

Biosystematic Studies of Ceylonese
Wasps, XVII: A Revision
of Sri Lankan and South Indian
Bembix Fabricius (Hymenoptera:
Sphecoidea: Nyssonidae)

KARL V. KROMBEIN
and
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SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY • NUMBER 451

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SMITHSONIAN INSTITUTION PRESS

Washington, D.C.

1987

ABSTRACT

Krombein, Karl V., and J. van der Vecht. Biosystematic Studies of Ceylonese Wasps, XVII: A Revision of Sri Lankan and South Indian *Bembix* Fabricius (Hymenoptera: Sphecoidea: Nyssonidae). *Smithsonian Contributions to Zoology*, number 451, 30 pages, 36 figures, 1987.—Accounts are presented of the ecology and behavior of four species of sand wasps belonging to the genus *Bembix* in Sri Lanka. All species prey upon adult Diptera and practice progressive provisioning.

Bembix orientalis Handlirsch nests in sandy loam and makes a short, shallow, unicellular nest. The species is apparently a generalist, preying upon flies of various habits.

Bembix glauca Fabricius nests in pure sand along the coast. It digs one of the longest and deepest nests on record, and is unique because its burrow has several abrupt angulations in contrast to the usual one slight angulation or none at all. Nests were found during an early stage and had only a single partially provisioned cell. The species may possibly build multicellular nests because of the burrow length and depth. This wasp preys upon flies attracted to domesticated animals.

Bembix antoni, new species, nests in coarse riverine sand sometimes underlaid by sandy loam. It constructs a simple unicellular nest and uses as prey about two dozen flies that are attracted to filth or organic debris. An adult wasp emerged in the laboratory from a cocoon collected 11 months earlier, suggesting that the species may be univoltine.

Bembix borrei Handlirsch nests in pure sand or sandy loam and also exploits piles of sand accumulated for building purposes, constructing a short, shallow, unicellular nest. This wasp is a generalist, preying upon flies found around domesticated animals, those attracted to filth or organic debris, and some that may have been visiting flowers.

The revisionary section includes a key to differentiate the taxa occurring in Sri Lanka and South India, and synonymy, descriptions, locality data, and figures for each. A new species, *antoni*, is described from several localities in Sri Lanka and South India. A lectotype is designated for the closely related *budha* Handlirsch, an Indian species not known to occur in Sri Lanka. *Bembix nigrocornuta* Parker, 1929, and *borrei thaiiana* Tsuneki, 1963, are synonymized with *borrei* Handlirsch, 1893, and a lectotype is designated for *borrei*.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year*. SERIES COVER DESIGN: The coral *Montastrea cavernosa* (Linnaeus).

Library of Congress Cataloging in Publication Data

Krombein, Karl V.

Biosystematic studies of Ceylonese wasps, XVII.

(Smithsonian contributions to zoology ; no. 451)

Bibliography: p.

Supt. of Docs. no. 1.: SI 1.27:451

Bembix—Sri Lanka—Classification. 2. Bembix—India, South—Classification. 3. Insects—Classification. 4. Insects—Sri Lanka—Classification. 5. Insects—India, South—Classification. I. Vecht, J. van der (Jacobus). II. Title. III. Series.

QL1.S54 no. 451 591s [595.79'8] 86-600342 [QL568.S7]

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Biosystematic Studies of Ceylonese Wasps, XVII: A Revision of Sri Lankan and South Indian *Bembix* Fabricius (Hymenoptera: Sphecoidea: Nyssonidae)

*Karl V. Krombein
and J. van der Vecht*

Introduction

The solitary sand wasps of the genus *Bembix* are a conspicuous element of the Ceylonese wasp fauna. Their relatively large stocky build, conspicuous and usually extensive yellow or glaucous markings, and rapid flight make them conspicuous denizens of the sandy areas in which they dwell. Although individual wasps are solitary, they form nesting aggregations in suitable areas that may persist for generations.

BIOLOGY.—Those species worldwide for which behavioral data are available are all progressive provisioners. That is, each female prepares a cell at the end of a burrow in the soil, usually hunts for and places in it a single prey (in Sri Lanka an adult fly so far as we have observed), deposits an egg on the prey, and then seals the entrance of the burrow. One or two additional flies are added to the cell in a day or two when the egg is ready to hatch. As the wasp larva grows larger additional flies are brought to it on subsequent days until a sufficient store is accumulated to bring the larva to the cocoon-spinning stage. The cell is sealed and the wasp either begins a second cell nearby or starts an entirely new unicellular nest.

Behavioral data were obtained for *orientalis* Handlirsch, *glauca* Fabricius, *antoni*, new species, and *borrei* Handlirsch during field work in Sri Lanka by the first author assisted by Ceylonese technicians between 1975 and 1981. Survey work during each field trip was planned around moving to

a new locality every two or three days. This precluded extended observations of a nesting aggregation over a sufficient period to ascertain certain details of the nesting cycle. The only extensive previous behavioral account of any species from this area is that of Iwata for *borrei* (1964, cited as *borrei thaiana*). Brief notes from the literature are also included for *tranquebarica* (Gmelin), *lunata* Fabricius, and *budha* Handlirsch.

SYSTEMATICS.—This revisionary study includes the species occurring in Sri Lanka and South India. The taxa found in both areas are *orientalis*, *tranquebarica*, *glauca*, *lunata*, *antoni*, and *borrei*. The study was expanded to include southern India because *budha* Handlirsch may be found eventually in the more xeric areas of northern Sri Lanka. These seven taxa belong to five of the species groups recognized by Handlirsch. The first two are members of the *hova* Group, *glauca* is the sole member of the *glauca* Group, *lunata* belongs to the *bidentata* Group, *antoni* and *budha* to the *papua* Group, and *borrei* to the *oculata* Group.

The descriptions follow the format used by Evans and Matthews (1973) and their useful formulae for mandibular index (length of inner margin from base to end of tooth divided by basal width) and wing index (length of wing from humeral plate to base of stigma divided by width of scutum between projecting angles of mesoscutal laminae). The mandible is said to have a cutting edge when there is an oblique thickening of the inner margin beyond the subapical tooth (cf. Figures 25a–29a and 23a–24a). Vein cu-a in the hindwing does not offer differentiating characters in these species because its two ends are about equidistant from the wing base.

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The present contribution completes the biosystematic account of the Ceylonese Nyssonidae. Two previous studies covered the subfamilies Alyssoninae, Nyssoninae, and Gorytinae (Krombein, 1985) and Stizinae (Krombein, 1984b). A key to separate the five subfamilies was included in the 1985 paper.

The preceding number in the series "Biosystematic Studies of Ceylonese Wasps" is "XVI: A Revision of *Gastrosericus* Spinola (Hymenoptera: Sphecoidea: Larridae)," Smithsonian Contributions to Zoology, 436: 20 pages, 34 figures, 1986, by Karl V. Krombein and Wojciech J. Pulawski.

ACKNOWLEDGMENTS.—Field work in Sri Lanka was funded by Smithsonian Research Foundation Grant SFG 0-6955, "Biosystematic Studies of the Insects of Ceylon," to the first author and his travel was provided in part by grants from former Secretary Ripley's Fluid Research Fund.

Within Sri Lanka the first author is indebted to co-principal investigator W.T.T.P. Gunawardane, now Director, Department of National Museums, for planning itineraries and arranging accommodations for our field parties. He is particularly thankful to P.B. Karunaratne, former curator of insects at the Colombo Museum, who accompanied him on many of the field trips that resulted in the behavioral data reported herein, and for permitting him to include his personal observations on *borrei*.

The revision is based primarily upon material collected during the first author's survey work in Sri Lanka. The following have loaned other specimens that we used in the revision: R. Danielsson, Lund University, Lund; G.R. Ferguson, Oregon State University, Corvallis; M. Fischer, Zoologisches Museum, Vienna; W.T.T.P. Gunawardane, Colombo Museum, Sri Lanka; F. Keiser, Natural History Museum, Basel, Switzerland; C. O'Toole, Oxford University, England; T. Naito, Kobe University, Japan. The first author studied the Indian *Bembix* in the collections of the Natural History Museum, Paris, and the British Museum (Natural History), London, through the cooperation of S. Kelner-Pillault, and Michael C. Day, and Colin R. Vardy respectively.

The first author thanks the following specialists for identification of the prey of *Bembix* or of insects associated with their nests: J. Bowden, Rothamsted Experimental Station, England (Bombyliidae, in part); J.F. Burger, University of New Hampshire, Durham (Tabanidae); R.W. Crosskey, British Museum (Natural History), London (Tachinidae, in part); R.H. Foote (Otitidae), R.J. Gagné (Calliphoridae, Muscidae, Sarcophagidae except Miltogramminae), L.V. Knutson (Bombyliidae, in part), C.W. Sabrosky (Tachinidae, in part), G.C. Steyskal (Platystomatidae), F.C. Thompson (Syrphidae), and W.W. Wirth (Stratiomyidae), all Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington; W.N. Mathis, Smithsonian Institution, Washington (Ephydriidae); and Yu.G. Verves, Kiev University, U.S.S.R. (Miltogramminae, in Sarcophagidae).

Both authors are grateful to Wojciech J. Pulawski, California Academy of Sciences, San Francisco, and Don R. Davis, Smithsonian Institution, for critical review of the manuscript.

The illustrations are by George E. Venable, Smithsonian Institution, except Figures 23–26 and 28–36 by the second author, and Figures 3 and 6 by Masashi Kimura, Tokyo, former illustrations intern at the Smithsonian.

Ecology and Behavior

The field notes and voucher specimens of wasps and associated insects are in the National Museum of Natural History, Smithsonian Institution. The accounts given below for *orientalis*, *glauca*, *antoni*, and *borrei* are condensed from the following field notes:

<i>orientalis</i>	12175 C; 21575 A,N,O
<i>glauca</i>	91380 A,B,C,E,F,G; 10680 A,B,C; 10780 A
<i>antoni</i>	3779 A,B; 3879 C; 4481 A,B,C,D,E,F
<i>borrei</i>	11975 D; 2475 A,B; 2575 A; 2675 C; 51575 A; 62975 A,B,C; 31176 A,B; 31576 A; 31876 A,B; 31976 A; 51376 A,B; 51976 A; 62478 A; 12179 A; 91380 D,H

1. *Bembix orientalis* Handlirsch

We obtained a small amount of information on this species in a flat sandy loam field adjacent to the Ratmalana Airport near Colombo. *Bembix borrei* Handlirsch nested here in larger numbers, and also *Sphex obscurus* (Fabricius) (Krombein, 1984a).

ADULT ACTIVITY.—Males of this species and of *borrei* do not perform a sun dance, but fly back and forth low over the ground, alighting occasionally to sun themselves, or to pounce on an unreceptive nesting female and attempt unsuccessfully to mate. As is frequent in *Bembix* males, they spend part of the day and all night in burrows in the sand. At 1500 on 17 January a male went into a burrow, pushing up sand behind him. At 1740 the burrow was excavated but the dry sand collapsed during the digging. A male in dazed condition was found along the burrow axis 12.7 cm from the entrance. On 15 February another male was caught at 1315 as he burrowed into loose sand.

NEST CONSTRUCTION.—One female made the final nest closure at 1310, 15 February. She was on the surface, scraping sand backward beneath her into the burrow. After several seconds she entered the burrow backward to push the sand farther down and to compact it. She was captured as she emerged and her nest was dug up.

NEST STRUCTURE.—In this first nest the burrow went downward at an angle of 45° for 11.5 cm, then turned at right angles and terminated in a cell 3.8 cm long and 1.3 cm wide. The burrow diameter varied from 5 to 10 mm in width, depending on the looseness of the sand. The wasp had filled the bottom 5 cm of the burrow. There was a

short empty space and then a narrow plug at the cell entrance.

Earlier on this same date at 0900 another female without prey flew low over the ground. She alighted on the sand, sunned herself for a few moments, then flew again, alighted in several seconds, sunned some more, and then scratched open a closed burrow at 0904. She entered her nest and pushed up sand behind her to close the entrance, leaving a small depression to mark the burrow site. At 1010 we excavated the nest and found that the burrow went downward at an angle of 30° for about 7.6 cm, then turned at right angles at 30° and went downward for 5 cm. The wasp was in this latter section, which presumably was the cell, but there was no prey in it. We did not obtain the cell dimensions because the sand walls collapsed.

PREY.—The cell of the first nest contained a large, presumably nearly full grown wasp larva, three whole paralyzed flies that had been brought in recently and were near the cell entrance, and at the inner end the skeletal fragments of a number of flies that had been eaten. The flies were a mixture of calyptrate and acalyptrate Diptera as follows: Muscidae, *Stomoxys calcitrans* (Linnaeus), 5 mm long; Calliphoridae, *Chrysomya megacephala* (Fabricius), 9 mm long; and Platystomatidae, *Plagiostenopterina* species, 7 mm long.

NATURAL ENEMIES.—A large, pale brown bombyliid with dark wings, *Ligyra sphinx* (Fabricius) was common at Ratmalana, and occasionally settled on the ground near *Bembix* nests. I did not observe oviposition, but I suspect that this species parasitizes *orientalis* and *borrei* Handlirsch. Ruiz Perera (1929) recorded another species of *Ligyra* (as *Exoprosopa*) parasitizing a Chilean *Bembix*.

The chrysidid *Parnopes viridis* Brullé undoubtedly parasitizes *orientalis* and *borrei*. We collected only one specimen during a dozen years in Sri Lanka and that was at Ratmalana at the nesting site of those *Bembix*. It was not associated with nesting activity of the wasps but other species of *Parnopes* are known to parasitize only bembicine wasps.

Three of the 10 *orientalis* that we collected in Sri Lanka were parasitized by female stylopids; 23 *orientalis* from southern India were not parasitized. Two stylopized females were taken at Ratmalana, Colombo District, 19–21 Jan and 15 Feb 1975, and one stylopized male at Ma Villu, Mannar District, 17–21 Feb 1979. The flattened cephalothorax of the parasite protruded between two of the abdominal terga of the host wasp. One female wasp had three exerted stylopids, one between terga 2 and 3 on the right side, one between 3 and 4 on the left side and one between 4 and 5 on the right side. Each of the other two *orientalis* had only one exerted stylopid between terga 3 and 4 on the right side. This stylopid may be host specific on *orientalis* for, significantly, none of seven *borrei* from Ratmalana was infested; they were captured on the same dates as six *orientalis*. There were no other stylopized *Bembix* among nearly 400 specimens that we examined. The stylopid is being

described as a new species of *Paraxenos* by Kifune and Hirashima (in press). It is not likely that it is the same species they recorded (1980) as *Paraxenos* species from a male puparium in the abdomen of the larrid wasp, *Tachytes modestus* Smith (?), from Sri Lanka.

This is the first record of *Bembix* stylopization outside of the Australian Region where Evans and Matthews (1973:14) stated that both sexes of *Bembix* were commonly parasitized by Stylopidae. They reported stylopization rates as high as 11.5% among some populations of the Australian *littoralis* Turner.

2. *Bembix tranquebarica* (Gmelin)

We did not collect this species in Sri Lanka, but Rahman (1940:430) noted at Lyallpur, Pakistan, that it visited flowers of *toria* and *sarson* (cultivated varieties of *Brassica*), nested in the ground, and provisioned progressively with unspecified species of Syrphidae, Muscidae, and Calliphoridae. He gave no details of nest architecture. He concluded that the species was "an undesirable visitor to *toria* and *sarson* flowers," presumably because it included Syrphidae, an important pollinator, among its prey.

3. *Bembix glauca* Fabricius

FIGURES 1, 2

This distinctive species was found in areas of fine beach sand along the coast. Other collectors also have taken it only at coastal localities in Sri Lanka, presumably on sand. Nesting occurred at Pamunugama, Colombo District, a tiny fishing village 12 mi N of Colombo on the west coast, and near the Wildlife and Nature Protection Society Bungalow, Palatupana, Hambantota District, on the extreme southeastern seacoast.

HABITAT.—There are no dunes at Pamunugama and the nests were in gently sloping pure sand several meters above high tide mark. Presumably these areas might be inundated during sporadic heavy storms. The sand was quite moist immediately below the surface. Although there are dunes at Palatupana, *glauca* did not nest in them but on the lee side (NW) of small hillocks, 1.0–1.5 m high and about 50 m from the ocean at an elevation of some 3 m above sea level, where they were protected from the constant SE breeze in March 1981. It may be that the species nests in flat sand at Palatupana during periods when the wind is not so intense.

Our most extensive notes were made 13 September 1980 at Pamunugama, where we found two small aggregations at 0900 separated by some 30 m. Several beach areas at Pamunugama were visited on 16 March 1981, but only one female was just beginning a nest.

ADULT ACTIVITY.—At Pamunugama in September 1980

females were already digging nests or bringing in prey to established nests when we reached the site at 0900. Males were flying low over the whole area, occasionally alighting on the sand, sometimes a pair circling around each other during flight. Females were beginning nests or bringing in prey between 0900 and 1030. One female digging a nest was interrupted occasionally by a male pouncing on her and attempting to mate. Later in the morning when she flew to her nest with prey, she was followed by a male that tried to mate when she landed at the nest entrance.

About 1030 both sexes began to take shelter from the increasing temperature on the surface and none was observed after 1100. Males entered open burrows and pushed up damp sand from immediately below the surface to block the entrance. The females ceased nesting activities, entered their nests, and pushed up damp sand to block the entrance. At 1430 when the temperature moderated the wasps were again on the wing and were still active when we left at 1545. Several males tried unsuccessfully to couple with flying females. The females confined their activities to brief flights, working on old nests or beginning new ones, but did not bring in prey.

At Pamunugama in March 1981 there were 6–8 males flying low over the ground in one area, occasionally fighting in pairs, alighting on the sand for a few seconds, or visiting flowers for nectar. There was only one female, just beginning to nest.

The first nesting notes at Palatupana were made 6–7 October 1980, a period marked by strong winds of variable intensity from the southeast and a thunderstorm the evening of the 6th with 8.5 mm of rain at the saltern several hundred meters distant. Three females were beginning nests. Several males were flying around but did not attempt to mate. We revisited Palatupana late in March 1981. On the 30th there were 6–8 males flying low over the area where *glauca* nested the previous year. This must have been prior to emergence of females, for we saw none in 1981.

Both sexes visited the pale blue flowers of a prostrate succulent plant, *Hydrophylax maritima* Linnaeus (Rubiaceae), for nectar at Pamunugama and Palatupana.

NEST CONSTRUCTION.—A female was digging a nest at Pamunugama at 0920. The sand already excavated was spread in a low spoil heap behind the burrow entrance over an area 2.5 cm long and 1 cm wide. As she deepened the burrow, she pushed sand up to the entrance, and backed out only after several minutes to kick it with her forelegs backward over the spoil heap. She emerged headfirst at 1013, but re-entered at once, continued digging and then spreading the excavated sand over the spoil heap. She had plugged the burrow by 1100 and had not emerged by 1545.

Nest construction at Palatupana was abnormal because of the strong winds and thunderstorm. Three females began nests between 0925 and 0942 on the bare NW lee slope of a small hillock. One burrow extended horizontally for about

20 cm at 0942. There was no further activity in any nest between 0945 and 1135. The burrow entrances were still open and the wasps were not in evidence. During the afternoon the winds intensified and drifting sand covered the burrow entrances, leaving only shallow dimpled depressions. I blew away the loose sand at the entrance to one nest and found that the burrow had not been blocked from within by damp sand. Apparently this nest, and presumably the other two, had been abandoned that morning because of the difficulty of excavation during the wind.

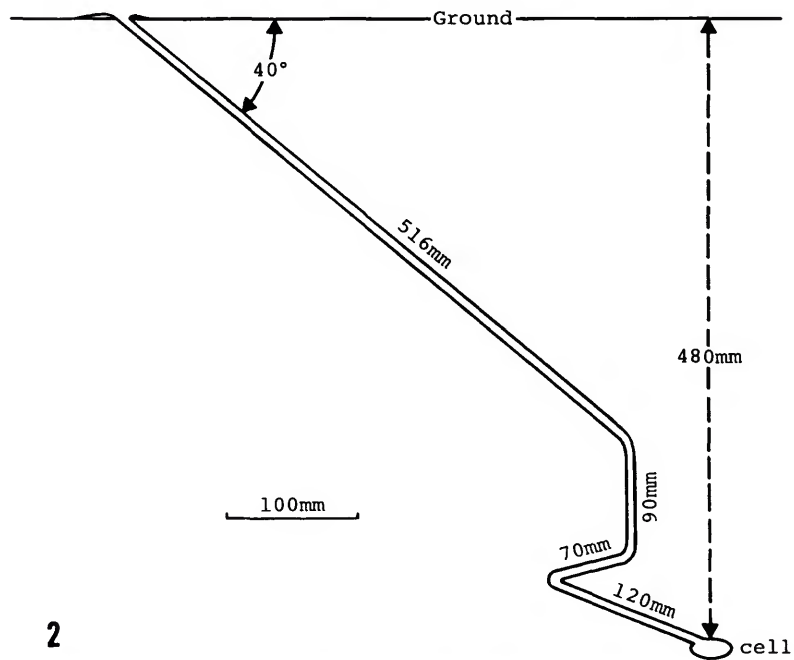
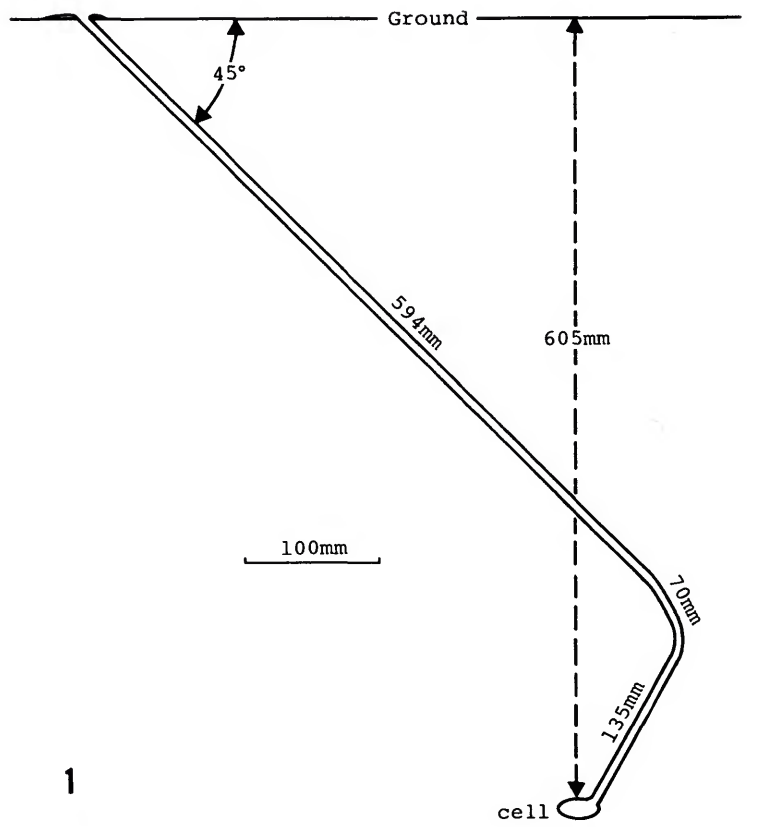
At 1155 on the second day at Palatupana a female was digging a burrow in the 45° slope on the lee side of another hillock. She had already begun two other burrows nearby, and occasionally stopped work on the third to dig in one of the other two. At 1201 she began still another burrow a few centimeters above and to the right of the first three. When I left at 1211, she was back digging in the third burrow. This nest was excavated at 1430 and we found that it had not been completed. The burrow penetrated at an angle of 15° to the horizontal for 31.5 cm, turned downward at 75° for 5 cm, and then turned at another steep angle for 11 cm where it ended without a cell; the wasp was not inside the burrow. The other three burrows were not sealed and were 1.0–2.5 cm long. These burrows were possibly aborted because of some unacceptable characteristic of the soil. They could not have been true accessory burrows that are made after the true nest has been dug.

NEST STRUCTURE.—Two excavated nests contained a partially provisioned cell. The burrow of one (Figure 1) penetrated the sand for 59.4 cm at an angle of 45°, turned more steeply downward for 7 cm, then turned backward, continuing at a steep angle for 13.5 cm, and terminated in a cell at a depth of 60.5 cm below ground level. The horizontal ellipsoid cell contained a wasp larva about a third grown, four whole flies 4.0–10.5 mm long, and fragments of three flies.

The burrow of the other nest (Figure 2) went in at an angle of 40° for 51.6 cm, vertically for 9 cm, then backward at a steep angle for 7 cm, then forward at a shallow angle for 12 cm, and terminated in a cell 48 cm below the surface. The cell contained a wasp larva about a third grown, three whole flies 4.5–5.0 mm long, and fragments of three flies.

A third nest was excavated at 1150 after the wasp entered the nest at 1055 and plugged the entrance from within. Earlier she had brought in prey at 0929 and 0931. This burrow went in at an angle of 40° for 45 cm and then continued at a shallower angle for 10 cm. The burrow was lost at this point and neither wasp nor prey was recovered.

The burrow of a fourth nest penetrated at an angle of 30° for 41.2 cm, then angled in another direction at 45° for 15 cm, then in still another direction at 30° for 5 cm, and finally backward at 30° for 15 cm. The wasp was found at a depth of 54 cm but the cell was not found, although earlier she brought in prey twice.



FIGURES 1, 2.—Nest profiles, *glauca* (initial section of burrow shortened): 1, nest 91380 C; 2, nest 91380 E.

The burrow of one aborted nest at Palatupana went into the sloping sand of the hillock at an angle of 15° to the horizontal for 14 cm. Then it made a slight angle and continued downward for 17 cm. The burrow ended at that point and there was neither a wasp nor a cell at the inner end.

The extreme length and depth of the nests in which we found only a partially provisioned cell poses a question that can be answered only by additional observations. Would it not be advantageous for a species that expends so much energy constructing a long, deep, tortuous nest to make a multicellular nest?

NEST PROVISIONING AND PREY.—We observed prey being brought to the nest by four wasps. The fly was carried beneath the wasp, venter to venter, and was transferred to the hind legs when the wasp landed at the closed entrance. She rapidly scratched open the temporary closure with her forelegs and crawled into the nest, carrying the prey beneath her, protruding beyond the tip of her abdomen. During nine such visits the wasps remained inside for periods ranging from 30 seconds to 8 minutes (mean 2 min, 21 sec). The tempo of provisioning was frequently rather rapid but occasionally quite slow: one returned with prey at 0929, 0931, and 1055; another brought in prey at 1026 and 1037; a third came with prey at 0948, 0951, 0956, 1002, 1005, and 1027; and the fourth brought three prey at 1003, 1008, and 1010.

The wasps always emerged headfirst after taking in prey. Three of them spent from 30 to 60 seconds making a temporary closure by scratching sand from the spoil heap backward into the entrance. This closure was done in a more leisurely manner than when the closure was opened to bring in prey. One wasp twice varied the closing routine by excavating at the entrance and a short distance into the burrow for a minute or so before making the closure. The wasps flew off as soon as the closure was complete.

Both nests at Pamunugama contained a mixture of tabanids and muscoids, suggesting that the wasps were preying upon Diptera that were flying around the tethered water buffalo grazing nearby. Consolidated prey records from the nests and a prey taken from a wasp are as follows:

TABANIDAE

Tabanus griseifacies Schuurmans Stekhoven: 3 ♀, 10–11.5 mm long, and fragments of 2

OTTITIDAE

Physiphora aenea (Fabricius): 1♀, 4.5 mm long

Physiphora species: 1♀, 5.5 mm long

MUSCIDAE

Musca domestica Linnaeus: 2♀, 5.0 mm long

Musca inferior Stein: 1, 6.5 mm long

SARCOPHAGIDAE

Sarcophaga species: 1♀, fragment

Unidentified Diptera

Fragments of 3 individuals

NEST ASSOCIATES.—A pale sarcophagid fly, *Leucomyia cinerea* (Fabricius), sat nearby on the sand while one wasp

was digging her burrow. The fly entered the burrow once for a couple of seconds. Larvae of this fly are known to act as scavengers.

4. *Bembix lunata* Fabricius

We did not collect this species in Sri Lanka, but Ayyar (1919) listed some prey records in India. He found it at Hillgrove, Nilgiri Hills, 2000 ft, preying upon *Stomoxys*, *Haematobia* (recorded as *Lyperosia*), and *Musca* (recorded as *Philaematomyia*), all biting species of Muscidae that were attacking a cow. He also noted *lunata* preying on the same flies attacking cart bullocks in Thanjavur (= Tanjore).

The mandibles of our females are quite eroded, to or a bit beyond the cutting edge on the inner surface and the subbasal tooth, suggesting that *lunata* may nest in stony soil. Mandibles of males do not exhibit the same degree of wear, so they may occupy the original resting burrow on subsequent nights once it has been dug.

5. *Bembix antoni*, new species

FIGURE 3

This large species was found nesting only in or near lowland rain forest in Ratnapura District in the southwestern part of Sri Lanka where the average annual rainfall is some 3900 mm. One male was collected in a Malaise trap in the Kanneliya section of the Sinharaja Jungle, Galle District, another locality in the lowland rain forest. However, other collectors have captured the species at localities in the Dry Zone where the average rainfall is as low as 1500 mm annually.

HABITAT.—The first nesting site was in the Induruwa Jungle, Gilimale, where *antoni* nested in level, coarse, riverine sand along the banks of a rocky stream. There were many boulders in the stream bed and on the banks, and rather heavy vegetated cover of grasses, herbaceous plants, and shrubs on the banks. The area was shaded by taller trees during much of the day. The soil below the surface was a damp sandy loam underlaid by a hard clay stratum. A second nesting site was found at a small, wayside, Hindu shrine, Ambame Hena, 13 km W of Kalawana. Adjacent to the shrine is a rectangular courtyard of some 50 m² with a flat surface of coarse, firmly compacted, riverine sand brought up from the Kukulua Ganga, flowing some 20 m below. Viable cocoons of the wasp may have been brought up with the fill, or perhaps females nesting on the banks below may have found this area when they searched for prey. The surface of the compacted sand was swept every morning, so most nests did not have a spoil heap of excavated soil. The sand was very moist beneath the surface and overlaid a stratum of stone rubble at a depth of 15–19 cm that limited the depth of the nests.

ADULT ACTIVITY.—Three females were nesting at Gili-

male 7–8 March 1979. There was also an aggregation of 15–20 males flying swiftly and erratically low over this site of about 100 m² on these dates but none attempted to mate with a nesting female; perhaps they were awaiting the emergence of virgin females. Two more females were collected in a Malaise trap nearby on 13–14 March, males were again flying over the nesting area but no females were nesting. The colony was not active when we revisited Gilimale several times during March and April 1981.

Karunaratne saw several males flying over the nesting site at Ambame Hena on 27 March 1981, and also noted a pair flying in copula. Six females were nesting when we revisited the site on 4 April. We saw only one male that hovered close above a digging female but it did not attempt to mate.

NEST CONSTRUCTION.—We did not observe initiation of a nest. Two incompleted nests at Ambame Hena had burrows penetrating at 20°–30° for 13–14 cm where they ended blindly at the layer of rubble. Both wasps were inside when we dug these nests and had sealed the entrances from within. One nest at Gilimale went downward at 30° for 25.8 cm, ended at the stratum of hard clay at a depth of 34.7 cm, and there was no cell. The wasp was not in that nest when we dug it up but was captured later.

A wasp at Ambame Hena emerged from a sealed burrow at 1000. She had begun this nest that morning for there was a large spoil heap of excavated soil behind the entrance about 6 cm long, 4 cm wide at the middle and 2 cm high. (Other nests did not have such spoil heaps because the sandy area was swept quite early every morning.) She continued to excavate sand, pushing it backward, but sometimes emerging head first. At 1007 she sealed the entrance, using loose sand from the spoil heap, and then flew off. She returned without prey in 5 minutes, scratched open the entrance and leveled some of the spoil heap. She then excavated a little more sand, made a temporary closure and leveled more of the spoil heap. She flew off at 1020, leaving a spoil heap that was now 15 × 10 cm maximum length and width and 1 cm high in the middle. The nest had now been completed for she returned with a first prey at 1045.

NEST STRUCTURE.—The single completed nest at Gilimale had a burrow diameter of 10 mm, went downward at an angle of 30° for 39 cm, and ended at the stratum of hard clay. The cell dimensions could not be ascertained because of the occurrence of fine roots adjacent to the cell, but we recovered a small wasp larva, a whole prey, and head of a second prey.

Four nests at Ambame Hena had a burrow diameter of 7–11 mm. The burrows went downward at shallow angles of 30°–35° for 16.9–24.8 cm and turned horizontally for 3.8–9.1 cm when each met the stratum of hard rubble at depths of 15–19 cm. The ellipsoid cells were 2.4–3.5 cm long and 2.0–2.5 cm wide and high at the middle.

NEST PROVISIONING AND PREY.—The single provisioned nest at Gilimale contained a very small wasp larva, a whole

calliphorid, *Chrysomya megacephala* (Fabricius), 8 mm long, and the head of a large syrphid, *Eristalinus arvorum* (Fabricius). There were no wings in the cell so the female may have removed them before bringing in the second prey.

At Ambame Hena one female brought prey at 0951 to a burrow that had a temporary closure. She left the burrow at 0954 but did not make a closure. She returned without prey at 1004, flew away at once without entering the nest, and returned with prey at 1005. She left at 1008, again without making a closure. At 1013 she returned with a prey, took it into the nest, and sealed the burrow entrance from within in a few seconds. The burrow was still sealed at 1025 and again at 1130 when we excavated the nest. The upper 12 cm of the burrow was solidly plugged. One may speculate from this that the wasp had brought in a sufficiency of food for the rest of that day. The wasp was in the cell 15 cm beneath the surface together with a small larva, four fresh female calliphorids, *Calliphora megacephala* (Fabricius), 8.5–9 mm long, and the remains of a fifth. Females usually made a temporary closure at the burrow entrance before departing upon a provisioning flight. However, one of the Gilimale females flew with prey to a nest whose entrance was open.

Two other nests at Ambame Hena contained fresh whole flies and some fragmented prey identified as follows:

SYRPHIDAE

Eristalinus arvorum (Fabricius): ♂, 11 mm long

Eristalinus quinquestriatus (Fabricius): ♂, 8 mm long

CALLIPHORIDAE

Calliphora megacephala (Fabricius): 3♀, 8–9 mm long, and fragments of 2

Calliphora species: ♀, 8.5 mm long

Hemipyrellia liguriens (Wiedeman): ♀, 8.5 mm long

Metallea species near *notata* (van der Wulp): 5♀, 8–9 mm long, and fragments of 3

SARCOPHAGIDAE

Sarcophaga species: ♀, 9 mm long

TACHINIDAE

Genus and species: 1 fragment

It should be noted that almost all of the flies are associated with decaying organic material or filth.

IMMATURE STAGES AND LIFE CYCLE.—A cell in which the wasp had just placed her first prey contained the fly lying on its back. The right wing was flexed forward somewhat and the right leg was twisted so that the tibia and tarsus extended toward the side. This manner of preparing the prey for oviposition is customary in species of *Bembix* in which the egg is placed on the first prey. The egg was attached upright at the base of the wing with the anterior end upward and supported in this position by the flexion of the right midleg (Figure 3). Several grains of sand adhered firmly to the base of the egg and may have helped to maintain the egg in an upright position. The sausage-shaped wasp egg was 5.7 × 1.3 mm. The fly was a female calliphorid, *Hemipyrellia liguriens* (Wiedemann), 7 mm long.

We found a viable *Bembix* cocoon with remains of numerous flies at its posterior end about 10 cm from the end of

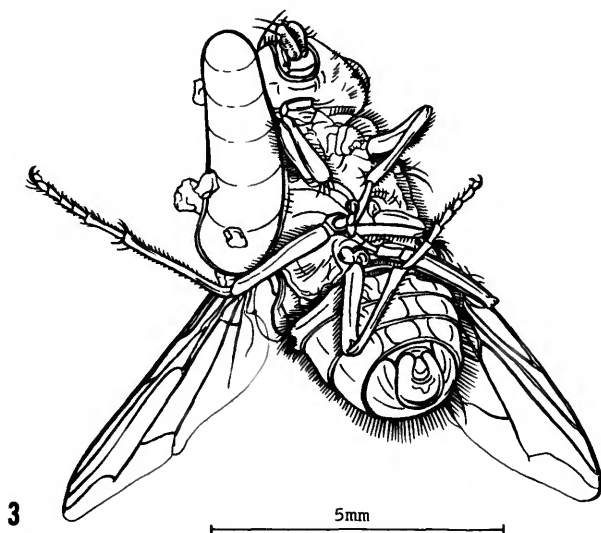


FIGURE 3.—*Hemipyrellia liguriens* (Wiedemann), prey of *antoni*; wasp egg attached at base of forwardly flexed right wing and supported by twisted right midleg.

the burrow of another wasp. There was no trace of a connection between the two cells, and it seems unlikely that this was a multicellular nest. There were 46 wings at the end of the cell containing the cocoon. It appears that about two dozen prey may be needed to bring a larva to maturity unless this mother had removed some remains before sealing the cell. I brought the cocoon to Washington in a tin of damp sand. On 25 June I made a small hole near the anterior end of the cocoon and saw a typical diapausing larva within. The cocoon was kept in my office where the temperature was 18°–21° C, the sand was moistened occasionally and the condition of the larva was checked. It was still a resting larva on 27 December but had changed to a pale pupa by 3 January. It transformed to an adult about 6 February and a male left the cocoon about the 12th. This prolonged prepupal diapause suggests that *antoni* may have only a single generation annually.

NEST ASSOCIATES.—We found no parasitic or commensal flies (Sarcophagidae, Miltogramminae) or parasitic wasps attending nests of *antoni*.

6. *Bembix budha* Handlirsch

Maxwell-Lefroy (1909:209) reported that this species (as *sulphurescens*) was usually found flying over the soft sand by rivers, etc., that it was believed to keep its burrow open, and that it fed its larva daily with fresh Diptera.

7. *Bembix borrei* Handlirsch

FIGURES 4–6

This is the most abundant and widely distributed of the six Ceylonese *Bembix*, and we obtained more nesting and prey records than for any other species. The account is based on notes made by me (KVK) and/or P. B. Karunaratne at Padaviya, Kaludiya Pokuna at Mihintale and Galapitawewa, Anuradhapura District; China Bay, Trincomalee District; Pamunugama, Ratmalana, and Papiliyana in Nugegoda, Colombo District; Uggalkaltota, Ratnapura District; Angunakolapelessa, Monaragala District; and Palatupana, Hambantota District.

HABITAT.—It nested in fine sand or sandy loam along or near the coast or in river banks, and occasionally in piles of sand dumped at various sites for building purposes.

ADULT ACTIVITY.—Males were noted at several nesting sites flying low and erratically over the ground, or alighting to sun themselves, but only one attempted to mate with a nesting female. Several females were captured at Palatupana visiting flowers of *Eupatorium rivale* Regel (Compositae) for nectar. Most females, were engaged in bringing prey to the nest or in making temporary or final closures.

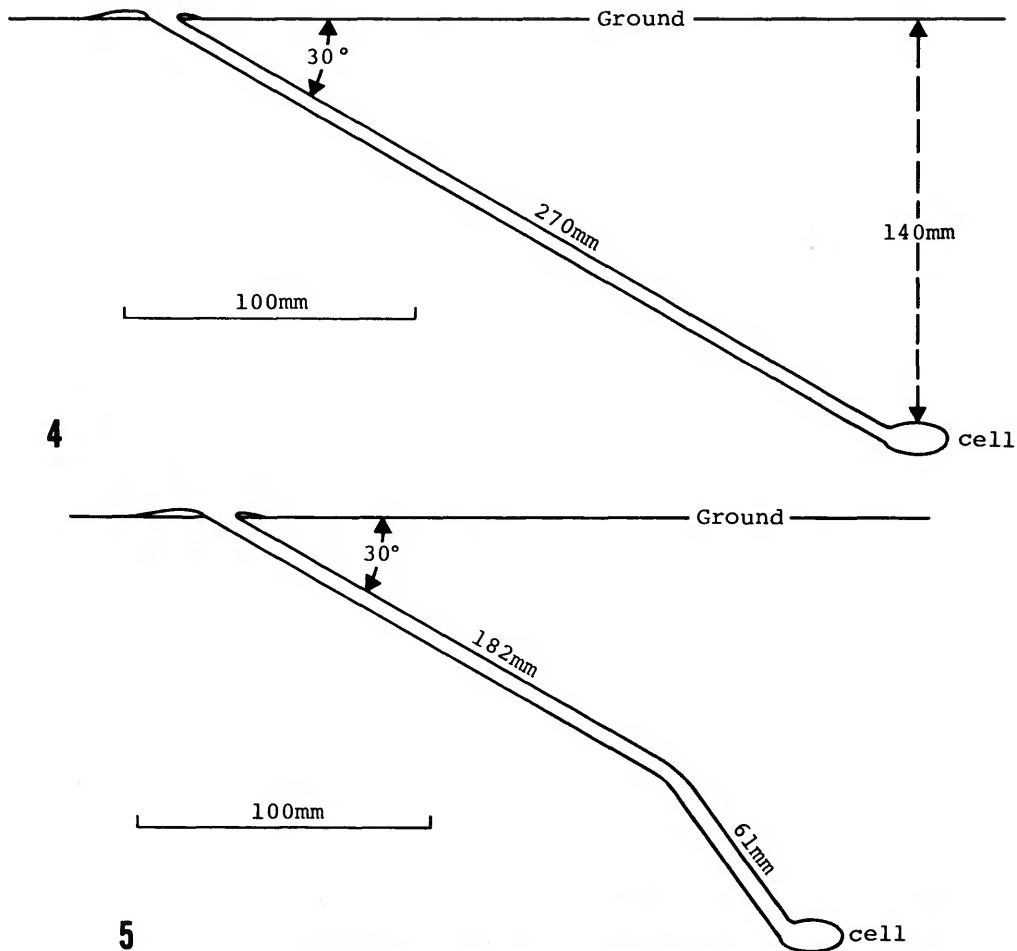
NEST CONSTRUCTION.—We saw no females initiate new nests so we can furnish no data on method and duration of excavation, or size and shape of the spoil heap.

After completion of the cell, the wasp always emerged headfirst from the burrow and made a temporary closure of the entrance before flying off for prey or some other purpose. The closure was made in a much more hurried manner than in *glauca*; the wasp just scratching dry sand backward into the entrance as she walked quickly forward, and then flying off.

Final closure of a nest was observed at Ratmalana. This female scratched dry sand backward beneath her toward and into the burrow entrance that was just a shallow depression by 1500. Every few minutes she flew over an area of about a square meter around the entrance to inspect the closure. She had dug a shallow furrow about 5 cm long and 2 cm deep in the dry sand in front of the entrance to obtain sand for the closure. The entrance was filled almost flush with the surface by 1510 when we captured the wasp.

NEST STRUCTURE.—The burrows were normally about 5 mm in diameter once damp sand had been reached, but at and near the entrance in dry sand they could be as much as 20 mm wide. They penetrated the ground in one direction, but in four of 11 nests the burrow angled downward at a steeper angle after an initial section at a shallow angle.

Four of the 11 nests were constructed in level or gently sloping sand. In two of them the burrow was at angles of 15° and 30° to the horizontal, and penetrated directly to the cell at distances of 26–27 cm from the entrance (Figure 4). In the other two nests, one burrow went in at 30° for 6



FIGURES 4, 5.—Nest profiles, *borrei* (initial section of burrow shortened): 4, nest 91380 D; 5, nest 91380 H.

cm, then turned downward at 45° for 7.5 cm to the cell, and the other went in at an angle of 30° for 18.2 cm, then turned downward at 60° for 6.1 cm (Figure 5). These burrows in undisturbed sand ranged from 13.5 to 27.0 cm in length (mean 22.7 cm).

The other seven nests were constructed in piles of sand accumulated for building purposes and left for periods of some weeks or months. In five nests the burrows were straight, penetrated the sand at angles of 35° to 40° for distances of 11.4 to 25.4 cm (mean 17.5 cm) where they terminated at the cell. In the other two nests, one burrow penetrated almost horizontally for 15.2 cm, then turned downward at an angle of 30° to the first section for 15.9 cm, ending at the cell 16.5 cm below the surface. The second burrow, made in the same pile of sand, had much the same dimensions except that the second section was only 15.2 cm long.

The cells were usually horizontal and aligned along the burrow axis, but occasionally one was at an angle to the axis or at a slight angle downward. Cells were normally ellipsoid and 5 cm long, 2–2.5 cm wide and 1.5–2 cm high. Two anomalous cells were spherical, 3 cm in diameter, and ellipsoid, 2 cm long by 0.8 cm in diameter.

PROVISIONING AND PREY.—Prey capture was not observed, but many wasps were noted returning to the nest with prey. As is customary, the prey was carried beneath the wasp, venter to venter, and was transferred to the hind legs while the wasp scratched open the temporary closure at the burrow entrance. Usually the prey was carried into the nest rapidly, but Karunaratne observed one female at Papiliyana that left her prey just inside the entrance while she went farther into the nest. She came to the entrance headfirst in a few seconds, grasped the fly with her mandibles and backed down the burrow with it.

The wasp left the nest from eight seconds to a minute and a half after bringing in prey. However, sometimes the wasp pushed up damp sand from within to block the entrance. This occurred during the day, presumably when enough prey had been accumulated for the day, or at the end of the day when nesting activity was concluded. We saw prey being brought to the nest at various times between 0950 and 1450, but undoubtedly storage of prey could begin earlier in the day and continue later than mid-afternoon.

Flights to and from the nest were timed for two females at Pamunugama. One wasp left her nest at 0945, revisited the nest five times between 0947 and 1131, only twice with prey, remained inside from 20 to 90 seconds each visit (mean 48 seconds), and made a temporary closure of the entrance each time that she departed. The other wasp made ten visits between 0955 and 1103, bringing in prey on five visits, remained inside from 8 to 45 seconds each visit (mean 23 seconds), and made a temporary closure only eight times when she departed.

Eighty percent of the prey were calyprate Diptera but several nests contained a mixture of calyprate Diptera and Stratiomyidae, Bombyliidae, or Syrphidae. Most prey were thoroughly paralyzed when brought into the nest and exhibited reflex movements of the legs for some hours. A few, however, were killed outright, perhaps because of an overdose of venom. The following flies were found in nests or were obtained from a wasp while she was flying to the nest with prey:

STRATIOMYIDAE

Oplodontha rubrithorax (Macquart): 3♂, 5.5–6.5 mm long

BOMBYLIIDAE

Exhyalanthrax absalon (Wiedemann): 2♀, 6♂, 6.5–9 mm

Bombylisoma, new species: 1♂, 4 mm

Exoprosopa, new species: 1♂, 7.5 mm

Villa species: 1 thorax

Two species: 2 thorax, 1 wing

SYRPHIDAE

Ischiodon scutellaris (Fabricius): 1♂, 9 mm

Eristalinus megacephalus (Rossi): 2♀, 1♂, 10–11 mm

MUSCIDAE

Orthellia lauta (Wiedemann): 4♀, 5.5–6 mm

Orthellia indica (Robineau-Desvoidy): 2♀, 7–8 mm

Stomoxys calcitrans (Linnaeus): 6♀, 4.5–5 mm

Lispe species: 3♀, 1♂, 5–5.5 mm

Musca lusoria Wiedemann: 4♀, 7.5–8 mm

Musca domestica Linnaeus: 9♀, 11♂, 5–6.5 mm

Musca formosana Malloch: 1

Musca pattoni Austen: 4♀, 5–6.5 mm

Musca species: 1♀, 7 mm, and 6 fragments

Xenosia species: 1♀, 7 mm

CALLIPHORIDAE

Lucilia illustris (Meigen): 1♀, 6 mm

Thoracites abdominalis (Fabricius): 5♀, 13♂, 7–8 mm, and some fragments

Chrysomya megacephala (Fabricius): 7♀, 7–8 mm, and 4♀ fragments

Chrysomya rufifacies (Macquart): 1♀, 1♂, 8 mm

Phaenicia cuprina (Wiedemann): 2♀, 2♂, 6.5–7 mm, and 3 fragments

Species: 1 thorax

SARCOPHAGIDAE

Sarcophaga species: 2♂, 8–9 mm, and 1 fragment

Genus and species: 1, wings only

TACHINIDAE

Prosenia sibirita Fabricius: 4♀, 6.5–7 mm

Sturmia convergens (Wiedemann): 1♂, 10 mm

Many cells contained a small wasp larva and relatively few flies. Several cells, however, contained many fresh and fragmentary flies. A nest from Mihintale contained a wasp larva about half grown and 22 flies or identifiable fragments belonging to 13 species of Stratiomyidae, Bombyliidae, Muscidae, and Calliphoridae. Another from Pamunugama contained a small wasp larva about a third grown and 28 flies belonging to three species of *Musca*. Earlier the maker of the latter nest brought five prey to the nest between 0957 and 1044, and she was captured at 1103 when she came out of the burrow. Presumably she might have made a final closure then or soon thereafter.

The female does not remove uneaten prey fragments from the nest. In several cells there was a compacted mass of such fragments at the inner end, then an empty space of about a centimeter, next the wasp larva feeding on a fly, and finally one or more fresh uneaten flies. The empty space between fragments and wasp larva indicates that the wasp probably compacted the fragments.

Two to four dipterous maggots were found in four cells. Several of these may have been larvae of Diptera discussed below in the section "Nest Associates." One cell, however, contained a healthy wasp larva and four maggots that were identified with question as Calliphoridae. Members of this family are not known to be parasites, inquilines, or scavengers in nests of wasps, so these maggots may have been progeny of a gravid calliphorid female brought in as prey.

IMMATURE STAGES.—The egg is deposited on the first prey brought into the cell. One fly was placed on its back at the posterior end of the cell, the right wing was twisted forward to serve as a platform, and the right midleg was flexed outward (Figure 6). The egg was placed upright at the base of the wing, extended upward along the side of the thorax, and the flexed right midleg helped maintain the egg upright. Only one nest contained an egg almost ready to hatch. It was sausage-shaped, slightly curved, 3.9 mm long and 0.8 mm in diameter.

NEST ASSOCIATES.—At Palatupana we observed a number of small flies with pictured wings, 1.7 mm long, congregating around burrow entrances of this *Bembix*. Two females were identified as Ephydriidae, *Actocetor beckeri* Hendel, and an unidentified species of *Actocetor*. It is not likely that maggots of these flies would be injurious to the wasp larva. If the flies actually oviposited in the nest, presumably the maggots would act as scavengers.

The one wasp egg recovered from a nest at Papiliyana, Nugegoda near Colombo, had a dipterous egg, 1.0 × 0.2 mm, two dipterous larvae, 0.6 × 0.2 mm, and a mite, 0.2 mm long, near its base. The Diptera were too small to be

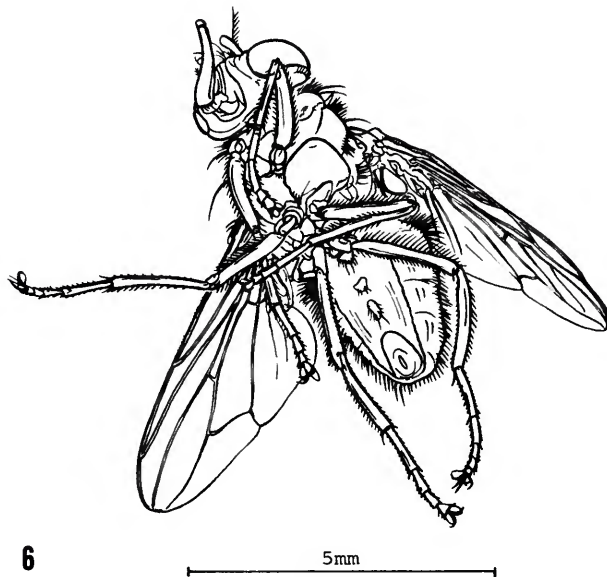


FIGURE 6.—*Stomoxys calcitrans* (Linnaeus), prey of *borrei*; egg removed from base of forwardly flexed right wing to show area of attachment.

Miltogramminae (Sarcophagidae) but they might have been Ephydriidae.

There were almost no adult Miltogramminae around the nests. Karunaratne captured a female *Craticulina tabaniformis* (Fabricius), 6 mm long, when it tried to follow the wasp into a nest at Galapitawewa.

A nest at Uggalkaltota contained a newly dead wasp larva and a dipterous maggot feeding on one of two fresh flies in the cell. The maggot may have killed the wasp larva before feeding on one of the prey. The cells in two other nests each contained a healthy wasp larva and two to four maggots. It is not known whether the larvae in these three nests were Miltogramminae or those of some other group. However, in wasps that practice progressive provisioning such as *Bembix*, usually enough prey is stored so that both the wasp larva and the inquilinous maggots reach maturity.

As noted under *orientalis* Handlirsch, a large, pale brown bombyliid, *Ligyra sphinx* (Fabricius), may parasitize these two species of *Bembix* at Ratmalana. The chrysidid wasp, *Parnopes viridis* Brullé, probably parasitizes both *Bembix* at Ratmalana.

PREVIOUS OBSERVATIONS.—In Java van der Vecht (1939:84) reported *borrei* as nesting in colonies in sand and preying upon Diptera. Cherian (1943:435) stated that in India it preyed upon *Lucilia* (Calliphoridae) and nested in sand.

Iwata (1964:364–366, figs. 27, 62, 72) published some observations in Thailand on *borrei* under the synonymous name *borrei thaiana* Tsuneki. He found it to be the most abundant species of *Bembix* in Thailand as we did in Sri

Lanka. Nests were in mounds of sand next to a building or resulting from tin-mining operations, and in a sand hill adjacent to a river. He observed males pursuing females at one locality but saw no mating, and found that females visited flowers of *Leucaena glauca* Bentham (Leguminosae) for nectar at another site.

Nesting operations were the same as described for the Ceylonese population. One wasp began a nest at 1030 and had completed it by 1140 when she made a temporary closure. The burrow had a diameter of 1 cm and was at a slight angle for 6 cm, then at 45° for 10 cm, and ended in a horizontal cell 4 cm long. Another burrow was 1 cm in diameter and 9 cm long. A third had a diameter of 0.8 cm, was at an angle of 45° for 12 cm and terminated in a horizontal ellipsoidal cell 3.7 cm long and 1.3 cm in diameter. He noted that the burrow of the latter nest had a sand plug 2 cm from the anterior end of the cell.

Prey were recovered from only one uncompleted nest, and all six were bombyliids, probably *Exoprosopa puerula* Brunetti, 8 mm long. A newly hatched wasp larva was found, oriented as described above for the egg in the section "Immature Stages." Iwata noted a female wasp carrying off small flies from human dung, and surmised that the prey probably included a wide range of Diptera.

Iwata reported the egg as being 4.5 mm long and 1 mm wide, slightly larger than the single egg I measured. He dissected two female wasps, and found that the ovaries contained one or two mature or nearly mature ovarian eggs, and some very small oocytes.

Summary

Species of *Bembix* are gregarious and occasionally occur in large aggregations, but we found only associations in small numbers even where the nesting areas were relatively undisturbed, such as the beach at Palatupana.

We did not observe males and females of any species performing a "sun dance," i.e., flying in large numbers just above the ground in rhythmical gliding movements and mating occasionally on the ground as has been reported for several Nearctic and Palearctic species. Such mating flights apparently happen only during the first few days after emergence of the first males and females. This behavior may be characteristic of temperate areas where emergence is synchronized and large numbers emerge within a few days. It has not been reported from tropical areas where nesting usually takes place throughout the year and emergence may not occur simultaneously in large numbers.

Most species make unicellular nests, but multicellular nests have been reported for some species. We found only unicellular nests, but extended observations over longer periods may demonstrate that some Ceylonese species, particularly *glauca*, may construct multicellular nests.

Bembix glauca is unique among the *Bembix* whose nesting

habits are known in that the burrows had more angulations than those of any other species, and that its nests were among the deepest on record. We found a cell in each of two nests at depths of 48.0 and 60.5 cm at the end of burrows 79.6 and 79.9 cm long. Evans (1957, table 19) recorded cell depths of 16–56 cm at the end of burrows 23–84 cm long in the North American *pruinosa* Fox. He correlated depth of the cell with height of the dune in which it was constructed, finding cells at depths of 50–56 cm in the largest dunes. Evans theorized that the depth was also correlated with the amount of blowing sand. Evans and Matthews (1973:71–74, fig. 425) reported that their Australian *gunamarra* constructed multicellular nests in pure to gravelly sand 15–30 m from the sea, with cells at depths of 50–65 cm, and burrows 112–130 cm long reaching a depth of 68–85 cm. Burrows of *glauca* were more complex in having two or three abrupt angulations whereas there was only one slight angulation in nests of *pruinosa* and *gunamarra*.

Several species construct empty accessory burrows near the true nest, presumably to confound parasites, but the Ceylonese species did not exhibit this behavior.

Most *Bembix*, including the four species that we observed, practice progressive provisioning. That is, fresh prey is brought into the nest daily until the larva is fully fed. The majority of species prey upon adult Diptera, as do the four Ceylonese taxa, but a few Australian species prey upon wasps, bees and flies, or damselflies, or antlions (Evans and Matthews, 1973: 4).

The Ceylonese species were opportunistic in their prey selection but apparently most of them searched for flies with particular habits. *Bembix antoni* stored flies associated with decaying organic matter or filth, whereas *glauca* specialized on flies associated with livestock. *Bembix borrei* is a generalist, preying upon both of those groups of flies, as well as others that it may have captured on flowers. *Bembix orientalis* and *tranquebarica* also are generalists judged from

the few available prey records.

Most species deposit the egg on the first prey brought into the nest, but a few, such as the Australian *variabilis* Smith, are known to place the egg at the end of the empty cell before bringing prey into the nest (Evans and Matthews, 1973:4). The egg is laid on the first prey in *antoni* and *borrei* but the method of egg deposition is unknown in *orientalis* and *glauca*.

The information suggests that at least three of the four species we observed are among the generalized *Bembix* in that there is a unicellular nest and the egg is laid on the first prey brought into the cell. It will be of interest for future observers to ascertain whether *lunata* and *tranquebarica* exhibit different elements of nesting behavior from what we discovered for the other four Ceylonese species.

Ceylonese *Bembix* are singularly untroubled by parasites so far as we observed. We found three adult *orientalis* stylotized by a new species of *Paraxenos* (Kifune and Hirashima, in press) among nearly 400 specimens of *Bembix*. Two of them, however, were among the six *orientalis* collected near Ratmalana airport. A female miltogrammine fly, *Craticulina tabaniformis* (Fabricius), was collected when it tried to enter a *borrei* nest. One cell of *borrei* contained a dead wasp larva and several larger dipterous maggots, probably of a species of Miltogramminae. We suspected that a bombyliid fly, *Ligyra sphinx* (Fabricius), might be a parasite of *orientalis* and *borrei*. The rare chrysidid, *Parnopes viridis* Brullé, undoubtedly parasitizes *orientalis* and *borrei*. Two species of the ephydrid *Actocetor* were noted commonly around burrow entrances of *borrei*; their larvae could be commensals in the nest. Another *borrei* cell had a viable wasp egg on which were tiny dipterous eggs and a maggot, possibly those of a commensal species. Another probable commensal, the sarcophagid *Leucomyia cinerea* (Fabricius), watched a female *glauca* digging and then entered the nest after the wasp left.

Bembix Fabricius

Key to Sri Lankan and South Indian Species of *Bembix*

1. Ground color predominantly light red, male with slight amounts of black on head and thorax; foretarsus yellow beneath; abdominal terga 1–3 with paired transverse pale spots separated on midline, those on 2–3 sublunate; male midcoxa with short acute spine at inner ventral angle . . . 4. *lunata* Fabricius
- Ground color black; foretarsal segments beneath with a dark maculation, reduced to only a streak on basitarsus in some females; tergum 1 with paired pale spots or a transverse band, 2–3 banded; male midcoxa not spinose . . . 2

- 2. Clypeus strongly protuberant; mandible extremely slender, index 2.8–2.9; maxillae and labrum unusually long, latter \times 0.9 eye height; males relatively unmodified, terminal flagellar segments shallowly concave beneath and not greatly widened, midfemur smooth beneath, rarely weakly serrate 3. *glauca* Fabricius
- Clypeus moderately convex; mandible stouter, index 1.8–2.2; maxillae and labrum normal in length, latter \times 0.7–0.8 eye height; males more modified, some of terminal flagellar segments deeply excavate beneath and widened, midfemur moderately serrate beneath 3
- 3. Clypeus with dense appressed silvery vestiture; scape black; front mostly dark except for small pale spots below ocellar triangle and rarely a short narrow perpendicular line between and above antennal sockets; mandible without a cutting edge on inner margin beyond subapical tooth [Figure 24] 7. *borrei* Handlirsch
- Clypeus with sparser erect to suberect silvery setae; scape with at least a narrow yellow stripe beneath, frequently more extensively yellow; front with more extensive yellow markings at least on lower half; mandible with a cutting edge in all females [Figures 25a, 26a, 28a, 29a] and in males of *antoni* and *budha* [Figures 28b, 29b], this process lacking in males of *orientalis* and *tranquebarica* [Figures 25b, 26b] 4
- 4. Smaller species, 9.5–15.5 mm long; mandible with a smaller cutting edge or none at all (males) [Figures 25, 26]; wing index 1.7–1.8; male forefemur flattened beneath, unusually widened at middle, \times 2.5–2.6 as long as wide, sharply margined posteriorly 5
- Larger species, 17–20 mm long; mandible with large cutting edge in both sexes [Figures 28, 29]; wing index 1.9; male forefemur rounded beneath, normal in shape, \times 2.9–3.0 as long as wide, not sharply margined posteriorly . . . 6
- 5. Abdominal tergum 6 of female and 7 of male black; black area covering ocellar triangle extended to inner orbit leaving pair of isolated yellow spots on vertex; male forebasitarsus beneath with larger black marking on each segment; first and second segments with short carina preceding apical tooth, tergum 7 rounded apically; genitalia [Figure 13] with cuspis narrower and parameral flange more massive 1. *orientalis* Handlirsch
- Tergum 6 of female and 7 of male with a pair of apicolateral spots; black spot on ocellar triangle restricted to that area so yellow marking adjacent to inner orbit coalesces above with vertexal spots; male forebasitarsus beneath with reduced black marking, without carina preceding apical tooth on two basal segments, tergum 7 emarginate apically; genitalia [Figure 11] with cuspis broader and parameral flange more slender . . . 2. *tranquebarica* (Gmelin)
- 6. Clypeus convex at base beneath median keel, of female with a pair of large black spots at base that may coalesce on midline, of male with a pair of somewhat smaller basal spots; female abdominal tergum 1 with pair of transverse pale spots, tergum 6 entirely black; male tergum 7 lobate apically [Figure 19], usually black but occasionally with pair of small pale spots; paramere of male genitalia [Figures 7, 8] broader, setae longer and denser, and transverse carinae on ventral surface stronger and more numerous than in *budha* 5. *antoni* Krombein and van der Vecht, new species
- Clypeus with a vaguely defined flat triangular area beneath median keel, usually yellow but occasional females with a pair of small basal black spots; female tergum 1 with transverse band, 6 with large yellow spot; male tergum 7 with margin before rounded apex only slightly concave [Figure 20], with a large median yellow area; paramere of male genitalia [Figures 9, 10] narrower, setae shorter and sparser and transverse carinae on ventral surface weaker and fewer than in *antoni* 6. *budha* Handlirsch

1. *Bembix orientalis* Handlirsch

FIGURES 13, 14, 26, 31

Bembix [sic] *orientalis* Handlirsch, 1893:737, 738, pl. 1: fig. 18, pl. 5: fig. 19, pl. 6: fig. 16 [♂, ♀; Bengal, Tenasserim, Himalaya; syntypes in Vienna, Berlin, Brussels, Munich]; 1895:1051 [listed].—Bingham, 1897:289 [brief description].—Dalla Torre, 1897:510 [listed].

Bembix orientalis Handlirsch.—Parker, 1929:101, figs. 153–155 [redescribed].—Bohart and Menke, 1976:548 [listed].

This species and *tranquebarica* (Gmelin) are closely related and are the only Ceylonese and South Indian representatives of the *hova* Group. This group is distinguished by the rather elongate wings (index 1.7–1.8 compared to 1.8–2.0 in other species of this fauna). Males of the group are also characterized by the seventh tergum that has a projecting subapical lobe on the margin and a rearward directed subbasal flange on the ventral surface of the paramere. Some males, including *orientalis* and *tranquebarica*, have the forefemur flattened beneath, expanded in the middle, and the posterior margin sharply margined.

Males of *orientalis* from Sri Lanka and southern India may be distinguished from those of *tranquebarica* by the comparatively larger black markings of the foretarsal segments beneath, stronger teeth at apices of first four segments of foretarsus beneath preceded by a short median carina on first two segments, and the entirely black seventh tergum with a rounded rather than emarginate apex and the distinctive genitalia (Figures 11–14). Females of *orientalis* have the sixth tergum black rather than with a pair of moderately large yellow spots and males have the seventh tergum black rather than with a pair of yellow spots. Both sexes of *orientalis* have a black stripe across upper front from inner orbit across ocellar triangle instead of having the black area restricted to the triangle.

MALE.—Length 12.5–14.5 mm, forewing 9.7–10.5 mm, wing index 1.79; mandible (Figure 26b) relatively slender, slightly curved toward apex, without cutting edge on inner margin beyond subapical tooth, index 1.9; clypeus 1.85 times as wide as high, slightly flattened in middle at apex; least interocular distance about a third distance from antennal sockets to anterior ocellus, 0.54 times eye height; center of vertex as high as top of eyes; scape 2.4 times as long as wide; first flagellar segment 2.7 times as long as wide; flagellar segments 5–10 widened, in profile 5–8 tuberculate, 9–10 lobate, 11 concave and truncate at tip, 4–6 with small sensory areas beneath at apex, 7–11 concave beneath, sensory areas covering entire venter; forefemur widened at middle, 2.5 times as long as greatest width, flattened beneath and with sharp posterior margin; forebasitarsus 3.8 times as long as wide, with 7 pecten spines, all but first quite stout; first four segments of foretarsus beneath with apical tooth, teeth becoming progressively weaker on third and fourth, first and second segments with strong, short, median carina ending in the tooth; midfemur with many small

serrations beneath, not sharply margined; apex of midtibia produced into a short spine adjacent to spur; tergum 7 rounded apically, lateral margin angulately emarginate at middle, posterior section forming a projecting lobe that is depressed below anterolateral margin at that point; sternum 2 with median process well developed, relatively stout, not strongly raised; median process of 6 triangularly raised, tapering to a narrow angle near apical margin; genitalia (Figures 13, 14).

Color: black with yellow markings, dorsum of thorax and abdomen in middle, pale markings as follows: mandible except apical third, labrum, clypeus, front below ocellar triangle except pair of spots halfway between antennae and anterior ocellus, black area on ocellar triangle continued laterad to inner orbit, band along posterior orbit narrowing above to top of eye, pair of spots laterad of and posterior to ocellar triangle, scape except blotch above at apex, pronotum except pair of small spots anteriorly on collar, scutum with median U-shaped mark and lateral stripe both extending anteriorly almost to base, apical fourth of scutellum broadened laterally, apical third of metanotum, mesopleuron except narrow stripe behind pronotal lobe, propodeal triangle except broad basal band and apical spot, posterior propodeal surface except broad V-shaped band margining triangle, most of legs except small spots on mid- and hind coxae and trochanters, blotch above on forefemur toward apex, narrow basal stripe above and below on foretibia, small spot at base above on midtibia, narrow stripe above on hind tibia, all tarsi except foretarsus with median stripe narrowly interrupted on basal segment beneath and spots on second and third beneath, tergum 1 with transverse band narrow in middle, broadened at side, biemarginate medially on anterior margin, basal bands on 2 and 3 enclosing pair of transverse median dark spots, each band rather deeply and angularly emarginate posteriorly, 4 and 5 with narrower median bands biemarginate anteriorly and angularly emarginate posteriorly, 6 with pair of transverse spots at apex, sterna 1–4 except 2 with large median dark blotch, 3–4 with basal dark blotch in middle, that on 3 smaller than on 4, 5 with posterolateral spot.

FEMALE.—Length 12.0–14.5 mm, forewing 7.5–9.0 mm, wing index 1.75; mandible (Figure 26a) relatively slender, curved on apical third, slight cutting edge on inner margin beyond subapical tooth, index 2.1; clypeus 2.05 times as wide as high; least interocular distance halfway between antennal sockets and anterior ocellus, 0.58 times eye height; center of vertex as high as top of eyes; scape 3.1 times as long as wide; first flagellar segment 3.3 times as long as wide; forebasitarsus 2.9 times as long as wide, with 6–7 pecten spines; scutum with small subcontiguous punctures; sternum 2 with moderately large scattered punctures medially, punctures smaller laterally and separated by less than diameter of a puncture; margin of tergum 6 narrowly rounded at apex, apical rim smooth, otherwise with moderately large dense punctures.

Coloration similar to that of male except mandible, labrum, clypeus, and middle of thorax and abdomen whitish, otherwise yellow as in male except as follows: clypeus except pair of oblique spots on base, front except pair of triangular spots extending from near antennal sockets to level of ocellar triangle, foretibia yellow above, tarsi entirely yellow, tergum 6 black, sternum 1 except narrow median stripe, broad lateral stripe on 2, posterolateral spots on 3–5 decreasing in size on successive segments.

VARIATION.—Available specimens are from Sri Lanka and southern India. If *orientalis* occurs in the Thar Desert, that population may have more yellow than detailed below as does *tranquebarica* from that xeric area. The descriptions above are of specimens from the middle of the range of color variation.

The darkest males have an inverted black V at base of clypeus, large black spot on front leaving only a narrow stripe along inner orbit and transverse stripe below anterior ocellus, scape above mostly dark except base, narrower stripe along posterior orbit, black blotch on pronotal lobe, scutal markings represented at least by narrow anterior remnants of U and short narrow stripe adjacent to tegula, scutellum with only a narrow apical line, metanotum immaculate, mesopleuron with large black spot behind pronotal lobe and one posterolaterally, mesepimeron dark, metapleuron mostly dark except anteriorly below, propodeal triangle with only a small yellow mark laterally on dorsal area, posterior propodeal surface dark, lateral surface with large dark area behind spiracle, black spots and stripes on legs more extensive including on foretrochanters, most of upper surface of forefemur, stripes above on mid- and hind femora, stripes beneath on all tibiae, yellow on tergum 1 reduced to narrow median line on side, median bands on 2–5 quite narrow, widely and shallowly biemarginate anteriorly and angularly emarginate posteriorly, those on 4 and 5 narrowly interrupted on midline, transverse spots on 6 more separated, sternum 1 with narrow apical band, 2–5 with posterolateral spots decreasing in size on successive segments.

The most highly maculated males have front and vertex yellow except pair of small spots halfway between antennae and anterior ocellus, ocellar area, small bar along upper inner orbit, pale markings on scutum comparatively broader, apical half of metanotum, band on tergum 1 broader, enclosing pair of oblique elliptical spots, paired dark spots on 2 and 3 narrower, 6 with subapical pale band, sternum 2 except inverted T-shaped mark on process, 3–5 with yellow areas comparatively more extensive.

The darkest females have the clypeal spots fused to form an inverted black V, frontal spots may extend upward to fuse with band below ocellar triangle, yellow scutal U reduced to separate narrow lateral and apical stripes, stripe adjacent to tegula narrowed, scutellum with narrow apical line broadened at sides, stripe on apical third of metanotum, mesopleuron except black stripe anteriorly, mesepimeron

black except on anterior half above, mesosternum dark, most of dorsum of propodeal triangle and apex dark, posterior propodeal surface dark except laterally, lateral propodeal surface with large black spot behind spiracle, black spots and stripes on legs more extensive, narrow median band on tergum 1 shallowly biemarginate anteriorly, bands across 2–4 deeply biemarginate anteriorly and angularly emarginate in middle posteriorly, 5 with narrow transverse band interrupted in middle, narrow apical band on sternum 1, posterolateral spots on 2–5 decreasing in size on successive segments.

The most maculated females have clypeus entirely pale, markings on thoracic dorsum broader, mesopleuron yellow except narrow line behind pronotal lobe, black areas on propodeum relatively smaller, band on tergum 1 broader, enclosing pair of transverse spots, bands on 2–5 relatively broader.

LOCALITIES AND MONTHS OF COLLECTION (USNM unless indicated otherwise).—Sri Lanka, **NORTHERN PROVINCE**, *Vavuniya District*: Mullaivivu (♀; Nov; Colombo); *Mannar District*: Ma Villu (♂; Feb), Marichchukkadi (♀, ♂; Jan, Mar; Colombo). **NORTH CENTRAL PROVINCE**, *Anuradhapura District*: Hunuwilagama (♂; Mar). **EASTERN PROVINCE**, *Trincomalee District*: Amarivayal (♂; May), Tennamaravadi (♂; May), Niroddumunai (♀; Sep; Colombo). **NORTH WESTERN PROVINCE**, *Kurunegala District*: Naranmulla (♀; Feb; Colombo); *Puttalam District*: Puttalam (♀; Nov; Basel). **WESTERN PROVINCE**, *Colombo District*: Ratmalana near airport (♀, 2♂; Jan, Feb), Colombo (2♀; Feb). **SOUTHERN PROVINCE**, *Hambantota District*: Palatupana (♀; Aug).

India, Madras: Karikal (5♀; Mar, Apr), Kurumbagaram (16♀, ♂; Mar), Puttuchcheri, Karaikkal (♂; Mar; Leiden), Pondicherry (2♂; Apr; Leiden).

2. *Bembix tranquebarica* (Gmelin)

FIGURES 11, 12, 25, 30

Bembex [sic] *repanda* Fabricius, 1787:286 [♂; Tranquebar; syntypes in Copenhagen].—Olivier, 1789:291 [brief description].—Fabricius, 1793:250 [brief description]; 1804:225 [brief description].—Jurine, 1807:175 [listed].—Dahlbom, 1845:487 [in key].—Handlirsch, 1893:896, 897 [copied original description].

Vespa (*Bembyx* [sic]) *Tranquebarica* [sic] Gmelin, 1790:2769 [new name for *repanda* Fabricius, preoccupied in *Vespa* by *Crabro repanda* Fabricius, 1787, also placed in *Vespa* by Gmelin, 1790:2761].

Bembex [sic] *trepada* Dahlbom, 1844:181, 182 [♂, ♀; India; syntypes in Lund University].—Smith, 1856:328 [listed].—Bingham, 1896:445 [Ceylon locality].—Handlirsch, 1893:736, pl. 1: fig. 17, pl. 5: fig. 20, pl. 6: fig. 15 [India, Ceylon, Mauritius; redescription]; 1895:1051 [listed].—Bingham, 1897:288 [described].—Dalla Torre, 1897:515 [listed].—Rahman, 1940:430 [flower visits, prey].

Bembix trepada Dahlbom.—Parker, 1929:101, figs. 207–209 [described].

Bembix repanda Fabricius.—van der Vecht, 1961:60, 61 [lectotype designation; placed *tranquebarica* and *trepada* in synonymy].

Bembix tranquebarica (Gmelin).—Bohart and Menke, 1976:548 [listed *repanda* and *trepada* as synonyms].

This species is very similar to *orientalis*. Specimens of

tranquebarica from Sri Lanka and southern India are separated readily by the characters noted under *orientalis*.

MALE.—Length 14.5–15.5 mm, forewing 10–11 mm, wing index 1.70; mandible (Figure 25b) relatively slender, slightly curved toward apex, without cutting edge on inner margin beyond subapical tooth, index 1.9; clypeus 1.86 times as wide as high, somewhat flattened apically in middle; least interocular distance about a third distance from antennal sockets to anterior ocellus, 0.52 times eye height; center of vertex as high as top of eyes; scape 2.5 times as long as wide; first flagellar segment 2.6 times as long as wide; flagellar segments 5–10 widened, in profile 5–8 tuberculate, 9–10 lobate, 11 concave and truncate at tip, 4–6 with small sensory areas beneath at apex, 7–11 concave beneath, sensory areas covering entire venter; forefemur widened at middle, 2.6 times as long as greatest width, flattened beneath and with sharp posterior margin; forebasitarsus 3.7 times as long as wide, with 7–8 pecten spines, all but first quite stout; first four segments of foretarsus beneath with median tooth at apex, teeth becoming weaker on successive segments; midfemur with many small serrations beneath, not sharply edged; apex of midtibia produced into short spine adjacent to spur; tergum 7 emarginate at apex, lateral margin angulately emarginate at middle, posterior section forming a projecting lobe and depressed below anterolateral margin at angulation; sternum 2 with median process well developed, relatively stout, not strongly raised; median process of 6 triangularly raised, tapering to a narrow angle near apical margin; genitalia (Figures 11, 12).

Color: black, head and thorax with yellow markings, abdomen mostly white but terga yellow laterally and sterna apically, pale markings as follows: mandible except apical fourth, labrum, clypeus, front except pair of small triangular spots between antennal sockets and black ocellar triangle, broad stripe laterad of ocellar triangle extending almost to occipital margin, band along posterior orbit narrowing above to top of eye, scape except apical blotch above, flagellum beneath, pronotum except pair of small spots anteriorly on collar, scutum with median U-shaped mark and lateral stripe, both extending to near base, apical third of scutellum broadened laterally, apical half of metanotum, side of thorax except mesopleuron with small blotch adjacent to pronotal lobe and occasionally a small one posterolaterally, propodeal triangle except narrow basal band and small apical spot, lateral propodeum except small spot behind spiracle, posterior propodeum except broad V-shaped band margining triangle, most of legs except small spots on coxae and trochanters, apical blotch above on fore- and midfemora, apical stripe behind on hind femur, narrow basal stripe above and below on foretibia, narrow stripe above on hind tibia, small median spot beneath on forebasitarsus, tergum 1 with broad band on basal horizontal half or more enclosing, or almost so, a pair of round black spots anteriorly, 2 and 3 with broad basal bands enclosing a pair

of transverse oval spots, 4 and 5 with broad bands shallowly biemarginate anteriorly and narrowed in middle posteriorly, broad lateral spots on 6 that may meet anteriorly, 7 with pair of small apicolateral spots, sterna 1–5 except narrow streak on process of 2, or 2 also with pair of small spots near process, 4 and 5 with large lateral spots, and 6 with large or small apicolateral spot. Wings hyaline; dense pale erect vestiture, long on front, vertex and gena, shorter on thorax and base of tergum 1, quite short on apex of 1 and 2–6.

FEMALE.—Length 9.5–14.5 mm, forewing 7.5–10.3 mm, wing index 1.68; mandible (Figure 25a) relatively slender, curved on apical third, slight cutting edge on inner margin beyond subapical tooth, index 2.1; clypeus 2.04 times as wide as high; least interocular distance halfway between antennal sockets and anterior ocellus, 0.57 times eye height; center of vertex as high as top of eyes; scape 2.9 times as long as wide; 1st flagellar segment 3.4 times as long as wide; forebasitarsus 3.1 times as long as wide, with 6–7 pecten spines; scutum with small subcontiguous punctures; sternum 2 with moderately large scattered punctures medially, punctures smaller laterally and separated by less than diameter of a puncture; margin of tergum 6 narrowly rounded at apex, apical rim smooth, otherwise with moderately large dense punctures.

Coloration similar to that of male except white markings present only on mandible, labrum, clypeus, and front, otherwise yellow; foretibia yellow above, forebasitarsus yellow, pygidium with pair of yellow spots, sternum 2 with large median black spot, 3–5 with large basal black spots. Wings and vestiture as in male.

VARIATION.—The descriptions of coloration above are of specimens from southern India. Three females from Deesa, Rajasthan in the Thar Desert have more extensive yellow markings and it is expected that males from such desert areas will be similarly colored. The black areas on head are reduced in extent, pronotum entirely yellow, U and lateral stripes on scutum broader and extending to base, markings on scutellum and metanotum broader, propodeum may be entirely yellow except base of triangle narrowly and tiny spot behind spiracle, bands on terga 1–3 correspondingly broader, each enclosing a pair of spots, bands on 4–5 broader, 6 may be yellow except narrow median and lateral lines and apex, sterna 1–5 may be entirely yellow, and 6 may be yellow except narrow median line and apical spot.

LOCALITIES AND MONTHS OF COLLECTION (USNM unless indicated otherwise).—Sri Lanka, NORTH CENTRAL PROVINCE, *Polonnaruwa District*: Polonnaruwa (♀; Basel). EASTERN PROVINCE, *Amparai District*: Pottuvil (♂; Basel).

India, Madras: Coimbatore (2♀; Sep; Corvallis); Karikal (♂; May, Corvallis), Kurumbagaram (2♀; Mar, Aug), Tranquebar (9♀, ♂; Feb, Mar, Jul, Corvallis). Rajasthan: Deesa (3♀; Apr, Oct).

3. *Bembix glauca* Fabricius

FIGURES 23, 34

Bembex [sic] *glauca* Fabricius, 1787:285, 286 [♂; Tranquebar; type in Copenhagen Museum].—Olivier, 1789:291 [brief description].—Fabricius, 1793:249 [brief description]; 1804:224 [brief description].—Jurine, 1807:175 [listed].

Bembex [sic] *indica* Handlirsch, 1893:771, 772, pl. 1: fig. 33, pl. 6: fig. 33 [♂, ♀; Ceylon, Decan; syntypes in Vienna, Hamburg, Berlin, Brussels, Zurich, Colombo]; 1895:1053 [listed].—Bingham, 1897:291 [re-described].—Dalla Torre, 1897:506 [listed]. [All listed *glauca* as a questionable senior synonym.]

Bembix glauca Fabricius.—van der Vecht, 1961:59 [note on type; synonymized *indica*].—Bohart and Menke, 1976:546 [listed].

Handlirsch assigned *indica* to his monotypic *indica* Group, which should now be termed the *glauca* group. The group is distinguished by the strongly protuberant clypeus and extremely slender mandibles (index 2.8–2.9 compared to 1.7–2.3 in other species), and in the males by having the terminal flagellar segments relatively slightly modified, the midfemur smooth beneath and the second abdominal sternum with only a low median keel. It is also behaviorally distinctive, for it constructs a much deeper nest with more angles than any other species of the Indian subcontinent whose nesting habits are known.

The species is known only from the Indian subcontinent where all precise locality records are from coastal localities. Based on collecting experience in Sri Lanka (KVK), *glauca* appears to be restricted to the seashore where it nests in pure sand above the high tide mark. Handlirsch's record of *indica* syntypes from Decan is troublesome. No such locality is listed in the available Indian gazetteer. The label "Decan" may mean from the Deccan plateau, a highly unlikely locality for an essentially littoral species.

The identity of a pair listed in the key by Dahlbom (1845:491) as "26. *Bemb. glauca* nob. ♂, ♀ India & Egypt" is puzzling. A pair of *Bembix* identified by de Beaumont as an unnamed subspecies of *olivacea* is in the Lund University collection that houses the Dahlbom collection. The male bears several labels, one printed "Coll/L.gh," one on creamy paper with a handwritten "glauca" underlined and one on blue paper in the same handwriting, "glauca" not underlined. R. Danielsson advises that L.gh stands for S.I. Lungh who collected probably only in Scandinavia. The female bears only one handwritten label, "Egpt"; it may be the specimen misidentified as *glauca* by Dahlbom.

MALE.—Length 12.0–19.5 mm, forewing 8.0–12.0 mm, wing index 1.95. Mandible (Figure 23b) slender, straight, no cutting edge beyond acute subapical tooth, index 2.8; clypeus strongly protuberant and convex, 1.47 times as wide as high; least interocular distance midway between antennal sockets and anterior ocellus, 0.56 times eye height; center of vertex slightly below top of eyes; scape 2.6 times as long as wide; first flagellar segment 3.8 times as long as wide;

terminal flagellar segments slightly modified, 7–8 slightly widened at apex, 9–11 slightly concave beneath; forebasitarsus 3.2 times as long as wide, with 6 pecten spines; midfemur smooth beneath, very rarely weakly serrate; tergum 7 shallowly emarginate at apex; sternum 2 moderately punctate, median keel low, not dentate at apex; sternum 7 swollen in middle, not carinate.

Color predominantly pale, mostly white or whitish yellow on head, tibiae, tarsi, and across middle of terga, pale yellow on middle of face, thorax, coxae, femora, bases, and apices of terga, and sterna, the following black: apical third of mandible, antenna above, narrow oblique streak from clypeus to side of antennal socket, paired triangular spots above antennal bases fused above, vertex except oblique band adjacent to ocellar triangle connecting below with broad stripe on front, scutum except broad, U-shaped mark in middle and broad stripe laterally, basal band rounded posteriorly on scutellum, narrow line on base of scutellum, mesosternum, narrow lines along episternal sulcus and meso- and metapleural sutures, narrow transverse band at base of propodeum, spot around spiracle, narrow lines along basal half of propodeal enclosure and small spot at its apex, small blotches on coxae, trochanters, femora, and foretibia beneath, several small spots on declivous surface of tergum 1, small paired elliptical spots on terga 1–6, those on 5–6 normally invisible because of being on retracted bases of sclerites, lateral spots on terga 2–6 occasionally lacking on posterior terga, irregular median stripe on sternum 2, basal spot on sternum 3, sterna 4–6 except for yellow spots of variable size on sides, and sterna 7–8. Wings hyaline; vestiture dense, pale, erect on base of clypeus, front, vertex, gena, thorax, and base of tergum 1, short and suberect on remaining terga, sparse and subdecumbent on sterna.

FEMALE.—Length 14.0–17.0 mm, forewing 10.0–12.0 mm, wing index 1.95. Mandible (Figure 23a) slender, straight, no cutting edge beyond acute subapical tooth, index 2.9; clypeus strongly protuberant and convex, 1.64 times as wide as high; least interocular distance 0.56 times eye height; center of vertex slightly below top of eyes; scape 3.0 times as long as wide; first flagellar segment 3.7 times as long as wide; forebasitarsus 2.8 times as long as wide with 6 pecten spines; scutum with small subcontiguous punctures; sternum 2 moderately punctate, more closely so laterally, medially with a narrow elliptical area that does not reach base or apex of sclerite; tergum 6 narrowly rounded apically, closely punctate except on a narrow median strip.

Coloration similar to that of male though pale markings less extensive as follows: clypeus with a median subbasal black spot, lateral stripe on face absent adjacent to ocellar triangle, vertexal stripe small, arms of U on scutum narrower, legs yellow, upper surface of forefemur dark, foretibia with a short stripe externally, terga 2–4 with apical dark bands, 5 with a short transverse dark stripe at apex, tergum 6 with a pair of small yellow spots, sterna 2–5 with

progressively smaller lateral yellow spots. Wings and vestiture as in male.

LOCALITIES AND MONTHS OF COLLECTION (USNM unless indicated otherwise).—Sri Lanka, NORTHERN PROVINCE, *Vavuniya District*: Mullaittivu (♀; Nov; Colombo); *Mannar District*: Olaithoduva, 10 mi W Mannar, 0–50 ft (♀, 3♂; Nov), Marichchukkadi (♀; Dec; Colombo). EASTERN PROVINCE, *Trincomalee District*: Kokkilai Beach (3♂; Nov). WESTERN PROVINCE, *Colombo District*: Pamunugama, sea level (10♀, 14♂; Jan, Mar, Sep), Uswetakeiyawa, 0–50 ft (♀, 3♂; May), Colombo (♀, 2♂; May, June; Colombo), Mt. Lavinia (♂; Feb, Colombo). SOUTHERN PROVINCE, *Galle District*: Bentota (2♀, 4♂; Aug, Colombo); *Hambantota District*: Palatupana, 0–50 ft (2♀, 9♂; Jan, Mar, Apr, Sep, Oct), Butawa Modera (♀; Dec; Colombo).

India, Madras: Pondicherry (3♀, ♂; Paris), Tranquebar (7♂; May; Corvallis). Kerala: Mahe (♀; Paris), Malabar (9♀, 5♂; Paris).

4. *Bembix lunata* Fabricius

FIGURES 27, 35

Bembix [sic] *lunata* Fabricius, 1793:249 [♂, ♀; Tranquebar; syntypes in Copenhagen]; 1804:224 [brief description].—Jurine, 1807:175 [listed].—Dahlbom, 1845:492 [♂; in key].—Smith, 1856:328 [listed].—Handlirsch, 1893:777, 778 [redescribed]; 1895:1054 [listed].—Bingham, 1897:285, 286, pl. 2: fig. 4 [redescribed].—Dalla Torre, 1897:507 [listed].—Ayyar, 1919:909, 910, pl. 141 [prey].
Bembix lunata Fabricius.—van der Vecht, 1961:59, 60 [lectotype designation].—Bohart and Menke, 1976:547 [listed].

Bembix lunata is the only Ceylonese and South Indian representative of the small *bidentata* Group. It is unique in that group, and also in this fauna because of its predominantly light red ground color and the presence in the male of a short spine on the inner ventral angle of the midcoxa.

MALE.—Length 14.2–18.5 mm, forewing 11.0–14.0 mm, wing index 1.87. Mandible (Figure 27b) stout, slightly curved toward tip with large cutting edge beyond tooth, index 1.66; clypeus 1.81 times as wide as high, slightly flattened below basal keel; least interocular distance about halfway between antennal sockets and foreocellus, 0.56 times eye height; center of vertex slightly below top of eye; scape 1.9 times as long as wide; first flagellar segment 3.8 times as long as wide; terminal flagellar segments less modified than in other species, 6–10 somewhat widened, in profile 7–8 slightly dentate and 11 concave, 6–11 with concave sensory areas beneath, that of 6 small and apical, those of 7–11 increasing in size toward tip and covering most of surface; forebasitarsus 4.2 times as long as wide, bearing 7 pecten spines; midcoxa with short acute spine at inner ventral angle; midfemur beneath on apical half with sharp teeth along posterior margin; tergum 7 rounded apically; sternum 2 without median process, a median strip smooth, laterad of that with rather scattered small punctures

gradually becoming denser toward side and separated by width of a puncture; sternum 6 convex, occasionally slightly raised in middle.

Ground color predominantly light red but black on head, apical three or four flagellar segments, pronotum, scutum except normal yellow markings light red, sides of meso- and metapleura, mesosternum except red at apex, and propodeum; pale markings white on clypeus, front and propodeal dorsum, otherwise yellow, as follows: mandible except apical third, labrum, clypeus, median triangular spot above clypeus, lateral stripe on front shading to light red opposite ocellar triangle, pair of small median spots below anterior ocellus, elongate triangular spot along outer orbit sometimes shading to light red near top of eye, pronotum except median anterior bar, normal U-shaped mark on scutum red, tiny posterolateral spot or stripe on scutum, mesopleuron except behind pronotal lobe and small area ventrally, mesepimeron usually red but occasionally yellow above, metapleuron, propodeal triangle with a broad V-shaped mark across middle, posterior and lateral surfaces except a broad V-shaped mark from abdominal attachment extending upward toward spiracle, forecoxa, mid- and hind coxae except most of ventral surface, trochanters, forefemur except narrow black streak on basal half posteriorly, midfemur, hind femur except beneath, tibiae and tarsi, pair of triangular spots on tergum 1 usually well separated in middle but occasionally almost touching, paired sublunate spots on 2–4 narrowly separated at midline, those on 4 sometimes joined, broad band over most of 5 biemarginate anteriorly, 6 at apex with or without narrow band or small median spot, 7 with apical spot, sterna 2–5 with posterolateral triangular spots connected by narrow apical band and 6 with apical band. Wings hyaline but stained with light brown along some veins; vestiture dense, pale, erect on front, vertex, gena, thorax, and base of tergum 1, short, suberect and with yellowish cast on remainder of terga, sterna with sparse subdecumbent setae except 5 and 6 with dense longer erect yellowish setae.

FEMALE.—Length 14.0–19.3 mm, forewing 10.6–15.0 mm, index 1.97. Mandible (Figure 27a) stout, curved on apical third, inner margin with large cutting edge beyond subbasal tooth, index 2.29; clypeus 1.88 times as wide as high, flattened in middle beyond basal keel; least interocular distance midway between antennal insertions and anterior ocellus, 0.60 times eye height; vertex slightly below top of eyes; scape 2.2 times as long as wide; first flagellar segment 4.5 times as long as wide; forebasitarsus 3.5 times as long as wide, with 7 pecten spines; scutum with small subcontiguous punctures; sternum 2 with narrow smooth median area on basal half, laterad of this with a narrow area bearing larger scattered punctures and on sides with smaller punctures mostly separated by about a puncture's width; tergum 6 narrowly rounded apically, with close small punctures.

Color similar to that of male but ground color entirely

light red except black are apex of mandible, ocellar area, narrow base of scutum in middle, posterolateral mark or stripe on scutum, narrow basal stripe on propodeal triangle, narrow V-shaped line or stripe margining triangle, spot behind spiracle; pale markings entirely yellow and as in male except clypeus not entirely yellow but red on base, tergum 4 always with an anteriorly biemarginate band, and band on 5 sometimes divided into three spots. Wings and vestiture as in male except clypeus with two areas of appressed silvery setae, not so dense nor conspicuous as in *borrei*.

LOCALITIES AND MONTHS OF COLLECTION (USNM unless indicated otherwise).—Sri Lanka, NORTH CENTRAL PROVINCE, *Polonnaruwa District*: Polonnaruwa (♂; Basel). EASTERN PROVINCE, *Trincomalee District*: Kantalai (2♀; Aug; Colombo). SOUTHERN PROVINCE, *Hambantota District*: Katagama (♀, ♂; Sep; Colombo).

India, Madras: Karikal (♀; May; Corvallis), Kurumbagaram (7♀; Mar), Nilgiri Hills, Singara, 3400 ft (♂; May; Corvallis), Puttuchcheri, Karaikkal (2♀, 2♂; Feb, Mar; Leiden).

5. *Bembix antoni*, new species

FIGURES 7, 8, 15, 17–19, 21, 22, 28, 33

ETYMOLOGY.—The taxon is named for the late Anton Handlirsch, whose monograph of the world fauna of *Bembix* (1893) set a high standard for systematic work on the genus.

This is one of the two largest Ceylonese *Bembix*, females being 19–20 mm long, and males 17–20 mm. *Bembix lunata* Fabricius may attain this size but it is readily distinguished from *antoni* by the red rather than black ground color of the body. Both sexes of these species differ from their Ceylonese congeners in having more robust mandibles with an oblique cutting edge beyond tooth (Figure 11).

Bembix antoni occurs in both Sri Lanka and South India, apparently in forested areas. Within Sri Lanka it occurs more commonly in the Wet Zone where the average annual rainfall is some 3900 mm. However, single individuals have been collected at Mau Aru, Dambulla, and Padaviya in the Dry Zone where the average annual rainfall may be no more than 1100 mm. Its closest relative, *budha* Handlirsch is widely distributed in eastern India but has not been collected in Sri Lanka. The two species are not known to occur together in South India where *antoni* has been collected only in the Walayar Forest in south Malabar near the west coast and *budha* only in Karikal, Thanjavur (= Tanjore) near the east coast.

This species belongs to the small *papua* Group of Handlirsch. He placed in that group his *papua*, *budha*, *pinguis*, and *pugillatrix* together with *melancholica* Smith. An additional distinguishing character of this species group not noted heretofore is the series of strong transverse carinae

across the middle of the venter of the paramere (cf. Figures 7, 9) some of which become lamellate in certain species. These parameral carinae occur in males of *papua*, *budha*, *antoni*, and *pugillatrix* but not in *melancholica*; we have not seen males of *pinguis*. Such parameral carinae were not found in any of the North American or Australian species studied by Evans and Matthews (1968, 1973) and may be unique to the *papua* group. The parameral flange is relatively small and directed laterad.

The male genitalia of *antoni* and *budha* (Figures 7–10) are strikingly different, particularly the parameres. Those of *antoni* are broader, have denser, longer setae and more numerous, stronger transverse carinae across the middle. The external differences between these two species other than color are few and subtle. Both sexes of *antoni* have the clypeus slightly convex medially beneath the basal keel whereas this median area is slightly flattened in *budha*. A more noticeable distinction is the outline of male abdominal tergum 7, which is definitely lobate at the apex in *antoni* (Figure 19), whereas in *budha* (Figure 20) the sides are only slightly concave before the rounded apex.

Minor but reasonably reliable color differences separate the two species. Females of *antoni* have a pair of large, basal, black spots on the clypeus that sometimes coalesce, the transverse yellow band on tergum 1 is divided in the middle and tergum 6 is entirely black, whereas females of *budha* have the clypeus yellow, at most with a pair of tiny black spots, a broad uninterrupted band on tergum 1 and a large yellow spot sometimes covering almost the entire exposed part of tergum 6. Males of *antoni* have black clypeal spots though smaller than in the female and tergum 7 is usually black, only occasionally with a pair of tiny yellow spots, but those of *budha* have a yellow clypeus and tergum 7 has a large yellow area. Males of both species have a broad, uninterrupted, yellow band on tergum 1, but the bands on this and succeeding terga are narrower in *antoni*.

MALE (all figures from paratypes).—Length 20 mm, forewing 13 mm, wing index 1.87. Mandible (Figure 28b) stout, curved toward apex, inner margin with large oblique cutting edge beyond tooth, index 1.8; clypeus 1.76 times as wide as high, slightly convex medially below basal keel; least interocular distance about a third of distance between antennal sockets and anterior ocellus, 0.49 times eye height; center of vertex slightly below top of eyes; scape 2.3 times as long as wide; first flagellar segment 3 times as long as wide; flagellar segments 6–8 widened, tuberculate in profile, 11 concave in profile (Figure 22); flagellar segments 4–11 modified ventrally, with sensory concavities increasing in size toward 10, that on 11 small and on basal third (Figure 21); forefemur rounded beneath, $\times 3.0$ as long as wide; forebasitarsus 3.8 times as long as wide, bearing 6 pecten spines; midfemur weakly serrate beneath, not sharply edged; tergum 7 lobate at apex (Figure 19); sternum 2 (Figure 17) moderately punctate, median process low,

rather thin, apex in profile forming a blunt tooth; median process of sternum 6 low, obtuse in profile, continuing to apex as a low ridge (Figure 18); sternum 7 (Figure 15); genitalia (Figures 7, 8).

Color: black, the following yellow: mandible except apical third, labrum, clypeus except pair of oblique basal spots, scape beneath and a narrow line laterally, front except small oblique spot from clypeus to lateral margin of antennal socket and broad U-shaped mark surrounding anterior ocellus and extending halfway to antennal insertions, band along posterior orbit narrowing above, pronotum except transverse anterior blotch, scutum with median U-shaped mark and lateral band, broad curved band across middle of scutellum, metanotum except narrowly at apex, mesopleuron except blotch adjacent to pronotal lobe, most of metapleuron, most of propodeum except narrow line adjacent to metanotum, broad V-shaped mark on posterior surface and vertical bar on middle of lateral surface, forecoxa beneath, mid- and hind coxae laterally, trochanters apically, all femora except stripes above and spots at apices beneath of mid and hind, tibiae except short lines or spots beneath, tarsi except apices beneath of fore and of apical segments of mid and hind, broad band across anterior two-thirds of disk of tergum 1, tergum 2 except pair of narrow transverse subbasal spots and narrow band angularly widened in middle on posterior fourth, tergum 3 similarly marked but spots wider, terga 4–6 with basal black areas not enclosed, posterior black band on apical third angularly produced anteriorly in middle; tergum 7 with small lateral spot posteriorly adjacent to lobate apex; posterolateral spot on sterna 2–6 decreasing in size posteriorly. Wings hyaline; vestiture pale, short, and suberect on clypeus, long, denser and erect on front, vertex, gena, shorter, dense and erect on thorax, brown on dorsum, pale on sides, terga with quite short, moderately dense, suberect brown setae on terga, parser setae on sterna.

FEMALE.—Length 19 mm, forewing 12.5 mm, wing index 1.86. Mandible (Figure 28a) stout, curved toward apex, inner margin with large oblique cutting edge beyond tooth, index 1.8; clypeus 1.88 times as wide as high, slightly convex medially below basal keel; least interocular distance 0.53 times eye height; vertex slightly below top of eyes; scape 2.8 times as long as wide; first flagellar segment 3.5 times as long as wide; forebasitarsus 2.8 times as long as wide, with 6 pecten spines; scutum with small subcontiguous punctures; sternum 2 with moderately large, scattered punctures medially, punctures laterally smaller and separated by less than the diameter of a puncture; tergum 6 narrowly rounded apically, laterally with dense small punctures, a narrow median strip smooth medially except for a few larger scattered punctures.

Color: black, the following yellow: mandible except apical third, labrum with a median decolorized strip, clypeus with a pair of large basal spots narrowly joined above, stripe on

venter of scape, front except small oblique spot from clypeus to lateral margin of antennal socket and broad U-shaped mark surrounding anterior ocellus and extending halfway to antennal insertions, stripe on outer orbit narrowing above, pronotum except transverse mark anteriorly and small blotch on lobe, scutum with median U-shaped mark and lateral stripe, median band on scutellum broadened at side, metanotum except narrowly at apex, mesopleuron except blotch below pronotal lobe, most of metapleuron, most of propodeum except broad V-shaped mark on posterior surface with a median extension dorsad and vertical strip on lateral surface, coxae and trochanters black and yellow, rest of legs yellow except stripes posteriorly or ventrally on femora, beneath on tibiae, stripe beneath on forebasitarsus and at apices of next three segments, tergum 1 with a median stripe narrowly interrupted on midline, tergum 2 black anteriorly and with a broad stripe across middle posteriorly enclosing two transverse oval spots, terga 3–5 with a transverse band across middle, deeply biemarginate anteriorly and with a median emargination posteriorly, sterna 2–4 with rounded posterolateral spot decreasing in size posteriorly. Wings and vestiture as in male.

VARIATION.—Males are 17–20 mm long. The process on sternum 2 is sometimes evanescent in Sri Lankan specimens but better developed in South Indian specimens, and the process on sternum 6 is rarely weaker. Most males are maculated like the holotype; the clypeus is rarely entirely yellow and spots on tergum 7 are lacking in most. The male from Ambame Hena and one from South India are notably less maculated; the U-shaped mark on the scutum is reduced to three lateral and apical spots or to a pair of tiny spots anteriorly near middle, and the lateral band is narrower or separated into two spots; and tergum 1 has separated narrower spots and bands on terga 2–6 are noticeably narrower.

Females are 19–20 mm long. They are very similar to the allotype in structure but there is slight variation in coloration. Specimens from Padaviya and South India have more reduced markings. The darkened, decolorized streak on the labrum is occasionally lacking, the clypeal spots may be broadly joined, the U-shaped mark on the scutum may be divided into lateral and posterior spots or represented just by a pair of short, narrow, anterior spots, and the spots on the sterna may be smaller, that on 4 lacking or one present on 5 also.

COCOON.—The cocoon is ovoid with a more tapered posterior end, 25 × 10 mm, with firm walls of sand grains spun together with silk. It has six elevated single pores scattered around the circumference about 12 mm from the anterior end.

TYPE MATERIAL (USNM except as noted in parentheses).—*Holotype* ♂: Sri Lanka, SABARAGAMUWA PROVINCE, Induruwa Jungle, Gilimale, 13–15 Mar 1979, K.V. Krombein.

Allotype ♀: Same label data but 8 Mar 1979.

Paratypes: 20♂, 4♀, same label data but 7–8 and 13–15 Mar 1979 (1♀ in Malaise trap); 1♀, same locality but 16–19 Apr 1981, K.V. Krombein, L. Weeratunge, P. Leanage; 1♂, 4♀, *Ratmalana District*, Ambame Hena, 8 mi W Kalawana, 27 Mar (♀) and 4 Apr 1981 (3♀), and ♂ reared ca 12 Feb 1982 from cocoon collected 4 Apr 1981, K.V. Krombein, P.B. Karunaratne; 1♂, SOUTHERN PROVINCE, *Galle District*, Sinharaja Jungle, Kanneliya section, 13–16 Jul 1978 (in Malaise trap), K.V. Krombein, P.B. Karunaratne, T. Wijesinhe, V. Kulasekera, L. Jayawickrama; 1♀, NORTH CENTRAL PROVINCE, *Anuradhapura District*, Padaviya, 180 ft, 2–8 Nov 1970, O.S. Flint, Jr.; 1♀, CENTRAL PROVINCE, *Matale District*, Dambulla, 21 Feb 1953, F. Keiser (Basel); 1♂, WESTERN PROVINCE, *Colombo District*, Labugama, 12 Aug 1975, P.B. Karunaratne (Colombo); 1♀, India, S(outh) Malabar, Sep 1946, P.S. Nathan; 2♂, 2♀, S(outh) India, S(outh) Malabar, Walyar Forests, 1000 ft, 8 Sep 1947 (♂), Apr 1951 (♀), Sep 1952 (♀) and Sep 1956 (♂), P.S. Nathan (latter pair in Corvallis). A pair of USNM paratypes will be deposited in the National Museum, Colombo, two males and one female in the Rijksmuseum van Natuurlijke Historie, Leiden, a pair in the British Museum (Natural History) and a male in the Oxford University Museum.

Three specimens of *antoni* from the Colombo Museum are excluded from the type series because of their poor condition. Label data are: 1♀, (Southern Province, Matara District) Dondra, Sep 1911; 1♀, # 23; 1♂, Ellahara, Oct 1909, O.S. Wickwar (this locality not listed in available gazetteer.)

6. *Bembix budha* Handlirsch

FIGURES 9, 10, 16, 20, 29, 32

Bembex [sic] *sulphurescens* Dahlbom.—Smith, 1856:328 [Madras, Punjab].—Cameron, 1890:247 [listed].—Bingham, 1897:287, 288 [described; India, Burma].—Maxwell-Lefroy, 1909:209 [nesting in riverine sand]. [All the foregoing misidentified.]

Bembex [sic] *budha* Handlirsch, 1893:782, 783, pl. 5: fig. 16, pl. 7: fig. 2 [incorrectly spelled *Budha*; Ostindien; syntypes in Hamburg (♂) and Vienna (♀) Museums].—Handlirsch, 1895:1054 [listed from India].—Bingham, 1897:287 [translated Handlirsch description].—Dalla Torre, 1897:503 [listed].

Bembix budha Handlirsch.—Bohart and Menke, 1976:545 [listed].

Cameron (1890:247) had a series of both sexes of this species from several localities in India that he misidentified as *sulphurescens*. Handlirsch recognized that it was a new taxon and described *budha* from two syntypes, a male in the Hamburg Museum and a female in the Vienna Museum that he received from Cameron. The male was destroyed during the bombing of Hamburg in World War II, so the female automatically becomes the lectotype. It bears two labels, one "Budha/det. Handlirsch," the other "Cameron det./Bembex/ sulphurescens Smith." It agrees well with a

series of nine females and seven males, presumably topotypic, from Barrackpore, India in the Oxford University Museum that stood over the name *sulphurescens*. We added our lectotype label to the female in the Vienna Museum.

Bingham (1897:287) stated that the species occurred through much of Burma and India but that it had not been collected in western India. Although it has not been collected in Sri Lanka, it may be found eventually in the more xeric northwestern parts of that country. It is included because of that possibility and also to record the lectotype designation.

The species is very close to *antoni* and may be separated as noted in the discussion of that new taxon.

MALE.—Length 17.0–19.5 mm, forewing 11.5–13.5 mm, index 1.88. Mandible (Figure 29b) stout, curved toward apex, inner margin with large oblique cutting edge beyond tooth, index 1.8; clypeus 1.82 times as wide as high, with a vaguely defined, triangular, flattened area below basal keel; least interocular distance about a third of distance between antennal sockets and anterior ocellus, half the eye height; center of vertex slightly below top of eyes; scape 2.2 times as long as wide; first flagellar segment 3 times as long as wide; flagellar segments 6–8 widened, tuberculate in profile, 11 concave in profile; flagellar segments 4–11 modified ventrally with sensory concavities increasing in size toward 10, that on 11 narrow and on basal half; forefemur rounded beneath, × 2.9 as long as wide; forebasitarsus 3.7 times as long as wide, bearing six pecten spines; midfemur weakly serrate beneath, not sharply edged; tergum 7 (Figure 20) not lobate apically, lateral margin weakly concave as compared to *antoni*; median process toward apex of sternum 2 sometimes evanescent, sometimes developed as a low, rather thin process ending in a blunt tooth; median process of 6 low, obtuse in profile, continuing to apex as a low ridge; sternum 7 (Figure 16); genitalia (Figures 9, 10).

Color: black, the following yellow: mandible except apical third, labrum, clypeus, scape except black spot above and narrow line laterally, front except narrow oblique stripe from clypeus to side of antennal insertion and broad U-shaped mark surrounding ocellar area, extending halfway to antennal insertions, pronotum except narrow band or pair of spots on neck, scutum with median U-shaped mark that may be interrupted posterolaterally and lateral stripe extending almost to base, scutellum except a transverse stripe on basal third or half not reaching side and a narrow posterior strip, metanotum except narrow posterior margin, mesopleuron except small area adjacent to pronotal lobe and small spot above and anterior to midcoxa, metapleuron, most of propodeum except narrow line adjacent to metanotum, narrow stripe margining triangle and extending downward on lateral surface, forecoxa beneath, mid- and hind coxae laterally, trochanters, femora except stripe above on fore and blotches of varying size above on mid- and hind, tibiae except short spots or lines beneath, tarsi

except apices beneath of fore and apical segments of mid- and hind, dorsum of tergum 1 except narrowly at apex, anterior margin biemarginate in middle, tergum 2 except apical fourth or fifth enclosing a pair of small transverse black spots near middle, 3 with an equally broad band enclosing a pair of similar black spots or deeply biemarginate anteriorly, 4 and 5 with broad band across middle deeply biemarginate in middle anteriorly, exposed area of 6 except narrowly at apex, 7 except anterolaterally, base of sternum 1, 2-5 with large posterolateral spots decreasing in size on successive segments and connected by a narrow apical band, 6 with large posterolateral spots. Wings hyaline; vestiture pale, short and suberect on clypeus, denser and erect on front, vertex, gena, thorax, and base of tergum 1, short, suberect, light brown on succeeding terga, and short, sparse, subdecumbent on sterna.

FEMALE.—Length 18.0–19.5 mm, forewing 12.0–12.5 mm, index 1.87. Mandible (Figure 29a) stout, curved on apical third, inner margin with large oblique cutting edge beyond tooth, index 1.9; clypeus 1.95 times as wide as high; least interocular distance 0.54 times eye height; vertex slightly below top of eyes; scape 2.8 times as long as wide; first flagellar segment 3.6 times as long as wide; forebasitarsus 3.6 times as long as wide, with 6 pecten spines; scutum with small subcontiguous punctures; sternum 2 with scattered, moderately large punctures medially and smaller punctures laterally separated by less than diameter of puncture; tergum 6 narrowly rounded at apex, laterally with dense small punctures, a narrow median strip smooth except for a few scattered punctures.

Color: black, the following yellow: mandible except apical third, labrum, clypeus entirely but some specimens with a pair of small black spots at base that may coalesce medially, scape except black stripe above on apical half, usually a spot at apex beneath of first flagellar segment, front except narrow oblique stripe from clypeus to side of antennal insertion and broad, U-shaped mark surrounding anterior ocellus and extending halfway to antennae, elongate triangular stripe along outer orbit extending on occiput opposite lateral ocellus, pronotum except pair of transverse median spots on collar, scutum with broad, U-shaped median mark and lateral stripe, both extending to a short distance from base of sclerite, median band across scutellum broadened at sides, metanotum except narrowly at apex, mesopleuron except small blotch behind pronotal lobe, metapleuron, propodeal triangle except narrow transverse band anteriorly, propodeum except black stripe bordering triangle extending downward on lateral surface, most of coxae and trochanters, most of femora except broad stripe above and narrower one below on fore, shorter stripes above toward apex and below from base of mid- and hind, tarsi except small spots at apices of foretarsal segments, broad undulating band on basal half or more of tergum 1, broad band on basal two-thirds or more of 2 enclosing a pair of median

transverse black spots, bands on basal two-thirds of 3–5 deeply biemarginate anteriorly, large rounded spot on 6 and posterolateral spots on sterna 2–5 decreasing in size on successive segments. Wings and vestiture as in male.

LOCALITIES AND MONTHS OF COLLECTION (USNM unless indicated otherwise).—India, Madras: Madras (♂; London), Pondicherry (♀, 2♂; Paris), Tanjore, Karikal (♀; Sep), Coromandel (♂; Paris), Negungadu (♀; Oct; London); Puttuchcheri, Karaikkal (2♂; Aug, Oct; Leiden). Orissa: Jeypore, 1775 ft (2♀, ♂; Oct; Corvallis). West Bengal: Calcutta (♂; Leiden), Barrackpore (11♀, 8♂; Oxford, London), Ranchi (♂; Aug; London). Madhya Pradesh: Jubbulpore (♀; May, London). No locality label: lectotype (♀; Vienna).

7. *Bembix borrei* Handlirsch

FIGURES 24, 36

- Bembex* [sic] *borrei* Handlirsch, 1893:866–868, pl. 3: fig. 12, pl. 7: fig. 37 [misspelled *Borrei*; ♂, ♀; Java, Andaman Islands, Burma, India, Ceylon; syntypes in Vienna, Brussels, Budapest, Munich, Stuttgart, Dresden, Geneva]; 1895:1058 [listed].—Dalla Torre, 1897:502 [listed].—Bingham, 1897:289 [♀, ♂; Sikhim, Burma, Tenasserim, Ceylon; description].—Parker, 1929:148, 149 [Philippines; description].—van der Vecht, 1939:84 [nest, prey].—Cherian, 1943:435 [misspelled *borrai*; nest, prey].—Bohart and Menke, 1976:545 [Timor].
- Bembix nigrocornuta* Parker, 1929:106–108, figs. 141–144 [♂, ♀; Deesa, India, Sikhim, Tavoy, Burma; type in USNM].—Bohart and Menke, 1976:547 [listed]. [New synonymy.]
- Bembix borrei thailiana* Tsuneki, 1963:25, 26, figs. 49–54 [♂; Thailand; type in Kobe University].—Iwata, 1964:364–366, figs. 27, 62, 72 [biology].—Bohart and Menke, 1976:545 [listed]. [New synonymy (K.V. Krombein).]

Both sexes of *borrei* are readily distinguished in the Sri Lankan and South Indian fauna by the dense, silvery, appressed vestiture of the clypeus. The male paramere is long, slender, and clothed with quite long dense setae, the mid-femur is serrate beneath, the second abdominal sternum has a weak or well-developed process, and the seventh has a low, slightly raised triangular area. *Bembix borrei* is a member of the *oculata* Group.

This is a wide-ranging polytypic species with the known range extending from the Indian subcontinent eastward through southeast Asia to Indonesia and the Philippines. Both sexes are readily recognized in the Indian subcontinent by the dense, appressed, silvery pubescence on the clypeus and the predominantly black front. The species occurs at low altitudes with light to moderate rainfall within Sri Lanka.

The second author studied the 12 *borrei* syntypes in the Vienna Museum and placed his lectotype label on a male from Java collected by van Lansberge that was labeled *borrei* by Handlirsch.

We recognize that the population occurring in the Indian subcontinent, Burma, and Thailand is subspecifically distinct from typical *borrei* from Java. We have not had suffi-

cient material from southeast Asia and Indonesia to allow us to delimit the range of the two or more subspecies of *borrei*. If subspecific differentiation is possible at a later date, the population occurring in the Indian subcontinent, Burma, and Thailand will be designated as *borrei nigrocornuta* Parker, with *b. thaiana* Tsuneki as a synonym.

MALE.—Length 10.0–13.0 mm, forewing 8.0–11.5 mm, wing index 1.86. Mandible (Figure 24b) slender, straight, no cutting edge beyond acute subapical tooth, index 2.2; clypeus convex, not strongly protuberant, index 1.8; least interocular distance halfway between antennal sockets and anterior ocellus, 0.60 times eye height; center of vertex slightly below top of eyes; scape 2.6 times as long as wide; first flagellar segment 4.3 times as long as wide, segments 4–7 progressively more dentate as viewed in profile, 5–10 increasingly concave beneath, 7–10 progressively broadened; forebasitarsus 3.3 times as long as wide, with 6 pecten spines; midfemur serrate beneath; tergum 7 rounded apically; sternum 2 ranging from slightly tumid in middle to bearing a stout, backwardly curved projection that is concave on posterior margin; sternum 7 with a slightly raised, low, triangular process subapically.

Markings white on head except yellow posteriorly, pale are mandible except apical third, labrum, clypeus except extreme base and a narrow apical line interrupted in middle, three small spots across front at anterior ocellus, band on gena extending to top of eye; markings of thorax yellow except white on scutellum and metanotum, pale are most of pronotum except lateral blotch, scutum with a broad U-shaped mark in middle and a lateral stripe on posterior two-thirds, stripe on apical third of scutellum broadened laterally, stripe on apical half of metanotum, triangular mark on mesepimeron, metapleuron, propodeal enclosure except basal third, lateral propodeal surface except a black area surrounding spiracle connecting with a broad black stripe covering most of posterior surface; legs yellow except mid- and hind coxae, parts of trochanters, femora with small blotch beneath near base and larger stripe above, tibiae with black spots beneath and a small spot on upper surface of foretibia, and all tarsi; markings of abdomen yellow except apices of tergal bands white, pale are band on basal two-thirds of disk of tergum 1 deeply biemarginate anteriorly, broad band on basal two-thirds of tergum 2 enclosing a pair of transverse elliptical spots, bands on terga 3–5 progressively more shallowly biemarginate anteriorly, triangular spots posterolaterally on sterna 2–5 becoming progressively smaller and posterior edge of median process on sternum 2. Wings hyaline; vestiture dense, appressed and silvery on clypeus; elsewhere on head long, pale, erect, that on thorax and tergum 1 shorter, pale, and erect, that on terga 2–5 quite short, pale and erect, that on 6 dark, and sterna with sparse, short, suberect setae.

FEMALE.—Length 11.0–15.4 mm, forewing 9.5–11.2 mm, wing index 1.92. Mandible (Figure 24a) slender,

slightly curved on apical third, no cutting edge beyond acute subapical tooth, index 2.1, clypeus convex, not strongly protuberant, 2.1 times wider than high, least interocular distance about a third of distance from antennal sockets to anterior ocellus, 0.64 times eye height, center of vertex slightly below top of eyes, scape 2.9 times as long as wide, first flagellar segment 4.5 times as long as wide; forebasitarsus with six pecten spines, 3.0 times as long as wide; scutum with small subcontiguous punctures; second sternum with punctures medially larger and separated by diameter of puncture or more, laterally more finely and closely punctate, tergum 6 narrowly rounded apically, closely punctate except on narrow median strip.

Color pattern similar to that of male but pale markings less extensive as follows: Head with labrum, basal two-thirds of mandible and narrow, apical, clypeal margin whitish, otherwise yellow; tiny, oblique, inwardly directed line above antennal socket and another anterolaterally on ocellar area, narrow triangle on gena extending to top of eye; markings of thorax yellow, most of pronotum except anterior and lateral blotches, scutum with U-shaped mark, the sides narrower than base of U, and lateral stripe adjacent to tegula, narrow apical stripe on scutellum broadened laterally to cover side of sclerite, band on apical half of metanotum, mesepimeron, metapleuron except spot posterior to lower pit, posterior half of propodeal triangle except small spot at apex, black stripe laterad of triangle extending on otherwise yellow posterior surface almost to abdominal attachment, side of propodeum except a large subtriangular spot posterior to spiracle, fore- and midfemora except stripe beneath, posterior femur except stripe beneath on basal half, all femora also with black stripes posteriorly, fore- and midtibiae except black stripe on inner surface not attaining base or apex, hind tibia except narrow line beneath along inner surface, tarsi; stripe on basal half of horizontal surface of tergum 1 deeply biemarginate anteriorly in middle, broad band on basal two-thirds of tergum 2 enclosing a pair of transverse black spots, bands on anterior two-thirds of terga 3–4 shallowly biemarginate anteriorly, large lateral spot on tergum 5, and triangular posterolateral spots on sterna 2–5 diminishing in size posteriorly. Wings and vestiture as in male.

VARIATION.—The foregoing descriptions are typical of specimens in the middle of the range of color variation. There is a gradation in both sexes toward more melanistic or more extensively maculated specimens whose extremes are detailed below. Darker or more brightly marked individuals may occur at any locality, but the majority of darker specimens are from areas of greatest annual rainfall (\approx 2400 mm) and the majority of more extensively maculated specimens are from the more xeric areas (1000–1500 mm.)

The darkest males have the clypeus mostly dark except anterolaterally, frontal spots very small, pronotum with larger area black laterally, scutal U reduced to short, nar-

row, lateral stripe and apical spot, lateral stripe on scutal margin narrower, stripes on scutellum and metanotum narrower, mesopleuron with smaller vertical stripe in middle, metapleuron yellow on lower half only, propodeal stripes much reduced, dark spots or stripes on femora more extensive, tergal markings narrower and white, that on 1 covering median third, shallowly and broadly emarginate anteriorly, that on 2 not enclosing dark spots but anterior margin deeply and semicircularly biemarginate, and spots on sterna smaller and white.

The males with the most pale markings have the clypeus pale except very narrowly at base, short narrow perpendicular line above antennal socket, five spots across front at anterior ocellus, U and lateral stripes on scutum a bit broader, stripe on apical half of scutellum broadened laterally, stripe on apical two-thirds of metanotum, entire mesepimeron, metapleuron, propodeal enclosure except narrowly at base, lateral propodeal surface except small spot around spiracle, posterior propodeal surface except narrowly adjacent to enclosure, black areas reduced on femora and tibiae beneath, entire outer surface of tibiae, band on tergum 1 broader, enclosing a pair of round black spots, sternum 2 with a large triangular mark laterally, its apex extending nearly to anterolateral corner of sclerite and coalescing near posterior margin with a transverse stripe that extends onto apex of process, sterna 3–5 with larger triangular posterolateral spots decreasing in size on successive segments.

The darkest females have whitish rather than yellow markings, spots above antennae lacking, pale areas on pronotum reduced to narrow posterior stripe on collar and lobe, anterior spot on propleuron, scutum with U reduced to small transverse spot at apex and lateral stripe narrower, apical stripes on scutellum and metanotum narrower, mesepimeron with narrow perpendicular stripe beneath tegula, metanotum with small spot below, propodeal triangle with pair of oblique stripes along lateral margin, lateral and posterior propodeal surfaces dark except for short narrow line above near their juncture, femora dark except narrow stripes on apical half or third above and beneath, band on tergum 1 reduced to tiny median spot and larger lateral blotches, bands on terga 2–4 narrower and across middle of segment, that on 2 deeply biemarginate in middle anteriorly, those of 3–4 shallowly biemarginate, lateral spots on 5 smaller, sterna 2–4 with smaller spots decreasing in size posteriorly.

The females with the most extensive yellow markings have, in addition to the normal pattern, anterolateral spots on clypeus, rarely coalescing medially to form a stripe on apical third or half, median spot or pair of spots below anterior ocellus, stripe on gena broader and extending on vertex opposite posterior ocellus, pronotum except narrowly on each side of neck, propleuron except small blotch, scutum with U and lateral stripe wider, extending farther

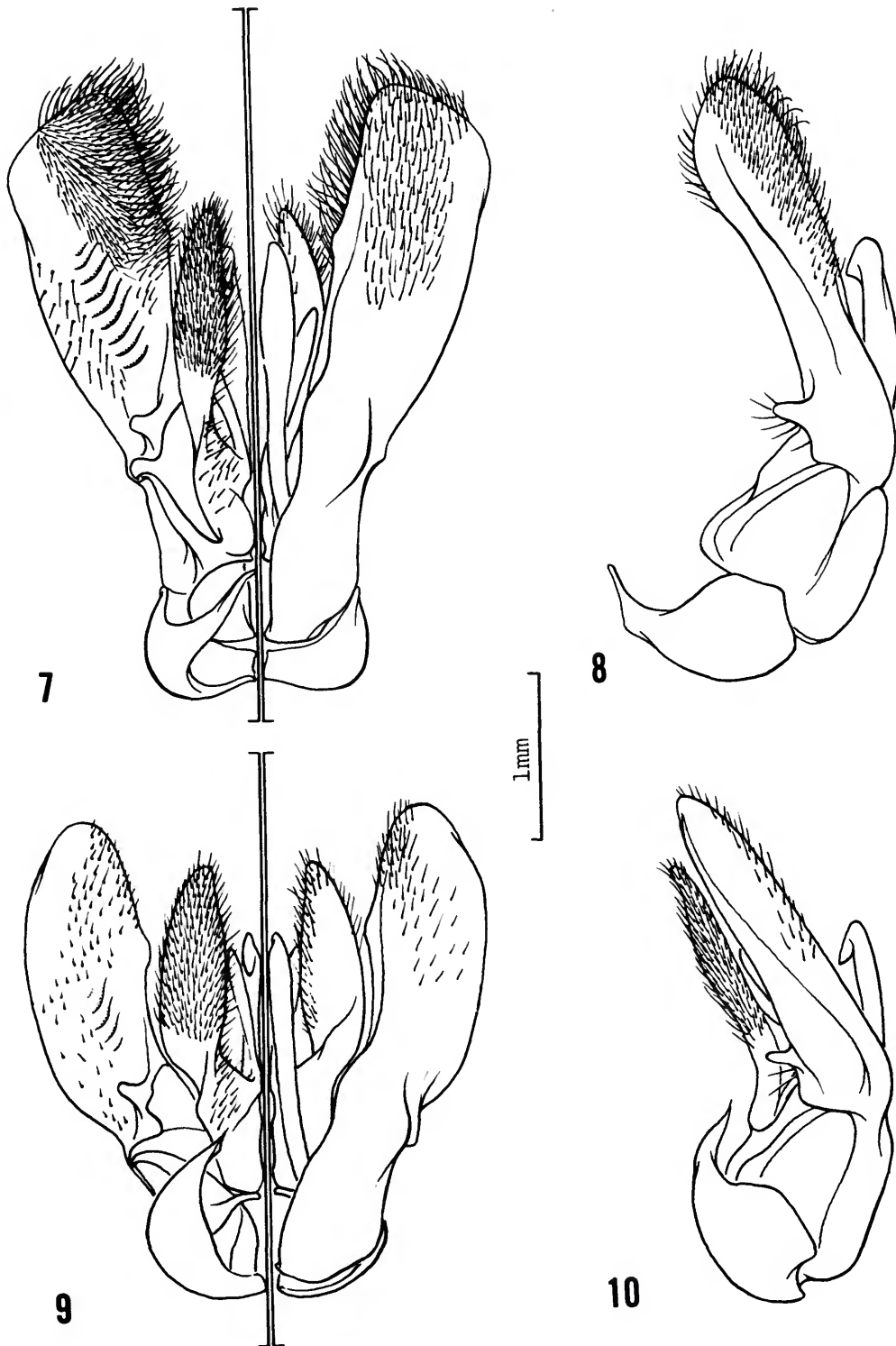
toward base of sclerite, sides and posterior half of scutellum, apical two-thirds and sides of metanotum, mesepimeron except narrow anterior strip, anterior third of hypopimeuron, metapleuron except narrow posterior strip, propodeal triangle except narrow band at base and spot at apex, lateral and posterior propodeal surfaces except black spot on spiracular area extending as a narrow streak along margin of triangle, femora except black stripes posteriorly and narrower stripes anteriorly on fore and mid and at base on hind, narrow median elongate spot beneath on fore- and midtibiae and small median spot anteriorly on fore, band on basal two-thirds of horizontal surface of tergum 1 enclosing (or almost so) a pair of median spots anteriorly, band on anterior three-fourths of 2 with narrower enclosed spots, broader band on 3 enclosing a pair of transverse spots across middle, band on 4 broader, 5 with spots larger, almost meeting in middle, and posterolateral spots on sterna 2–5 larger, decreasing in size posteriorly.

LOCALITIES AND MONTHS OF COLLECTION (USNM unless specified otherwise).—Sri Lanka, NORTHERN PROVINCE, *Mannar District*: Silavathurai (♀; Jan), Kondachchi (♀, 3♂; Jan), Pesalai beach 14 km NW Mannar (4♀; Jan, Apr), Marichchukkadi (♀, ♂; Jan, Mar; Colombo). NORTH CENTRAL PROVINCE, *Anuradhapura District*: Padaviya, 180 ft (15♀, 11♂; Mar, May), Galapitawewa (9♀, 2♂; Mar), Mihintale, Kaludiya Pokuna (2♀; Mar). EASTERN PROVINCE, *Trincomalee District*: Trincomalee, China Bay, 25–50 ft (9♀, 7♂; Jan, Feb, May, Jul, Oct), Nilaveli (♀; Nov), Paraiyankulam (♀; May); *Amparai District*: Lahugala Sanctuary (♀; June). CENTRAL PROVINCE, *Kandy District*: Kandy, Udawattakele Sanctuary (2♀; Sep), Ambacotta (♀; Basel). WESTERN PROVINCE, *Colombo District*: Ratmalana near airport, 50 ft (9♀, 3♂; Jan, Feb, June), Colombo (16♀, 11♂; Jan–May, Jul, Aug, Oct, Nov), Nugegoda, Papiliyana (5♀, 3♂; Mar, May, June, Sep, Nov), Katunayake (♀; Sep), Pamunugama sea level (10♀, 9♂; Jan, Mar), Battaramulla (2♀; May; Colombo), Labugama Reservoir, 400 ft (3♀, 8♂; Feb, May, Jul, Oct). SABARAGAMUWA PROVINCE, *Ratmalana District*: Uggalkaltota, 350–500 ft (4♀, 2♂; Jan, Feb, June, Oct). UVA PROVINCE, *Monaragala District*: 13 mi E Uda Walawe along Mau Aru (3♀, ♂; June, Sep), Angunakolapelessa, 100 m (7♀, 2♂; Jan, Mar, June, Sep, Oct). SOUTHERN PROVINCE, *Hambantota District*: Tangalla (♀; Aug; Colombo), Hambantota, 10 ft (♀, ♂, Oct), Bundala Sanctuary, 5–50 ft (♀; Aug), Katagamuwa (♀; Sep; Colombo), Yala, Palatupana, 0–50 ft (21♀, 5♂, Jan–Mar, Oct).

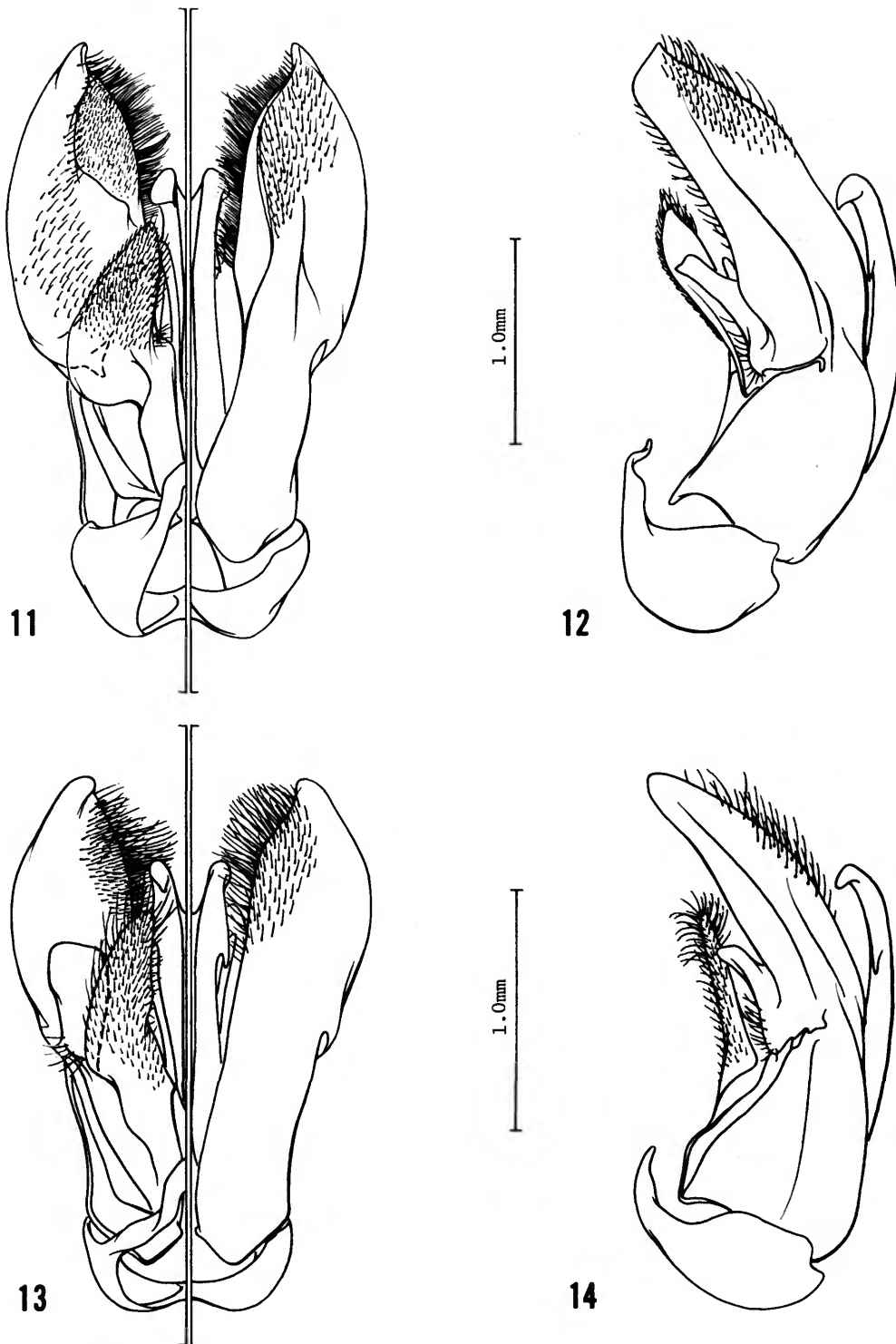
India, Madras: Pondicherry (3♀; Paris), Coimbatore (14♀, 11♂; Jan, Mar, Apr, Aug, Oct, Nov, Dec; USNM, Corvallis), Karikal, Kurumbagaram (2♀, ♂; Jan, Sep, Dec). Kerala: Malabar (Paris), Walayar Forest, 1000 ft (♀; May). Mysore: S. Coorg, Ammatti, 3100 ft (♀, ♂; Feb, Corvallis). Orissa: Jeypore, 1775 ft (♀; Oct, Corvallis). Maharashtra: Bombay (2♀, ♂, Oct, Nov).

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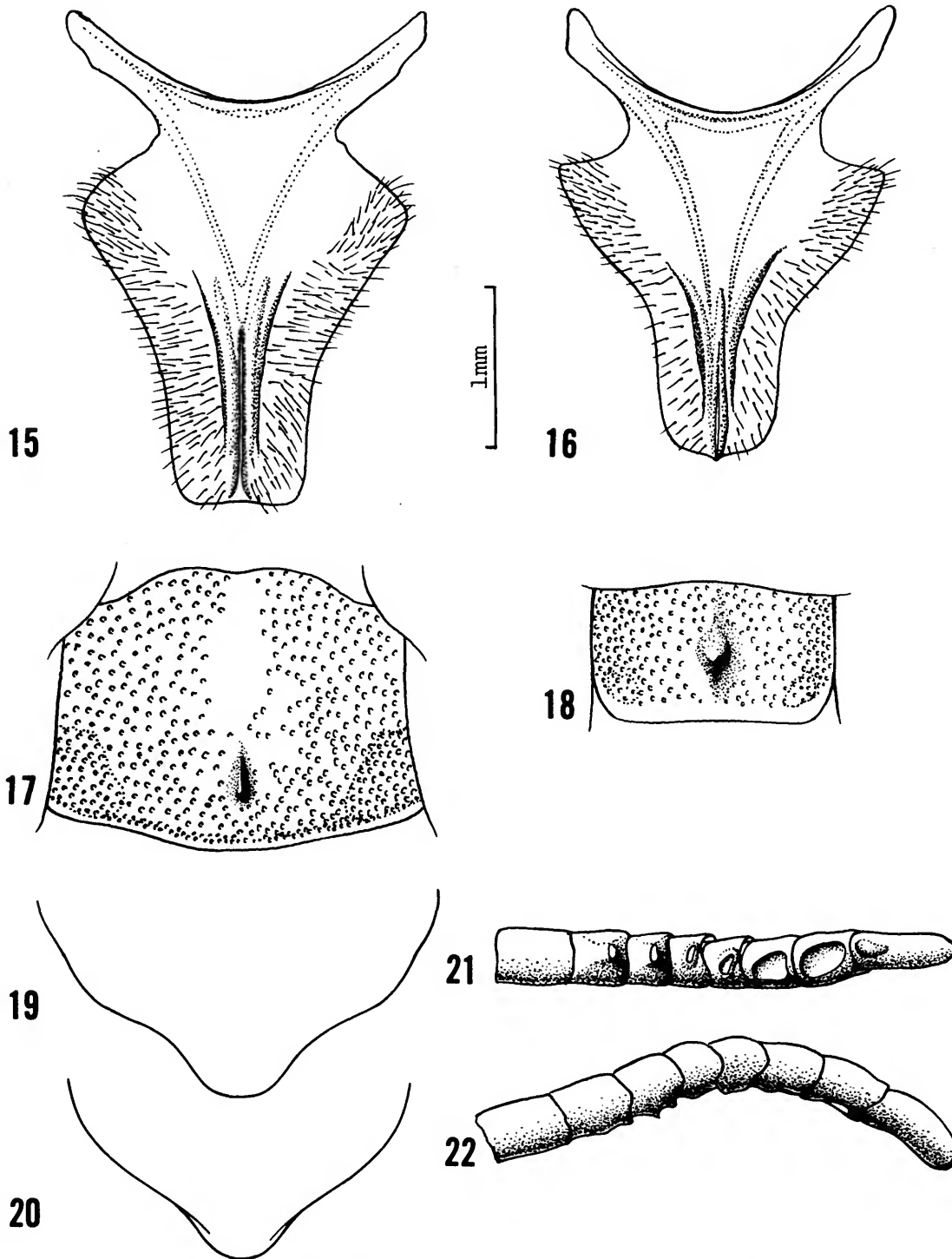
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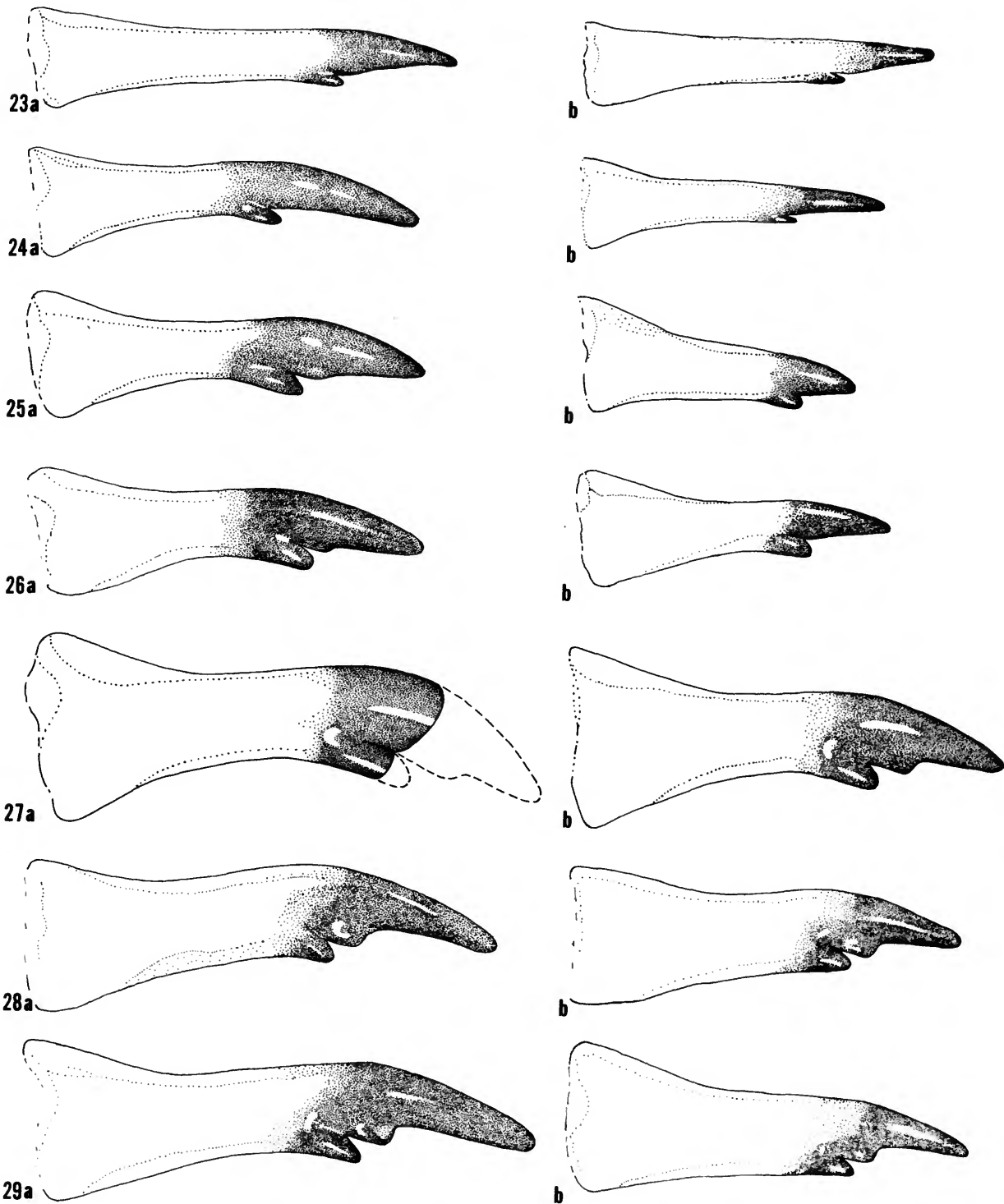
FIGURES 7-10.—Male genitalia: 7, *antoni*, ventral at left, dorsal at right; 8, *antoni*, lateral; 9, *budha*, ventral at left, dorsal at right; 10, *budha*, lateral.



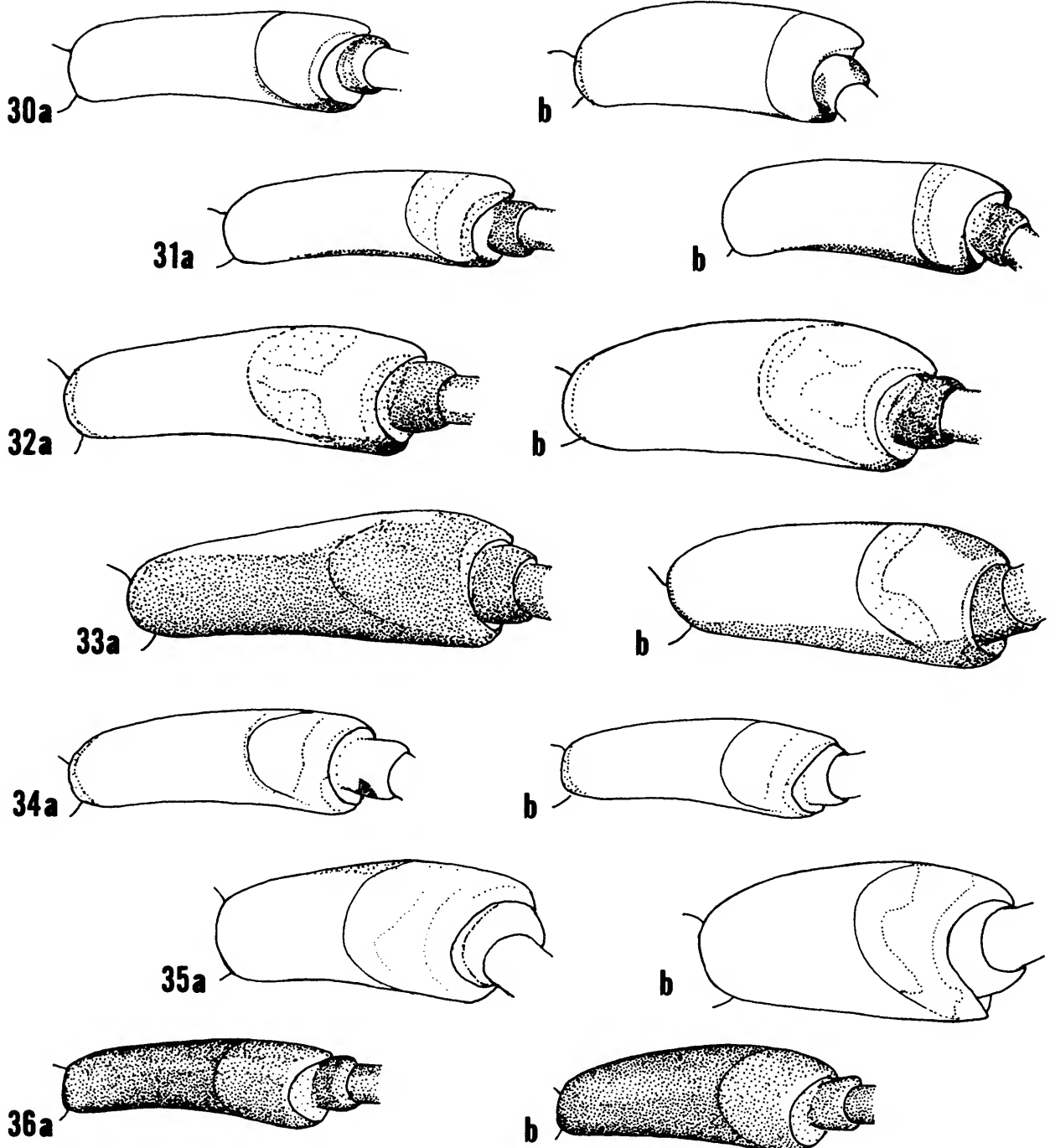
FIGURES 11-14.—Male genitalia: 11, *tranquebarica*, ventral at left, dorsal at right; 12, *tranquebarica*, lateral; 13, *orientalis*, ventral at left, dorsal at right; 14, *orientalis*, lateral.



FIGURES 15-22.—Male *Bembix*: 15, *antoni*, sternum 7; 16, *budha*, sternum 7; 17, *antoni*, sternum 2; 18, *antoni*, sternum 6; 19, *antoni*, tergum 7, apical margin; 20, *budha*, tergum 7, apical margin; 21, *antoni*, flagellar segments 4-11, ventral aspect; 22, *antoni*, flagellar segments 4-11, lateral aspect.



FIGURES 23-29.—Mandibles (a = female, b = male): 23, *glauca*; 24, *borrei*; 25, *tranquebarica*; 26, *orientalis*; 27, *lunata* (probable outline of eroded apex indicated by dashed line); 28, *antoni*; 29, *budha*. $\times 46$.



FIGURES 30-36.—Scape, ventral (a = female, b = male): 30, *tranquebarica*; 31, *orientalis*; 32, *budha*; 33, *antoni*; 34, *glauca*; 35, *lunata*; 36, *borrei*. $\times 31$.

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