Comparative nest architecture of the dwarf honey bees

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(Received 7 August 1995, accepted subject to revision 27 October 1995, accepted for publication 19 March 1996)

SUMMARY

Complete descriptions using a variety of measurements are provided for nests of *Apis andreniformis* from south-eastern Thailand, Sichuan and Hunan Provinces of China, and Palawan, Philippines and *Apis florea* from south-eastern Thailand and Hunan Province of China. Overall, the single-comb nest of *A. andreniformis* has a very different structure from that of *A. florea*. The comb built by *A. andreniformis* has a mid-rib both above and below the supporting branch. However, the comb built by *A. florea* has a mid-rib only in the brood area below the supporting branch. The honey storage mid-rib of *A. andreniformis* nests gives them a characteristic crown appearance. Other differences include the overall size of the nest, the width and depth of worker cells and the width of drone cells.

Keywords: honey bees, *Apis andreniformis*, *Apis florea*, dwarf honey bees, nest architecture, Thailand, China, Philippines

INTRODUCTION

The small, dwarf honey bee, *Apis andreniformis* Smith (1858), has recently been re-evaluated and recognized as a valid biological species based on the morphological evidence of a unique endophallus, characteristic worker bee wing venation, and a distinctive furcation of the male basitarsus (Wongsiri *et al.*, 1990). The Wongsiri *et al.* study supported the conclusions of Wu and Kuang (1986, 1987) who studied furcated basitarsus differences between drones of *Apis florea* and *A. andreniformis*. A species specific characteristic of *A. andreniformis* identified by Smith (1858) of worker bees having black hairs on the hind tibia and dorsolateral surface of the hind basitarsus, as opposed to the white hairs of *A. florea* was confirmed by both of these studies. Further confirmation of the valid biological species status of *A. andreniformis* was provided by Rinderer *et al.* (1993) who reported that the mating flights of drones from sympatric *A. andreniformis* and *A. florea* were temporally separate. Rinderer *et al.* (1995) provide morphological measurements of characteristics commonly used in modern honey bee taxonomy (Ruttner, 1988) for both *A. andreniformis* and *A. florea*. Simple visual inspection suggests that there are important differences in the nest architecture of the two species as well (Otis, 1990). Ruttner (1992) observed that *A. florea* honey storage areas lacked a mid-rib but that *A. andreniformis* honey storage areas had a mid-rib. However, details of comparative nest structure were not presented by either Otis (1990) or Ruttner (1992) suggesting the need for a study of comparative nest architecture. This paper provides a detailed comparison of the nests of these two species of dwarf honey bees in Thailand, China, and Palawan, Philippines (de Guzman *et al.*, 1992).

MATERIALS AND METHODS

Nests were collected in a variety of ways. Thirty-two *A. florea* nests were purchased in the market in Bangkok, Thailand. Twelve *A. florea* nests and nine *A. andreniformis* nests were collected from the field in and around the Chanthaburi Horticultural Research Centre of the Thai Department of Agriculture near Chanthaburi, Thailand. Five *A. andreniformis* nests were collected in the north of Thailand in Chiang Rai Province, and four were collected in Palawan, Philippines. In addition, twenty nests of *A. andreniformis* were collected in Sichuan and Yunnan Provinces in southern China. Observations in China indicated that nests of *A. andreniformis* that contained drone cells soon produced queen cells. Hence, 'mature' combs were considered to be those that had drone or drone and queen cells. Using this criterion, all nests were mature. Nests were classified according to species by the morphology of the occupant bees. Nests from markets had emerging adult workers which permitted identification.

Observations of the position and relation of cells and nest areas, cell usage, and support branch position were made. Overall measurements of the nests were taken (fig. 1). From these measurements the diameter of the branch used to support the nest at the central point of

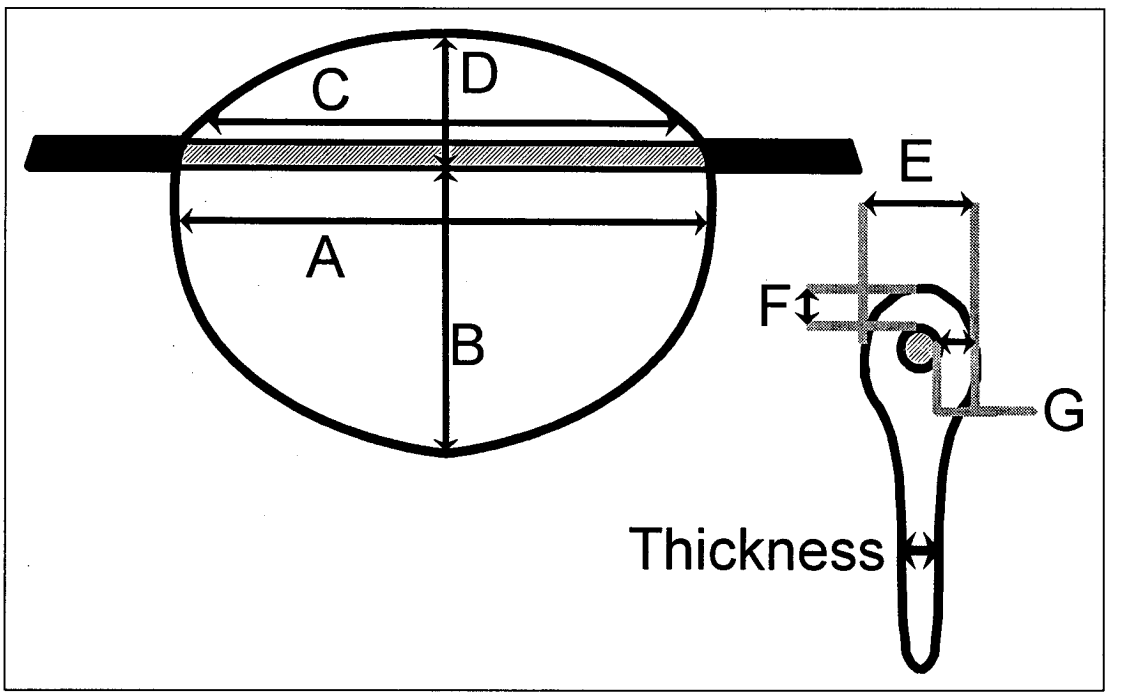

FIG. 1. Nest dimensions reported in table 1. All measurements were taken at the widest or thickest place on the nests.

TABLE I. Nest characteristics of *Apis andreniformis* and *Apis florea*.

Nest characteristic	*Apis andreniformis* n[1]	$\bar{x} \pm$ s.d.[2]	*Apis florea* n[1]	$\bar{x} \pm$ s.d.[2]	T[3]	d.f.	P > T
Nest dimensions[4]							
A	18	12.2 ± 3.6	42	16.9 ± 5.3	−3.42	58	0.00
B	17	10.0 ± 3.3	41	12.0 ± 3.3	−2.06	56	0.04
C	14	10.2 ± 3.0	44	12.5 ± 5.3	−2.06	40.5[6]	0.05
D	11	3.7 ± 1.2	44	4.2 ± 1.1	−1.39	53	0.17
E	14	5.0 ± 1.1	44	5.7 ± 1.2	−2.03	56	0.05
F	13	2.0 ± 0.7	44	2.4 ± 0.8	−1.71	55	0.09
G	15	1.6 ± 1.0	43	2.5 ± 0.6	−3.20	17.6[6]	0.01
Branch diameter							
E-(2G)[5]	13	1.7 ± 1.7	38	0.8 ± 0.7	1.77	13.4[6]	0.10
Worker cell size							
depth of cell	19	0.76 ± 0.02	42	0.93 ± 0.07	−4.46	20.7[6]	0.00
width of 10 cells	19	2.78 ± 0.23	43	2.98 ± 0.15	−3.47	24.6[6]	0.00
Drone cell size							
depth of cell	4	1.45 ± 0.71	7	1.33 ± 0.07	0.36	3[6]	0.74
width of 10 cells	6	4.18 ± 0.24	10	4.88 ± 0.21	−6.10	14	0.00
Queen cell size							
depth of cell	10	1.24 ± 0.26	5	1.41 ± 0.15	−1.30	13	0.22
internal diameter of cell	10	0.54 ± 0.08	5	0.47 ± 0.09	1.59	13	0.14

[1]Number of observations (Numbers of observations are usually fewer than the number of nests; some measurements were not taken by some authors)
[2]Mean centimetres ± standard deviation
[3]Two tailed *t*-test
[4]Nest dimensions A through G are shown in fig. 1
[5]Calculation used to determine the diameter of the supporting branch near the middle of the honey storage area
[6]Degress of freedom adjusted for unequal variance

nest attachment was estimated as E −2G. (fig. 1). Measurements of the depth and width of drone, worker and queen cells were also taken. Measurements were taken using rulers and calipers. Three measurements on each of fourteen characteristics were made per nest and the average calculated. These individual nest averages were used to calculate the means and standard deviations of the fourteen characteristics for the two species. Comparisons between the species were done using a series of *t*-tests.

In six tests the degrees of freedom were adjusted for unequal variances and in four tests there was insufficient information to verify the assumption of normality ($n < 10$). The increased risk of type I error caused by constructing fourteen individual *t*-tests suggests detailed inspection by readers of the information provided for measurements of special interest.

In addition, the cells of several nests of both species from Thailand and of *A. andreniformis* from the Philippines were cut vertically at a 90° angle to the surface of the comb. This revealed the orientation of the cells in the nests. These nests were photographed and the photographs were used as guides to produce figures.

RESULTS

Both species have a nest comprised of a single exposed comb situated in shrubs, bushes or small trees. Typically, a single branch is used as a support for the nest. The surface of the brood area of the nest is parallel to the branch direction. The brood area is below the supporting branch and a honey storage area is above and around the supporting branch. On occasion an *A. florea* nest will have another branch through its brood nest. This was never observed with nests of *A. andreniformis*.

In both nests, pollen is stored at the top of the brood nest area, drone cells are found at the lower margin of the nest, and queen cells are found protruding vertically from the lower edges of the broodnest. Both have a mid-rib through the brood nest and pollen storage area with worker cells from one side meeting worker cells from the other side in the same registry fashion as *A. mellifera*, and drone cells meeting drone cells. Both species apply sticky resin on support branches near the edge of their nests which aids in defence against ants. In almost every aspect, the nests of *A. florea* are larger than the nests of *A. andreniformis*.

The height (A, fig. 1) and width (B, fig. 1) of the *A. andreniformis* brood area are about 25% and 16% smaller, respectively, than the height and width of the *A. florea* brood area (table 1). The difference in the comparisons

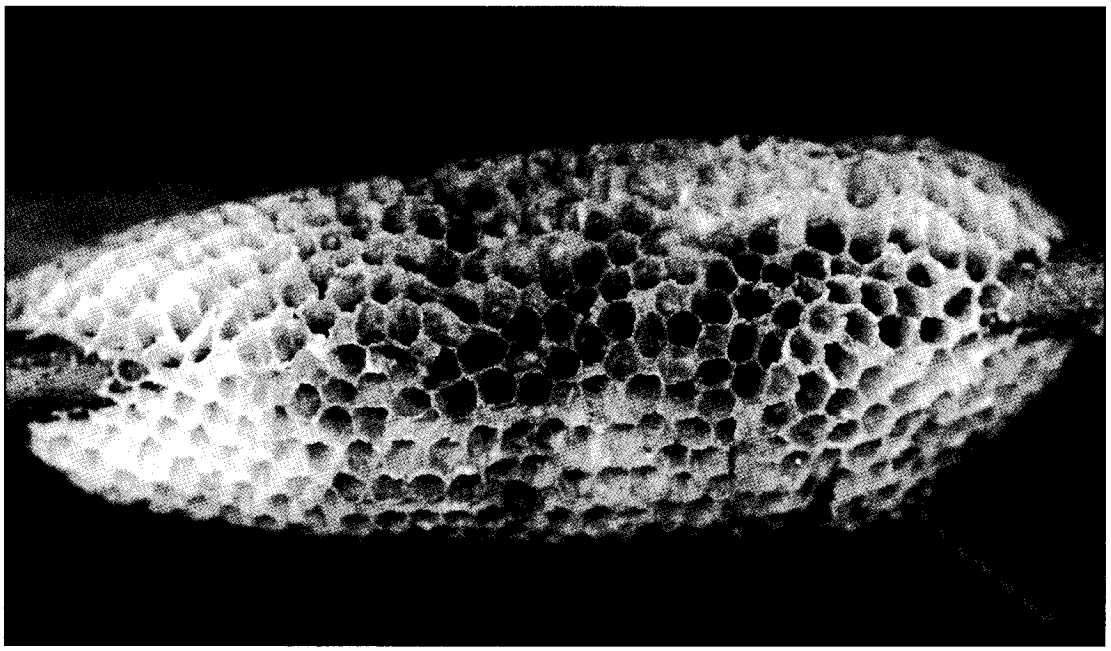

FIG. 2. Photograph of the honey storage area or crown of a nest of *Apis florea* as seen from a superior position (above).

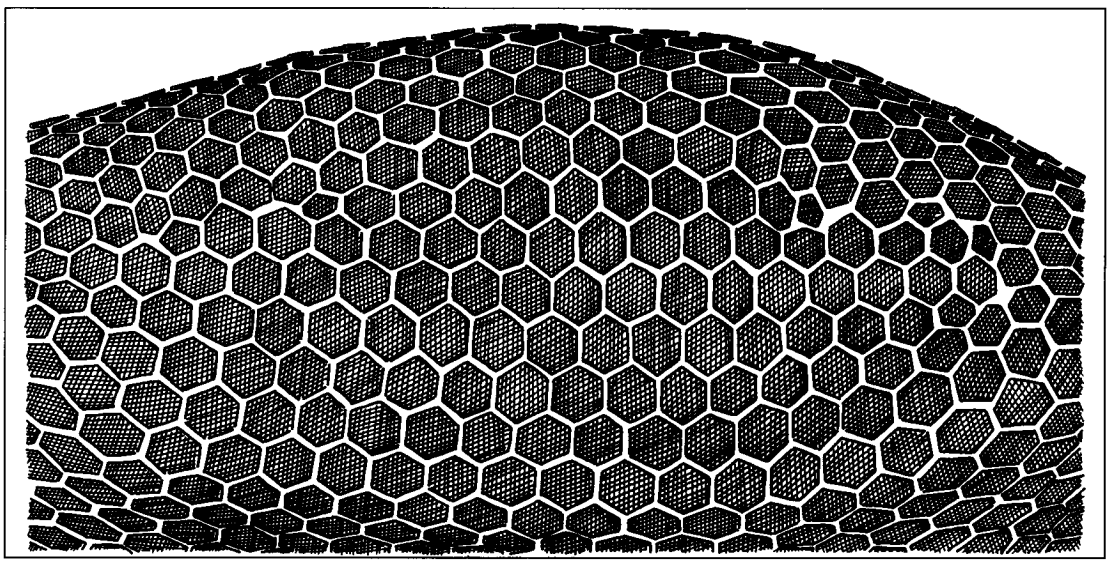

FIG. 3. Diagram of the honey storage area or crown of a nest of *Apis florea* as seen from a superior-lateral position.

of height and width supports the general impression that *A. andreniformis* nests are closer to being round than *A. florea* nests.

The honey storage area of an *A. andreniformis* nest is less wide (C, fig. 1) than the honey storage width in an *A. florea* nest (table 1). The proportional relationships of the height and width are quite similar for the nests of both species, with measurements in the smaller *A. andreniformis* nests being about 15% (C) ($P < 0.05$) and 12% (D) ($P < 0.17$) less than those for the nests of *A. florea*. The breadth (E, fig. 1), the top depth (F, fig. 1), and the side depth (G, fig. 1) of the honey storage area are all smaller in the nests of *A. andreniformis* (table 1). The estimated branch thickness (E–2G) is about 1 cm larger for the *A. andreniformis* nest (table 1).

The comparative sizes of cells are generally in accord with the smaller size of *A. andreniformis*. The depth and width of worker cells and the width of drone cells are all significantly larger in nests of *A. florea*. The depth of drone cells is similar for both species. However, we did not measure the shape of the drone cell capping, which might be sufficiently different to provide more length for developing *A. florea* drones. This measurement was not made, although we did note that both species constructed non-perforated domed cappings similar to those of *A. mellifera*. The depth of queen cells is numerically larger for *A. florea* and the internal diameter is numerically larger for *A. andreniformis*. In both cases, there was insufficient information to detect a statistical difference.

The most remarkable difference between the nests is the presence or absence of a mid-rib in the honey storage area above the support branch. The honey storage area or 'crown' of an *A. florea* nest has cells that seem to be orientated inward towards the supporting branch when viewed from the outside surface. Because the crown is generally rounded and tapered to the supporting branch at the ends, some of the cells are distorted from the standard hexagon. Three- and four-sided cells and smaller or larger cells as well as cells with unequal sides occur (figs 2 and 3). A cross-section of the crown of an *A. florea* nest (fig. 4) reveals that three levels of internal organization occur. First, cells from the side are

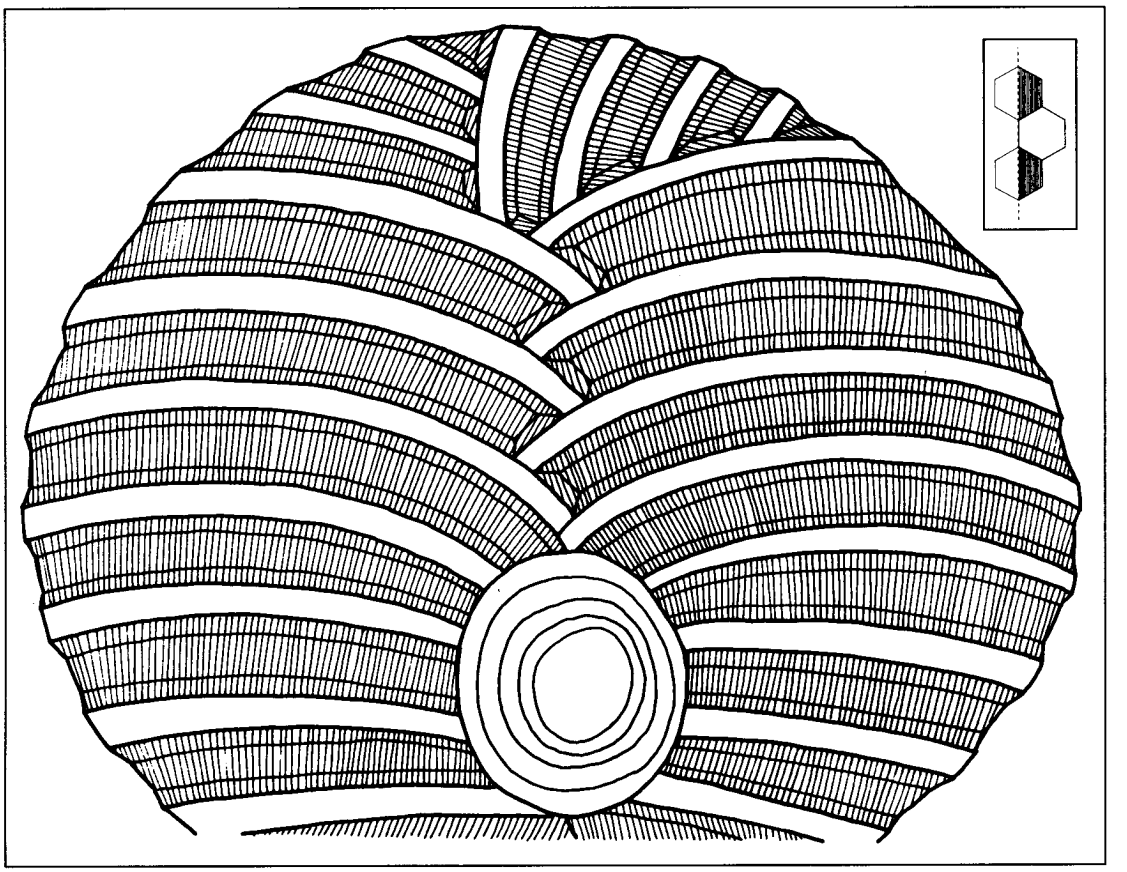

FIG. 4. Diagram of a cross-section view of the honey storage area or crown of a nest of *Apis florea* showing the internal relationships of the honey storage cells above the supporting branch. The central concentric circles represent the supporting branch. The insert at the top right provides an interpretation of open and closed cells. The diagram shows the lack of a clear mid-rib structure.

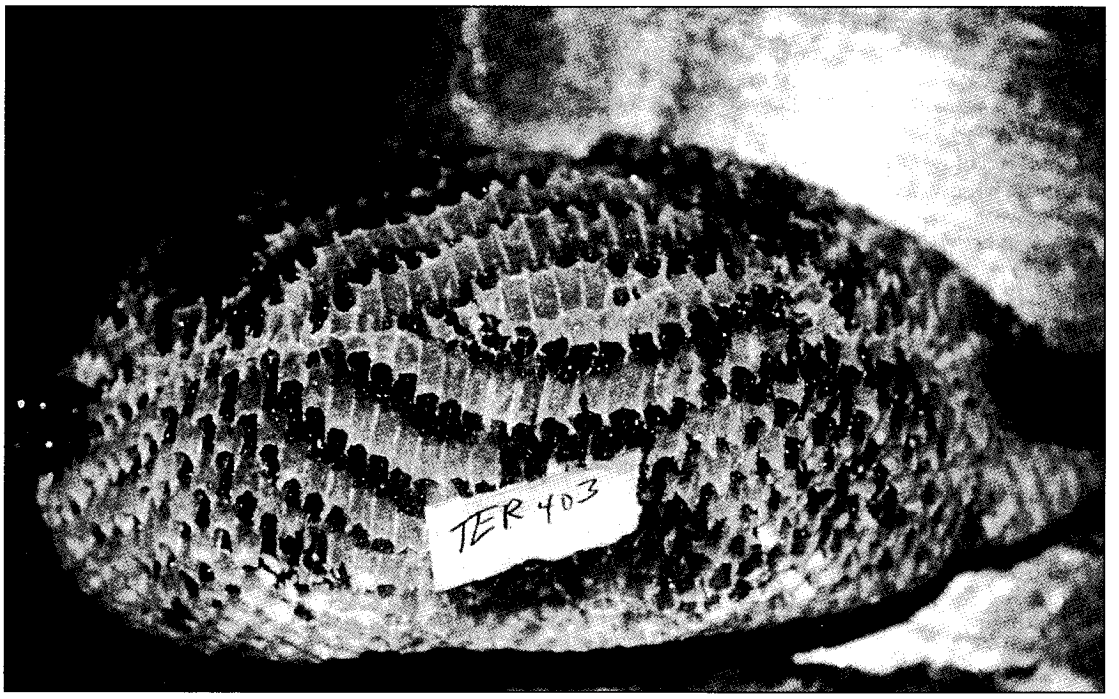

FIG. 5. Photograph of the honey storage area or crown of a nest of *Apis andreniformis* as seen from a superior position (above).

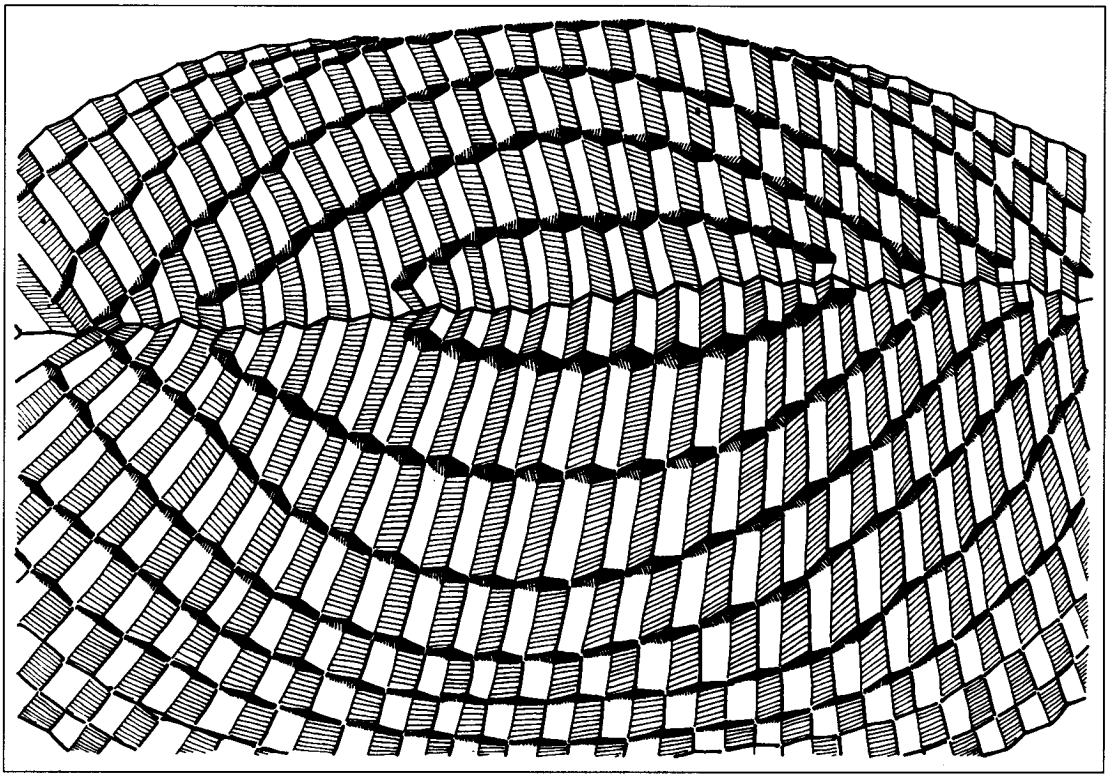

FIG. 6. Diagram of the honey storage area or crown of a nest of *Apis andreniformis* as seen from a superior-lateral position.

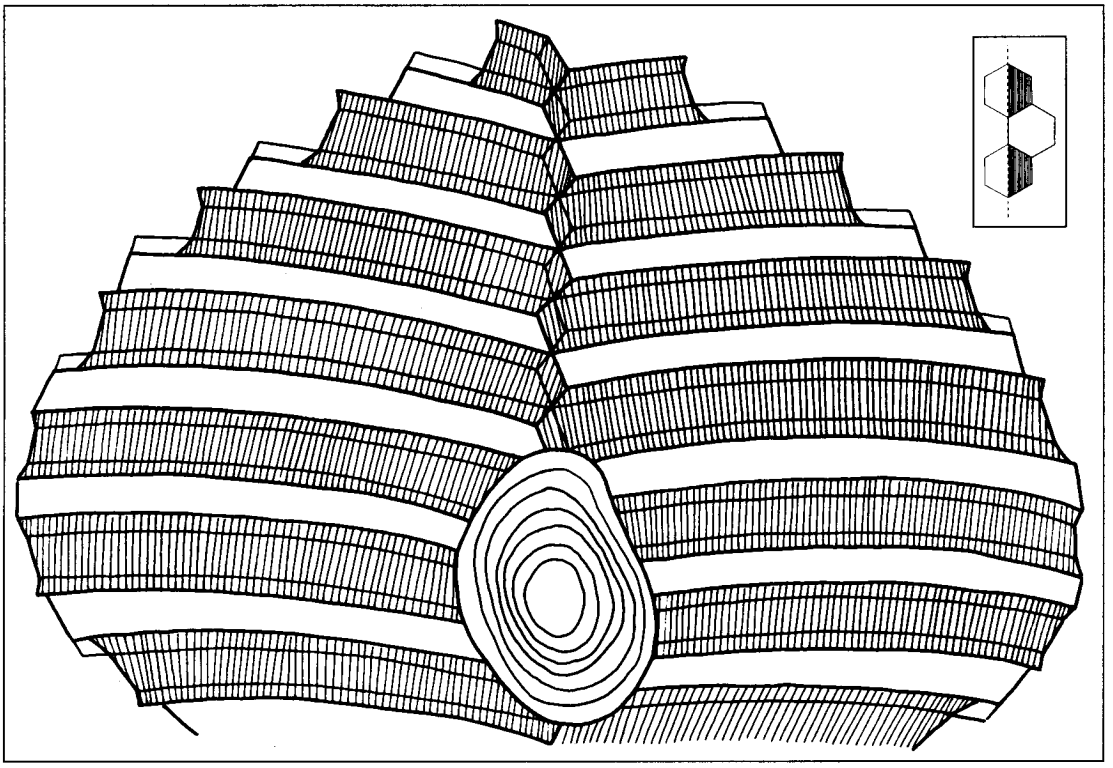

FIG. 7. Diagram of a cross-section view of the honey storage area or crown of a nest of *Apis andreniformis* showing the internal relationships of the honey storage cells above the supporting branch. The central concentric circles represent the supporting branch. The insert at the top right provides an interpretation of open and closed cells. The diagram shows a clear mid-rib structure.

very long and extend to the supporting branch. Above this area, cells coming from opposite sides have their base at the sides of cells coming from the other side. Cells coming from the top of the crown have this same pattern, however the use of an adjacent sidewall as a base is more extreme with some cells open to the top surface having their base well away from the base of the supporting cell.

This contrasts with the crown of an *A. andreniformis* nest. This crown has a characteristic crest appearance when viewed from the outside surface. Each cell has a regular hexagonal shape. Cells are arranged in layers with each layer offset by the width of half a cell, much like roofing tiles. A slight curvature of cells in combination with cells having different lengths (and being present or not being present) provides the adjustments that produce tapering and rounding (figs. 5 and 6). Each layer of cells distal from the supporting branch is narrower than the previous layer with the opening of the cell longer at the bottom than at the top. Hence, the arrangement of cells is quite regular. A cross section shows a clear mid-rib structure where the bases of opposing cells come together in the same way as cells in the brood nest area (fig. 7).

DISCUSSION

This study reinforces the concern that previous literature concerning *A. florea* might derive from work done with *A. andreniformis* before it was recognized as a separate species (Rinderer *et al.*, 1995). The figures of *A. florea* nests by Ruttner (1988) indicate the presence of a mid-rib, a characteristic of the nests of *A. andreniformis*, not *A. florea*. More correct drawings are provided by Ruttner (1992). However, Ruttner's (1992) figures are only accurate in correctly indicating a mid-rib for the nest of *A. andreniformis* and the lack of a mid-rib in for the nest of *A. florea*. The descriptions and figures presented here provide an accurate representation of the arrangements of cells and their physical relationships to one another in the nests of both species.

Although the specific measurements of *A. florea* nests are generally larger than those of *A. andreniformis* nests, the overall impression of the nests is similar and only measurements would permit the identification of a nest using size characteristics. However, the external appearance of the crowns of the two nests are clearly distinct and can be used to quickly identify them. From the examination of cross-sections it is clear that the external crown differences derive from the presence of a honey storage area mid-rib in nests of *A. andreniformis*

and the lack of a honey storage mid-rib in nests of *A. florea*.

The use of a mid-rib above the supporting branch may influence the size of the branch chosen to support the nest by *A. andreniformis*. However, the variance in branch diameter is large, and the difference in branch sizes chosen by the two species is marginal. If a true difference exists, it is small and may arise from slight differences in habitat selection .

ACKNOWLEDGMENTS

We thank Dr Hiran Hiranpradit, Director of Chanthaburi Horticultural Research Centre, Department of Agriculture, Chanthaburi, Thailand, and Assistant Director, Ms Surmsuk Salakpetch for hosting us at the Centre and providing housing for our research group and access to the Centre's orchards in our search for honey bee colonies. We also thank the Research Affairs Division, Chulalongkorn University and USAID project number 936-5544G-SS-9282-00 for providing funds in 1986–1992 and travel grants to TER, BPO, and LIdeG. A travel grant to HAS was provided by the Thai National Science and Technology Development Agency through the US National Academy of Sciences. We thank L Beaman for figure 1, and G Perrone for figures 3, 4, 6, and 7. This study was made in co-operation with Louisiana Agricultural Experiment Station.

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