractor road. They were usually shaded by the trees and shrubs of the woods, although sunlit areas were common throughout the day. The nests in this area were usually widely scattered, with only one group of three nests being found clustered together.

Size. The area occupied by an aggregation is variable, depending on the number and spacing of the individual colonies. The smallest aggregations were from one or two meters long and half a meter wide (PP, CR), the largest about 20 meters along each side (DP, CQ). Within an aggregation, nests are variably spaced from about 5 mm to 50 or 60 cm apart. Clusters of three to six nests of striata were
frequently found close together, usually around a stone or clump of grass. No such clustering was noted for *persimilis*.

**Survival.** Aggregations appear to continue year after year but may die out or shift in location. At SS and RR, many of the nests were dug up during a period of one summer, and those that remained either died out or could not be found in the following summers. However, at DP, a large aggregation, nesting continued from 1957 through the five years of this study, even though over 100 nests were excavated from the area and many other nests were destroyed by ant colonies. At both DP and SP it was found that, although the aggregation as a whole continued to be active year after year, the center of activity or the concentrations of active colonies shifted, and new areas would be utilized in different years.

Individual nests may continue in the same location for two or more years. The site of one such nest was used for 5 consecutive years before the colony finally died out, 9 others continued for 3 years, and 32 lasted for 2 years in the same locations at DP. It is not clear what makes a suitable nesting site or what limits the size or area of the aggregation.
NEST STRUCTURE

The first nest of *Augochlorella* to be described (Hicks, 1931) was a nest of *striata* in Colorado. Sakagami and Michener (1962), in discussing the architecture of halictine bees, compared the general features of *Augochlorella* nest structure with those of other halictines. Other references to *Augochlorella* nests were made by Knerer and Atwood (1962) who noted briefly that nests of *striata* in Canada have one inch turrets and that cell clusters "are constructed in the floor of expanded burrows", and by Ordway (1961, 1964) who summarized the general structure of nests of *striata* and *persimilis*.

The nests of *striata* and *persimilis* are similar in structure so that unless otherwise noted, all details discussed below apply equally to both species. Nests can be placed in groups IVa, b, VIIa and VIII of Sakagami and Michener (1962).

The Entrance: When the bees first emerge from hibernation in the spring, the emergence holes at the surface of the ground are uneven and rough. Within a week, the hole and burrow below it are smoothed off to form a round tube extending deep into the ground. The entrance of this tube is slightly constricted so that its diameter is about one millimeter less than that of the burrow below it. Entrances to nests of *persimilis* range in diameter from 2 to 3 mm, whereas those of *striata* are normally from 3 to 5 mm ($\bar{x} = 4$ mm), although they have been measured up to 7 mm. The diameter of the entrance may differ through the season in any one nest. The diameters
in millimeters of two typical *striata* nest entrances varied through the season from April through August as follows (measured about twice monthly): Nest 1: 4, 4, 5, 4, 4, 4, 4, 4; Nest 2: 3, 4, 4, 4, 4, 5, 5, 4.

When the bees start excavating a cluster cavity, excess earth may be brought up from below and deposited around the entrance to form a pile or tumulus with a compacted, smooth-walled burrow in the center (see Sakagami and Michener, 1962, for details). This tumulus may result in a fragile, loosely structured turret at the nest entrance, often differing in color from the ground surface and varying in height depending on the depth of the tumulus. This turret usually disintegrates after a few days and may be replaced by a deliberately constructed turret (see below) or by a newly repaired, constricted entrance hole at or just above ground level. During the rest of the season, the entrance may or may not have a turret, but the entrance is usually kept in repair as long as the colony is active and the soil moist. A tumulus is not formed again until the fall, when excess earth excavated from a hibernation burrow may be deposited at the entrance.

**The Turret:** The usual turret is a constructed, cylindrical extension of the main burrow above the surface of the ground. Its inside diameter is the same as that of the main burrow except for the constriction at the top. The walls of the turret are usually parallel,
1 to 2 mm thick (slightly thicker at the constriction), with the inside surface smooth and unlined and the outside rough but firmly compacted. The height of the turret is variable, ranging from a ring of earth constricting the entrance to a chimney more than 40 mm high (anything less than 3 mm high was not considered a distinct turret and is referred to as a "well formed entrance"). Since the turret is a continuation of the main burrow, it is usually vertical, but if obstructed by sticks, stones or leaf litter, it may extend at any angle. Such obstructions are often incorporated into the construction. During dry periods, many nests are without turrets since a turret can only be constructed when the soil is moist (see Nest Construction). (Data on the stimulus for initiating turret construction will be published later.)

Nests of *persimilis* usually lack distinct turrets. Occasional nests were found with turrets as high as 10 mm, but most nests simply had well formed entrances only 1 to 3 mm high. The nests of *striata*, however, nearly always had a turret at some time during the season but ranged from "no turret" to structures 30 mm high (one colony with a turret 40 mm high was not identified to species) with a mean of 11.9 mm. There was no evidence that the age of the nest or the time of year was in any way correlated with the height of the turret.

The presence of a turret effectively prevents water from draining into and inundating the nest. It also serves to raise the nest entrance to the top of leaf and stick litter on the surface of
the ground thus facilitating the orientation of foraging bees. It may also serve to prevent small arthropods that crawl on the surface from falling into the entrance.

**The Main Burrow:** The main burrow extends from the surface of the ground directly to the cavity containing the cell cluster, so that its length depends on the depth of the cavity and on the number of cavities formed (see below). The diameter of the burrow is usually uniform for its entire length, but it may be asymmetrical or occasionally variable at different depths. In nests of *persimilis*, diameters range from 3 to 6 mm, with a mean of 4.5 mm in May and 4.0 mm in June and July. In nests of *striata*, diameters also range from 3 to 6 mm but have a mean of 5.0 mm (from 5.3 mm in May to 4.9 mm in June and July). Hicks (1931) reported one nest in Colorado as having a main burrow with a diameter of 8 or 9 mm. This is considerably larger than any found in Kansas.

The burrow is usually straight and vertical, but it may bend or curve around stones, roots or other obstructions in the soil and its upper end may slant to the surface, especially when the entrance emerges from an embankment or from under a stone.

The walls of the burrow are smooth as in most halictine nests. They have no visible lining under normal circumstances but may be coated, at least near the entrance, with a transparent salivary secretion. This invisible material apparently acts as a repellent to certain other insects (see Ordway, 1964); its existence is inferred
because after a bee is seen to lick the walls intruding arthropods react when they contact the areas licked. Bonelli (1948) has reported that workers of *Lasioglossum malachurum* line the upper section of their burrow with a salivary substance, but in this case the lining was plainly visible and shiny like the inside of a cell. *Lasioglossum imitatum* (Michener and Wille, 1961) and *L. versatum* (Michener, in press) also place a salivary coating at the entrance. Jørgensen (1912) reported the turret and entire burrow of *Megalopta ipomoeae* (= *Megommation insigne*) coated with a lining that could be removed from the burrow intact, although Michener and Lange (1958) found no such lining in nests of the same species. This type of lining has never been noticed in nests of *Augochlorella* in the field, but in observation nests in the laboratory, the lower ends of blind terminal burrows (below the cell clusters) in two nests contained similar distinct linings. The lining was a thin, transparent, flexible, cellophane-like material and in one case extended into an air space below the burrow. It was not determined how far up the burrows the linings extended, but they did not reach the cluster cavity. The probable reason these two nests were lined is that the soil in the nest box was moistened from below (see section on Methods) and water regularly entered these burrows. In other nests, the burrows either did not extend as deep and were not as close to the source of the water, or were obscured and could not be observed. The nests of *insigne* that Jørgensen observed were in wet soil. It
seems possible, therefore, that such waterproofing could be an adaptation to excessively wet conditions and would not be noted under ordinary circumstances.

Supplementary Burrows: In addition to the main burrow there may be short side burrows near the surface of the ground and one or more blind terminal burrows extending down from the cluster cavity (Fig. 94). The side branches run horizontally about 2 to 3 cm below the surface of the soil, may be 1 to 60 mm long, averaging about 17 mm, and are the same diameter as the main burrow. About 27% of the nests excavated throughout the season contained one or more such side burrow. They are probably formed when the bees excavate soil to repair the entrance or turret since the color of the turret is the same as that of the surface soil; if deeper soils were used, a different color or texture usually could be detected. The side branches may be partially filled with loose earth or periodically filled with earth probably mined when the cluster cavity is being expanded. The lack of such side branches in some striata nests that regularly have tall turrets could thus be explained.

The blind terminal burrow, when present, extends vertically below the cluster cavity and ends abruptly with a rounded bottom. It may or may not be a direct continuation of the main burrow below the cluster cavity. The diameter is usually the same as that of the main burrow or it may be irregular in shape. There may be more than one burrow descending from the cluster cavity in different places or there may be none as in about 45% of the nests that were dug up throughout the
season. The length of this burrow ranges from a few millimeters to 30 cm or more, depending on the time of year, the history and the stage of development of the nest. Nests that are one or more years old usually have a long blind burrow in the early spring. This is the remains of a hibernation burrow. During the summer (Fig. 93) this burrow becomes at least partially filled with earth excavated from the cluster cavity, but by fall the burrow is again extended to various depths depending on weather and soil conditions. Nests without blind burrows in the spring are invariably new nests started by a single female in a new location. If nests are found with several short burrows descending from the cluster cavity, the cavity is probably being expanded. The blind burrow is usually without branches except at the bottom of the hibernation burrow where bees may build individual cell-length extensions in which to pass the winter (Fig. 97). It is possible that the deeper terminal burrows are maintained to serve some homeostatic function as suggested by Sakagami and Michener (1962). During the summer, if the soil should become too dry at the level of the cell cluster, the terminal burrow is extended and a new cavity is constructed at a lower depth (see Nest Construction). At the beginning of such activity, the blind burrow may look branched. Sometimes there are short burrows to the side of the cavity. These, apparently, are retreats where inactive bees rest. Such inactive bees have been seen in observation nests and if disturbed will fight off other bees. Branches may extend near the top or side of the cluster cavity and bend
Fig. 93. Mean depths of nests in centimeters. A. Total depths of nests. B. Lengths of blind burrows.
downwards. These represent the initial stages in the expansion of the cluster cavity.

Few differences in the structure of burrows could be found between nests of *striata* and *persimilis*. Side branches from the upper burrows were more frequently found in nests of *persimilis* than in those of *striata*, but this could be due to the times of year when nests were opened for study. The blind terminal burrows often seem to persist throughout the summer in nests of *striata* but are rarely found during July and August in nests of *persimilis*.

The Cluster Cavity: The cavity containing the cell cluster is, in its final form, a smooth-walled enlargement of the main burrow with an irregularly spherical or elongate shape. It may occur part way along the burrow or at its end and may be built to one side of the burrow, or the burrow may be central with respect to the cluster (Figs. 96 and 98). A central or slightly off-center position is most common (85% of all nests), the position apparently dependent on the method by which the cavity was constructed (see Nest Construction).

The space between the cell cluster and the wall of the cavity is usually about equal to the diameter of the burrow. The mean overall dimensions throughout the season are given in Table 4.

The depth of the cluster cavity depends chiefly on the moisture content of the soil at the time of its construction. In drier soils or at a dry time of year, the clusters are deeper, so that it is not uncommon to find two or even three separate clusters at progressively lower depths, since the soil ordinarily becomes dryer as the summer
TABLE 4. Mean height and width in millimeters of cluster cavities.

<table>
<thead>
<tr>
<th></th>
<th>persimilis</th>
<th></th>
<th>striata</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>length</td>
<td>width</td>
<td>length</td>
<td>width</td>
</tr>
<tr>
<td>MAY</td>
<td>20.63</td>
<td>21.67</td>
<td>22.87</td>
<td>17.87</td>
</tr>
<tr>
<td>JUNE</td>
<td>29.33</td>
<td>24.50</td>
<td>27.07</td>
<td>26.10</td>
</tr>
<tr>
<td>JULY</td>
<td>20.50</td>
<td>15.00</td>
<td>32.13</td>
<td>23.00</td>
</tr>
<tr>
<td>AUG.-OCT.</td>
<td>29.33</td>
<td>23.50</td>
<td>30.09</td>
<td>22.40</td>
</tr>
</tbody>
</table>
progresses. There is therefore considerable difference in mean depths at the different aggregations and at different seasons as seen in Figure 94. At DP the aggregation is in the woods, well shaded during the summer, often with a thin humus layer over the surface. The soil is clay and holds the moisture well except in exceptionally dry years. Two other sites (SS and SP) in open fields had, at most, some grass cover, and the soil often became dried and cracked during the summer. Out of a total of 121 nests excavated at these three sites, 19 had multiple clusters. Only 6% of the nests at DP had multiple clusters and the depth of active (deepest) clusters did not increase much during the season, whereas 26% and 39% had two or more clusters at SP and SS respectively so that the mean depth of active (deepest) clusters increased during the season (Fig. 94).

The Cell Cluster: The cells are grouped together in a cluster or comb supported by means of earthen pillars in the cluster cavity. The pillars are smoothly rounded, variable in size and number and run from the sides of the cluster to the cavity wall. In soil with many roots, as in grassy areas, the cell cluster often incorporates the rootlets into its construction and is, therefore, at least partially supported by them. Sometimes also, a pillar is built around a rootlet. In many cases, especially when the number of cells is being increased, the cluster may be broadly joined to the cavity walls in one location, to form a broad pillar or bridge of earth.
Fig. 94. Mean depths of active (deepest) cell clusters at three aggregations: Daly's Place, solid line; Sycamore Slope, dashed line; State Property, dotted line.
The cluster consists of a varying number of cells (Fig. 95) lying parallel to each other, usually horizontal (Fig. 96) or subhorizontal in position, with their anterior ends tilted slightly upwards (Fig. 106). They are built in a sequence as illustrated in Figs. 108 to 114. The addition of new cells usually occurs at the top or bottom of the cluster, or after the cluster has reached a certain size, anywhere that there is space around the edges. Occasionally cells are added to the sides, making a cluster that is wider than long (Fig. 113). During the summer, old cells may often be cleaned and reused. At this time the closed end of the cell is removed so that a cylindrical hole may be found through the cluster near the center (see Nest Construction). Only a few cells are reused in this way and only one is reconditioned at a time. Other old cells remain uncleaned and later get filled with earth. In some persimilis nests (4 out of 38), one or more cells were built apart from the others and oriented in a different direction. These were always at the edge of the cluster and often placed in the broad attachment areas of the cluster noted above and were only observed in nests with numerous cells. In nests of known striata, such cells were found in 4 out of the 86 nests excavated.

**Cells:** The cells are like those of other halictine species, rounded at the posterior end, constricted at the neck and with the bottom surface somewhat flattened (Fig. 115). Cells of striata are 9 to 11 mm long, 4 to 5 mm in diameter at the widest point and about
Fig. 95. Mean number of cells and adults per nest. Since only two nests of persimilis were examined during July, those means are of questionable significance.
Figs. 96-106. Diagrams of actual nests. White areas indicate burrows or cavities. Stippled areas inside the nest indicate earthen supports connecting cell cluster to outside walls of cavity. Irregular lines inside nest indicate unexcavated earth through which connecting burrows have been made.

Fig. 96. Complete nest of *Augochlorella striata* showing short turret, constricted entrance, side burrow, main burrow, cluster cavity and cell cluster, a short blind burrow and blind terminal burrow.

Fig. 97. The end of a hibernation burrow, showing hibernacula.

Fig. 98. The enlargement of main burrow to form lateral cluster cavity.

Fig. 99. A single constructed cell supported in cavity.

Fig. 100. A single cell constructed on top of loose earth.

Fig. 101. Construction of cluster cavity by branched burrows.

Fig. 102. Construction of cell into center of loose earth.

Figs. 103-104. Cluster cavity formation by extensions of branch burrows.

Fig. 105. Enlargement of cluster cavity by extension of branch burrows.

Fig. 106. Cell construction before completion of a cavity.
Fig. 107. Diagram of large cell cluster with constricted center between older and newer parts. Short side burrows indicate regions for new expansion.
Figs. 108-114. Construction sequence of cells from representative nests of both *Augochlorella persimilis* and *striata*. Numbers indicate cell contents as follows: 1. new cell, empty; 2. being provisioned with pollen; 3. egg; 4. small larva; 5. medium sized larva; 6. three-quarters grown larva; 7. full grown larva (all food consumed); 8. prepupa; 9. white pupa; 10. white pupa with eyes colored; 11. partially colored pupa; 12. entirely colored pupa; 13. imago; cells without numbers are old used cells. Cells with heavy dark lines have been reused.
Fig. 115. Cell cluster with cavities and burrows cast with plaster showing cells containing egg and larvae. Scale at right is in millimeters.
3 mm at the entrance or neck. Those of *persimilis* are 7 to 8 mm long and 3 to 4 mm at the widest part. The cells within any one nest are not necessarily of equal sizes, the differences, perhaps, depending on the size of the bees that constructed them.

The inside of the cell is smooth and coated with the transparent waxlike substance found in cells of most other halictines. Beneath this coating the walls are smooth but show small depressions, apparently made by the bee during construction when tamping the walls with her abdomen (Fig. 115). The walls of the cells vary in thickness, so that the earth between two adjacent cells varies from about 1/3 mm at the widest part of the cell to about 1/2 mm in the neck region (Fig. 115). For this reason the axes of the cells are more or less parallel and the front and rear surfaces of the cluster are about equal in area.

The closure or plug of a completed and provisioned cell is about 1 mm thick and consists of small, chunks of finely granulated earth. These chunks are placed firmly together in the entrance of the cell but are not compacted or smoothed in any way and do not form a spiral or other type of pattern. The result is a firm but rough and granular plug that may be easily crumbled when dry. No coating or secretion could be detected in or on the plug.

Other Species: The only other species of *Augochlorella* whose nests have been seen is *A. michaelis* (Vachal), a species found in Brazil. The three nests found (Michener and Lange, 1958b), differed from
each other in size (i.e., age) and therefore reflected differences in certain structural details. But they differed from *striata* and *persimilis* nests in some fundamental architectural features.

The main burrows in nests of *michaelis*, unlike those of *striata*, were in each case built nearly horizontally into a bank of earth. If *striata* or *persimilis* build into banks, their burrows almost immediately bend downward, so that in all cases the main burrow is mostly vertical. The cells in nests of *michaelis* are built in a cluster like those of *striata*, are located to one side of the burrow and open directly into the burrow or an enlargement thereof. In two of the nests (containing only a few cells) the cells slanted downward at a $45^\circ$ angle whereas the cells of the third nest (with many cells) all were horizontal. Although cells of *striata* may be horizontal or slanting, they have never been found to slant as much as those of some *michaelis*. In a nest of *striata*, there is usually a cavity or space between the cells and the surrounding earth, although it may be lacking or incomplete around clusters with few cells. In *michaelis* this space was not present in the smaller nests although a cluster could be removed from the earth in one piece and is, therefore, built apart from the adjacent hard earth, rather than excavated into it. In the larger nest, a network of passageways extended around the cluster, thus, in effect, forming an irregular or incomplete cavity around the cluster as is sometimes found in *striata* nests.
NEST CONSTRUCTION

The material in this section is based on numerous observations and on nests in all stages of construction found in the field. New nests are started in the spring, either by single queens excavating a nest in a new location or by one or more females utilizing the nest site of the previous year. If a new site is selected, the bee starts digging into the ground with her mandibles. Loosened earth is collected into a small, irregularly shaped ball with the front legs and then passed back to the middle and hind legs and pushed out of the hole. If the burrow is long, the ball is dragged backwards up the burrow between the front legs and under side of the head, then is passed to the back legs and kicked out the entrance. The bee works first on one side of the hole then on the other, so that the burrow is circular and slightly greater in diameter than the bee. Periodically the bee stops digging to check and smooth the entire length of the burrow. She works up and down in the burrow or occasionally moves in a spiral. The antennae and mouthparts go over a small area at a time, and any rough spots are leveled with the mandibles. Depressions are filled in with bits of dirt and the wall is then tamped with the front of the head, probably the clypeus. The bee then turns around so that her head is downward in the burrow and tamps the entire surface with the posterodorsal tip (pygidium) of the abdomen. This procedure is continued until the burrow is smooth and firm, then digging is resumed. Thus excavation and smoothing go on simultaneously.
Once the main burrow is made, the entrance may be repaired, or sometimes a turret constructed. If the entrance is shaped or turret made, a small ball of finely granulated earth, the size and consistency of that removed during excavation, is brought backwards up the burrow as before. When the tip of the abdomen reaches the top of the burrow or a depression in the side of the burrow, it begins tamping movements, and at the same time earth from the ball is gradually fed backwards and tamped into place. When earth is added at the margin of the entrance, the abdomen is used to guide its position, with the result that the earth is placed in the lowest spot along the rim. The bee works on one side for a while, then comes up facing another direction to work on another side, so that the turret remains symmetrical as it grows in height. After four or five trips the bee comes up head first and inspects the area with antennae and mouthparts, makes minor repairs, then continues tamping and adding to the turret. Time needed to bring dirt up from below averages 30 seconds per trip. This brief interval indicates that the bee does not go far for the dirt, presumably only as far as a short side burrow just below the entrance.

The next structure to be made is the cluster cavity. Nests found in various stages of development show that the cavity may be formed in various ways. A common method is by simply enlarging the main burrow either at its end (in the case of newly started nests) or at a point along the burrow (in the case of nests from a previous year with a long hibernation burrow). In the latter instance, the burrow below
the enlargement becomes automatically the blind burrow in the terminology of Sakagami and Michener (1962). Enlargement is accomplished by scraping or excavating earth from one or more sides of the burrow. The cavity may therefore occur to one side of the burrow (Fig. 98) or be centrally located with the main burrow entering the cavity at or near its center. The excess earth may be deposited outside the nest, in the side or blind burrows, or some of it may remain as loose earth in the cavity (Fig. 101). Another common method of making a cavity is by the downward extension of two or more curving branch or terminal burrows until they meet again at a lower point (Figs. 101 to 104), after which the intervening earth is removed, or some of it may be left in a compact pile at the bottom or side of the cavity. In this case the resulting cavity is usually centrally located in relation to the burrow. Sometimes a combination of both methods is used (Fig. 105).

The first cell is apparently formed according to the nature of the cavity and the amount of loose earth available. Occasionally one or two cells are dug into the substrate or into a pile of loose dirt before the cavity is complete (Fig. 106), but if four or more cells are present they are always surrounded by a cavity. In an otherwise empty cavity, the first cell is usually suspended between two or more pillars (Fig. 99). In this case both pillars and cell are smoothly molded and probably constructed in a manner similar to that of the turret, and the cell is surrounded by the air space of the cavity. When a mass of loose earth occurs in the cavity (Fig. 100) the bottom
of the first cell is usually built into the earth and forms an integral part of the mass, but the sides and top of the cell are distinctly built up, or constructed, as can be seen from partially completed cells. Cells may also be built into the center of a mass of loose earth (Fig. 102). In this case it must be assumed that the cells have been excavated, although their inside walls are as firm and smooth as other obviously constructed cells and presumably are added after excavation. When cells are built into the wall of the burrow or of a partially completed cavity, a space or roughed out cell slightly larger than a finished cell is formed in the hard earth. Loose granules of earth are then brought in and the smooth cell wall is constructed. This is as in all halictines which excavate cells, so far as known. At least for cells being constructed in the cavity, the floor of the cell is made first unless the cell is being added to the lower side of a cluster. After the floor is at least mostly complete, the rear end and sides are finished. The top of the cell is put on last. As during construction of a turret, the cell is smoothed on the inside as it is being built, and the waxlike layer is applied simultaneously since all areas of partially built cells were always found to be smooth and lined.

After the first cell is made, provisioned and closed with a firm but granular plug of dirt, another cell is built adjacent to it, usually either slightly above or below the first cell. Subsequent cells are added as illustrated in Figs. 108 to 114. The suggestion
of Sakagami and Michener (1962) that construction of several cells simultaneously is a prerequisite to establishment of social behavior is not applicable to *Augochlorella*.

The cells are added onto the cluster wherever there is space between the cluster and cavity wall. Expansion of the cavity is accomplished in ways similar to the original excavation. The cavity may be widened or lengthened to a limited degree by scraping earth from existing walls, but the usual method is by extending two or more short burrows below the existing cluster cavity so that the cavity and cell cluster is enlarged downward. Many of the larger cell clusters and cavities show evidence of this type of expansion with a distinctly narrowed area at the middle of the cluster indicating the lower end before expansion (Fig. 107). Apparently only one such major enlargement is made. By the time this becomes filled with cells, some old cells are vacated and available for reuse. Further peripheral expansion therefore is not necessary although new cells are occasionally added at the edge of the cluster if space is available (Figs. 107, 113). One or more burrows may also be dug into the earth beside the cluster cavity resulting in the eventual enlargement of the cavity laterally (Fig. 107).

Some halictines do not enlarge the cavity and separate clusters are therefore built to allow for expansion. This is true of forms such as *Lasioglossum duplex*, which excavates its cells and then the cavities around them instead of building the cells in a cavity as is usual in *Augochlorella*. Additional clusters in *persimilis* or *striata* are not
built for the purpose of expansion, however, for when a second cavity and cluster is built, the first is essentially abandoned and none of its cells are reused. From many observations of multiple clusters it seems certain that new clusters are built deeper in nests primarily as a response to dry soil conditions at shallower levels rather than to provide more space.

As mentioned above, old cells may be reused. This can be demonstrated in those clusters where young offspring occur in cells at the center of the cluster and are surrounded by older larvae and pupae (Figs. 113, 114). The bees clean old cells by removing the posterior ends containing the larval fecal material so that a smooth, cylindrical tube can be seen extending through the cell cluster. A new rear end is then constructed on the cell. Only one cell seems to be reconditioned at a time since no more than one such tube was ever found in a single nest. Cells are apparently reused only in nests with cell clusters of seven or more cells.

After the middle of August, cell construction ceases. Many nests at this time have a short blind burrow, but this is gradually lengthened, in the weeks that follow, into a hibernation burrow. The excavated earth is placed in empty cells, in side passages, and eventually in the cavity surrounding the cell cluster, so that by October only a single burrow remains open to the surface. If the available spaces below ground are filled, earth is brought to the surface and deposited in a loose pile or tumulus around the entrance. The entrance
thus gradually becomes plugged, and the burrow below it becomes loosely plugged at irregular intervals down to the depth at which the bees are hibernating. In every case when nests were excavated during midwinter, hibernation burrows terminated at depths below the frost line. The bees in all cases were immobile or could move only very slowly.
NEST CONTENTS AND POPULATIONS

Provisions and Immature Stages: Cell clusters excavated in the field were brought to the laboratory to be opened and examined. The eggs, larvae and pupae were sometimes preserved for future study, but attempts were also made to rear them to adulthood in the laboratory. Thirty such individuals were successfully reared, but if larvae were not yet half-grown when collected they did not mature, possibly because of high or fluctuating room temperatures in the laboratory (26° to 43° C). The entire sequence, from the start of provisioning to the emergence of the imago, was found in the numerous cells that were opened during the course of study. The estimate of the duration of each stage is based on the relative number of individuals of each stage present in the nest (see also Tables 5, 6), on experiments in which the pollen loads of returning bees were marked with colored powders (see Michener et al., 1955) and on the comparative duration of each stage in the laboratory.

Usually only one cell is built and provisioned at a time, with all pollen collectors in the colony cooperating to provision the cell. This process takes between one and two days to complete, judging by the marking experiments and by the developmental duration of successive larval stages reared in the laboratory (mature larvae from any one nest pupated at about 24 to 48 hour intervals and adults emerged at similar intervals). The time it takes to provision a cell depends on the types and abundance of flowers available (see section on
Foraging), on the number of worker bees in a nest, and on weather conditions that permit collecting to take place.

Dry pollen is brought into the nest on the scopas of the females and deposited near the posterior end of the cell. After a few loads have accumulated, a small, moist, irregularly shaped ball is made. More dry pollen is then brought in and deposited near the ball. When a small amount has accumulated, it is added to the ball and moistened, presumably with nectar. The ball becomes rounded as it grows and is located at the posterior end of the cell. This process continues until the pollen mass forms a cake, flattened on the top, of from 4 to 5 mm in diameter and 2 mm deep (Fig. 115, upper cell). This cake keeps its shape as a compact mass but easily breaks into pieces when moved or handled. A smooth, white, arched egg is laid on top and near the front of the pollen mass (Fig. 115).

Eggs of *striata* range in size from 2.2 to 2.56 mm. Other eggs, perhaps those of *persimilis* are 2.0 to 2.36 mm long. The egg rests on its anterior and posterior tips with its axis oriented with the length of the cell and its anterior end facing the anterior end of the cell (Fig. 115, upper cell). Frequently, small drops of moisture are found on top of the egg when the cell is opened. This may be due to condensation when the cluster was removed from the cavity, but this same phenomenon has been noted on eggs of other halictines as well (Michener, verbal communication; Batra, 1964) and may serve some function in the development of the egg.
Provisioning and egglaying start about the first week in May and continue through August (latest egg, species doubtful, was found on August 27). Since most active nests contain only one to three eggs at a time, the duration of the egg stage must be about three days. Up to five eggs have been found in a single nest (one nest in early June) but this is unusual. In *striata* colonies, eggs are most numerous during early May (eggs plus half-grown larvae were found on the 7th) and again during late June, after the first brood has emerged (Table 5). Between these two periods of egg production, many colonies are inactive. During July and August, production continues at a low but steady rate, but the number of eggs per nest decreases (Fig. 116) as a result of an increasing number of inactive nests (see below). Few eggs are laid after the end of July.

Peak egg production in *persimilis* colonies seems to take place during the middle of May, about two weeks later than *striata* (Table 5). After a brief period of inactivity at the end of May, before individuals of the first brood emerge, egg production is resumed and continues through June and probably rather steadily through the rest of the summer at a rate somewhat higher than that in *striata*, judging by the total number of cells per nest at the end of the season (Fig. 116). As in *striata* the mean number of eggs per nest decreases as the number of inactive nests increase during the season. The numbers of nests studied, especially of *persimilis*, are too small to make the differences indicated in this paragraph certain but the results seem worth recording.
Table 5. Numbers of eggs found in nests by five day periods. Figures indicate the numbers of nests found containing the designated number of eggs. Thus for *persimilis*, May 6-10, five nests were found to contain no eggs and one nest had one egg.

<table>
<thead>
<tr>
<th>No. of eggs</th>
<th>May 5 10 15 20 25 30</th>
<th>June 5 10 15 20 25 30</th>
<th>July 5 10 15 20 25 30</th>
<th>August 5 10 15 20 25 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRIATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PERSIMILIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Fig. 116. Mean numbers of eggs (solid lines), larvae (dotted lines), and pupae (dashed lines) in nests of *A. striata* and *persimilis* throughout the nesting season.
NUMBER OF NESTS

STRIATA

PERSIMILIS

MEAN NUMBER PER NEST

MAY JUNE JULY AUG. SEPT.

MAY JUNE JULY AUG. SEPT.
When the larva hatches, it flattens itself against the pollen mass (Fig. 115, lower cell) and starts eating at the anterior end of the pollen ball. As the larva eats, its mandibles open and close in a steady rhythm and its head moves slightly from side to side, very slowly and with a slight bobbing motion. At any one time (depending on the size or age of the larva) the head is held at a specific angle to its body (or gravity?), so that under normal conditions the mouth is in continual contact with the pollen ball. If a larva falls off its pollen ball (during transport from field to laboratory) and is not replaced in the exactly proper position in relation to the pollen ball, or if the cell containing a larva on its pollen ball is laid flat instead of in a tilted position, the larva will continue its feeding motions but will not have its mouth parts in contact with its food and will die within a few days. Correct orientation was found to be necessary for very young larvae as well as half grown larvae and is probably necessary in all developmental stages. It may be a factor in the vain attempts to rear young larvae.

Larval development takes an estimated 10 days from the time the larva hatches to the time it has exhausted its supply of food. Due to the longer developmental period there are normally more larvae per nest than eggs. As the larva grows, it eats around the pollen ball until it has consumed most of its pollen. At this time, it gradually twists to the side with its anterior and posterior ends against the sides of the cell. As a mature larva, it is shaped like
a C with its anterior end at the top of the cell. Gradually the larva straightens out, resting on its dorsum, with its head at the anterior end of the cell. It is still partially curled so that the tip of the abdomen is against the upper posterior wall. The larva then begins to defecate, moving its posterior end from side to side and applying the fecal pellets to the cell wall until the whole posterior end of the cell is layered with feces. After defecation the larva is a prepupa and remains in this stage for about three days (2 to 4 days in the laboratory), then molts into a pupa remaining in this stage from 7 to 16 days (averaging about 13 days).

The number of pupae per nest increases through August in striata nests and through mid-September in persimilis nests (Table 6). Considerably more pupae are found in nests of persimilis than in those of striata the larger number being correlated with the greater adult persimilis population at this time of year.

Upon emergence, the imago remains in its cell until its body and wings have hardened. Adults with milky or soft wings were found only in plugged cells and never in nest passageways or cavities. Males probably leave the nest shortly after they open their cells since few are found in the nest passageways when nests are excavated. Females remain with the colony for the rest of their lives or overwinter and found new colonies in the spring.

**Cells:** During May, in nests of striata, 0 to 6 cells were found. Most nests (9 out of 14) contained 2 to 4 cells with a mean of 2.9 cells per nest. During the same period, in persimilis nests, the
Table 6. Numbers of pupae found in nests by five day periods. Figures indicate the number of nests found containing the designated number of pupae.

<table>
<thead>
<tr>
<th>No. of pupae</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25 30</td>
</tr>
<tr>
<td>STRIATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

| PERSIMILIS   |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 15           |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 14           |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 13           |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 12           |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 11           |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 10           |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 9            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 8            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 7            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 6            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 5            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 4            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 3            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 2            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 1            |      |       |       |        |        |      |       |       |        |        |      |       |       |        |        |
| 0            | 6    | 1     | 1     | 4      | 1      | 1    | 3    | 1      | 1      |        |      |      |       |        |        |

282
number of cells found, ranged from 0 to 8 with a mean of 2.7; most nests (9 out of 12) contained 0 to 2 cells. There is little evidence to indicate that the mean number of cells per nest is increased by an increase in the number of bees in a nest during this early period. As is shown in Table 7, most nests contain from one to four cells regardless of the number of bees present. Nests with multiple queens in the spring may sometimes, however, have a larger number of cells in them than nests with only a single queen. (One *persimilis* nest in May contained three queens and seven cells, and one in June with 10 cells still had two queens present. A colony of *striata* with two queens had produced six cells by the end of the first week in May!)

The number of cells in a nest increases during the season (Fig. 95), the number at any particular time depending on whether the colony has been continually active during the season, whether the nest has been parasitized, on the moisture content of the soil, on the number of cells being reused (later in the season), and doubtless on other factors as well. As the June broods emerge and effects of early parasitism and queen inactivity (see below) start to wear off, the nests become reactivated, and the number of cells in a nest increases at a rapid rate. By September it is not uncommon to find nests (particularly of *persimilis*) with 20 to 40 cells although these are usually earth filled so that the total number of cells frequently was not recorded. Thus, during the early part of the season, in May, nests of *striata* seem to contain a greater number of cells per nest
Table 7. The number of cells in relation to the number of bees per nest before emergence of the first brood. Numbers indicate number of nests found.

<table>
<thead>
<tr>
<th>Adults per nest</th>
<th>Cells per nest</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
than do those of *persimilis* but fewer bees per nest. In the fall, the *persimilis* nests are usually the larger and have higher populations.

**Adults:** During May, before the first broods emerged, a total of 47 nests was excavated. Each was occupied by 1) a solitary queen (a female with enlarged ovaries), 2) two or more queens, 3) a queen with from one to three workerlike females (individuals with slender ovaries), 4) one or more individuals with slender or partially developed ovaries or 5) no bees whatever (see section on Castes).

At this time, nests of *striata* contained up to four females per nest including the egglaying queen. Most of the 13 nests had either a solitary individual with or without enlarged ovaries (6 nests) or an egglaying queen plus one other female (4 nests). Two nests contained multiple queens.

During the same period, 10 nests of *persimilis* contained up to 5 individuals including the egglaying queen, most of the nests being occupied by either one queen and one or more workerlike females (4 nests) or multiple queens plus one or more workerlike females (3 nests). Only one nest contained a solitary queen. Thus, it appears, from the small sample studied, that there are more independent nests started in the spring by *striata* queens than by *persimilis* queens but there are more queens per nest in *persimilis* colonies.

During June, adults of the first brood are continually emerging, and yet the average number of females per nest does not increase (Fig. 95). A few new nests are founded at this time (4 out of 51
nests in June), but they are too few to account for this lack of increase in adult female population. Many of the older bees that had helped to found the nests die off at this time as evidenced by the decrease of worn bees (see Castes) from June to July. (Because of a time lag before new bees replace the old ones on flowers, Table 13 shows replacement taking place in July.) From July on, nest populations increase (Fig. 95) as young females are continually being produced and replacement of the old individuals continues.

Periods of Colony Activity: Nearly all nests at all aggregations had periods of activity or inactivity that lasted from several days to several weeks. There is frequently a delay of two or three days between eggs or series of eggs, sometimes due to poor weather conditions that prevent bees from collecting pollen. Longer delays may result if a new cluster is built (see Nest Construction), if the queen is lost, or if the nest contents are parasitized. A colony is considered to be inactive if there are no eggs or small larvae present. It is considered to be reactivated if there are eggs or small larvae but no medium sized larvae, or similar gaps at any stage, suggesting a delay of at least 10 days. Activity can best be observed externally by the frequency of bees entering or leaving the nest or internally by the number and age of offspring within an excavated nest. When observed from the outside, most colonies would appear to be inactive most of the time except for the guard that is usually at the nest entrance during the summer. This apparent inactivity is due to the
prolonged trips made by the foraging bees and by the comparatively few bees in many colonies, factors which together keep traffic in and out of the nest at a minimum (see section on Foraging).

When colonies are temporarily inactive, various members of the colony may take turns guarding the nest. Bees occasionally leave the nest for several hours but return without pollen. The nests of colonies that are inactive for long periods usually remain open only if there are adult bees inside. In such nests, even if bees are present, they rarely guard, and entrances, although open, are usually unrepaired. Normally, about 50% of the nests die out during the season (Table 8), either because the nests are destroyed (by ants, beetles, etc.) or because the queen is lost and not replaced or for reasons that are not obvious. In 1963 (Table 9), less than 20% of the nests survived a severe drought that dried the soil to below 15 cm in many areas and prevented the construction of new cells except in those nests where cell clusters were deep in the ground (see Nest Construction). In 10 nests excavated during July and August of that year, all but one contained adult bees, but only three had viable offspring. The others contained dried cell clusters with old earthfilled cells or dead and dried brood. Live young adults of Sphecodes pimpinellae (a nest parasite) were found in three of these nests although Augochlorella brood had been unable to survive in two of the same nests.

In colonies that become reactivated, the queen may have remained in the nest during the inactive period, or she may have been replaced
Table 8. Number of nests open at DP (1960). Records taken irregularly about every 4-5 days (* indicate number of nests dug up, 
8 = 20%).

<table>
<thead>
<tr>
<th></th>
<th>Total no. nests open V-16 or earlier</th>
<th>Total no. nests found by VI-1</th>
<th>Total no. nests found by VII-7</th>
<th>Total no. nests found by VII-3</th>
<th>Total no. nests found by VIII-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. open VI-1</td>
<td>12***</td>
<td>17*</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% open VI-1</td>
<td>70</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. open VII-7</td>
<td>9</td>
<td>13</td>
<td>16</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% open VII-7</td>
<td>53</td>
<td>56</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. open VIII-1</td>
<td>8</td>
<td>12</td>
<td>13</td>
<td>20</td>
<td>--</td>
</tr>
<tr>
<td>% open VIII-1</td>
<td>47</td>
<td>52</td>
<td>50</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>No. open VIII-29</td>
<td>7</td>
<td>11</td>
<td>12*</td>
<td>17*</td>
<td>23</td>
</tr>
<tr>
<td>% open VIII-29</td>
<td>41</td>
<td>48</td>
<td>46</td>
<td>51</td>
<td>59</td>
</tr>
<tr>
<td>No. open IX-26</td>
<td>7</td>
<td>11</td>
<td>12</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>% open IX-26</td>
<td>41</td>
<td>48</td>
<td>46</td>
<td>51</td>
<td>54</td>
</tr>
</tbody>
</table>
Table 9. Number of nests open at DP (1963). Records taken at weekly intervals. The number of nests increases through the season as new nests were found by the observer; percentages open are based on totals found up to the date indicated (* indicates number of nests dug up, 4; destroyed by ants, 4 = 9%).

<table>
<thead>
<tr>
<th></th>
<th>Total no. nests open V-13 or earlier</th>
<th>Total no. nests found by VI-3</th>
<th>Total no. nests found by VII-3</th>
<th>Total no. nests found by VIII-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. open VI-3</td>
<td>17</td>
<td>29</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>% open VI-3</td>
<td>81</td>
<td>91</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>No. open VII-3</td>
<td>8</td>
<td>16</td>
<td>25</td>
<td>--</td>
</tr>
<tr>
<td>% open VII-3</td>
<td>38</td>
<td>50</td>
<td>60</td>
<td>--</td>
</tr>
<tr>
<td>No. open VIII-7</td>
<td>7</td>
<td>14</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>% open VIII-7</td>
<td>33</td>
<td>44</td>
<td>52</td>
<td>53</td>
</tr>
<tr>
<td>No. open IX-4</td>
<td>4</td>
<td>8*</td>
<td>9***</td>
<td>9</td>
</tr>
<tr>
<td>% open IX-4</td>
<td>19</td>
<td>25</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>No. open X-2</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>% open X-2</td>
<td>19</td>
<td>22</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>
by another member of the colony (see Castes). As the percentage of inactive nests increases during the season, the percentage of reactivated nests also increases, at least through July (Table 10). Few nests become reactivated later in the season since the production of new brood declines after the end of July (*striata*) or mid-August (*persimilis*) (see above).
Table 10. Seasonal activity and inactivity of nests of *striata*, *persimilis* and total (including undetermined) *Augochlorella*.

Inactive nests do not have eggs or young larvae (see text).

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of inactive nests</th>
<th>No. of reactivated nests</th>
<th>No. of inactive parasitized* nests</th>
<th>No. of reactivated queen-parasitized nests</th>
<th>No. of less parasitized nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>14</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>S</td>
<td>12</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>43</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>June</td>
<td>18</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>S</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>22</td>
<td>13</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>July</td>
<td>12</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>S</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>19</td>
<td>11</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Aug.</td>
<td>20</td>
<td>12</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>19</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

*Parasites: Sphecodes pimpinellae and mutillids, Pseudomethoca frigida (see Ordway, 1964).*
CASTES

Most studies on mechanisms of caste differentiation have been made on the more highly social insect societies in which the castes are readily distinguishable by size, morphological and behavioral differences. Brian (1957) has reviewed much of this literature. Michener (1961) has discussed the differentiation and determination of castes in the social Hymenoptera and includes information on the primitively social species in which there is little or no polymorphism; Plateaux-Quéné (1961) has briefly described the castes of all groups of social insects, also including the primitively social species. Among the social halictine bees, the castes are distinguished by functional or behavioral differences (division of labor within the colony and related internal or physiological features such as ovarian development, mating, and longevity). The wing and mandibular wear also give useful information on activities and probably often age of individuals.

In Augochlorella striata and persimilis, even these features are not always decisive and some conditions which are indicative of caste in many halictines occur in both castes of Augochlorella. Differences between castes were studied by collecting entire nest populations as well as foraging bees, measuring and dissecting them to determine size, ovarian development, and the contents of the crop and spermatheca. In many cases the bees from nests had been marked so that their role, prior to dissection, in the activities of the colony was partly
known. In general, the techniques recommended by Michener et al. (1955) and Michener and Wille (1961) were used.

Ovarian Development: The development of the ovaries in both striata and persimilis is similar to that of Lasioglossum imitatum (= inconspicuum, Michener and Wille, 1961) and can be used with slight modifications, together with data on insemination, to divide the bees into groups as follows:

A. Inseminated, with ovaries much enlarged (Fig. 117). At least two of the ovarioles of each ovary contain distinctly enlarged oocytes with one fully developed or almost fully developed ovarian egg (1.5 mm or larger) present in one of the ovarioles. There is rarely the bent or convoluted appearance that is found in ovaries of imitatum, and only one mature ovarian egg is present at a time.

B. Inseminated, with moderately enlarged ovaries (Fig. 118) (largest oocyte between 0.9 and 1.5 mm) but no single large egg ready for laying. A female may be in this condition just after she has laid an egg, and might be expected to alternate from Group A to B as she lays eggs. Bees of Groups A and B are considered to be queens.

C. Inseminated, with all ovarioles slender except for one that is enlarged and contains a mature or nearly mature ovarian egg (Fig. 119). Unlike the condition in imitatum, bees with such ovaries are always inseminated.

D. Inseminated, with slender or only slightly enlarged ovaries (largest oocyte less than 0.9 mm) (Fig. 120).
Figs. 117-120. Diagrams of ovarian development of females placed in Groups A to E. Fig. 117. Ovaries much enlarged, Group A; Fig. 118. Ovaries moderately enlarged, Group B; Fig. 119. Ovaries slender except for one enlarged ovariole, Group C; Fig. 120. Slender ovaries, Groups D and E.
E. Uninseminated, with slender ovaries.

The ovaries are considered slender if they have only small oocytes and clumps of nurse cells, or if they are long, thin and ribbonlike, or short and cylindrical but with no distinct oocytes visible upon dissection (without sectioning). Sometimes the spermatheca was lost during dissection. Data from such specimens were not used when Groups D and E were being compared but were considered when the two groups were lumped together. The groupings were so similar in _striata_ and _persimilis_ that until otherwise specified the two species will be discussed as one although the data are presented separately in the tables.

All stages of ovarian development (i.e., enlargement) occur from D to A since all bees belong to Group E on emergence from the pupal stage and may develop progressively to any of the other groups. Also, under certain conditions, oocytes of queens are resorbed and ovaries may shrink in size. As mentioned above, Group A individuals regress to B; they may also seemingly regress to Group D. Such individuals are called Group D' (see below). In nest populations during May, before the first brood emerges, all groups from A to D occur. At this time, and only at this time, more than one bee in Groups A and B may be found in a single nest and in at least one _striata_ nest, it was evident from the number of cells present that more than one individual had been laying eggs in the cell cluster. More than one queen was found in 22% of the _striata_ nests (n = 23) and in 37% of
the *persimilis* nests (n = 16) during May (see Nest Contents). All females at this season had overwintered and presumably all could develop into queens, but some 40% do not (33% of the 50 *striata*; 47% of the 71 *persimilis*), and they appear to remain in the Group D condition. Throughout the rest of the season from late May through August there is, at most, only one individual in each nest that could be placed in either Group A or B, and bees in both groups are the egglayers or queens of the colonies. Queens are regularly found on flowers collecting pollen during May. But after the first brood emerges in early June, only C, D and E females collect pollen although A and B females may occasionally be found on flowers and were seen to enter and leave their nests throughout the season.

Only 11 females belonging to Group C were found, or about 2% of the bees examined. Three were taken in early May in one *striata* nest where there was another individual with more fully developed ovaries (Group A) present. One was in a nest of *persimilis*, in the middle of May, where there was also another egglaying individual (Group A) present. The rest were taken during May, June and August on flowers and at least two were collecting pollen. Females of Group C probably lay an occasional egg or possibly develop into auxiliary queens, should anything happen to the founding queen. In size, they are not significantly different from queens nor from the individuals of Groups D and E.
Females comprising Group D are found throughout the season. This group includes about 42% of the specimens examined or about half the females with slender ovaries, the percentage depending on the time of year (Fig. 121). In the spring, the group consists of overwintered individuals whose ovaries have not become enlarged, while in the summer it also includes the mated females of the summer broods as well as the temporarily or permanently inactive queens (Group D') usually distinguishable by their slightly enlarged, misshapen and lumpy ovaries that contain small, yellowish and irregularly shaped oocytes. During September, all females have slender or only slightly enlarged ovaries and therefore belong to Groups D and E. Group D at this time, consists of both worn and unworn individuals of the summer population and the new, unworn, or relatively unworn, individuals that have been mated and will overwinter to become the queens of the following spring. There is no significant difference in size between the worn and unworn groups in either species. During October, virtually the entire population belongs to Group D, as the worn individuals gradually die off and the young emerging females become mated. In size, they are not significantly different from either the worn or unworn September females. Throughout the nesting season all members of the D group actively collect pollen.

Group E are rare in early spring and late fall (Fig. 121). Only five individuals, or about 4% of the April and May females were found to be unmated (these were found only in 1963) and all had slender ovaries. The number of unmated individuals increases during June and
Fig. 121. Percentages of females of *A. striata* (left-hand column) and *A. persimilis* (right-hand column) belonging to Groups A to E during each month of the nesting season. Both field caught bees and specimens from nests are included.
July as new females emerge. Although a few males are produced at this time (Table 11), the percentage is low and few females become inseminated. As the male population increases during July, August and September, the percentage of unmated females decreases (Fig. 121). During the summer, Group E consists almost entirely of new females that have not yet become mated. Slightly worn individuals are found but they rarely become excessively worn (Table 13), indicating either that they are short lived or, more likely, that they mate and pass into Group D. Like those of Groups C and D, they also collect pollen. A few are found on the flowers in September, but by October (and April and May) they are about all mated, although as shown above and in Table 13, a few occasionally remain unmated through the winter.

**Size:** The width of the head and length of the wing were used as measurements of body size. These measurements are significantly correlated with other body measurements in the genus *Lasio glossum* (Michener and Lange, 1958) and are significantly correlated with each other at the .01 level in both *A. striata* and *persimilis* although the r values are only .6 and .5 respectively. In comparing differences in size among the castes, the length of the wing was used since more of these measurements were available for dissected individuals. Only those individuals were considered that could be definitely identified as either *striata* or *persimilis*, since these species differ in size. Measurements of the intermediates, or about one-fourth the total number of specimens available, were not used. Thus, it is possible
Table 11. Percentage of males among pupae or imagines still in cells from nests of both *striata* and *persimilis*. The decrease in percentage during September can be explained if males of the last brood emerge and leave the nests before the females.

<table>
<thead>
<tr>
<th>Month</th>
<th>Total pupae and young adults</th>
<th>% males</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>73</td>
<td>19</td>
</tr>
<tr>
<td>July</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>August</td>
<td>53</td>
<td>57</td>
</tr>
<tr>
<td>September</td>
<td>67</td>
<td>31</td>
</tr>
</tbody>
</table>
Table 12. Mean wing lengths (in millimeters) of females with enlarged and slender ovaries.

<table>
<thead>
<tr>
<th>Month</th>
<th>STRIATA enlarged ovaries (Groups A, B)</th>
<th>STRIATA slender ovaries (Groups C, D, E)</th>
<th>PERSIMILIS enlarged ovaries (Groups A, B)</th>
<th>PERSIMILIS slender ovaries (Groups C, D, E)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>x ± SE</td>
<td>n</td>
<td>x ± SE</td>
</tr>
<tr>
<td>APRIL</td>
<td>8</td>
<td>4.87 ± .11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MAY</td>
<td>29</td>
<td>4.60 ± .07</td>
<td>21</td>
<td>4.56 ± .11</td>
</tr>
<tr>
<td>JUNE</td>
<td>18</td>
<td>4.74 ± .13</td>
<td>32</td>
<td>4.56 ± .06</td>
</tr>
<tr>
<td>JULY</td>
<td>8</td>
<td>5.13 ± .12</td>
<td>37</td>
<td>4.62 ± .05</td>
</tr>
<tr>
<td>AUGUST</td>
<td>9</td>
<td>4.81 ± .13</td>
<td>72</td>
<td>4.57 ± .05</td>
</tr>
<tr>
<td>OCTOBER</td>
<td>22</td>
<td>4.87 ± .06</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 13. Percentages of females of *Augochlorella* in Groups A-B, C-D, and E showing seasonal wear of wings (W) and mandibles (M). Groups A-B are queens, C-D are inseminated workerlike females, E are uninseminated workerlike females and young females. The symbols represent: -, unworn; ±, slightly worn; +, moderately worn; ++, very worn (see text). N = total number of individuals.

<table>
<thead>
<tr>
<th></th>
<th><strong>A-B</strong></th>
<th></th>
<th><strong>C-D</strong></th>
<th></th>
<th><strong>E</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>±</td>
<td>+</td>
<td>++</td>
<td>N</td>
</tr>
<tr>
<td><strong>Apr.-May 15</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>97</td>
<td>3</td>
<td>38</td>
<td></td>
<td>89</td>
</tr>
<tr>
<td>M</td>
<td>78</td>
<td>18</td>
<td>4</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td><strong>May 15-30</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>76</td>
<td>12</td>
<td>6</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>M</td>
<td>65</td>
<td>15</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td><strong>June</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>77</td>
<td>18</td>
<td>5</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>65</td>
<td>10</td>
<td>20</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td><strong>July</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>70</td>
<td>25</td>
<td>5</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>55</td>
<td>27</td>
<td>18</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td><strong>Aug.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>60</td>
<td>13</td>
<td>7</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>M</td>
<td>32</td>
<td>24</td>
<td>32</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td><strong>Sept.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>84</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>56</td>
</tr>
<tr>
<td>M</td>
<td>82</td>
<td>9</td>
<td>7</td>
<td>1</td>
<td>73</td>
</tr>
<tr>
<td><strong>Oct.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>92</td>
<td>4</td>
<td>4</td>
<td>26</td>
<td>100</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


that some of the larger *persimilis* and smaller *striata* were eliminated from the analysis, the former perhaps being queens from the earlier part of the year and the latter being workers during July and August. For all multiple comparisons of means, an Analysis of Variance and the Student-Newman-Keuls multiple range test for unequal n was used at the .05 level of significance (Steel and Torry, 1960, p. 114). For paired comparisons Student's t-tests were used.

In each species the mean for size (wing length) of all queens (Groups A and B combined for all months) is significantly larger at the .01 level than is that for Groups C, D and E combined for all months. During May, there is no significant difference in size between bees with and without enlarged ovaries in either species. This might be expected since all females in these samples had overwintered; after the middle of May, when young adults might have emerged, no specimens of Group E were included in the samples. In spring nests containing more than one bee, usually the largest or one of the largest individuals had the most fully enlarged ovaries, but exceptions were found in both species.

After the first brood emerges in early June, only one queen (or none) is found per nest (except one *striata* nest at the end of June was found with two queens). For this reason, sample sizes of queens during the summer months are small and the differences found among the monthly means (Table 12) are of questionable validity. The sample sizes for Groups C, D and E are larger and appear to be more meaningful. Since the monthly means vary in different ways for *striata* and
**persimilis**, these two species are considered separately in the following discussions.

In **persimilis**, the total size range of workerlike females encompasses that of queens (Fig. 122). There is a statistically nonsignificant decrease in size of females with slender ovaries from May through July (Table 12). By August, the trend is reversed and the mean size increases with the production of larger fall individuals and the gradual mortality of the smaller workers. There is no significant difference in mean size among Groups C, D or E for June through August, nor is there a significant difference among monthly means of all females with slender ovaries at this time. But the mean size of July females of Group E is significantly smaller than that of other groups in that month and smaller than each of the other groups in all of the other months except August. July females of Group E are not significantly smaller than either Groups A or E during August. It is also interesting that queens during June, July and August, in contrast to queens for the entire season, are not significantly larger than the workerlike females for these months. Both of these data seem to confirm the field and laboratory observations (see section on Wear and Longevity) that females of the summer brood may replace the spring queens.

In **striata**, the females of Groups C, D and E show a different pattern of size variation. As in **persimilis**, the means of the three groups are not significantly different during the summer months, nor
Fig. 122. Frequency of size ranges (wing lengths) of queens and workerlike females for *A. striata* and *A. persimilis*. 
is there any significant difference among the monthly means for the three groups. Unlike *persimilis*, however, the mean size of individuals from May through August remains rather constant, except for a slight increase during July (Table 12). This July increase may have resulted when some of the smaller individuals (often "form e" of Part I) that could not be positively identified to species were removed from the sample, as mentioned above. The July queens are significantly larger than the workerlike groups for June, July and August, and the largest queens are larger than the largest workerlike females, whereas the smallest workers are smaller than the smallest queens (Fig. 122). This relationship is different from that of *persimilis* and more like some of the *Lasioglossum* species. Apart from the size relationships discussed, no external morphological differences could be found in either species that would distinguish the castes.

**Wear and Longevity:** In addition to size and ovarian development, all females were examined for the condition or amount of wear to wings and mandibles in order to get information concerning the age and activity. Four classes of wear were recognized for wings and mandibles: unworn, slightly worn, moderately worn and much worn. The four classes of wing wear are illustrated in Fig. 123. Only the fore wings were classified since they wear more and faster than the hind wings. The four classes of mandibular wear are illustrated in Fig. 124. All gradations occur between the unworn and the much worn condition, so that in some cases specimens had to be placed somewhat arbitrarily into one or another of two classes. It was found that
few specimens ever became very much worn (Tables 13-15). At any time during the nesting season except early spring, about 75% of the bees, both mated and unmated, are unworn.

Mandibular wear is believed to occur largely as a result of cell construction rather than from ordinary excavation activities (Michener & Wille, 1961). During late September and October, overwintering females dig hibernation burrows deep into the often very hard soil in preparation for winter. Yet, the mandibles of these overwintering bees are at most only slightly worn. Most wear occurs during May, June and August, after periods of extensive cell construction. Wing wear is believed to result primarily from foraging activities as bees fly to flowers and among the vegetation. The Group D, pollen collecting females show the highest incidence of wing wear (see Table 13, June). However, since the wings of some queens also become considerably worn, especially later in the season at a time when they seldom leave the nests, it seems probable that the wings may also become worn as the bee moves around the cell cluster inside the nest cavity.

Since there is little difference in occurrence of wing and mandibular wear between striata and persimilis (Tables 14 and 15), these species will be considered together in the following discussion (totals, Table 13).

As mentioned above, the overwintering females rarely show signs of wing or mandibular wear. However, during May some of the queens
Table 14. Percentages of females of *persimilis* in Groups A-B, C-D, and E showing seasonal wear of wings (W) and mandibles (M). Groups A-B are queens, C-D are inseminated workerlike females, E uninseminated workerlike females. The symbols represent: - unworn; ± slightly worn; + moderately worn; ++ very worn (see text), N total number of individuals.

<table>
<thead>
<tr>
<th></th>
<th>A-B</th>
<th></th>
<th></th>
<th>C-D</th>
<th></th>
<th></th>
<th>E</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>±</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>±</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr.-May 15</td>
<td>93 7</td>
<td>14</td>
<td>85 12</td>
<td>4</td>
<td>26 100</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.87 13</td>
<td>15</td>
<td>95 5</td>
<td>21 100</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 15-30</td>
<td>100</td>
<td>4</td>
<td>78 22</td>
<td>9</td>
<td>100</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>62 38</td>
<td>8</td>
<td>92 8</td>
<td>13 100</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>75 25</td>
<td>12</td>
<td>38 12 23 27 26</td>
<td>91 6 3 32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>73 18</td>
<td>9</td>
<td>33 57 5 5 21</td>
<td>81 8 11 26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>100</td>
<td>1</td>
<td>64 36</td>
<td>11 89 11</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>1</td>
<td>50 30 20</td>
<td>10 77 15 8 26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug.</td>
<td>50 50</td>
<td>4</td>
<td>83 11 6 18 88 12</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 25 25</td>
<td>4</td>
<td>80 10 10</td>
<td>20 83 7 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept.</td>
<td></td>
<td></td>
<td>86 5 10</td>
<td>21 75 8 17 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>90 3 7</td>
<td>30 79 21</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td>100</td>
<td>6</td>
<td>100</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 15. Percentages of females of *striata* in groups A-B, C-D, and E showing seasonal wear of wings (W) and mandibles (M). Groups A-B are queens, C-D are inseminated workerlike females, E are uninseminated workerlike females. The symbols represent: - unworn, ± slightly worn; + moderately worn; ++ very worn (see text),

\(N = \text{total number of individuals.}\)

<table>
<thead>
<tr>
<th></th>
<th>A-B</th>
<th></th>
<th>C-D</th>
<th></th>
<th>E</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>±</td>
<td>++</td>
<td>N</td>
<td>-</td>
<td>±</td>
</tr>
<tr>
<td>Apr.-May 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>100</td>
<td>11</td>
<td>89</td>
<td>11</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>79</td>
<td>21</td>
<td>66</td>
<td>22</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>May 15-30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>33</td>
<td>33</td>
<td>17</td>
<td>17</td>
<td>6</td>
<td>88</td>
</tr>
<tr>
<td>M</td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>5</td>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>88</td>
<td>12</td>
<td>17</td>
<td>25</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>M</td>
<td>64</td>
<td>6</td>
<td>18</td>
<td>12</td>
<td>17</td>
<td>44</td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>56</td>
<td>33</td>
<td>11</td>
<td>9</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>M</td>
<td>22</td>
<td>33</td>
<td>44</td>
<td>9</td>
<td>70</td>
<td>15</td>
</tr>
<tr>
<td>Aug.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>66</td>
<td>17</td>
<td>17</td>
<td>6</td>
<td>68</td>
<td>14</td>
</tr>
<tr>
<td>M</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>10</td>
<td>78</td>
<td>16</td>
</tr>
<tr>
<td>Sept.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59</td>
<td>27</td>
</tr>
<tr>
<td>Oct.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>11</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>82</td>
<td>9</td>
</tr>
</tbody>
</table>
Fig. 123. Fore wing of *Augochlorella* showing the four classes of wear.

Fig. 124. Mandible of *Augochlorella* showing the four classes of wear.
and females of Groups C and D become worn. The incidence of mandibular wear increases more rapidly than wing wear among queens, even though at this time of year queens do collect pollen. Among the females with slender ovaries, wing wear occurs at about the same rate as mandibular wear (in terms of the classes of wear), suggesting that in nests with multiple females, those with slender ovaries do more of the foraging than those with enlarged ovaries. Throughout the rest of the summer, the percentage of worn queens gradually increases (Table 13) even though unworn individuals are always present. The percentage of females of Groups C and D with worn wings and mandibles also increases through June as does the amount of wear. But by July, few worn individuals are found, suggesting that they die off shortly after the first brood emerges in June. Worn females of Groups C and D can be found during August and September but production of new individuals occurs rapidly at this time and the percentage of worn individuals decreases throughout the rest of the season so that in October few worn females of any group can be found.

Females of Group E rarely become extensively worn (Table 13). The few that do show only slightly to moderately worn mandibles (37 out of 166 specimens) or occasionally, worn wings (8 out of 161 specimens). The highest percentage of worn individuals was found in September at the end of the season before the summer workers died off.

The steady increase in occurrence of worn queens during the season, especially through July when other worn females disappear, indicates that some queens may be longer lived than many of the females
with slender ovaries. Since wear takes place slowly, if at all, worn females are undoubtedly old. Unworn females, however, may or may not be young bees as demonstrated by the longevity records of marked individuals (Table 16). The bees (queens) that were marked in early spring were rarely recovered. But once a colony had become established, marked bees usually lived and participated actively in nest activities. One marked pollen collector lived more than 60 days without becoming worn; others lived up to at least 22 days without becoming worn, and three marked queens lived 16, 22 and 50 days and remained unworn.

It is not known whether summer bees can or do overwinter. No worn bees were ever found in fall nests where hibernation burrows had been started, but females marked in July were found in nests during September and others marked in early August were recovered in early October. If the small, unworn, inseminated, summer females of *striata* are able to overwinter, could this not be a source of the small spring females of *striata* that cannot be distinguished from *persimilis* (see Part I, Biosystematics)?

**Division of Labor:** A more complete account of activities and behavior among the members of the colony is given in the sections on Activities and Social Behavior or will be published later. To summarize here, it was found that in the spring when the nest is first established by one or more females, little or no segregation of duties is encountered, and all females of any one nest cooperate in performing all activities, including the laying of eggs if they are capable of it.
Table 16. Survival and condition of marked females. Only those bees recovered 10 days or longer after marking are included.

<table>
<thead>
<tr>
<th>Nest No.</th>
<th>Species</th>
<th>Date marked</th>
<th>Date last seen or captured</th>
<th>Days survived</th>
<th>Wear condition</th>
<th>Queen examined</th>
<th>Non-queen examined</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>striata</td>
<td>VI-5-57</td>
<td>VI-21-57</td>
<td>16</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td>215</td>
<td>&quot;</td>
<td>VI-17-57</td>
<td>VII-12-57</td>
<td>26</td>
<td>m &amp; w +</td>
<td>X</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td>195</td>
<td>&quot;</td>
<td>VI-24-57</td>
<td>VII-12-57</td>
<td>19</td>
<td>mand. +</td>
<td>X</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td>136</td>
<td>&quot;</td>
<td>VI-8-58</td>
<td>VIII-21-58</td>
<td>44</td>
<td>mand. +</td>
<td>?</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td>320</td>
<td>&quot;</td>
<td>VII-21-60</td>
<td>VIII-10-60</td>
<td>20</td>
<td>unworn</td>
<td>X</td>
<td></td>
<td>Pollen collector</td>
</tr>
<tr>
<td>319</td>
<td>&quot;</td>
<td>VII-21-60</td>
<td>VIII-10-60</td>
<td>20</td>
<td>&quot;</td>
<td>X</td>
<td></td>
<td>conopid</td>
</tr>
<tr>
<td>302</td>
<td>&quot;</td>
<td>VI-10-60</td>
<td>VIII-19-60</td>
<td>41</td>
<td>mand. +</td>
<td>X</td>
<td></td>
<td>in and out of nest</td>
</tr>
<tr>
<td>209</td>
<td>persimilis</td>
<td>VII-9-58</td>
<td>IX-1-58</td>
<td>59</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guard, construction</td>
</tr>
<tr>
<td>200</td>
<td>&quot;</td>
<td>VII-24-58</td>
<td>IX-6-58</td>
<td>44</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>209</td>
<td>&quot;</td>
<td>VI-2-57</td>
<td>VIII-6-57</td>
<td>35</td>
<td>&quot;</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>&quot;</td>
<td>VI-5-57</td>
<td>VI-21-57</td>
<td>16</td>
<td>mand. +</td>
<td>X</td>
<td></td>
<td>pollen collector</td>
</tr>
<tr>
<td>89</td>
<td>&quot;</td>
<td>VIII-4-58</td>
<td>X-2-58</td>
<td>60</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guarding</td>
</tr>
<tr>
<td>22</td>
<td>&quot;</td>
<td>V-17-59</td>
<td>VI-8-59</td>
<td>22</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guard; comes &amp; goes</td>
</tr>
<tr>
<td>303</td>
<td>&quot;</td>
<td>V-5-60</td>
<td>VI-24-60</td>
<td>50</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guard; collector</td>
</tr>
<tr>
<td>310</td>
<td>&quot;</td>
<td>VII-7-60</td>
<td>VIII-18-60</td>
<td>42</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guard; comes &amp; goes</td>
</tr>
<tr>
<td>311</td>
<td>&quot;</td>
<td>VII-12-60</td>
<td>VIII-1-60</td>
<td>20</td>
<td>Unworn</td>
<td>X</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td>Nest No.</td>
<td>Species</td>
<td>Date marked</td>
<td>Date last seen or captured</td>
<td>Days survived</td>
<td>Wear condition</td>
<td>Non-queen</td>
<td>Not examined</td>
<td>Activity</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>-------------</td>
<td>----------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>-----------</td>
<td>--------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>312</td>
<td>?</td>
<td>VI-1-60</td>
<td>VII-21-60</td>
<td>50</td>
<td></td>
<td>X</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VI-1-60</td>
<td>VI-24-60</td>
<td>23</td>
<td></td>
<td>X</td>
<td></td>
<td>guard; construction</td>
</tr>
<tr>
<td>322</td>
<td></td>
<td>VII-26-60</td>
<td>IX-22-60</td>
<td>57</td>
<td></td>
<td>X</td>
<td></td>
<td>guard; comes &amp; goes</td>
</tr>
<tr>
<td>312</td>
<td></td>
<td>V-1-62</td>
<td>VI-10-62</td>
<td>10</td>
<td>unworn</td>
<td>X</td>
<td></td>
<td>pollen collector</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V-1-62</td>
<td>V-10-62</td>
<td>10</td>
<td>unworn</td>
<td>X</td>
<td></td>
<td>pollen collector; guard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V-1-62</td>
<td>V-10-62</td>
<td>10</td>
<td>mand. +</td>
<td>X</td>
<td></td>
<td>guard</td>
</tr>
<tr>
<td>207</td>
<td></td>
<td>VI-4-57</td>
<td>VII-24-57</td>
<td>50</td>
<td>unworn</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 16 (continued)
During the rest of the season, after the first brood has emerged, the roles of different members of the colony become more fixed although considerable overlap may take place. From this time on, only one female continues to lay eggs. She may occasionally leave her nest to feed, but she does not collect pollen and spends most of her time in the nest, helping to guard it and probably helping to build cells (to judge by progressive mandibular wear of queens). Her offspring, both mated and unmated, and the other cofounders of the colony, whose ovaries are now reduced in size, collect pollen and cooperate in provisioning the cells, guard the nest and repair the entrance and burrows and probably also help to build the cells. Thus, division of labor does occur and the role of the queen is a specific one, although she can and does share some duties with the other members of the colony.

In addition to the division of labor, certain interactions among the members of the colony suggest a mechanism by which caste differentiation can be maintained. In data taken from observation nests (to be published later), it was found that members of the colony regularly came into contact with each other in the space surrounding the cell cluster. The amount of data is not large but it appeared to me that during the early part of the season, such contacts result in minor fights or skirmishes that last until one bee backs away or is chased up the main burrow. By midsummer, such encounters are brief and little or no fighting can be observed. If a hierarchy or peck order should become operational, the alpha individual might become the queen of the
colony. However, if she should lose her alpha position either to another nestmate, to a nest parasite such as *Sphecodes* (Ordway, 1964) or because of rough or excessive handling during marking or examining procedures her ovaries might become reduced in size. It is evident, from data on colony activity and inactivity (see Nest Activity), from the number of activated nests (Table 10) and from the number and size of unworn queens found in nests during the season (see above), that the ovaries of the queen may become reactivated or, if she dies, that she may be replaced by another individual. All queens found have been mated and no nests were found that contained only male offspring; therefore, replacement queens must come from the Group C or D individuals and not from the very young females since these are not mated. Few of the females emerging in early June become mated because of the scarcity of males. If a queen is to be replaced at this time, it must often be by one of the other overwintered females. If the colony becomes queenless later in the season, either the colony dies out or one of the mated offspring takes over the queen's functions. At least 33 such reactivated nests have been found, recognized by a gap in ages of brood (see Nest Activity).

Other Species: Caste differences in *Augochlorella* are perhaps as well defined as in other adequately studied, primitively social, halictine species (Table 17), but for different reasons. In size relationships, the castes of *Augochlorella* are similar to those of *Lasioglossum rhytidophorum*, *L. imitatum* and *L. versatum* in that only
Table 17. Comparison of characteristics for determination of caste differences between queens and workers.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Size and morphology</th>
<th>Ovarian development</th>
<th>Fecundation</th>
<th>Longevity</th>
<th>Number of oocytes</th>
<th>Red size / age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lasioglossum duplex</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(Sakagami &amp; Hayashida, 1958)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lasioglossum malachurum</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(Stöckhert, 1923; Noll, 1931)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lasioglossum marginatum</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(Plateaux-Quéné, 1960)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lasioglossum imitatum</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>1 or more</td>
<td></td>
</tr>
<tr>
<td>(Michener &amp; Wille, 1961)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lasioglossum rhytidophorum</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>1 or 2</td>
<td></td>
</tr>
<tr>
<td>(Michener &amp; Lange, 1958)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lasioglossum versatum</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>several</td>
<td></td>
</tr>
<tr>
<td>(Michener, in press)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lasioglossum zephyrum</td>
<td>?</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>several</td>
<td></td>
</tr>
<tr>
<td>(Batra, 1964)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+= distinct difference between queen and worker
+= indistinct or occasional difference
-= no difference
?= no information available
+?= probable difference
average differences exist between queens and workerlike females. In *L. malachurum* and *L. duplex*, the sizes of queens and workers are distinct, whereas in *L. marginatum* no caste difference in size can be detected. Females of *Augochlorella*, like those of *L. rhytidophorum*, *imitatum* and *versatum*, can be more readily segregated into egglayers (queens) and non-egglayers than can the females of *L. zephyrum*, even though any stage of ovarian enlargement may be found within a colony. The whole matter of distinguishing castes in *zephyrum* is confused by the frequency of unfertilized females with large ovaries like those of queens. The workers of *marginatum* and *duplex*, on the other hand, rarely, under normal conditions, show any sign of ovarian development. In *Augochlorella*, more than half the workerlike females may be inseminated. This is in contrast to all other species here considered. During the season, a few fecundated workers are occasionally found in colonies of *rhytidophorum*, *versatum* and *imitatum*, but generally speaking, the workers in the *Halictus* and *Lasioglossum* species can be distinguished from the queens by their uninseminated state. There is only one queen in *Augochlorella* colonies, so that in this respect *striata* and *persimilis* are similar to *marginatum*, *malachurum* and *duplex*. Colonies of *imitatum* and *rhytidophorum* may have one or two queens and the other species have usually more than one active egglayer or queen at one time in each colony.

A functional caste system in *Augochlorella* obviously does exist, although in all respects it is poorly defined. The broadly overlapping
nature of ovarian development, fecundation, division of labor, size and longevity suggests that the development of castes in this group is at a primitive stage. Yet, the colony is bound together by a social organization in which there is cooperative activity. Caste is probably determined imaginarily in response to the social organization present in the colony. The role of the queen is specific, and her presence may inhibit the ovarian development of other members in the colony; moreover, the presence of workers may inhibit pollen collecting by the queen.
MALES

As indicated in the section on Castes, males are produced throughout the season. Only a few are produced in the first brood, but the number increases during the summer, reaching a peak in August and September (Table 11). No nests were found in which brood consisted only of males. When males emerge, they leave their nests during the day and can occasionally be seen in the nest entrances. When leaving, they are as timid as the young females and may stay in the entrances 30 minutes or more before they fly. Often they land on a stone or leaf near the nest after their initial flight, clean themselves, then fly away. They have never been found flying around the nest entrances and apparently spend the rest of their lives on or about flowers.

At night, in the laboratory, males crawled into any dark crack or hole to sleep and often could be found among the bracts of flowers or hidden by leaf bases when these lay close to the stem of the plant. When pieces of wood through which small holes had been bored were hung from the ceiling, the males (all persimilis) crawled into the holes, one bee per hole even if the hole were large enough to hold more. Holes only slightly larger than the bee itself were preferred to larger holes and the wood blocks seemed to be preferred to hiding places among the flowers.

Males are rarely found in groups, but occasional swarms of males have been found around flowers or plants where no females could be seen. Such a group was found clustered around two bushes of
Symphoricarpos one morning, licking the leaves and stems and feeding from the small white flowers. Groups of males have also been found around congregations of females but only a few were seen at any one time (see Activities Outside the Nest).

Mating has not actually been observed for either striata or persimilis. This must take place on or near flowers or among the vegetation when the females are licking the plants (see Activities Outside the Nest). During the day, males were seen hovering in front of a leaf on which a female was sitting. If the female moved the male moved also, darting forward, backward or to the sides in a manner similar to that of a syrphid fly. Males sometimes darted in and briefly grappled with the female and occasionally both rolled to the ground, but in all cases the encounter was so brief that it did not seem that copulation could have taken place. Mating was never noted in the laboratory even though many males were flying around.
ACTIVITIES OUTSIDE THE NEST

Conditions for Activity: Soil and air temperatures were recorded at weekly intervals at aggregation DP during 1963, and irregularly at various aggregations in other years. The temperatures were measured with a Weston stainless steel dial thermometer that was pushed 15 cm into the ground for soil temperatures or held in the shade about 30 cm above the ground for air temperatures. Soil temperatures were similar during the summer at each aggregation regardless of location, although fluctuations as much as 3° F may occur during the day at any one site. Air temperatures in the shade showed greater daily variation as would be expected during the summer. In the spring, emergence holes were rarely found before the soil had reached 12.78° C regardless of the date. By this time, air temperatures were usually from 16 to 26° C during the day, temperatures at which bees were frequently active once nesting had started. In the fall, bees were usually in their hibernation burrows by the time the soil reached 18.33° C in October.

Daily activity is probably stimulated by light intensity although temperatures must also play a part. In the spring (April and May), bees rarely left their nests before 10:00 a.m. even though sunrise at this time of year occurs before 6:00 a.m. and guards appeared in the nest entrances as early as 8:50 a.m. A bee seen leaving its nest at 9:40 a.m., when the air temperature was 18.3° C, spent most of the next 30 minutes sunning itself on stones and leaves in the vicinity of the nest. In June, when nests were observed from 5:45 a.m. (sunrise at about 5:15 a.m.), bees could be seen off and on in the entrances.
starting at 6:15 but in no case were bees seen to leave their nests before 8:30 although temperatures were from 21 to 31° C. (Table 18 shows the typical activity of a very active colony in June.) During July the bees were found on flowers no earlier than 6:45 a.m., and most foragers started leaving their nests at about 7:30 a.m.

Foraging: Collecting trips take a minimum of 20 minutes (even in the laboratory, when abundant flowers were available less than one meter from the nest entrance), but the usual collecting trip seems to last almost one hour. Collecting trips are shortest early in the morning but increase in duration during the day (Tables 18 to 20). Solitary bees, especially in spring, may collect pollen throughout the day, whereas during the summer, bees returning to the nests after about 1:00 p.m. seldom have pollen in their scopas. A bee may be gone several hours if it is not collecting pollen or nectar for the nest, this time apparently being largely spent licking grass and leaves (see below). Bees that are foraging usually make several consecutive trips during the day. The time spent in the nest between trips is minimal (Tables 18 to 20) and would seem to allow only for the bee to deposit her load in a cell before leaving again. Marked bees in the field were not seen to visit flowers in the immediate area of the nests although many of the bees probably do utilize these sources. When bees that were collecting nectar from flowers in the nesting area were marked (these were marked differently than those from known nests) some were found to return day after day to the same flowers.
Table 18. Activity taking place at nest entrance, State Property, 7 June 1957, Nest No. 58. *Augochlorella persimilis*. Bees were marked as follows: R = red (ovaries much enlarged, mated, mandibles slightly worn, queen); W = white (ovaries slender except for one enlarged ovariole, mated, unworn); Y = yellow (ovaries slender, mated, slightly worn).

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:45</td>
<td>no bees seen at entrance</td>
</tr>
<tr>
<td>6:15</td>
<td>guard appears (identity unknown)</td>
</tr>
<tr>
<td>6:15-6:55</td>
<td>W appears intermittently at entrance</td>
</tr>
<tr>
<td>6:56</td>
<td>Y guards intermittently</td>
</tr>
<tr>
<td>8:12</td>
<td>W guards</td>
</tr>
<tr>
<td>8:30</td>
<td>Y leaves, W guards</td>
</tr>
<tr>
<td>9:04</td>
<td>Y returns with pollen, W guards</td>
</tr>
<tr>
<td>9:07</td>
<td>Y leaves</td>
</tr>
<tr>
<td>9:30</td>
<td>W guards, R seen below</td>
</tr>
<tr>
<td>9:36</td>
<td>W leaves</td>
</tr>
<tr>
<td>10:34</td>
<td>R guards</td>
</tr>
<tr>
<td>10:36</td>
<td>Y tries to return (but cannot get passed R who has abdomen in entrance after being teased by observer)</td>
</tr>
<tr>
<td>11:10</td>
<td>W guards (had returned without being noticed)</td>
</tr>
<tr>
<td>11:20</td>
<td>R guards</td>
</tr>
<tr>
<td>11:40</td>
<td>R still is guarding</td>
</tr>
<tr>
<td>-----</td>
<td>Nest not observed</td>
</tr>
<tr>
<td>12:30-4:45</td>
<td>Y guarding intermittently all afternoon, no other activity</td>
</tr>
<tr>
<td>-----</td>
<td>Nest not observed</td>
</tr>
<tr>
<td>7:30</td>
<td>Y guarding, W in main burrow just below</td>
</tr>
</tbody>
</table>
Table 19. Activity taking place at nest entrance, Dalys Place, 28 July 1960, Nest No. 320. Augochlorella striata. The bees were marked as follows: Rt = red thorax (ovaries much enlarged, mated, wings unworn, mandibles slightly worn, queen); B = blue (slender ovaries, mated, wings slightly worn, mandibles unworn); Ya = yellow abdomen (slender ovaries, unmated, wings unworn, mandibles slightly worn); Ra = red abdomen (slender ovaries, unmated, unworn); Wa = white abdomen (slender ovaries, unworn, parasitized by conopid larva); Wt = white thorax; U = unmarked bees (some of these are marked during the morning as noted).

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>U guards</td>
</tr>
<tr>
<td>9:55</td>
<td>Ya returns, Ra returns</td>
</tr>
<tr>
<td>9:57</td>
<td>Ra leaves</td>
</tr>
<tr>
<td>10:02</td>
<td>Yt appears in entrance</td>
</tr>
<tr>
<td>10:03</td>
<td>Yt leaves</td>
</tr>
<tr>
<td>10:04</td>
<td>U guards (is marked Rt and flies away)</td>
</tr>
<tr>
<td>10:10</td>
<td>B leaves, Wa returns</td>
</tr>
<tr>
<td>10:12</td>
<td>U leaves</td>
</tr>
<tr>
<td>10:16</td>
<td>Wa leaves, no guard seen</td>
</tr>
<tr>
<td>10:27</td>
<td>Ya returns</td>
</tr>
<tr>
<td>10:34</td>
<td>Ra returns</td>
</tr>
<tr>
<td>10:35</td>
<td>Ya leaves</td>
</tr>
<tr>
<td>10:37</td>
<td>Rt returns</td>
</tr>
<tr>
<td>10:40</td>
<td>Ra seen in entrance, B returns, Ra leaves</td>
</tr>
<tr>
<td>10:46</td>
<td>U returns with pollen</td>
</tr>
<tr>
<td>10:50</td>
<td>Rt is in entrance</td>
</tr>
<tr>
<td>10:56</td>
<td>Wa returns (U returns, is marked Wt and returned to nest)</td>
</tr>
<tr>
<td>11:02</td>
<td>Wa leaves</td>
</tr>
<tr>
<td>11:15</td>
<td>Rt guards</td>
</tr>
</tbody>
</table>
Table 20. The morning activity of a solitary queen as observed outside the nest, Dalys Place, 8 August 1960. Nest No. 317.

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00-8:45</td>
<td>No bee seen at entrance.</td>
</tr>
<tr>
<td>9:25</td>
<td>Bee seen briefly in entrance.</td>
</tr>
<tr>
<td>9:30-10:00</td>
<td>Bee seen in entrance, starts to leave but goes back into nest. This action continues during period.</td>
</tr>
<tr>
<td>10:02</td>
<td>Bee leaves.</td>
</tr>
<tr>
<td>10:25</td>
<td>Bee returns with pollen.</td>
</tr>
<tr>
<td>10:28</td>
<td>Bee seen in entrance.</td>
</tr>
<tr>
<td>10:30</td>
<td>Bee leaves.</td>
</tr>
<tr>
<td>11:26</td>
<td>Bee returns with pollen.</td>
</tr>
<tr>
<td>11:31</td>
<td>Bee seen in entrance.</td>
</tr>
<tr>
<td>11:32</td>
<td>Bee leaves.</td>
</tr>
<tr>
<td>12:45</td>
<td>Bee returns with pollen.</td>
</tr>
</tbody>
</table>
Frequently they were only licking the plants (see below) or eating nectar or pollen, rather than collecting pollen in the scopa.

Foragers may collect only pollen on one trip or may collect both pollen and nectar (determined from dissections and laboratory observations); pollen may also be eaten by both queens and non-egglaying individuals, but pollen collecting foragers have rarely been found with pollen in their crops.

Tables 18 to 20 represent only samples of large quantities of similar data; the samples seem to illustrate the essential points, however. All represent unusually active days and nests; the most noteworthy feature of observations of this sort on Augochlorella nests is the frequent long periods when nothing happens.

Flower Preferences: The flowers on which striata and persimilis have been found are listed in Part I under each species. These bees are polylectic and visit a wide variety of flowers for both pollen and nectar. Pollen samples taken from the scopas of bees returning to their nests show that throughout the season any one bee may collect pollen from more than one genus of plants on any one trip. Preferences are noted, however, for particular plants that are seasonally abundant, and pollen loads frequently include a preponderance of one type of pollen.

Some flowers are not visited at all in the field by the Augochlorella even though they are seasonally abundant and are visited regularly by other species of bees. If these plants are brought into
the laboratory, they may be utilized by the bees in varying amounts. For example, in late June, 1964, one field contained a variety of flowers including Chrysanthemum leucanthemum (daisy), Petalostemum purpureum, P. candidum (prairie clovers) and Melilotus alba (white sweet clover). The number of bees visiting the plants were recorded for one hour by walking along a route that allowed about 5 minutes of observation for each type of plant during each round, and the number of Augochlorella of both species was recorded. A total of 73 Augochlorella females were seen. None of these visited the Melilotus or the daisy, 53% were on P. purpureum, 39% were visiting P. candidum and the remaining ones were on other flowers in the area. When these four flowers were brought into the laboratory, only males visited the Melilotus for nectar, none of the bees visited the P. candidum, but on the first day the females collected extensively on P. purpureum and visited the daisies only briefly. On the second day (fresh flowers of all four species were supplied each day), the bees collected extensively on the daisies and only visited the P. purpureum sporadically. On the third day all but one female collected exclusively on the daisies, the one that did not remained with the P. purpureum. Sunflowers were ignored in the laboratory, even though so much pollen was produced it dropped off the flower heads. Silphium was visited readily by males for nectar, but females collected pollen from it only when nothing else was available. In the field neither flower is utilized by Augochlorella. Tradescantia was preferred over all other
flowers in the laboratory after it was "discovered", although no 
*Augochlorella* were seen on it in the field. Other flowers such as 
*Melilotus officinalis* (yellow sweet clover), *Onopordum acanthium* L. 
(Scotch thistle) and *Cirsium pumilum* (Nutt.) (bull thistle) are 
readily utilized for pollen both in the field and in the laboratory. 

Such differences between the field and laboratory responses 
should be further investigated, for they suggest that the bees react 
to different stimuli in the two environments. 

**Licking:** When the bees are not collecting nectar or pollen for 
the nest, they may fly around among the leaves or grass, usually close 
to the ground, alighting on and licking the plant surfaces. This is 
noted only among females of the summer broods and so far only among 
females with slender ovaries. This activity takes place from June 
(after the first brood emerges) through August and is particularly 
oticeable in the afternoon. The females lick a variety of objects, 
both shiny and dull, light colored or dark, and wet or dry, and in the 
sun or shade, and when doing so their temerity is in sharp contrast to 
their timidity at the nest entrances. The function of this licking 
activity is not evident. It is particularly noticeable on hot, 
humid days, and this is the activity that has lead to the name sweat 
bees for the entire Halictinae. However, the action does not seem to 
be related to acquiring moisture since if wet cotton or a drop of 
water is placed near the licking bees, it is avoided, and on plants, 
both the upper and lower surfaces of the leaves are licked, as well
as the stems. The presence of one or two licking bees often seems to attract others to the area, especially if they are disturbed. This is particularly noticeable of *persimilis* in which a great number may be collected simply by sweeping a small patch of grass or weeds in a field, waiting a minute or two for others to appear in the area, and sweeping again. Each time the area is swept, more bees will be collected, even though no nests could be discovered nearby. It has not, however, been possible to collect large numbers of *striata* in this manner.

**Congregations:** Perhaps related to this licking behavior and possibly a result of it, large congregations of halictine bees can occasionally be found swarming around a clump of grass or a plant during the summer. These congregations are composed chiefly of females and may include species of a variety of genera including *Augochloropsis*, *Lasioglossum*, and *Augochlora* as well as both species of *Augochlorella*. A few males (of *Augochlorella* and *Lasioglossum*) are sometimes found in these gatherings, but they dart back and forth among the flying females, rarely attempting to enter the group although attempts at mating probably do occur. The females in these gatherings seem very excited and fly, alight, lick, and hover in rapid succession, often grappling or skirmishing with each other for space on a leaf or chasing another (usually smaller) bee away from a spot. These frenzied congregations were noticed in various years, always at about the same time of year and same time of day. They were seen on July 21, 22, 23
and 29, 1955, July 18, 1958 and July 23, 1959. All took place between 10:30 and 12:00 in the morning and lasted for one or two hours. In one case, bees congregated at the same hour at the same plant on at least three successive days. In at least two cases, the gathering slowly dissipated as the bees left the area.
ACTIVITIES AT THE NEST ENTRANCE

Entering and Leaving the Nest: Activity at the nest entrance occurs sporadically during the day or season, frequently necessitating long periods of waiting by an observer for some event to take place. However, in large aggregations there is sometimes one colony that is more active than others so that a series of events at one nest can occasionally be observed as are recorded in Tables 18 to 20. In the spring, activity is particularly slow since there are few bees to a colony (see Table 10). Bees at this time of year do not appear to be strongly attached to their own burrows, and marked bees were sometimes found in the "wrong" nest. Six such observations were made. The misplaced bees may remain in their new colony or return to their old nest after a few days; some start new nests. A similar shifting among nests was found when bees were first establishing nests in the laboratory. Later in the season, if a bee gets into the "wrong" nest it quickly leaves (either on its own accord or on the insistence of guard bees in the entrance) and flies to its "correct" hole.

Before leaving its nest, a bee may remain in the entrance up to one or two hours, starting to leave many times but each time retreating back into the nest (Table 20). During this period, the bee gradually eases itself farther and farther out of the entrance, its head turning from side to side and its antennae slowly waving. If an ant runs by the entrance or there is other movement near the nest, the bee drops quickly down into the burrow for a few minutes
before starting its gradual rise again. Shadows moving across the nest entrance do not frighten the bees, nor do noises such as clapping of hands or talking and shouting. Bees do retreat at vibrations of the ground caused by dropping a stone or a heavy footfall. They also retreat in response to movements of the observer or even of an ant beside the nest entrance. The time each bee spends in the entrance before leaving decreases as the number of trips it makes each day increases (Tables 18 to 20). An experienced forager (determined by marked individuals) that takes a considerable amount of time to leave on its first trip of the day will nonetheless spend less time in the entrance than younger, inexperienced bees and frequently leaves with only slight hesitation on its second or third trip of the day. Table 20 represents the normal activity of a solitary queen on a day when it was active. Tables 18 and 19 show the activity of bees in larger colonies. All three nests were observed on sunny days in midsummer, with abundant flowers growing in the area. They were chosen for observation because they were the most active nests in the aggregation on those particular days.

When a bee finally leaves, it frequently makes an orientation flight (see below) before flying off. If the weather is cool, the bee frequently lands on a leaf or stone near the entrance and suns itself by facing the sun for a while, then turning so that its side is toward the sun, then facing the sun again, and turning some more. Eventually the bee flies, apparently without any further orientation flight.
When the bee returns, it usually enters the nest quickly and
directly but sometimes it approaches the nest with a slight zig-zag
route at a high level. All bees from a colony seem to consistently
enter the nest from the same direction. Bees returning from foraging
trips frequently stop on nearby leaves or grass (usually in the sun)
and clean themselves by scraping pollen from the body to the scopa.
Such a bee then either circles the area and enters her nest or flies
straight to it. Foraging bees that do not stop nearby, were found to
be already clean when examined. (In the laboratory bees frequently
cleaned themselves before leaving the flowers.)

**Orientation:** An orientation flight is made when a bee leaves
its nest for the first time, the first time it leaves each day, and
in response to changed conditions at the nest entrance. In making a
full orientation flight, the bee climbs out of the nest entrance,
hovers above the entrance while facing the entrance hole, then slowly
moves from side to side in increasingly wider and higher zig-zag
patterns. The first time a bee leaves its nest (determined by
unmarked bees in otherwise marked colonies and in the laboratory
where bees were individually marked), it makes a very brief orientation
flight only over the entrance, then immediately returns to the nest
again. During these short flights the white meconium of the newly
emerged bee is at least sometimes dropped. One bee in the laboratory
was observed to make two such flights on successive days. As the bee
becomes more experienced, it may only zig-zag widely and quickly at
about 30 to 60 cm above the nest as it flies off, or may not even appear to orient at all. In returning, young bees circle the area at a height of 60 cm or more, then approach the entrance in a wide zig-zag pattern, hover over the entrance briefly before diving down the entrance hole. Experienced bees appear to fly quickly and directly into the entrance with little or no zig-zag motion.

Bees are easily confused by slight changes near the nest entrance or by alterations to the entrance itself. They become disoriented or "lost" if their turret is damaged or removed, even though the entrance hole is plainly visible. Slight disturbances to the soil around the entrance did not seem to bother most bees, but if sticks, pebbles or the leaf or ground litter around the entrance were moved, the bees became "lost". If an observer changed his position in relation to the nest entrance after a bee had left, the bee on its return will frequently search for its nest in a location that is correct relative to the original position of the observer and cannot find it so long as the observer remains in his new place. This provides a hint as to the sort of object utilized by these bees in their orientation. "Lost" bees zig-zag back and forth over the area where the entrance should be at a height of 30 to 40 cm. If the entrance is not found, such a bee circles the area at a higher elevation and again zig-zags in to the spot where the entrance should be and hovers or slowly moves back and forth. Occasionally the bee lands and searches the area on the ground. This searching may continue for 5 to 10 minutes; then the
bee flies away for 20 minutes or more before returning to repeat the process. If a bee could not find its nest directly and became "lost" it zig-zagged over the area until the entrance was found, or it flew away and returned later to search. One bee searched its nesting area on three consecutive days looking for an entrance that had been obliterated when other nearby nests were excavated by me. Usually if the entrance becomes closed, bees on the inside (if present) reopen it within 24 hours. On two occasions a guard bee was observed to climb part way out of its nest entrance and face the searching bee. In each case, the searching bee found the entrance almost immediately. Available data indicate that the orientation of these bees is based on visual clues.

Guarding: As in other halictine colonies, bees are frequently found guarding the entrances of the nests. Guarding may occur throughout the season but is more common in summer than in the spring, and occurs in nests with several bees rather than in those occupied by a solitary individual. During the summer, guards are found from about one hour after sunrise throughout the day until after dark in the evening. Guards are not present at all times but may appear at the entrance for a few minutes then disappear into the nest and reappear to guard some more. Many nests during the summer are guarded almost continually throughout the afternoon. The queens as well as pollen collectors and young bees take turns guarding during the day, so that young bees (unmarked individuals in an otherwise marked colony) are frequently seen guarding in the morning but alternate with foragers
that are preparing to leave (sometimes a lengthy process, see Entering and Leaving the Nest and Foraging) or with the queen. In the afternoon, the queen and one or two of the foragers alternate as guards. Individual bees can often be distinguished by their aggressiveness or by how frightened they become at small disturbances at the entrance. Most bees are easily frightened and drop down into the burrow at any movement near the entrance, but some guards actively attack intruding ants, bees of the same species that do not belong to that colony, or other organisms but will not leave their nests to do so as does Lasioglossum zephyrum. Some guards may be induced to block the entrance with the abdomen if teased with a fine blade of grass, but they have never been observed to do so naturally; others react by biting the grass or turning in the burrow so that their mandibles and the tip of their abdomen both protrude from the entrance, but most simply retreat a short way into the burrow. One guard, while repairing and licking the turret (in this case a glass tube used for observational purposes), did not allow returning foragers to enter the nest nor let bees on the inside come out so long as it was working, although one returning bee eventually forced its way past the guard when it became frightened by a movement outside the nest. Most guards rest quietly just below the entrance with their mandibles against the burrow wall, their head tilted back and their antennae held straight up. They do not completely block the entrance as do guards of L. imitatum since the entrance is usually larger than the
the head and they have never been observed to plug the entrance with earth except when constructing a turret.

**Fanning**: Occasionally guard bees can be seen leaning out of the entrances to their nests and fanning with their wings. This activity was noted on at least 10 occasions and apparently serves to ventilate the nest. It occurs after the nest has been invaded by the parasite *Sphecodes pimpinellae* (Ordway, 1964) and has also been noted on hot and humid days in summer or after a shower when the ground is very wet. In one case, after a long, dry period, water was poured onto the surface of the ground and into the nest entrance. Most of the bees at once came out of the nest while one remained in the entrance and started to fan vigorously. It was not determined specifically which bees of the colony fan but it is usually a bee that is guarding. The fanning bee may stand half way out of the nest or it may sometimes lean out so that only the tip of the abdomen remains in the entrance burrow. The action is usually continued for long periods of time but with frequent interruptions while the bee goes down into the nest before returning to fan some more.
SUMMARY

In a revision of the bee genus *Augochlorella*, descriptions and keys are given in Part I for seven species occurring north of Mexico and one species and a subspecies from Mexico. One species from Texas, *A. bracteata* and the subspecies *A. neglectula maritima* from Mexico are new, and the male of *A. edentata* is described for the first time; *A. neglectula* is raised from synonymy, and *A. aurata* of recent authors has been divided so that most of the specimens from north of the Gulf Coast states are placed in *A. persimilis*. Other species treated are *A. pomoniella*, *A. gratiosa* and *A. striata*. Regional as well as individual variations are treated in detail since there is considerable morphological intergradation among females of some species.

Aspects of the biology and behavior of *Augochlorella striata* and *A. persimilis* in eastern Kansas are presented in Part II. The biologies of the two species are similar and are discussed as one except where differences could be found. Colonies of both species occur together in mixed aggregations, usually in well drained soils, from May to September. A nest consists basically of a vertical burrow in the ground, enlarged to form a cavity at about 7 cm below the surface; the cavity contains a cluster or comb of subhorizontal earthen cells. There may or may not be a blind burrow below the cavity, a side branch below the constricted entrance, or a turret above the ground surface. Various methods of construction are used, but usually the cavity is excavated and brood cells are built within the cavity,
the cell cluster being supported by pillars of earth extending to the walls of the cavity. One to six overwintered females start a new nest in the spring, and eggs are laid irregularly throughout the summer from May to August. The life cycle takes about four weeks to complete. A few males appear in the first brood, but their numbers increase as the summer progresses. Emerging males leave the nests and do not return, whereas females remain with their natal colonies and perform such activities as the construction and provisioning of cells and guarding of nests.

The presence of two castes, the egglayers or queens and the non-egglayers or workerlike females, is demonstrated in _A. persimilis_ and _A. striata_ although the castes are poorly defined. One or more queens may be present in a nest during the spring, at which time all individuals of the colony may perform all nesting activities including the collecting of pollen for the cells. After the first brood has emerged in June, there is only one egglayer per colony, and this individual, although continuing to guard and build cells, does not collect pollen. The other females of the colony, although frequently mated, rarely lay eggs but do carry on all other nesting activities. There are average size differences between the queens and non-egglayers, but morphologically the two castes cannot be distinguished.

Slight differences between _A. striata_ and _persimilis_ were found in nest structure, in nest populations and in the periods of nesting activity. Differences in nesting sites can only be suggested since
both species were regularly found in the same aggregations. None of these differences appears to be significant in maintaining specific isolation, and yet no colony was found that contained individuals of both species.
ACKNOWLEDGEMENTS

The use of field notes and data obtained from 1953 to 1957 by Drs. E. A. Cross, H. V. Daly, C. D. Michener, C. W. Rettenmeyer, A. Wille and Mr. A. F. Shinn is very gratefully acknowledged.

I also wish to thank all the individuals and institutions listed in Table 1 for their cooperation in sending me specimens of Augochlorella for this study.

I am particularly indebted to Dr. C. D. Michener, Dr. G. W. Byers and Dr. H. S. Fitch for reading this manuscript and for their helpful comments and criticisms.

This study was aided by grants (No. G 11967, No. GB-91), from the National Science Foundation (Dr. C. D. Michener, principal investigator).


Stöckhert, E. 1923. Über Entwicklung und Lebensweise der Bienen- 
gattung Halictus Latr. und ihre Schmarotzer (Hym.). Zugleich 
ein Beitrag zur Stammesgeschichte des Bienenstaates. Knowia 
2:48-64, 146-165, 216-247.

Entomol. 33:133-137.

Pt. III. The Hymenoptera or Wasplike Insects of Connecticut. 