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# Observations on the Behavior of Brasilian Halictid Bees, III [1]

BY

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ABSTRACT: This paper presents data on the nests of several Brasilian halictine bees, as follows: *Neocorynura polybioides* (Ducke), *Pseudaugochlora nigromarginata* (Spinola), *Megommation insigne* (Smith), *Augochlora semiramis* (Schrottky) and *morrae* Strand, *Augochlorella michaelis* (Vachal), *Paroxystoglossa andromache* (Schrottky), *Habralictus canaliculatus* Moure, and *Caenaugochlora curticeps* (Vachal). Virtually all the data were collected on the Southern Brasilian plateau, in the State of Paraná.

Several of these species exhibit incipient stages in the establishment of social behavior, as discussed in the Conclusions.

## INTRODUCTION

This paper consists of fragmentary, but we believe significant, observations mostly on nesting behavior of various halictid bees. The observations were made on the southern plateau of Brasil, in the state of Paraná, except as otherwise noted. The altitude of this area is about 900 meters; some general features of its climate are noted by Michener, Lange, Bigarella and Salamuni (1958) in connection with data on bee nesting sites in the Bariguí roadside banks near Curitiba.

1. Part I on *Pseudagapostemon*, Ann. Ent. Soc. Amer., vol. 51, 1958, pp. 155-164. Part II, on *Paroxystoglossa jocasta*, Jour. Kansas Ent. Soc., vol. 31, 1958, pp. 129-138.

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2. Department of Entomology, University of Kansas, Lawrence, Kansas, U. S. A. Field work for this author's part in the study was made possible thanks to a John Simon Guggenheim Memorial Foundation Fellowship and aid kindly made available by the Campanha Nacional de Aperfeiçoamento de Pessoal de Nível Superior, Rio de Janeiro; the Conselho Nacional de Pesquisas, Rio de Janeiro, and the Rockefeller Foundation, New York. In particular, thanks are due to Father J. S. Moure for the use of facilities of the Secção de Zoologia, Faculdade de Filosofia, Universidade do Paraná, Curitiba, Paraná, Brasil.

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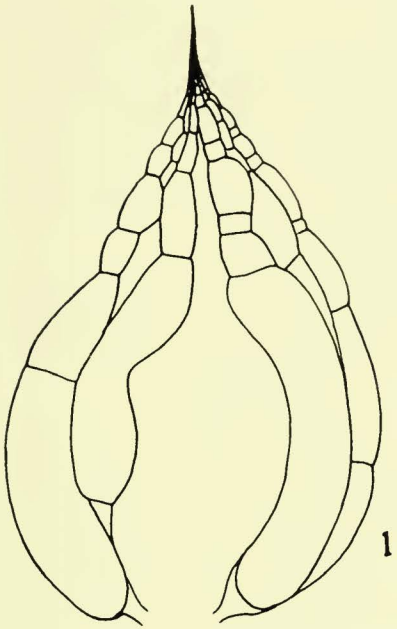
The methods of study used include several of those listed by Michener, Cross, Daly, Rettenmeyer and Wille (1955). Ordinarily nests were opened on cold days or at a time of day when all the occupants were presumed to be inside. If this were impractical or if there were time to obtain information on the activities of the various individuals inhabiting a nest, the nest was watched for one or more hours before opening it, and the pollen collectors (or bees exhibiting other behavior) were captured as they returned to the nest and separately preserved. Subsequently, dissections and measurements revealed whether such bees differed in ovary size, fertilization (shown by presence of sperm cells in the spermatheca), age or previous activities (shown by mandibular and wing wear), and size (as indicated by measurements of wing length) from bees found in the nest or exhibiting different behavior. Ovaries were classified in the following categories: very slender, slender, slightly enlarged, enlarged, and much enlarged. Each ovary has three ovarioles in halictine bees, and in the species discussed in the present paper, enlargement of the ovaries usually involved all or most of the six ovarioles. (This is in contrast to some workers in *Lasioglossum* where one ovariole, or one in each ovary, may become enlarged while the others remain very slender.)

Some presumably generic differences in the ovaries were noted, as follows: In *Paroxystoglossa andromache* (Schrottky), *jocasta* (Schrottky), *seabrai* Moure and *spiloptera* Moure, the anterior parts of the ovaries, where the ovarioles are small, have the ovarioles arranged in the same horizontal plane so that all of the ovarioles are visible in this region in dorsal or ventral view. The same is, to a lesser degree, true of *Pseudaugochlora nigromarginata* (Spinola). In other genera studied the three ovarioles of each ovary are crowded together so that if seen in section they form a roughly triangular figure. Also, in some genera, such as *Paroxystoglossa* and *Pseudaugochlora*, oocytes of moderate size occur anterior to the large oocytes that are nearing the size for laying. The result is rather long ovaries, a mature oocyte being not a great deal over half of the total length of the ovary (figure 1). In some other genera (e. g., *Neocorynura*), the oocytes anterior to the large posterior ones are small, so that the ovarioles seem to consist largely of one oocyte each, which is much more than half of the total ovary length (figure 2).

Mandibles were classified in the following categories: unworn, slightly worn, well worn, much worn, very much worn.



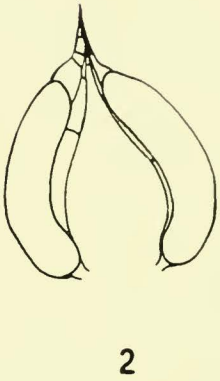




FIG. 1. Ovaries of egg laying female of *Pseudaugochlora nigromarginata.*
FIG. 2. Ovaries of egg laying female of *Neocorynura polybioides.*

*Neocorynura polybioides* (Ducke)

*Seasonal Cycle:* Females of this species appear early in the spring. A few were taken on flowers near Curitiba on August 30, 1955 and on October 1 a single female was seen flying about one of the Bariguí roadside banks. Males were first seen on December 14, when both sexes were found abundantly on flowers at Xaxim, a suburb of Curitiba.

Nests of this species were found on December 21, 1955, in the Bariguí roadside banks, in a vertical bank of decomposed gneiss, at a point where it overhangs and is therefore shaded. On this date four nests were opened. Several freshly opened cells, with feces, were found, indicating recent emergence of adults. One male and one female were found in their cells, not yet emerged. Three male and five female pupae were found, and one mature larva. No younger stages were found. One unmated, unworn (young) adult female was taken flying along the bank.

On January 3, 1956, a bee was found constructing a new nest in the same vicinity. This does not mean that there was synchronization of establishment of new nests and abandonment of old ones

at this time, however, for two nests opened in similar banks at Araucaria, Paraná, on January 13, 1956, were old nests containing half grown larvae, male and female pupae, and adults of both sexes ready to emerge from the cells. A nest from the Bariguí roadside banks opened on January 25 contained a half grown larva, four prepupae, three female and one male pupae, and an open cell apparently ready to be provisioned. Finally, a nest opened on March 11 contained one female and three male pupae.

From these data it would appear likely that this species passes the winter as fertilized females which emerge as early as the end of August, that their progeny reach maturity by mid-December, and that from that time until fall (March) new adults are produced more or less continually.

*Social organization:* Females, with worn mandibles or wings, but with slender ovaries and empty spermathecae, were not found. Therefore we judge that there is no worker caste nor approach to it. However *Neocorynura polybioides* is not an entirely solitary bee. One nest opened on December 21 contained two fertilized females with enlarged ovaries in approximately egg-laying condition (largest oocytes 1.3 and 1.9 mm. long) and with the crops full of pollen. Their mandibles were slightly worn, and we judge these to be bees that had overwintered and provisioned the twelve cells of the nest. Their progeny were emerging and one young unfertilized female was also in the nest. Although the youngest bee was a mature larva, it seems likely that the old bees would soon have resumed reproductive activity. Another nest opened on the same day also contained two fertilized females with somewhat enlarged ovaries (longest oocytes .6 mm.) but with unworn mandibles. We do not know whether they had overwintered and produced the brood emerging at this time; possibly the mother or mothers had died and these were among the progeny. A young unfertilized female was also in the nest, as was a female parasitized by a strepsipteran.

Although evidence such as that mentioned above indicates that at least two egg-laying bees may occupy one nest (and cell cluster) simultaneously, it is also apparent that a single bee may construct a nest. On January 3, 1956, one female was found building a nest; she had constructed a chamber but as yet no cells. A nest with three empty cells that had never been occupied and only four occupied cells, all containing pupae or adults ready to emerge, was found on January 13, suggesting that a single bee made the nest and that she died before we opened it. On January 25 a single female

was found in a nest containing pupae; she was mated and had much enlarged ovaries (largest oocyte 1.5 mm. long) but her mandibles were not or scarcely worn. We judge that the parental bee or bees had died and that this was one of their progeny nearly ready to start egg laying. On February 21 a fertilized female with much tattered wings, very much worn mandibles, and ovaries moderately enlarged and yellowish (longest oocyte, or chamber, .5 mm.) was found flying along the bank as though lost. Unpublished work on North American halictids has shown that senile bees often behave in this way and we judge that this may have been an overwintering bee nearing the end of its life.

*Nests:* Both at the Bariguí roadside banks and at Araucaria nests of this species were mostly in loose groups, several in one or two square meters (see Michener, Lange, Bigarella and Salamuni, 1958). Each nest consists of a burrow about 3 mm. in diameter, slightly constricted at the entrance, extending horizontally or sometimes slanting upward or downward into the bank of decomposed gneiss. At a distance of 2.5 to 9.5 cm. from the entrance, the burrow opens into a chamber, which is not especially smoothed on the inside. The chamber is rather irregular in shape, generally larger in horizontal diameters (up to 3.5 cm.) than in height (up to 2.7 cm.). There is no burrow extending on into the bank from the chamber.

Within the chamber is an earthen cell cluster sometimes supported by a single large central pillar (fig. 34), more often supported by three to five relatively slender pillars extending from the floor of the chamber to the under side of the cell cluster (fig. 34). Horizontal dimensions of the irregularly shaped and slightly rough cell clusters range from 1.8 to 2.7 cm., while vertical dimensions range from 1.2 to 1.7 cm.

Apparently completed clusters contain from 7 to 13 cells. Very inconclusive evidence suggests that a single female might produce as many as 7 cells while two females working jointly might produce 13 or so. The cells are usually nearly vertical but most clusters contain one or more slanting or even nearly horizontal cells. The walls around the cells and the earth of the cluster between cells is rather thick, in contrast to *Paroxystoglossa* and some others.

The cells are flatter on one side than the other, as usual in halictines. In slanting or horizontal cells the flatter side is lowermost, the more concave side uppermost. Vertical cells have the same shape. The pollen ball is placed near the lower end of the

flatter side, as in other halictines. The mature larva deposits feces on the more convex surface near the lower end of the cell (fig. 3.). The cells range from 9 to 10.5 mm. in length (from the surface of the cell cluster at the cell opening), 4.5 to 5 mm. in greatest diameter, with the opening 3 to 4 mm. in diameter. They are lined with a waxlike material except in the neck region.

We have little data on the manner of nest construction. The one nest excavated that was obviously being built had a small chamber (1 cm. in diameter) with a large mass of soft dirt resting on the center of the chamber floor. From this we assume that as the chamber is dug, some of the dirt from it is left in the center of the chamber and later formed into the firm cell cluster with its cells,

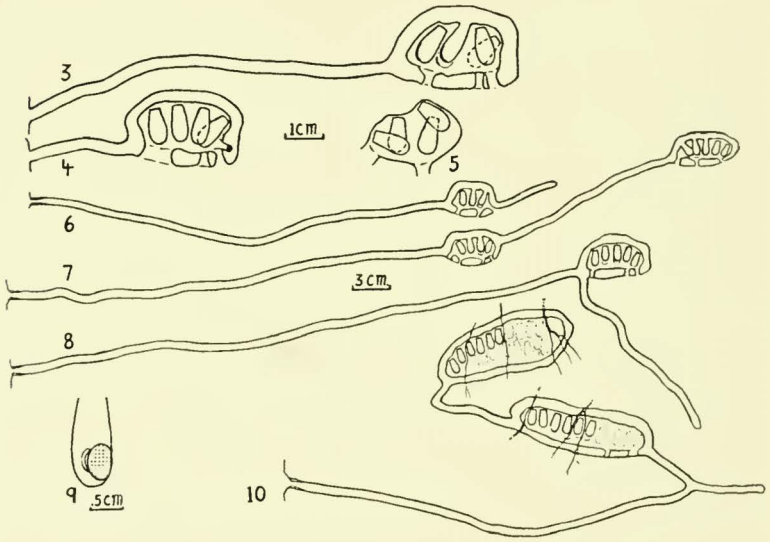



FIG. 3. Diagram of nest of *Neocorynura polybioides*. Heavy lines indicate deposition of fecal material in two cells. The open cell has been used twice.

FIG. 4. Diagram of nest of *Neocorynura polybioides*, showing a different cell arrangement. One supporting pillar of the cell cluster, which is more or less horizontal, is broken; the broken surface is shown as black.

FIG. 5. Diagram of cell cluster of nest of *Neocorynura polybioides*, showing an unusually irregular arrangement of cells.

FIGS. 6, 7, 8. Diagrams of nests of *Pseudaugochlora nigromarginata*. Some of the cells have been used twice. Cell clusters are of only moderate size.

FIG. 9. Diagram of unusual nest of *Pseudaugochlora nigromarginata*, showing large cell clusters. The upper cluster has been much thickened by repeated use; both cell clusters have inactive regions, shown by earthfilled cells. The cell clusters are largely or entirely supported by roots.

FIG. 10. Sectional view of cell with pollen ball and egg.

supporting pillars, etc. Cells may be reused at least twice (fig. 34). When this happens considerable soil is placed in the bottom of the cell before it is reformed and lined. Obviously the height of the cell cluster (and probably of the chamber) must be increased at the same time.

An interesting nest found on December 21, 1955 was being made by an unworn stylopized bee. Possibly it was quite abnormal. It contained a small mass of very soft, friable soil, in which was a single cell lined with waxlike material (fig. 34).

Lüderwaldt (1911) described the nests of another *Neocorynura*, *N. erinnys* Schrottky. They were in rotting wood, the cells closely clustered and rectangular in section, and in other ways also so different from those of *N. polybioides* as to make one wonder if Lüderwaldt's description applies to bees of the same genus as *N. polybioides.*

*Pseudaugochlora nigromarginata* (Spinola)

*Seasonal Cycle:* Observations were begun on this species on September 29, 1955, when a single nest was found in a Bariguí roadside bank and opened. It contained numerous open old cells, and one closed with a pollen ball and egg. We presume that females that had overwintered were at this time provisioning newly refurbished cells in old nests. The next occupied nest of this species was found in the same vicinity on November 22. It contained two female pupae, no other immature stages, perhaps because five cells were moldy. On February 2 a male was found in a burrow 10 cm. deep in a bank near Curitiba. (At Fazenda São José, Guaranesia, Minas Gerais, Dr. Domiciano P. de Souza Dias of Piracicaba, São Paulo, found a male in a short burrow in a bank on June 19, 1946. This is an area of milder winters than Curitiba.) Nests found in banks near São José dos Pinhais, Paraná, on February 21, 1956, contained cells being provisioned, cells with eggs, and in the same nests, prepupae and pupae of both sexes. We do not know whether the absence of feeding larval stages in the few cells examined was a happenstance or a significant fact. Females were observed on flowers collecting pollen as late in the fall as March 24 and visiting flowers for nectar on June 28, a warm winter day.

The fact that this species flies on warm days in winter suggests that it is active whenever temperatures are suitable and that winter may not cause a basic break in the life cycle as it does in many bees

typical of the southern Brasilian plateau. *P. nigromarginata* is basically tropical and it or close relatives range to Mexico and southernmost Texas. The well worn mandibles and much tattered wings of the fertilized egg-laying female that had evidently recently started her spring egg laying when the nest was dug on September 29 indicate that she must have been active also the preceding summer or autumn. The individual taken on flowers on June 28 was fresh, unworn, and unfertilized. If winter does not kill all but one age group, it will not have the synchronizing influence that it has for many bees and it is not surprising to find bees in various stages throughout the warmer part of the year. It appears certain, however, that reproduction ceases during the winter months in the vicinity of Curitiba. Bertoni (1911) states that this species passes the winter as adults in the nests and reported three individuals in a single nest.

*Social organization:* Our data is entirely too meager to give a clear picture of the social behavior of this bee. Several times we noticed a female plugging the nest entrance with her head, as did Ihering (1904), but we do not know whether such guarding occurs principally in nests with more than one bee or whether the guard will turn and plug the entrance with her abdomen, as do most halictines.

The nest opened on September 29 contained three females, all fertilized, only one of which was in egg-laying condition (all ovarioles enlarged, longest oocyte 2.6 mm.). The two with slender ovaries (longest oocyte .7 mm.) each contained a conopid larva among the abdominal organs so that they cannot be considered as normal. The nest opened on November 22 contained but one female; she was fertilized and had large ovaries (all ovarioles enlarged, longest oocyte 1.9 mm.). Although her nest was old, containing abandoned earth-filled cells probably used the previous season, it contained but seven cells used during the spring of 1955; possibly this is a normal number for a lone female to prepare and provision. An old nest opened on February 3 contained no immature stages; the single adult bee was an unworn unfertilized female with feebly enlarged ovaries.

On February 21 one old nest was found to contain a fertilized female, rather fresh, that was apparently constructing a new cell in the earth of the old cell cluster. On the same day another nest was found containing three females. One was a fertilized egg-laying individual (all ovarioles enlarged, longest oocyte 2.7 mm.)

showing slightly worn mandibles and wings. A second was also fertilized but unworn and with very slender ovaries (longest oocyte .8 mm.); probably it was young and a daughter of this nest. The third individual was workerlike in that, although its mandibles were well worn and its wings showed several nicks torn from the margins, indicating moderate age and considerable activity, it was not fertilized and its ovaries were very slender (longest oocyte .5 mm.). This is the individual that was carrying pollen into the nest. Neither of the fertilized ones was seen outside the nest in an hour of observation before we opened it. A third nest opened on the same day contained two females, one an only slightly worn but unfertilized individual with slender ovaries, probably workerlike; the other a not or slightly worn egg layer, fertilized, with large ovaries.

From February 26 to March 4 seven females were taken on flowers of *Cassia* in Curitiba while actively collecting pollen loads. Of these one was workerlike in being unfertilized and having slender ovaries in spite of well worn wings and mandibles. Three had large ovaries, and were fertilized; all three were but little worn. The remaining three were also but little worn; two were unfertilized, one of them with one oocyte in one ovary much enlarged (2 mm. long) but the ovaries otherwise slender, the other with the ovaries slender; the third was fertilized with slender ovaries.

It is possible to say from these data that the egg-laying individuals often collect pollen and presumably do the entire work of nest construction and provisioning. This may happen at any time during the season of activity of this bee. However, it is also apparent that some individuals (probably a minority) work extensively while not fertilized and probably never do mate or lay eggs. Such individuals have been found only after midsummer and may be absent in spring and early summer. These workerlike females occur in nests with egg layers and do some (or all) of the foraging.

There is a suggestion that an average size difference exists between egg layers and the workerlike individuals. Wing lengths of eight clearly egg-laying bees ranged from 7.8 to 8.8 mm. with a mean of 8.3 mm. while those of four obviously workerlike individuals ranged from 7.6 to 7.8 mm. with a mean of 7.7 mm. Individuals intermediate as to ovary development were found; from the enlargement of only one or two ovarioles we judge these individuals to be actually intermediate and not merely young which would later develop large oocytes in all ovarioles, but we cannot be certain of this.

*Nests:* The nests are found singly or in groups of three or four in vertical banks of soil; those which we found were in decomposed gneiss or basalt. The distribution and exposure of those in the Bariguí roadside banks is shown by Michener, Lange, Bigarella and Salamuni (1958). The nests are often high in banks, so that it may be difficult to open them.

At the entrance the burrow is constricted to about 4 mm. in diameter by material obviously transported from elsewhere in the nest by bees. Sometimes the entrance is located in the center of a conical depression as much as a centimeter in diameter. This depression is often circularly scratched, perhaps by the mandibles. The diameter of the burrow ranges from 6.5 to 8 mm. The burrow is usually unbranched and extends into the bank. It may be rather straight or sinuous, and often slopes upward, sometimes downward. Figures 6 to 9 illustrate some of the patterns which we have seen. At a depth of 14 to 48 cm. (average of eight, 34.1 cm.), the burrow opens into a large cavity or chamber. Horizontal diameters of the chamber in apparently completed nests range from 4.3 by 3.4 cm., in the case of a small chamber, to 10.5 by 6.0 cm. in the case of the largest chamber we found. Vertical heights of chambers vary from 2.7 to 4.7 cm. The chamber is irregular in shape, not particularly smooth walled. Most of the nests which we opened contained only a single chamber and had no burrow leading on from the chamber. However, several had such a burrow, connecting to almost any part of the chamber, and in two cases it lead on to a second chamber (figs. 7 and 9). Ihering (1904) described (under the name *Augochlora gramminea* Smith) a nest in which there were four chambers connected in sequence. He considered the cell clusters farthest from the surface to be the newest because of their smaller size and less regular shape.

In the chamber is a large earthen cell cluster supported by fairly robust pillars of earth. The number of pillars ranges from three to seven or eight. They are generally between the bottom of the cell cluster and the floor of the chamber, but in one nest a very large pillar connected the top of the cell cluster with the roof of the chamber (fig. 36). The distance between the wall of the cluster and that of the chamber is 6 or 7 mm.

Within the cell cluster the cells are in a generally vertical position. Their openings are rather widely separated, 5 to 8 or more mm. apart, the axes of the cells in general converging below. Cells do not usually closely approach one another nor the lower surface of

the cell cluster. This is in striking contrast to nests of such forms as *Paroxystoglossa jocasta* (Schrottky) (see Michener and Lange, 1958a) which are noteworthy for the thin walls between and around the cells, which diverge slightly from their openings.

The manner of construction of the cell cluster is unknown. However, one nest, excavated on November 24, 1955, contained a chamber 3 cm. long, in the center of which was a mass of soil so delicate that it fell apart at a touch. It certainly contained no wax-lined cells, and it is not clear whether it was supported by pillars or rested on the floor of the cavity. By analogy with *Paroxystoglossa* (Michener and Lange, 1958a) it seems probable that the cell cluster is built of friable soil probably removed from the walls of the chamber as it is enlarged and that only later does the cluster become firm. The nest mentioned above was inhabited and doubtless being built by a single female. She was an old bee, with wing margins entirely worn away and mandibles well worn. She had been fertilized and had large ovaries, but the longest oocyte was only 1.7 mm. long, not nearly large enough to be laid. The possibility exists that she was senile and her behavior abnormal, although the condition of the ovaries does not support this idea.

As already indicated, the size of the cell cluster is highly variable. It is not surprising that the number of cells in it is also variable. We have seen apparently completed clusters with from 7 to 43 cells (average number of cells in nine clusters, 15.5). The larger clusters often have occupied cells in only one area, *e. g.*, one end or much of the lateral margin, the rest of the cluster containing old, empty or earth filled cells which had once been used (fig. 9). The largest number of occupied cells that we found in any cluster was 22 in a nest opened on February 21; this cluster also contained 21 open cells, all old and empty except for one which was being provisioned. The nest was occupied by three bees when it was opened; one was a fertilized egg layer, one an unfertilized worker-like individual, and the third a fertilized but unworn, probably young individual.

Although the impression given by the distribution of abandoned and used cells in large clusters is one of cluster (hence chamber) growth during the seasons or years of occupancy, leaving sections of the cluster abandoned, the bees do re-use old portions of the cluster. It is common to find cells that have been used two or three times. In such cases some dirt is placed in the cell and the new wax lining is thus separated, at the base of the cell, by .5 to 5

or 6 mm. of soil from the old lining (figs. 6 to 8, 10, 35, and 36). The result is that new cells are at somewhat higher levels than those they replace, and hence the cell cluster becomes thicker as it is reused. Obviously the height of the chamber must be increased also.

The cells are lined with waxlike material except near the openings. Their length varies from 13 to 15 mm; maximum diameter, 6 to 7 mm; diameter of cell opening or neck, 4 to 4.5 mm. They are flatter on one side than the other, the flatter side corresponding to the lower surface of horizontal cells. The pollen ball is placed against the flatter side of the cell, near the lower end of the cell (fig. 9). The pollen ball is about 5 mm. in maximum diameter, little if any over 3 mm. in thickness. The curved white egg, 2.8 to 3 mm. long, lies on the free side of the pollen ball, in contact with it at both ends. The egg tapers distinctly posteriorly; near the anterior end it is .7 to .8 mm. in diameter while near the posterior end it is .5 to .6 mm. in diameter.

*Megommation insigne* (Smith)

*Seasonal cycle:* So few nests of this crepuscular or nocturnal species were opened that we can contribute practically nothing concerning the seasonal cycle. The nests were found in the packed soil of small paths through grassy or weedy areas of nearly level ground near forested areas in the vicinity of the Barigui roadside banks, Curitiba, Paraná. Jörgensen (1912) published a fairly extensive account of this species, which should be consulted for further information.

A nest opened on December 16, 1955, contained an adult female and, in the cells, two female pupae. A nest opened on January 5, 1956, contained two adult females and, in the cells, eggs, young larvae, and pupae. A nest opened on February 16 contained four adult females and, in the cells, eggs. A nest opened on May 4 contained two adult females, but the cells were entirely empty.

*Social organization:* From the above, it is obvious that more than one female may occupy a single nest. Of the two females in the nest opened January 5, one was fertilized and had large ovaries (longest oocyte 3.5 mm. long) while the other, which was unfertilized, had small slender ovaries, with the longest oocyte .6 mm. long. Both had slightly worn mandibles, the unfertilized one if anything showing more wear than the other.

Among the four females removed from the nest which was opened on February 16, one, which had been fertilized, had well-worn mandibles, a few nicks in the wing margins, and enlarged ovaries (although the longest oocyte was only 2 mm. long). Evidently this was the egg layer. The other three, all unfertilized, had unworn or slightly worn mandibles, undamaged wings, and slender ovaries with the longest oocyte .5 to .8 mm. in length.

To judge by these two nests, there must be workerlike individuals and egg layers, much as in *Pseudaugochlora nigromarginata.* Measurements of wing lengths of two egg layers were 10.1 and 11.0 mm.; of four probably workerlike bees, 9.5, 9.8, 10.1, and 10.2 mm.

Of the two bees which may have been preparing to pass the winter when their nest was opened on May 4, one was unworn and unfertilized, the other had much worn mandibles and wings and was probably also unfertilized.

*Nest structure:* This bee is especially remarkable for its beautiful nests, earlier described under the name *Megalopta ipomoeae* Schrottky by Jörgensen (1912) and Bertoni (1918). At the entrance, each nest opening is guarded by an erect turret made of soil. In bare places the turret is usually relatively low (fig. 37), 10 to 13 mm. in height, but in a grassy place a turret which reached nearly to the tops of the grass blades was 47 mm. high. The inside diameter of the turret is about 7 mm.; its walls range up to about 5 mm. in thickness.

The burrow below the ground surface enlarges to about 9 mm. in diameter. It descends straight or in sweeping curves to a depth of 31 to 42 cm. below the ground surface. At a depth of 17 to 30 cm. from the surface, a lateral burrow extends horizontally or usually slightly upward to a large, uniformly shaped, subspherical chamber which measures 5 to 6 cm. in any diameter (fig. 11). The inside surfaces of the burrows are beautifully smooth. They have no wax lining but are so smooth that a careful examination had to be made to be certain that there was no lining. The chamber is also very smooth, but one can see the marks of the mandibles on its walls, unlike the walls of the burrows.

The chamber contains a cell cluster, the entire surface of which is smooth and polished, but not covered with waxlike material. The cell cluster is 28 to 32 mm. long, about 24 mm. wide, and 24 or 25 mm. in height. It is supported well above the floor of the chamber

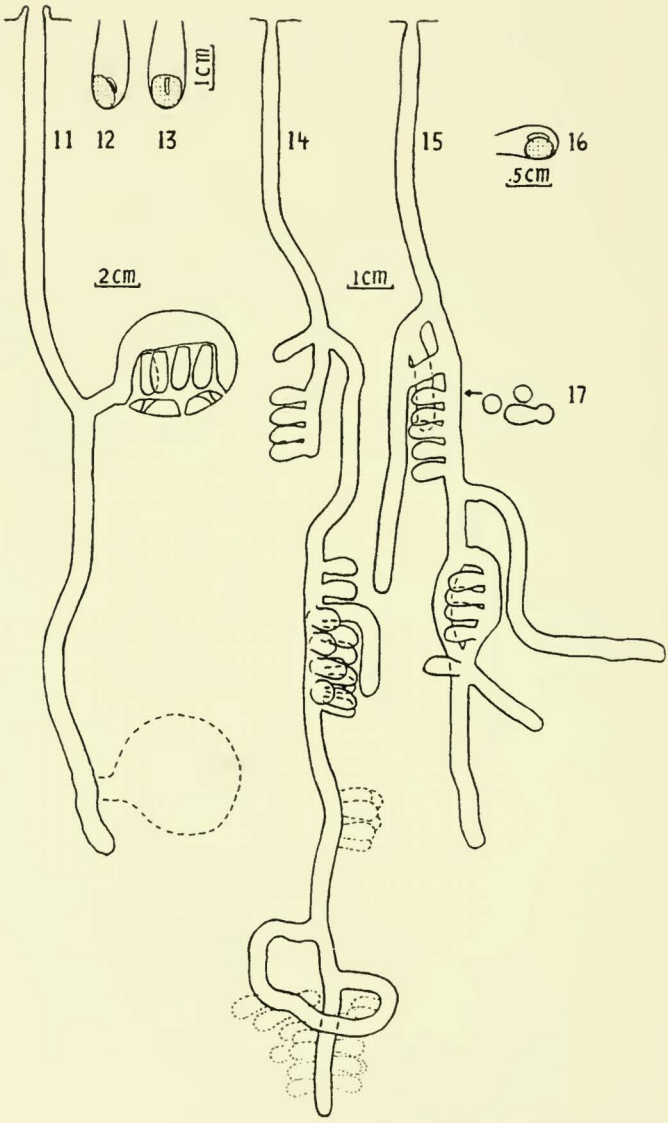



FIG. 11. Diagram of nest of *Megommation insigne*. Broken line near bottom shows position of abandoned, earth filled chamber.

FIGS. 12, 13. Sectional views of cell, showing pollen mass and egg.

FIGS. 14, 15. Diagrams of nests of *Augochlora semiramis* (October 25, 1955). Dotted cells in 14 are old and earth filled.

FIG. 16. Longitudinal section of cell of *Augochlora semiramis*, showing pollen mass and egg.

FIG. 17. Cross-section of nest shown in figure 15 at level indicated by arrow showing how vertical branch burrows pass close to a cell.

by four to seven pillars which are thick where attached to the cell cluster and taper to small diameters (1.5 to 4 mm.) where they attach to the floor of the chamber. The pillars extend downward from the cluster or more or less outward from its lower outer margins so that some of them can be seen from above [see especially Jörgensen's (1912) illustration]. They support the cluster at such a height that its flattened upper surface is 32 to 34 mm. above the floor of the chamber. The upper surface of the cluster slopes downward toward the main burrow of the nest. The measurements given above, as well as figure 11, show the unusual amount of space around, and especially above, the cluster.

The cells are vertical or nearly so, opening on the upper surface of the cluster. They vary from 18 to 20.5 long, 7.5 to 9.5 mm. in maximum diameter, with the entrances 5 to 5.3 mm. in diameter. Only about the lower half of each cell is waxed. The walls of the cluster beneath and lateral to the cells are about 1 mm. thick and convexities indicating the lower ends of the cells on the under surface of the cluster are not or scarcely visible. As usual in halictines, each cell has one side flatter than the others (fig. 12), and the pollen mass is placed near the bottom of the flatter side. It is quite soft and there may be a little liquid in the bottom of the cell. The pollen mass is about 7.5 mm. long (vertically), 6.8 mm. wide, and 4 mm. thick. It is slightly rectangular, seen from the side on which the egg is placed (fig. 13), and looks as though it had slumped down a little in the cell.

The egg is placed on the exposed subvertical surface of the pollen mass. It is white, 3.8 mm. long, arcuate, .85 to .90 mm. in maximum diameter near the anterior (upper) end, .8 mm. in diameter near the posterior end.

One nest had remnants of an old cluster, now abandoned and largely earth filled, below the level of the occupied cluster (fig. 11). This would indicate long continued use of the same burrow.

*Augochlora semiramis* (Schrottky)

This bee is extremely common, at least at some seasons of the year, in cleared and savanna areas near Curitiba, Paraná. Females were common on flowers of *Senecio trichocaulon* in the savanna near the suburb of Xaxim, Curitiba, in October, 1955. In December it was noted that they were much less common in the area, but were gathering pollen.

Twelve females taken on flowers of *Senecio* on October 9 all had slender to very slender ovaries and unworn or scarcely worn

mandibles and wings; all but one had been fertilized. Three of the twelve were collecting pollen loads on the scopa when they were captured. From this we suppose that young adult fertilized females survive the winter and start their nesting activities in the spring (October). The only nests opened were found on October 25. The three nests which we opened on that day had one, three, and eight bees (females) in them. These twelve bees all had not or but little worn mandibles and wings and had been fertilized. One bee in each nest had slightly to considerably enlarged ovaries; the others had slender to very slender ovaries. The ones with large ovaries were not the largest of the bees. These meager data show that several bees may occupy a nest, that bees with slender ovaries may collect pollen, but that such bees are not workerlike in the sense of being unfertilized or smaller than the egglaying individual. The social organization, so far as we know it, seemingly resembles that of *Augochloropsis sparsilis* (Vachal), to be described in a subsequent part of this series of papers. Workers may, however, appear later in the year.

The nests, opened on October 25, 1955, were vertical or slanting burrows in firm bare level ground. They were widely scattered, there being no evidence of gregariousness. The diameter of the opening was about 2 mm. and of the burrow elsewhere, about 4 mm. The burrows were unbranched to a depth of four to eight centimeters, below which there were several branches (figs. 14 and 15). Cells were located in groups of 5 to 11 or more, about as close as they could be placed, along the vertical main burrow, or on a branch. The axes of the cells are approximately horizontal. The cells do not project in all directions from the main burrow, but extend toward one quarter or another forming a vertical series. Commonly one to several of the branch burrows pass vertically close to the group of cells, often meeting one another to form complete rings, so that in some cases (not shown in the figures) the group of cells becomes rather well isolated from the surrounding soil. Since the cells are close together and their walls are built by the bees of very thin soil, the group of cells is very delicate. It cannot be removed intact, but can be removed in fragments from the surrounding soil, which then shows a series of concavities corresponding to the cells.

Many of the cells were old and earth filled, showing that the nests had been occupied at least the season before. However, cells being constructed, others being provisioned, and others containing

eggs, small larvae, and half grown larvae were found. Most of these cells constituted new or completely reconstructed groups but some were among groups of old cells of the previous season.

The cells are about 7 mm. long, 4 mm. or slightly less in greatest diameter, with the diameter of the entrance about 2.2 mm. They are lined with waxlike material. The lower surface is flatter than the upper (fig. 16). The pollen ball is considerably flattened, the horizontal diameters being 3.1 to 3.4 mm.; the vertical diameter 2.0 to 2.4 mm. The arcuate egg is placed on top of the pollen ball, parallel to the long axis of the cell as in other halictines. It is white, 2.1 to 2.3 mm. long, .52 to .56 mm. wide, only slightly thinner posteriorly than anteriorly.

*Augochlora morrae* Strand

Two nests of this species, as well as a male in a different burrow, were found in a vertical bank near São José dos Pinhais, Paraná, on February 21, 1956. In the nests roughed out but unlined cells, waxed cells ready for use, as well as small larvae and a white female pupa were found. Thus individuals in all stages could be expected at this season (late summer). Outside the region of the southern Brasilian plateau, we have data on one nest in a roadside bank between Boa Vista and Corcovado, Rio de Janeiro, opened February 25, 1956, by Dr. Carlos Alberto Campos Seabra and Father J. S. Moure. This nest contained a prepupa, eight female pupae, and two male pupae. A nest was excavated by us at about sea level in flat ground at Guaruva, Santa Catarina, on October 30, 1955. The burrow was closed at the surface; we found it by chance. A single female was in the nest. There were eight cells, those nearest the surface containing pupae (one male, one female), the rest containing larvae of various sizes, the smallest being in the deepest cells.

With such scanty data, we can only be indefinite about social relationships. It seems probable that the nest from Guaruva was made and the eight cells provisioned by the single female that was found in it. One of the nests opened February 21 contained only four cells and was occupied by a single fertilized female with well worn mandibles, much tattered wings, and rather slender ovaries, which may account for the fact that of the four cells, only one was or had been occupied (it contained a small larva). A group of old, earth-filled cells indicated that the nest was being reused. The other nest opened on the same day contained about eight

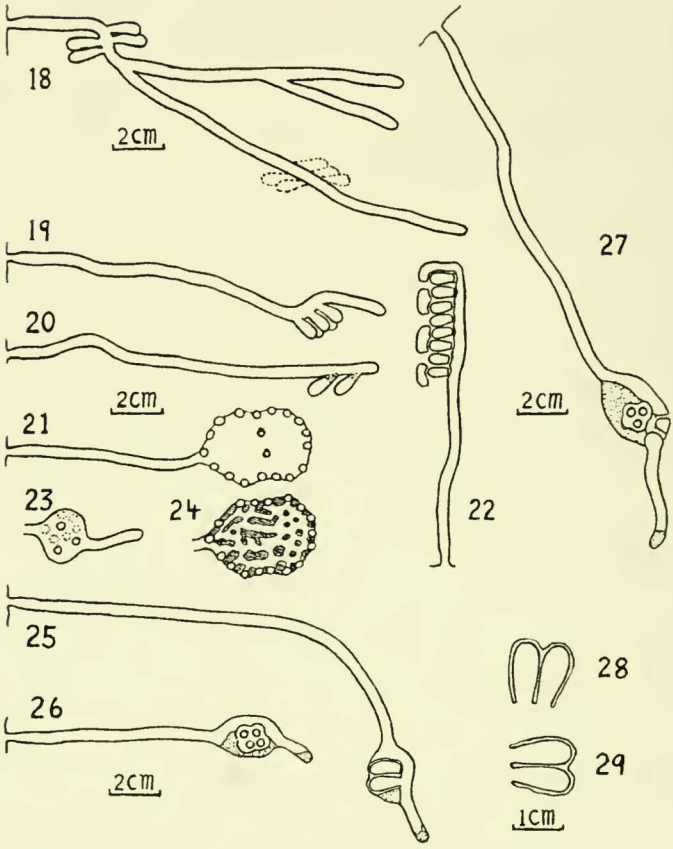



FIG. 18. Diagram of nest of *Augochlora morrae*. Cells indicated by dotted lines were old and earth filled (February 21, 1956).

FIGS. 19-21. Diagrams of nest of *Augochlorella michaelis* (Dec. 4, 1955; Jan. 13 and February 21, 1956, respectively). Fig. 19 and 20 are side views of nests with strongly slanting cells. Fig. 21 is side view of a nest with cells but slightly slanting. The marginal holes around the cell cluster (which has two open cells) lead to the passageways behind the cell cluster.

FIG. 22. Top view of nest shown in fig. 21, showing passageways behind cells.

FIG. 23. Front view of the cell cluster shown in fig. 19 (closed cells are shown dotted).

FIG. 24. Back view of cell cluster of nest shown in figs. 21 and 22. Shaded areas are earth supports between the passageways behind the cells.

FIG. 25. Diagram of nest of *Paroxystoglossa andromache* showing cell cluster in side view in contact with chamber wall and supported by loose dirt (Oct. 23, 1955).

FIGS. 26-27. Diagrams of nests of *Paroxystoglossa andromache* showing cell clusters in front view, in one case with pillars (Oct. 23 and 24, 1955).

FIG. 28. Top view of horizontal section of cell cluster of *Paroxystoglossa andromache* (Oct. 24, 1955).

FIG. 29. Side view, vertical section, of same.

cells, several parasitized by mutillids, others containing small larvae and pupae. There were three unfertilized, unworn young adult females with slender ovaries in the nest, probably recently emerged, but the bee or bees that made the nest seemingly had not survived. The nest from Rio de Janeiro similarly contained only young unfertilized females, in this instance four of them. In this case, however, the nest was dug on a warm day without a preliminary period of watching and it is possible that older bees were afield.

The nests are burrows about 5 mm. in diameter, narrowed at the entrance, and extending horizontally into a bank or slope slightly downward, or are vertical in flat ground. The burrows are 10 to 20 cm. deep and may be simple or branched. The cells are essentially horizontal, very like those of *Chloralictus*, but in denser clusters than usual in that group. Among the nests which we studied the cells were in groups of four to nineteen. The cells are lined with waxlike material, the lower sides flatter than the upper. The pollen is in the form of a flattened firm ball, with horizontal diameters 2.9 to 3.2 mm., the vertical diameter 2.1 mm.

*Augochlorella michaelis* (Vachal)

Only three nests of this species have been studied. One, in the Barigui roadside banks near Curitiba, Paraná, was found about November 4, 1955, and a bee was seen going in and out. It was excavated on December 4, at which time the entrance was closed. It contained a single fertilized female with well worn mandibles and wings, and in the six cells, young of various stages from egg to female pupa. Four of the cells eventually produced females, none males. Another nest was found in a bank at Araucaria, Paraná, January 13, 1956. It also contained an old fertilized female (mandibles much worn, wings tattered). Its two cells both contained female pupae. The small size of the nest combined with the worn condition of the female suggest that the nest may have been made by a senile bee that had worked elsewhere previously. The third was found in a bank near São José dos Pinhais, Paraná, on February 21, 1956. This last nest contained, in its cells, seven eggs, a half grown larva, four mature larvae, three prepupae, fifteen male pupae and six female pupae.

Unlike the first two nests mentioned, the last contained several bees. Three were captured as they returned to the nest with pollen loads on the scopa. These had slightly worn mandibles, indicating at least moderate age, but their ovaries were slender (longest oocyte .2 to .3 mm.) and they were unfertilized. Clearly they were worker-

like individuals. Three other females were in the nest when it was opened. One was unfertilized, unworn, with slender ovaries and was doubtless recently emerged. Two were fertilized and had very much worn mandibles, worn wings, and enlarged ovaries (longest oocyte 1.7 mm. in both cases). Clearly these two were egg layers. Their wing lengths were 5 and 5.1 mm.; those of the three workerlike bees were 4.6, 4.7, and 4.8 mm. The social relationships seem similar to those of *Pseudaugochlora nigromarginata*, in which there is also a suggestion of a size difference between the workerlike and the egg-laying females.

The three nests of this species that we studied were very different from one another, so that one is forced to doubt if they were really made by the same species of *Augochlorella*. Each consisted of a nearly horizontal, rather straight, unbranched burrow 7.5 to 10 cm. deep and 4 mm. in diameter, narrowed at the entrance. The burrow in the Bariguí nest ended in a sloping space on one side of which was a cluster of six completed closed cells and three rough, unlined cells (figs. 19, 23.) These cells were built of walls made by the bee, having a thickness of .7 to 1.0 mm. The subcircular cell cluster could be lifted out of its position intact, but there was no space around the cells except for the flat space over the cell entrances. The convexities of the closed ends of the cells were represented by concavities in the unworked earth in which the nest lay. From the space over the cells, a short burrow extended on into the bank. The axes of the cells were at an angle of about 45° to horizontal, as was the plane of the flat space providing access to them. The nest from Araucaria, having but two cells, lacked a space, the slanting cells merely extending downward from the burrow (fig. 20).

The nest from São José dos Pinhais was similar to the Bariguí nest in having a flat subcircular cluster or plate of cells, but this cluster was more nearly vertical, so that the cells themselves were more nearly horizontal. There were 38 cells, two of them empty, in the cluster. Around its margins a series of holes extended inward and connected with interconnecting passages between the backs of the cells and the soil, so that the cell cluster was supported by the spaces and pillars among these passages and by the soil between the holes leading to these passages (figs. 21, 22, 24). The passages had been excavated in the unworked soil behind the cells, leaving the convexities of the closed ends of the cells visible. The cell walls were .5 to 1.0 mm. thick throughout.

Cells, lined with waxlike material, are flatter on the lower surfaces than the upper, and are 9 to 9.8 mm. long, 4 to 5 mm. wide at the widest point, and 2.5 to 3 mm. wide at the neck. The pollen ball, which is a flattened sphere, about 3.3 mm. in the greatest diameter and about 2 mm. in the smallest (morphologically vertical) diameter, is placed on the flatter side of the cell near the closed end, as usual in halictids. The egg is 2.1 mm. long, arcuate, white, and placed on the upper surface of the pollen ball.

*Paroxystoglossa andromache* (Schrottky)

The biology of this species is probably similar to that of *P. jocasta* (Schrottky) (see Michener and Lange, 1958a). Our first record of it is of a burrow being dug on August 30, 1955 and a few nests were found in various stages of construction during September, October, and January, 1956. Cells being provisioned or containing eggs were found on October 14, 23, and 24, and cells with pupae were found on January 27. Unlike *P. jocasta*, nests are usually found in banks or steeply sloping ground. We found them in the Bariguí roadside banks (see Michener, Lange, Bigarella and Salamuni, 1958) and in a bank at Xaxim near Curitiba, in a bank near São José dos Pinhais, and in a bank near Campo Largo, all in the state of Paraná.

On a cold day (September 16, 1955) three males were found, one in a burrow 3 cm. deep in a bank, two in burrows of *Augochloropsis diversipennis* (Lepeletier).

Of twelve nests opened, only one contained two adult female bees. As in such cases in *P. jocasta*, one of the bees had enlarged ovaries, the other slender ovaries, but both had been fertilized.

The nests are similar to those of *P. jocasta* except that the burrow, which is 9 to 25 cm. deep, is horizontal or slants downward instead of being vertical. The cell cluster, like that of *jocasta*, consists of very thin-walled cells, usually very few in number (figs. 28, 29). The largest clusters we found contained only four cells. The cell cluster is placed in a chamber in which it may be supported by pillars as in *jocasta* but usually the lower part of the chamber, between the cluster and the wall of the chamber, is filled with friable soil which supports the cluster (figs. 25 to 27). Pillars may or may not be entirely absent in such cases.

The cells are horizontal and lined with waxlike material, and shaped as in *P. jocasta*. They are 11 to 12 mm. long, 5 to 5.25 mm. wide, the neck about 2.75 mm. wide; the pollen ball is slightly

flattened, about 4 mm. in horizontal diameter. The white arcuate egg is about 2 mm. long.

*Habralictus canaliculatus* Moure

*Seasonal Cycle:* This is a minute and inconspicuous, and apparently rather rare bee about which we can contribute but little. Three nests were found on October 23, 1955, in a small moss covered bank about 20 cm. high, completely shaded in the forest near the Bariguí roadside banks, Curitiba, Paraná. Later these nests could not be located in spite of weekly visits and were evidently closed but on January 8, 1956, loose dirt, indicating recent excavation, was noted at the same place and on January 15 one of the nests was dug. Two males and three unworn young females but no immature stages were found in it. It seems very probable that in spring (October) the nests were provisioned. Apparently they then became closed and another brood emerged in January. On February 29 a nest was found in one of the Bariguí roadside banks (see Michener, Lange, Bigarella and Salamuni, 1958). It contained four cells, one of them with a half-grown larva, two with eggs, and one being provisioned. On March 11 a nest in the same area, containing but one cell which was being provisioned, was found. On March 16 a nest was found containing two half-grown larvae, numerous mature larvae and prepupae, and twelve male and three female pupae (white). On March 18 another nest with three prepupae in it was found.

These data suggest a brood that matures in the fall and provisions cells in the spring. The summer brood from these cells, appearing in January and provisioning cells through February and early March, gives rise to the brood that matures in the fall. The two broods would be comparable to those of *Pseudagapostemon* (Michener and Lange, 1958).

*Social organization:* Of the very few nests examined, two were known to be occupied by but one female, and contained few cells, although they were still being enlarged and more cells would probably have been built. The large nest opened on March 16 contained 37 cells and a single old female with much worn mandibles. It seems very probable that this one bee did not make and provision so many cells. Probably several bees had lived together in this nest. The presence of some old dirt-filled cells in addition to the 37 occupied ones indicated that this nest had been occupied during the previous generation.

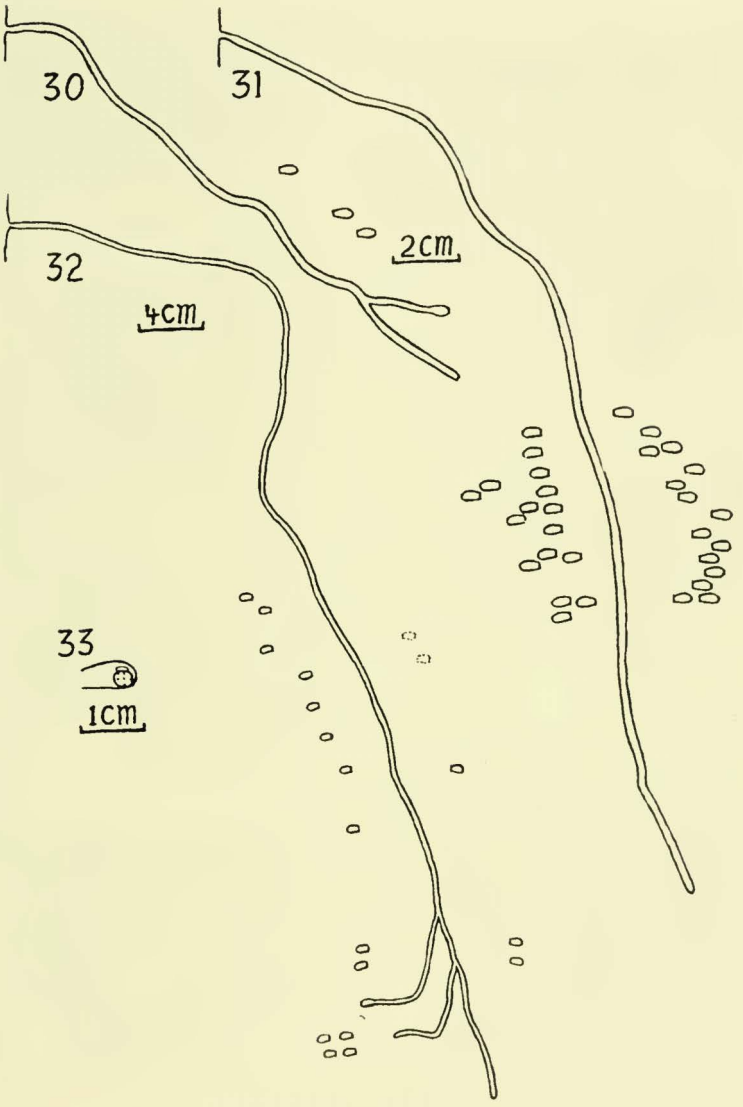



FIG. 30. Diagram of nest of *Habralictus canaliculatus* (Feb. 29, 1956).
FIG. 31. Diagram of nest of same (Mar. 16, 1956).
FIG. 32. Diagram of nest of *Caenaugochlora curticeps* (Oct. 17, 1955).
FIG. 33. Diagram of cell, with pollen mass and egg, of same.

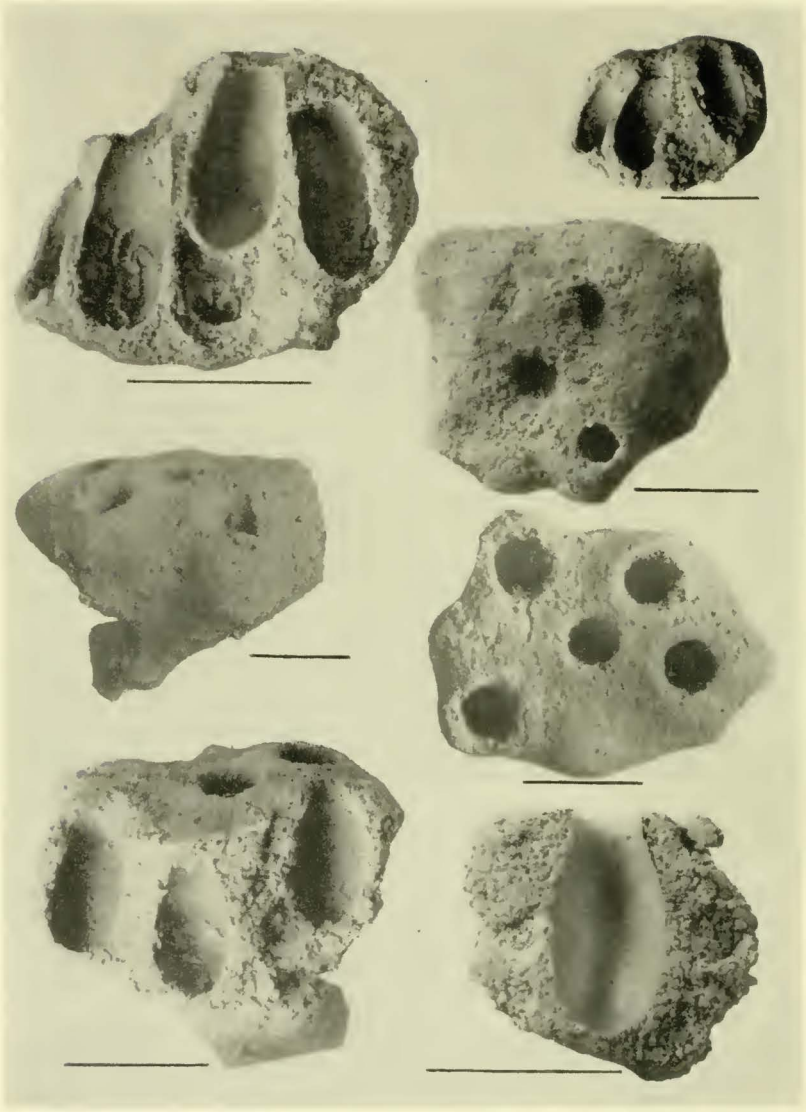


FIG. 34. Cell clusters of *Neocorynura polybioides*. Black lines represent 1 cm. *Top three* photographs show vertical sections and a top view of the cluster from a nest opened on Dec. 21. The central cell, at upper left, has been used three times. *Middle and lower left* show side view and a vertical section of a cluster that was unusual in being supported by a single large pillar (Dec. 21). *Middle right* is a top view of the same cluster. Two cells were closed, but their contents moldy. *Lower right* is a vertical section of a cell "cluster" (of one cell) in the nest of an unworn stylopized female (Dec. 21).

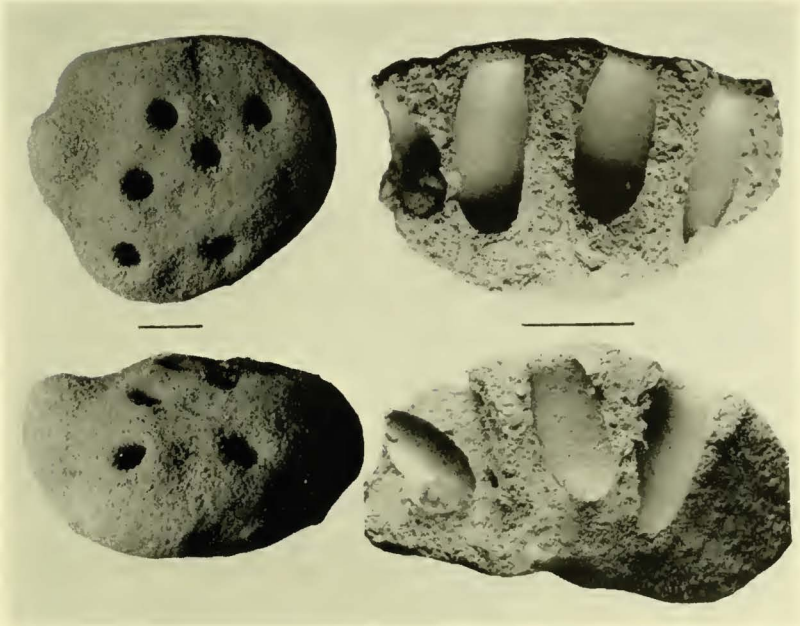


FIG. 35. Cell clusters of *Pseudaugochlora nigromarginata*. Black lines represent 1 cm. *At left*, top and side views of a cluster from a nest opened on Sept. 29. Faintly depressed areas are plugs of provisioned closed cells. *At right* are vertical sections through a cell cluster. The upper one shows a provisioned cell (left) and smooth but unwaxed cells (center) at least one of which had been used previously as shown by old fecal matter below the base of the present cell. The lower one shows the same provisioned cell (left), a shaped but not smoothed cell (center) and a smoothed but unwaxed cell (right).

Except for obviously young bees, every female dissected (six, including a few captured flying about banks in the Floresta da Tijuca, Rio de Janeiro, January 9, 1956, by Dr. Carlos Alberto Campos Seabra) had been fertilized and had enlarged ovaries with eggs. Thus there is no suggestion of a worker caste. When several females occupy one nest, their interrelationships may be similar to those of *Pseudagapostemon*.

*Nests:* Each nest consists of a slender, unbranched burrow extending into the bank and sloping downward. The burrow is 2.5 to 2.8 mm. in diameter, narrowed at the entrance to 1.5 mm. in diameter. These burrows reach a length of at least 32 cm. (large nest opened March 16); smaller and incomplete nests which might have been further deepened had burrows 12 and 18 cm. in length.

The cells are horizontal or but slightly slanting, 2 to 4 cm. from

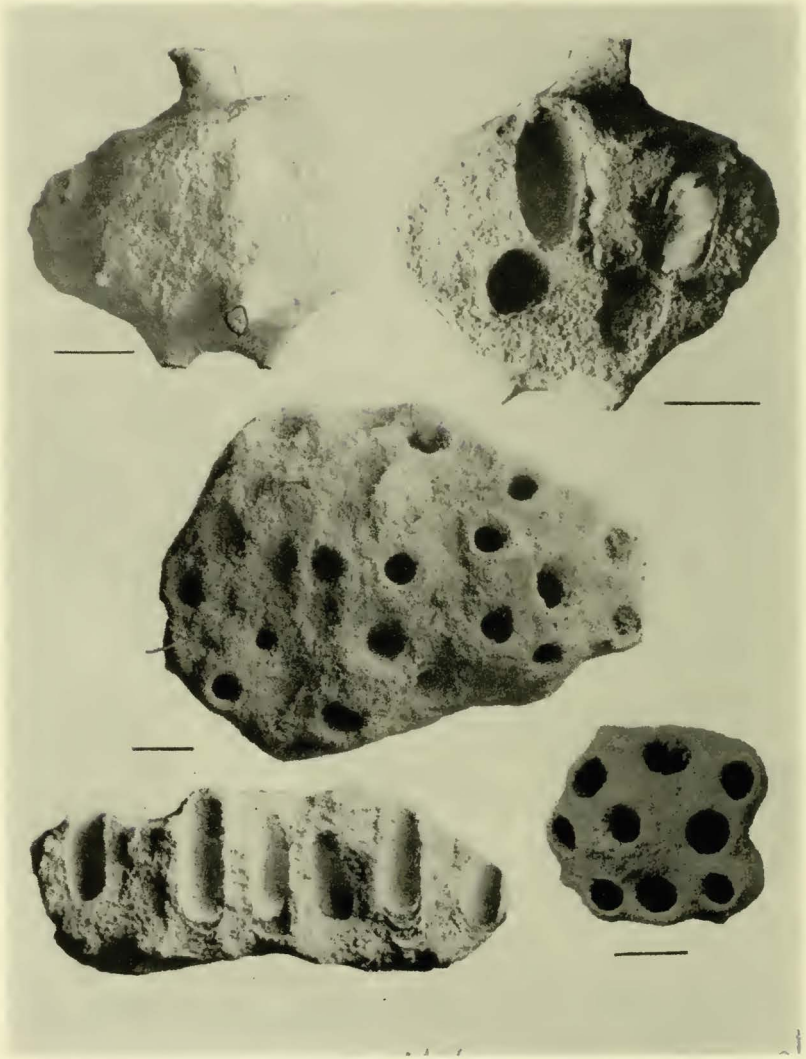


FIG. 36. Cell clusters of *Pseudaugochlora nigromarginata*. Black lines represent 1 cm. *Top*, side view and vertical section of cluster which had three supporting pillars below (broken surfaces outlined in black in side view) and an unusual pillar from top of cluster to roof of chamber. The section shows a horizontal cell (lower left) and an old earth filled slanting cell (lower right) (Nest opened Nov. 22). *Center*, top view of old cell cluster in which one cell (lower left) has been prepared for use. Rootlets which supported this cluster can be seen (Nov. 22). *Lower left*, vertical section of the same, showing fresh cell at left, and other cells, some of which, although abandoned, were closed at the surface. Reuse of several cells is evident. Fecal material is well shown in the third cell from the right. The second cell from the right shows particularly well how waxlike linings of various cells have been rasped away, apparently by mandibular action in enlarging the cell entrance. *Lower right*, top view of small cluster. All cells were open; entrances of some of them had been much enlarged.

the main burrow. In the smaller nests, being built by lone females, the youngest cell was that farthest from the nest entrance and the oldest cell was nearest the entrance. Each cell had presumably been constructed at the end of a different lateral burrow, but all laterals except that leading to the cell being provisioned were so well filled with soil as to be unrecognizable. In the large nest opened on March 16 the younger and older brood was not systematically arranged, and the cells were grouped in such a way as to suggest that several may have been constructed branching from the same lateral. However, since all the laterals were completely and indistinguishably earth filled, this is not certain.

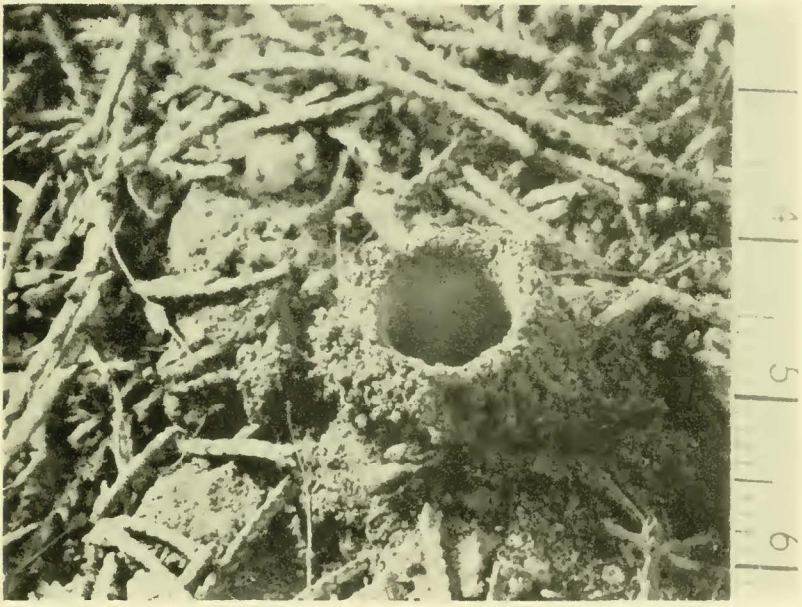


Fig. 37. Turret at nest entrance of *Megommation insigne*. Scale at right is in centimeters.

The cells measure 5 to 6 mm. in length, 2.8 to 3.3 mm. in maximum diameter, with the diameter of the neck about 1.8 mm. The cells are lined with waxlike material except for the necks. The lower surface or floor of a cell is flatter than the upper and the pollen ball lies on the floor near the distal end of the cell. Horizontal diameters of a pollen ball were 2.1 and 2.3 mm., the vertical diameter was 1.9 mm. The curved egg is placed on top of the pollen ball, in contact with it at both ends.

*Caenaugochlora curticeps* (Vachal)

*Seasonal cycle:* The few nests of this small species that were studied were scattered along the Bariguí roadside banks; their distribution there was indicated by Michener, Lange, Bigarella and Salamuni (1958).

The first nest found was on October 14, 1955. At this time both sexes were on the wing. The nest found on October 14 was opened three days later. It consisted of a burrow, with no cells. The females captured at this time were not or only slightly worn. The last spring male was seen on October 23. The next nest found was opened on October 29. It contained provisioned cells with eggs but no larvae. A nest opened on November 16 already had mature larvae, as well as small larvae and eggs. After the later part of November, no individuals of this species were seen until January 21, 1956 when both sexes were noted flying along the banks. On February 29, it was noted that while adults had not been seen for some time, a well worn female was found in a burrow. On March 11 a few females were again seen flying along the banks.

The number of observations of this small and uncommon species is small, but we may surmise that the seasonal cycle is similar to that of *Habralictus canaliculatus* (see above) and *Pseudagapostemon* (Michener and Lange, 1958). There seems to be a brood that appears in the fall (March); both sexes survive the winter and the females provision nests in spring (October, November). The progeny of this brood appear and provision nests in summer (January, February).

*Social organization:* Only three nests could be opened completely because of rarity of the bee and the difficulty of following the deep, slender burrows. Two of the three nests contained three females, one contained four. Observations of activities at nest entrances indicated that some nests contained at least five females. In these nests, during warm sunny weather, one or another of the females commonly plugged the entrance with her head.

As with *Pseudagapostemon* (possibly also *Habralictus canaliculatus*) activities seemed well synchronized. The bees taken from any one nest at one time had similarly developed ovaries, similarly worn mandibles, etc. Except for obviously young bees, all females found had been fertilized. There is, thus, no indication of a worker caste. Perhaps the interrelationships among females in a nest are similar to those that occur in *Pseudagapostemon*.

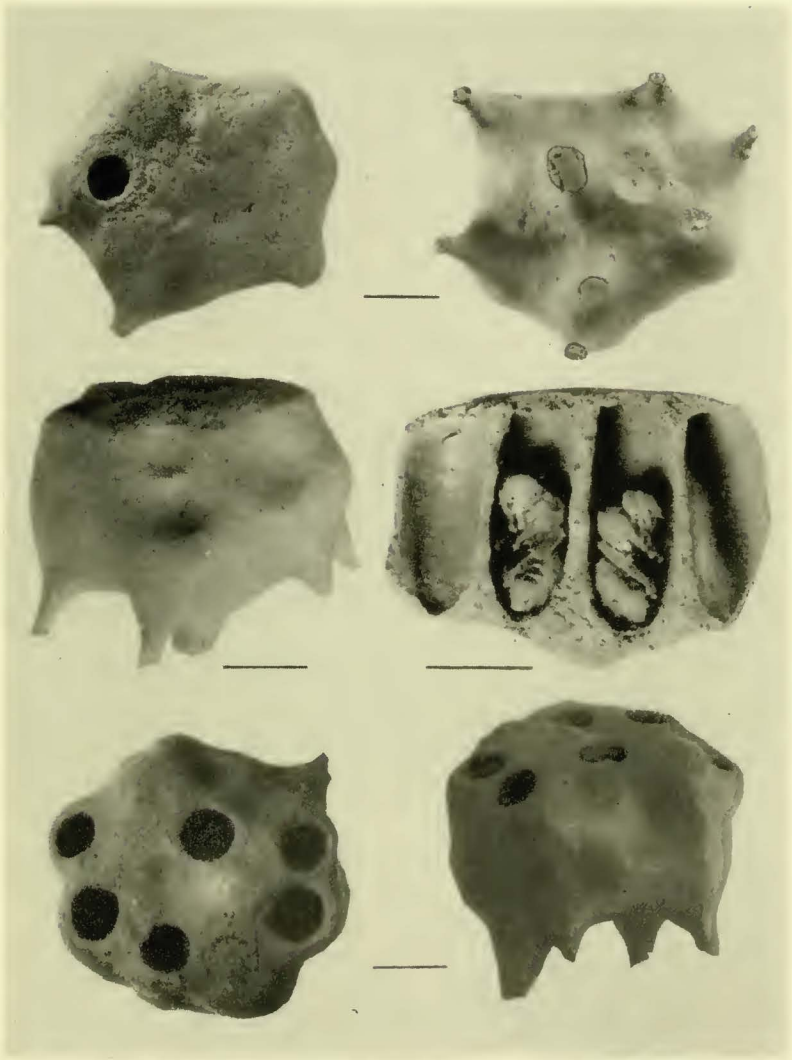


FIG. 38. Cell clusters of *Megommation insigne*. Black lines represent 1 cm. *Top left*, top view of cluster with one cell open, others closed and with immature stages (Nest opened Jan. 5). *Top right*, bottom view of same cluster. Broken ends of pillars are circled in black. *Middle left*, side view of same cluster. *Middle right*, vertical section of same cluster. *Bottom*, top and side views of cluster from nest opened on Feb. 16 (retouched to emphasize cell openings).

*Nests:* Each nest consists of a simple or branched burrow which extends into the bank, slanting slightly downward for 18 to 39 cm. and then turns more steeply downward. Total depth of the burrow ranges from 65 to 90 cm. In diameter the burrow ranges from 3 to 4 mm., narrowed to about 2.75 mm. at the entrance.

The cells are nearly horizontal, sloping slightly downward, and located one to four centimeters from the main burrow. As with *Habralictus canaliculatus,* they are often so arranged that each cell must have been constructed at the end of a separate lateral burrow, but sometimes they are in groups suggesting that several cells may have been connected to a single lateral. Also as in the

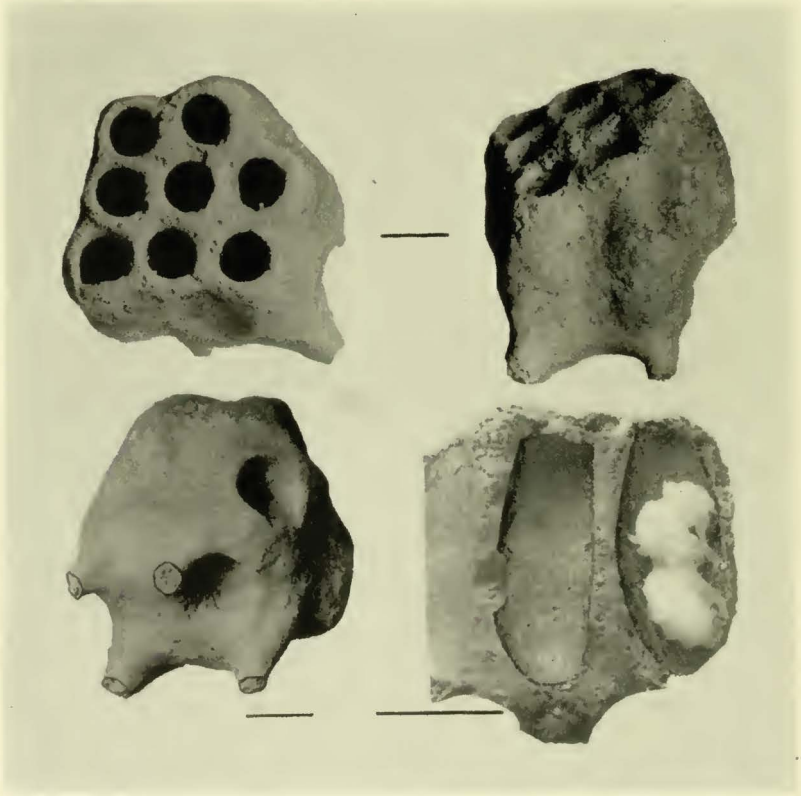


FIG. 39. Cell clusters of *Megommation insigne.* Black lines represent 1 cm. *Top,* top and side views of cluster from nest opened on May 4. *Lower left,* oblique bottom view of same. Black circles enclose broken surfaces of pillars. A curious canal, bridged in the center, was the outstanding feature of this cluster. *Lower right,* pupa in cell (Dec. 16). The reticulate pattern of pale lines in the waxed parts of the cells appears only after drying, and perhaps results from differential shrinkage (retouched to emphasize cell shape).

*Habralictus,* once a cell is provisioned and an egg laid in it, the lateral burrow is completely filled with dirt so that it is unrecognizable. In nests opened during the season of cell construction and provisioning, it was the lowermost one or two lateral burrows that were open, suggesting that the nests are deepened and new laterals constructed at the bottom as the season progresses.

The cells measure 8 to 9 mm. long, about 4.4 mm. in maximum diameter, about 2 mm. in diameter at the neck. They are lined with a waxlike substance except at the entrance. The pollen ball lies near the closed end of the cell, is nearly spherical, about 2.8 mm. in diameter. The curved white egg, about 1.5 mm. long, is placed on top of the pollen ball. The egg is but little narrower posteriorly than anteriorly.

The species of *Caenaugochlora* whose nests were described by Claude-Joseph (1926), *C. chloris* (Spinola), *opaciceps* (Friese) [= *scitulus* (Vachal)], and *rostraticeps* (Friese), construct nests with a cell cluster somewhat like that of *Augochlorella michaelis* or *Augochlora semiramis.* It seems probable that they belong in a genus distinct from that of *curticeps.*

## CONCLUSIONS

Table I summarizes certain of the data presented above. It is noteworthy that among the few species studied, a good series of progressive steps in establishment of social behavior can be recognized. *Paroxystoglossa* nests are usually made by individual females, although occasionally two females nest together. The same may be true of *Neocorynura* except that nests inhabited by two bees are perhaps more common. In *Caenaugochlora* and probably *Habralictus,* as in *Pseudagapostemon,* several females inhabit the same nest but all are fertilized and all lay eggs. In *Augochlora semiramis* the same is true except that when we opened the nests only one female was in egg laying condition. The others probably have workerlike functions, even though fertilized, as they do in *Augochloropsis sparsilis.* In *Psendaugochlora, Megammation,* and *Augochlorella,* unfertilized workerlike individuals exist with an egg laying individual in each nest. More clearly distinguishable workers and queens are not found among the species discussed in this paper.

Another feature that seems to show progressive development is the clumping of the cells and establishment of air spaces surrounding them. As this is a feature which arises in various lines of halic-

TABLE 1. *Summary of some biological characters of certain Halictinae*

| | Neocorynura | Pseud-augochlora | Megammation | Augochlora semiramis | Augochlorella morrae | Augochlorella michaelis | Paroxy-stoglossa | Habra-lictus | Caenaugochlora |
|---|---|---|---|---|---|---|---|---|---|
| cells | usually vertical, in cluster in chamber | usually vertical, in cluster in chamber | vertical, in cluster in chamber | horizontal, in groups with slight surrounding excavation | horizontal, in groups | horizontal or slanting in groups with partial surrounding excavation | horizontal, in cluster in chamber | horizontal, isolated in soil | horizontal, isolated in soil |
| no. of ♀♀ per nest | 1–2 | 1–3 | 1–4 | 1–8 | ? | 1–6 | 1 (rarely 2) | 1–several? | 3–5 |
| workerlike individuals | unknown | unfertilized present | unfertilized present | fertilized present? | ? | unfertilized present | unknown | unknown | unknown |

tine evolution, it must have some important selective advantage. Perhaps it makes possible a degree of control of the environment of the cells and the immature stages which they contain. In *Habralictus* and *Caenaugochlora*, as in most other burrowing bees, the cells are scattered with no surrounding air spaces. In *Augochlora morrae* they are clustered, with no surrounding spaces. In *A. semiramis* they are clustered, with burrows often passing near them. In *Augochlorella* (larger nest), the cells are clustered with anastomosing burrows excavated behind them. In *Neocorynura* and *Pseudaugochlora*, a space surrounds the cell cluster, which is supported only by pillars of soil (or by rootlets). The same is true of *Megammation* but the cell cluster is made of thinner earth, a tendency which reaches its extreme in *Paroxystoglossa*, although in the species here discussed some of the air space is usually filled with loose dirt.

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