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**THE MECOPTERA OF INDIA AND  
ADJACENT REGIONS**

**By**

**MICHAEL K. RUST and GEORGE W. BYERS**

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## The Mecoptera of India and Adjacent Regions<sup>1</sup>

BY MICHAEL K. RUST and GEORGE W. BYERS

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### ABSTRACT

Six species of *Bittacus*, 21 of *Neopanorpa* and 3 of *Panorpa* are described, compared, illustrated, and differentiated in taxonomic keys. The following new species are described: *Bittacus nodosus*, *Neopanorpa denticulata*, *N. echinata*, *N. gibbosa*, *N. indica* and *N. ochruva*. Previously unknown sexes of 5 species based on single holotypes are described and illustrated. *N. effusa* (Navás) and *N. furcata* (Hardwicke) are removed from *Leptopanorpa* to *Neopanorpa*. The geographical distribution of Mecoptera in the Indian subcontinent is correlated with elevation, rainfall, forest cover and other ecological factors, and zoogeographical relationships are discussed.

<sup>1</sup> Contribution no. 1607 from the Department of Entomology, The University of Kansas, Lawrence, Kansas 66045.

## INTRODUCTION

Accounts of insects of the order Mecoptera of the Indian subcontinent,<sup>2</sup> primarily species descriptions, have been published occasionally over the past 150 years. Of the 21 species so far described, many are still represented by single holotypes or a few syntypes, and little or nothing is known about their distribution. It is possible that the ranges of several Indo-Chinese and Chinese species extend into the Indian region.

Five previously unknown species of *Neopanorpa* and one of *Bittacus* are described in this paper. In addition, the previously undescribed sexes (one female, four males) for five species heretofore known only from single holotypes are described and illustrated. Two species previously assigned to *Leptopanorpa* have been transferred to *Neopanorpa*. It is our hope that this paper will serve primarily as a basis for future research on Mecoptera in the Indian region, especially since our survey has been so limited. In addition to those already mentioned, we have examined several specimens of undescribed species of *Neopanorpa* and *Bittacus* that have not been included because the males were badly damaged or only females were available.

Three species of *Panorpa* reported from Tibet, but probably from western China are discussed and illustrated to clarify the original locality data and to provide more useful illustrations of the types. We have examined an undescribed species of *Panorpa* from northern Burma, and it seems probable that the range of *Panorpa* extends into the hills of eastern Assam.

On the basis of wing pattern and genitalic characters of both males and females, three of the species of *Neopanorpa* form a compact group. We have called this the *appendiculata* group, after the oldest named species included. The members are: *appendiculata*, *salai*, and *indica* n. sp. Similarly, another four southern Indian species form a closely related group, which we have called the *denticulata* group, after the most abundant included species. Its members are: *denticulata*

n. sp., *hirsuta*, *echinata* n. sp., and *zebrata*. The other species of *Neopanorpa* cannot yet be arranged in useful taxonomic groups.

The most extensive collection of Indian Mecoptera is in the Snow Entomological Museum, University of Kansas. Three additional collections from the Indian region have been examined. They are from the British Museum (Natural History), London, loaned by Mr. Peter H. Ward, the Illinois Natural History Survey, Urbana, Illinois, loaned by Dr. L. J. Stannard, and the Naturhistorisches Museum, Basel, loaned by Dr. W. Wittmer. We also wish to thank Mr. P. Susai Nathan for his help in locating several of the collection sites.

Unfortunately, we have not been able to obtain on loan any specimens from the various institutions in India, Pakistan or adjacent countries. We are not aware of the extent to which this has limited our investigation.

Support for this study, through grants GB-30837 and GB-7045X from the National Science Foundation, is gratefully acknowledged.

## HISTORICAL REVIEW

The first record of Mecoptera from the Indian subcontinent was the description of *Neopanorpa furcata* by Hardwicke (as *Panorpa*) in 1825. Westwood's description of *Neopanorpa appendiculata* (1846, as *Panorpa*) was followed by the description of *Bittacus indicus* by Walker in 1853. Thirty-two years later Gerstaecker (1885) described *Bittacus latipennis*.

Between 1908 and 1935, Navás described nine additional Indian species, of which seven are still considered valid. He used the generic names *Aulops* Enderlein and *Campodotecnum* Enderlein for the species *suffusa* and *effusum* respectively. *Aulops suffusa* Navás was synonymized by Esben-Petersen (1915) with *Neopanorpa nipalica* Navás; and *Campodotecnum effusum* Navás was transferred to *Leptopanorpa effusa* by Esben-Petersen (1915) (but we consider it a species of *Neopanorpa*). The other species were *Neopanorpa ocellaris* (1908, as *Panorpa*),

<sup>2</sup> The Indian subcontinent, as used here, includes Assam, Bangladesh, Bhutan, Sri Lanka (Ceylon), India, Nepal, Pakistan and Sikkim.

*Panorpa stigmalis* (1908), *Panorpa davidi* (1908), *Neopanorpa nipalica* (1910, as *Panorpa*), *Neopanorpa salai* (1929), and *Neopanorpa benaci* (1935).

Needham (1909) added two new species, *Neopanorpa sordida* and *N. fenestrata* (both as *Panorpa*). In 1915, Esben-Petersen transferred most of the Indian species described as *Panorpa* into the genera *Neopanorpa* and *Leptopanorpa*. He presented no evidence justifying the synonymy of *Aulops suffusa* Navás with *Neopanorpa nipalica* Navás, and he agreed with Navás' earlier expectation that the female type of *P. davidi* was in fact a new species, *P. guttata*. In addition, he described *Neopanorpa cornuta*, *N. flava*, and *N. zebrata*. In his world monograph of the Mecoptera (1921), Esben-Petersen redescribed and illustrated most of these species.

Since Esben-Petersen's monograph, six further new species have been described. These are *Bittacus henryi* (Kimmins, 1928), *Neopanorpa hirsuta* (Crampton, 1931, as *Panorpa*), *N. contracta* (Cheng, 1954), *Bittacus taraiensis* (Penny, 1969), *Neopanorpa chillcotti* (Byers, 1971) and *Neopanorpa ramulata* (Byers, 1975).

The following species are recognized in this investigation.

#### BITTACIDAE:

- Bittacus henryi* Kimmins
- indicus* Walker
- insularis* Esben-Petersen
- latipennis* Gerstaecker
- nodosus* n. sp.
- taraiensis* Penny

#### PANORPIDAE:

- Neopanorpa appendiculata* (Westwood)
- benaci* Navás
- chillcotti* Byers
- contracta* Cheng
- cornuta* Esben-Petersen
- denticulata* n. sp.
- echinata* n. sp.
- effusa* (Navás)
- fenestrata* (Needham)

- flava* Esben-Petersen
- furcata* (Hardwicke)
- gibbosa* n. sp.
- hirsuta* (Crampton)
- indica* n. sp.
- nipalica* (Navás)
- syn. *suffusa* (Navás)
- ocellaris* (Navás)
- ochrura* n. sp.
- ramulata* Byers
- salai* Navás
- sordida* (Needham)
- zebrata* Esben-Petersen
- Panorpa davidi* Navás
- gutatta* Navás
- stigmalis* Navás

## MATERIALS AND METHODS

Dissections of male and female genitalia were preceded by removing the posterior abdominal segments from the specimen and gently boiling them for one to two minutes in water. In several cases, it was necessary to remove the male's hypovalves in order to examine the aedeagus. This was accomplished by carefully cutting the hypovalves and ninth tergum apart from the basistyles. To remove the genital plate of the female, it was necessary to make an incision through the pleural membrane on each side of segments 7-8. The genital plate is usually secured by tough membranous tissue, and care must be taken to prevent damage to it when this tissue is cut.

To soften pinned specimens for dissection or to be placed in fluids, a dilute solution of trisodium phosphate was used. Specimens should not remain in the trisodium phosphate solution over 24 hours, or the membranes disintegrate and only the sclerotized portions remain. Softened specimens should be thoroughly rinsed in water and placed in alcohol.

To photograph the wings, it was often necessary to remove them. A relaxing jar was used to soften the specimens, and the

wings were removed with a scalpel, mounted between glass slides and photographed.

Drawings and body measurements were made with the aid of a camera lucida. Considering the variable length of the abdomen due to the amount of abdominal contents at preservation, the method of preservation, and position, the recorded measurements of body length are at best approximations.

In descriptions of the genital plates of females, total length is measured in ventral aspect. In many species, total length is from the anterior apices of the apodemes to the posterior apices of the arms of the distal plate. The length of the arms is measured from the apices to a line perpendicular to the axial portion at its junction with the arms' inner margin (Fig. 70). Length of the axial portion is from posterior apex to apices of the apodemes. The length of the apodemes is measured along the mid-line from the anterior edge of the basal plate to the apices of the apodemes.

The total length of the male genital bulb in ventral aspect is the distance from the base of the bulb to an imaginary line extending through the most distal points on each dististyle (in a closed position). Hypovalves are occasionally compared to length of basistyles, which is measured from the base of the basistyles to a line connecting the most distal points on both basistyles.

Approximately 450 specimens were examined. Most were from South India (Nilgiri Hills), and collections from other parts of the Indian region were small and from scattered localities. Of these 450 specimens, 284, 24, and 39 represented *Neopanorpa denticulata*, *N. hirsuta*, and *N. appendiculata*, respectively. The remaining approximately 100 specimens represented about 20 species.

## THE INDIAN TOPOGRAPHY AND CLIMATE

The Indian subcontinent has a tremendously diverse topography, ranging from sea level to the highest mountain ranges in the world, and climatic pattern, varying from deserts to tropical rain forests. The central anchor-shaped mountain range of Ceylon ascends from the coastal plain to summits over 5000 feet. Extending north from Cape Comorin to Bombay along the western coast of India, the Western Ghats rise sharply and descend to the Deccan Plateau. Separating the Deccan Plateau and some outlying uplands (Vindhya Range, etc.) from the foothills of the Himalaya is a broad lowland area (the Indo-Gangetic Plain) extending from the valley of the Indus, across the Indian Desert and eastward to the Khasi Hills of Assam. Vast areas of Nepal, Sikkim, and Bhutan are in the foothills of the Himalaya.

The northeast monsoonal air mass flows southward and southeastward from a continuous high pressure region near the Hindu Kush. As the air mass flows over India, it is continuously diverted from the Bay of Bengal across southern India by the Coriolis effect. Beginning in December in the northern provinces, the monsoon continues until February. Commonly referred to as the cold season, this period is characterized by generally dry, cool air resulting in lower maximal and minimal temperatures.

With the termination of the northeast monsoon, a warming trend occurs from March until May in most of the Indian subcontinent. This period is characterized by clear skies and warm temperatures. In the northeastern provinces of India, violent storms result when dry land air meets humid sea air; these storms provide substantial rainfall that enhances agriculture.

Originating over the Indian Ocean in a zone of high pressure, the wet south-

western monsoonal air mass flows north-eastward. The beginning of the wet monsoon in Ceylon is around May; the air mass progresses northward slowly and reaches Karachi, Pakistan, about 15 July. The physical relief and plant cover of India and Burma and the upper wind currents are influential in diverting the winds through Assam, the northeastern provinces of India, and the Himalayan foothills. These regions receive about 25-30% of their annual rain in July, when it normally rains at least 20 days. As the air

mass slowly withdraws to the sea, there is a transitional period of cool, dry weather during October and November.

Along the western slopes of the Western Ghats, there is a substantial amount of rain (80 or more inches annually), supporting tropical evergreen forests (fig. 1). The eastern slopes and plateau receive only about 40 inches of rain annually and are covered predominantly by tropical dry deciduous and thorn forests. The eastern coast of southern India consists of many fertile delta areas now under heavy culti-

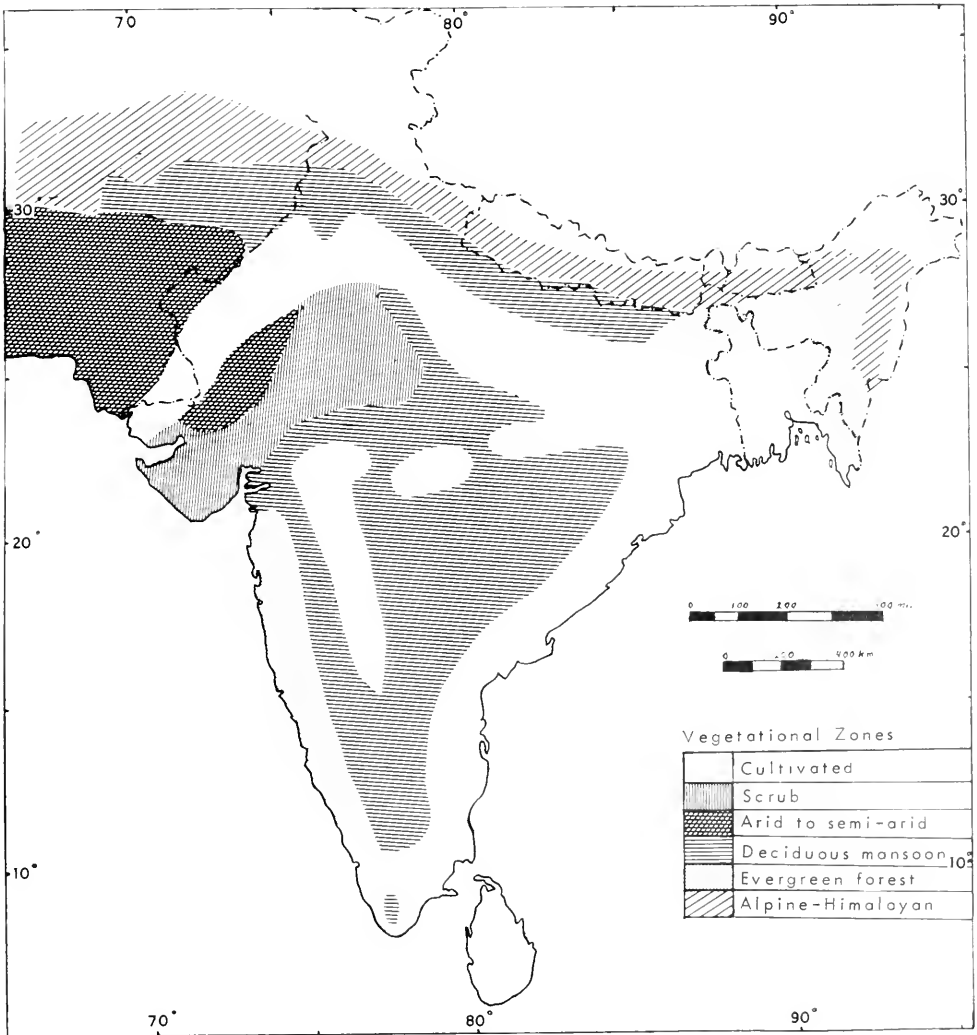


Fig 1. Vegetational zones of India and adjacent regions.

vation. In a very similar pattern, Ceylon is divided from west to east into climatic and vegetational zones.

The lowlands of western India and Pakistan do not receive much rain (0-10 inches in desert areas, up to 20 inches per year in western India) and are covered with semi-arid and arid vegetation. In sharp contrast, mid-central and mid-eastern India receive from 30 to 75 inches of rain annually and the area is intensely cultivated, especially the Ganges River basin. The higher plateaus are covered primarily by dry, tropical deciduous forests.

The lowlands and river basins of Assam and Bangladesh receive about 60 inches of rain annually, whereas the plateaus of Assam receive between 100 and 200 inches annually. Some areas receive considerably more rain, for example, Cherrapunji, Assam, about 428 inches. The forests in these areas are primarily tropical evergreen.

As elevation increases from the foothills into the Himalaya, the temperate forests change to coniferous forests at about 12,000 feet, and these in turn give way to alpine meadows and tundra on the southern slopes of the mountains at about 15,000 feet.

## DISTRIBUTION OF MECOPTERA IN THE INDIAN REGION

The climatic zones, topography, and natural vegetational zones (figs. 1, 2) can be considered together in forming a general picture of India with respect to Mecoptera and their distribution. The Shillong Plateau of Assam and the Western Ghats are similar in that they are covered primarily by tropical evergreen forests, and characterized by large seasonal rainfalls and cool temperatures. More than half the described species of Indian *Neopanorpa* are from these areas. The other areas in which *Neopanorpa* has been col-

lected are the deciduous monsoonal and dry tropical forest zones of the Himalayan foothills. The vegetation of these areas is stratified according to elevation. The exact environmental parameters important for the survival of *Neopanorpa* are not known.

There are no records of *Neopanorpa* from central India. Most of that area is agricultural and moreover lacks the combination of climatic, topographical, and vegetational conditions found in either northern or southern India. Along the northern edge of the Deccan Plateau, the forests are primarily of the tropical deciduous type, and possibly *Neopanorpa* occurs in these areas.

In southern India, the majority of the specimens of *Neopanorpa* were collected in early May, during the transitional period between monsoons. The remaining specimens were collected from late August through October, which is slightly prior to the termination of the southwest monsoon. In sharp contrast, the majority of specimens collected in northern India were taken from late July through September. In both of these areas and seasons, *Neopanorpa* was collected from 700 feet to about 7,000 feet.

Only *Bittacus* has been reported from Sri Lanka (Ceylon). From the few available specimens, it appears that *Bittacus* also emerges prior to the termination of the wet monsoon. All four Singhalese specimens were taken at elevations under 500 feet. Ceylon has a dense human population and the lowland areas are intensely cultivated. Destruction of suitable habitat has probably severely limited the recent distribution of *Bittacus* on Ceylon.

The apparent distribution of *Bittacus* is very different from that of *Neopanorpa*. The elevations of areas (fig. 2) in which *Bittacus* has been collected in India range from nearly sea level to 1400 feet. In general, these areas are warmer and drier



than those in which *Neopanorpa* has been collected. There is, however, a lowland species of *Neopanorpa* (undescribed) from Nepal, and the type locality of *B. latipennis* is Darjeeling, India. The ranges of some North American species, such as *B. strigosus* Hagen and *B. stigmaterus* Say, are over a thousand miles wide, so it is possible that some of the western Chinese species may extend into Assam and along the Himalayan foothills.

There are no records of *Panorpa* in the

Indian subcontinent. Within a hundred miles of the northeastern border of Assam, however, in the mountains of Sikang, China, there are ten species of *Panorpa* (Cheng, 1957). Only a single species is known from Yunnan Province, and there is an undescribed species in northern Burma. Since some species of *Panorpa*, such as the North American *P. helena* Byers, are wide-ranging, it seems that *Panorpa* may extend westward into the mountains of Assam and the Himalayan

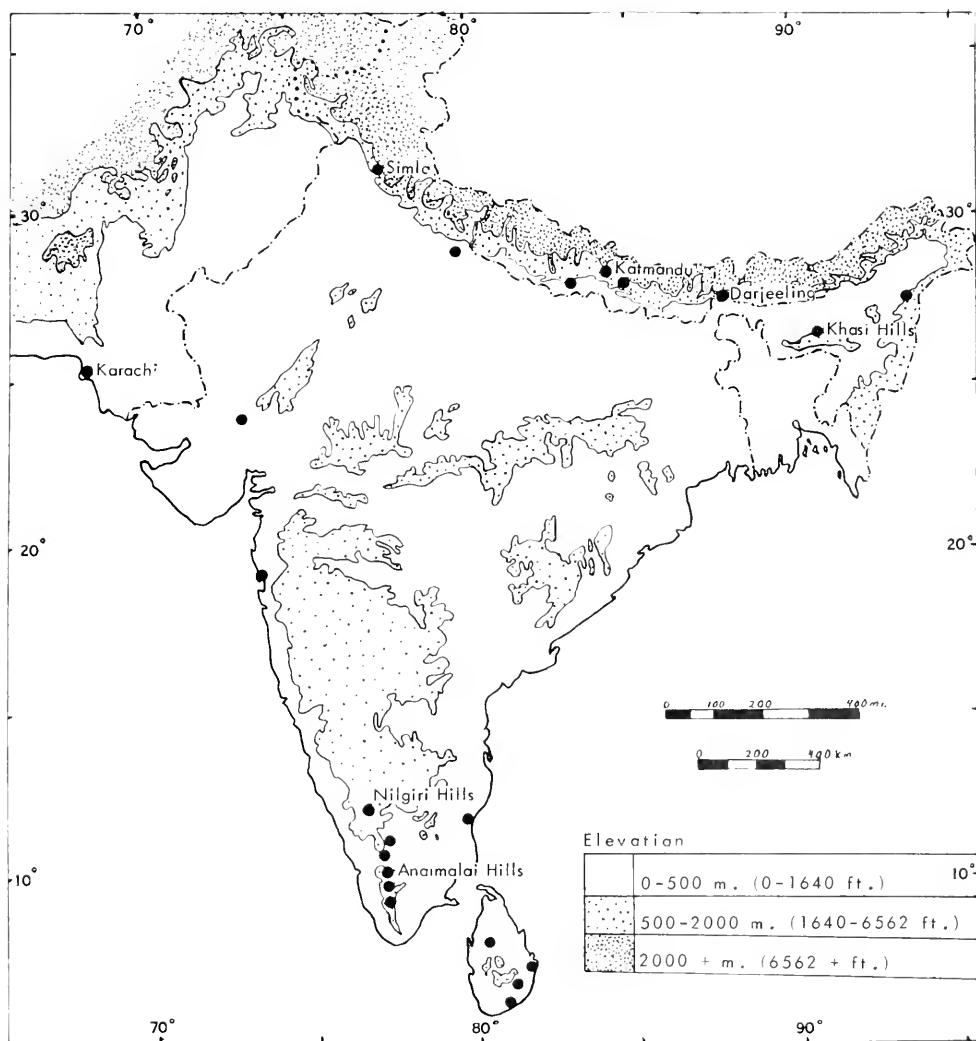


FIG. 2. Elevational map of India and adjacent regions. Black circles indicate localities where Mecoptera have been collected. See accompanying list for details.

foothills. *Panorpa* has never been collected there, however, due possibly to the lack of collecting or to its absence for ecological reasons.

### TAXONOMY OF THE GENUS *BITTACUS*

Since the head and thorax other than the wings are rarely used for taxonomic purposes, they have been omitted here. Setty (1940) and Hepburn (1969, 1970) discussed and illustrated these body regions in detail. Otanes (1922) and Matsuda (1965) provided a somewhat more generalized discussion of the head in Mecoptera. Storch and Chadwick (1968) investigated the thorax of *Bittacus strigosus* Hagen of North America.

**WINGS:** The color, shape, and venation of the wings (fig. 3) are extensively used in the taxonomy of *Bittacus*. The veins include the costa, a two-branched subcosta, a five-branched radius ( $R_2$  sometimes further branched), a four-branched media, a two-branched cubitus, and three anal veins (3A very short). Both fore and hind wings have similar shape, but the fore wings are longer (by one or more mm.). The only significant differences in venation between the fore and hind wings are that the basal fusion of veins Cu and M is longer in the hind wings, and  $Cu_2$  and 1A are partly fused in the hind wings, not independent as in the fore wings. The color of the wing membrane varies from clear to yellowish or tinged with brown. The apical wing margin may be bluntly rounded or more pointed, often a taxonomic character.

In many species, the position of certain cross-veins may be diagnostic, especially the apical and subcostal cross-veins. The number of pterostigmal cross-veins (fig. 3, Pcv) between veins  $R_1$  and  $R_{2+3}$  has often been used for taxonomic purposes, but since the number of cross-veins may vary within an individual specimen, this

character is not always reliable. The position of the subcostal cross-vein (Scv) in relation to the origin of the radial sector (ORs) and the first fork of the radial sector (FRs) is a taxonomically useful character, but the position of the Scv may vary. In many species, there is an apical cross-vein (Av) between  $Cu_2$  and the distal end of 1A near the hind margin of the wing; the presence or absence of this cross-vein appears to be a reliable taxonomic character.

**ABDOMEN OF THE MALE:** Many taxonomic characters are found on segments 9-11 (Tjeder, 1956). The general shape and the projections of the epiandrial lobes of the ninth tergum (figs. 5, 8) vary considerably between species and are usually diagnostic. The ninth sternum is not noticeably modified and is rarely included in descriptions. The basistyles are fused basally and extend posteriorly beneath the ninth tergum; their shape, size, and hairiness may be taxonomically useful. The dististyles, one on the posterodorsal apex of each basistyle, are small compared to the basistyles. Lobes (penunci) at the base of the aedeagus and the shape of the apical portion of the aedeagus are taxonomically useful in bittacids generally. However, in the Indian species, the base of the aedeagus is not modified and lobed as it is, for example, in some of the Chinese species. The proctiger, or combined tenth and eleventh segments, is usually small and inconspicuous, but in some species it is enlarged and extremely modified and extends dorsad between the epiandrial lobes. The single-segmented cerci are rarely important in taxonomy.

**ABDOMEN OF THE FEMALE:** In earlier descriptions, the female genitalia were almost completely ignored, but Tjeder (1956) based several descriptions of African species on female holotypes, using such characters as degree of sclerotization of the antecosta of the posterior ab-

dominal segments, subgenital plate, spermatheca and its duct, and cerci. These characters have not been thoroughly investigated, and nothing is known concerning their variation in Indian bittacids. When possible, these structures have been included in the descriptions in this paper.

The subgenital plate is below the eighth and ninth terga. The shape, hairiness, and degree of fusion of the sclerites of the subgenital plate appear to be reliable taxonomic characters. The supra-anale and subanale (tergum and sternum of the eleventh segment) often have characteristic posterior margins. The trichobothria of the cerci may also be used for taxonomic purposes (Tjeder, 1956). The spermatheca, which may be diagnostic of the species, is usually within segment 7 a little anterior to the subgenital plate. The width and degree of sclerotization of the posterior abdominal antecostae have also been used in taxonomy.

KEY TO THE INDIAN SPECIES  
OF BITTACUS

The males of *B. indicus* and *insularis* and the females of *B. taraiensis* and *nodosus* are unknown. The sex of the holotype of *latipennis* is unknown.

- 1 Vein 1A extends to or beyond level of FRs ..... 2
- Vein 1A extends at most to mid-point between levels of ORs and FRs ..... 3
- 2(1) Scv one-fourth distance from ORs to FRs; proctiger of male large, directed dorsad between epiandrial lobes ..... *taraiensis*
- Scv midway between ORs and FRs ..... *indicus*
- 3(1) Vein 1A joins hind margin opposite level of ORs; Scv before FRs; fore wing 14-16 mm ..... 4
- Vein 1A joins hind margin midway between ORs and FRs; Scv variable; fore wing over 17 mm ... 5

- 4(3) Scv midway between ORs and FRs; Cu<sub>2</sub> joins hind margin opposite level of fork of M<sub>3+4</sub>; epiandrial lobes of male stout, about twice as long as wide, with numerous spines at apex of each ..... *insularis*
- Scv slightly before FRs; Cu<sub>2</sub> joins hind margin slightly proximal to level of fork of M<sub>3+4</sub>; (male unknown) ..... *henryi*
- 5(3) Scv midway between ORs and FRs to slightly distal of FRs; Sc joins costal margin proximal to level of Cu<sub>1</sub>; epiandrial lobes of male stout, about twice as long as wide, with four or five spines on small dorsal protuberance at apex of each ..... *nodosus*
- Scv distal to FRs; Sc joins costal margin before level of Cu<sub>1</sub>, opposite level of Cu<sub>2</sub>; (male unknown) ..... *latipennis*

DESCRIPTIONS OF SPECIES: GENUS  
*Bittacus*

*Bittacus henryi* KIMMINS

*Bittacus henryi* Kimmins, 1928: 395-396, fig. 1.

Unfortunately the original description was based on a single female. This species closely resembles *B. insularis* but, on the basis of the holotype, differs from it in the positions of the Scv and Sc, the length of the fore wings (*henryi* about 16.1 mm. and *insularis* about 14.8 mm.), and the more basal position of Cu<sub>2</sub> with respect to the fork of M<sub>3+4</sub>. In *insularis*, the Scv is midway between the ORs and the FRs, and the Sc merges with the costal margin slightly distal to the FRs. In *henryi*, the Scv is nearly opposite the FRs, and the Sc merges with the costal margin barely past the FRs. Kimmins (1928) stated that the position of the FRs in relation to the fork of vein M is different in *henryi* and *insularis*. However, the position of the FRs

appears to be the same in the holotypes of both species. Another difference in the wing venation is the additional cross-vein between  $R_2$  and  $R_3$  in *henryi*, but it is present in only three of four specimens we consider to be *henryi*. Very little is known concerning variation in Indian bittacids, and there is a strong possibility that despite the described venational differences *henryi* and *insularis* may be synonyms.

The venation, particularly the position of the Scv, of males from southern India is similar to that of *henryi*; therefore, these males are included in the following redescription, which is otherwise based on notes and drawings of the female holotype:

**HEAD:** Vertex, genae, frons, and rostrum sordid yellowish brown; two lateral ocelli slightly larger than medium ocellus; a row of long yellowish hairs on ridge across frons. Antennal scape and pedicel sordid dark brown, flagellum blackish brown with short pilosity.

**THORAX:** One large black spine at each side on anterior margin of pronotum. Entire dorsum, pleural regions, and coxae sordid yellowish brown. Legs yellowish brown, femora and tibiae with blackish apices; hind femora slightly enlarged in male. Wing membrane with light yellowish brown tinge, outer margins slightly darker; longitudinal veins brown, cross-veins in basal portion of wing brown, several in distal portion pale. Av absent; Scv slightly basal to FRs; two Pcv. Sc merges with costal margin slightly beyond FRs; vein 1A merges with hind margin opposite ORs.

**ABDOMEN OF MALE:** Terga and sterna 2-9 yellowish brown. Base of tergum 9 with transverse ridge extending distally onto epiandrial lobes. Lobes stout, with numerous spines at apices, hairs longest at bases of lobes; mesal protuberance on lower inner surface with many small

spines (fig. 8). Angle of hind margin slightly acute. Dististyles short (figs. 6, 7), apices curved mesad. Cerci short, 0.8 length of basistyles. Aedeagus stout at base, tapering to a fine point.

**ABDOMEN OF FEMALE:** Terga 2-11 and corresponding sterna and subgenital plate yellowish brown. Subgenital plate bluntly rounded at apex. Cerci sub-equal in length to segment 9.

**LENGTH OF FORE WING:** Female holotype, 16 mm.; male, 14.6-15.0 mm., hind wing, 13.3-13.6 mm.

**HOLOTYPE:** Female, Vavuniya, N. P., Ceylon, 16 December 1923; in the British Museum (Natural History), London.

In addition, we have examined the following specimens: 1 male, Pondicherry, India (no date), Mairdron, in the Museum National d'Histoire Naturelle, Paris; 1 female, Yala, Ceylon, 18 December 1931, in Colombo Museum, Ceylon; 1 male, Coimbatore, Madras State, India, 1400 feet, November 1962, P. S. Nathan (figs. 5-8), and 5 males, 4 females, Coimbatore, June 1974, S. Bharathi, in the Snow Entomological Museum.

On the basis of male genital structures, this species resembles *B. nodosus* from Pakistan and certain African species, especially *B. chevalieri* Navás. The epiandrial lobes have a striking resemblance to those of *nodosus* and *chevalieri*, particularly the protuberance on the lower, mesal margin. In lateral view, the epiandrial lobes and basistyles of *henryi* are somewhat smaller but in shape resemble those of *B. sjostedti* Weele from Africa. The male genitalia suggest a closer relationship of *henryi* to several northeastern African species than to the western Chinese bittacids.

#### *Bittacus indicus* WALKER

*Bittacus indicus* Walker, 1853: 469.

This species is known only from the holotype, from which the abdomen has been largely eaten away by dermestids or

psocids. There are two eggs clinging to the remaining portion of the abdomen, which indicate that the species description was based on a female. There has been some confusion concerning the type locality; that on the label is "E. Ind." which Walker interpreted as East Indies. Esben-Petersen (1921) interpreted it to be East

India, which is the more probable locality, because no other *Bittacus* has ever been collected in the East Indies.

Esben-Petersen (1921) makes reference to a type series. A second specimen with the type is labeled "East Ind." and was also part of the Saunders collection, but it does not have a type label. Vein 1A ends

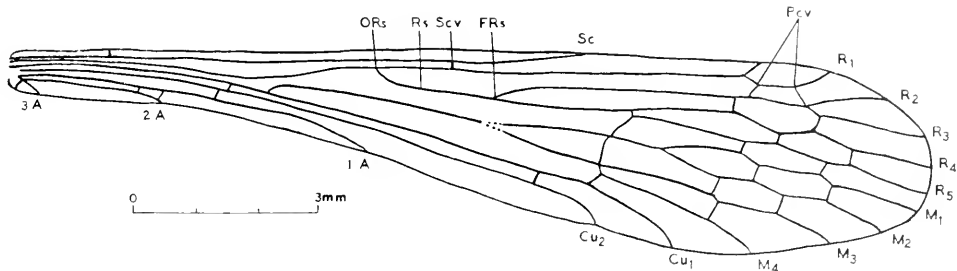
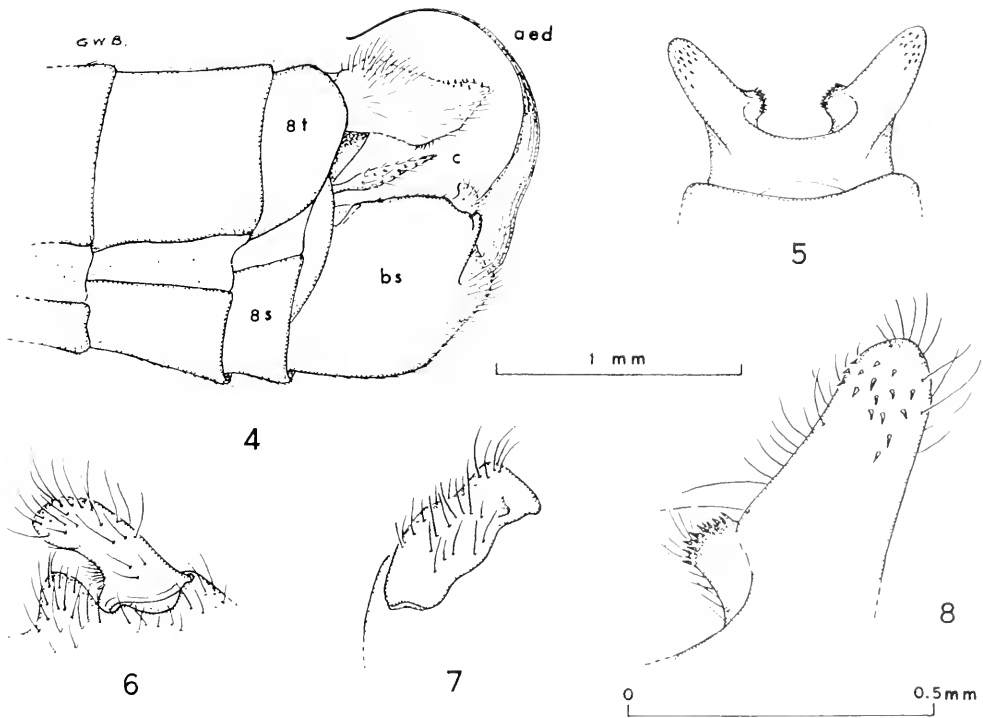


FIG. 3. Right fore wing of *Bittacus henryi* (length about 13.5 mm.): A—anal vein, Cu—cubitus, FRs—first fork of radial sector, M—media, ORs—origin of radial sector, Pcv—pterostigmal cross-vein, R—radius, Rs—radial sector, Sc—subcosta, Scv—subcostal cross-vein.



FIGS. 4-8. *Bittacus henryi* Kimmis. 4, terminal abdominal segments, male, left lateral aspect (aed—accedagus, bs—basistyle, c—cercus, ds—dististyle, s—sternum, t—tergum); 5, epiandrial lobes, dorsal aspect; 6, right dististyle, posterior aspect; 7, right dististyle, anterodorsal aspect; 8, left epiandrial lobe, dorsal aspect. Upper scale figs. 4-5, lower scale figs. 6-8.

opposite the ORs in the front wing of this second individual, which would indicate that it is not *B. indicus*. This condition is found in *B. insularis* and *B. henryi*, but the fore wing of this second specimen is over 3 mm. longer than that of either *insularis* or *henryi*. This specimen probably represents an undescribed species, but since it is in very poor condition, the species should not be described until additional specimens are available.

The following brief redescription is based partly on notes and drawings of the female holotype:

**HEAD:** Dorsum pale brown, except black ocellar prominence. Rostrum shiny brown. Antennae yellowish brown, short haired, 10 mm long.

**THORAX:** Dorsum and pleural areas brown. Legs brown, except tips of femora and tibiae narrowly banded blackish brown. Wing membrane tinged with pale grayish brown; longitudinal veins yellowish brown in distal portion. No Av; two Pcv; Scv equidistant between ORs and FRs; end of Sc opposite end of Cu<sub>2</sub>; end of 1A opposite FRs.

**ABDOMEN OF FEMALE:** Basal segments brown (terminal segments broken off).

**MALE:** Unknown.

**LENGTH OF FORE WING:** Female holotype, 19 mm.; hind wing, female holotype, 17 mm.

**HOLOTYPE:** Female, "E. Ind." (probably eastern India); in the British Museum (Natural History), London.

On the basis of wing venation, this species closely resembles *B. taraiensis*, but it differs slightly in that the Scv is midway between the ORs and FRs, not as proximally situated as in *taraiensis*. Another slight difference is that the end of vein 1A of *indicus* is nearly opposite FRs, not beyond it as in *taraiensis*, but this may result from differences in wing size (fore wing of *taraiensis*, 17.5-18.0 mm.; *indicus*, 19 mm.). The basal cross-vein between

veins 1A and 2A of *taraiensis* is at mid-length of 2A but is in the distal one-sixth of 2A in *indicus*. In two North American species of which numerous specimens were examined, *B. pilicornis* Westwood and *B. strigosus* Hagen, the position of this second cross-vein appears to be constant. In *B. stigmaterus* Say, also from North America, it is absent. Some variation occurs in *B. punctiger* Westwood from North America. The position of this cross-vein may prove to be taxonomically useful, but its reliability is still somewhat doubtful.

This species is distinct from the other Indian species, except *taraiensis*, in that vein 1A extends distally beyond the level of FRs. It seems probable that *indicus* and *taraiensis* are synonyms.

#### *Bittacus insularis* ESSEN-PETERSEN

*Bittacus insularis* Esben-Petersen, 1915: 234.

This Singhalese species was originally described from a single female. As stated in the redescription of *B. henryi*, there is a likelihood that these nominal species are synonyms. But several pairs of Chinese species, for example, *B. vexilliferus* Byers and *B. carpenteri* Cheng, have nearly identical wing patterns yet are readily differentiated by the male genitalia. Further species descriptions based on females only should therefore probably be avoided, at least until reliable diagnostic characters can be demonstrated.

The following brief redescription is based on drawings and notes of the female holotype:

**HEAD:** Vertex brown, except ocellar prominence black; rostrum brown grading to blackish brown towards apex. Antennae dark brown.

**THORAX:** Prothorax sordid brown. Meso- and metathorax reddish brown. Femora, tibiae, and tarsi brown grading to blackish brown at apices. Wing membrane

with yellowish brown tinge, with smoky brown apical margin. No Av. End of Sc extends distally beyond FRs. Scv midway between ORs and FRs. Vein Ia joins hind margin opposite ORS. End of Cu<sub>2</sub> extends distally beyond first fork of M<sub>1+2</sub>. Two Pcv.

ABDOMEN OF FEMALE: Terga and sterna brown. Subgenital plate slightly concave near mid-length; apex bluntly rounded with numerous long hairs. Cerci about .25 mm. long.

MALE: Unknown.

LENGTH OF FORE WING: Female holotype, 15 mm.; hind wing, 13 mm.

HOLOTYPE: Female, Hambantota, Ceylon, 29 November 1908, T. B. Fletcher; in the British Museum (Natural History), London.

This small species differs from the larger Indian species in having the end of vein IA opposite the level of the ORs. In *B. latipennis* and *B. nodosus*, the Scv is distal to the FRs, not midway between the ORs and FRs as in *insularis* (and *indicus* and *henryi*).

*Bittacus latipennis* GERSTAECKER

*Bittacus latipennis* Gerstaecker, 1885: 120.

Since the species was described from a single specimen from which the abdomen was absent, it is impossible to determine its sex. However, the position of the Scv distal to the FRs, the merging of vein IA with the hind margin beyond the level of ORs, and the width of the wing should permit recognition of either sex, when *latipennis* is again discovered. The position of IA with respect to the ORs is similar in *B. henryi* and *B. insularis*, but both of these species are smaller than *latipennis* and have the Scv located between the ORs and FRs.

Esben-Petersen (1921) adequately dealt with the general body coloration. His account of the wing venation is, however, somewhat incomplete. The following re-

description is based on his photographic illustration of the holotype of *latipennis*: WINGS: Membrane with yellowish brown tinge, except for several hyaline spots; longitudinal veins brown; cross-veins in basal portion brown, paler in distal portion. Av absent. Scv distal to FRs in fore wing, near ORs in hind wing. One Pcv. Sc extends about 2 mm. beyond end of FRs; IA merges with hind margin slightly distal to ORs.

LENGTH OF FORE WING: holotype, 19 mm.; hind wing 17 mm.

HOLOTYPE: Darjeeling, India, date unknown; in Zoologisches Institut und Museum, Ernst Moritz Arndt Universität, Greifswald, D. D. R. (East Germany).

This species can be easily recognized by the long, broad wings. In *B. indicus* and *B. taraiensis*, vein IA joins the hind margin of the wing distal to the FRs, not slightly beyond the level of ORs as in *latipennis*. There is a broad-winged, undescribed species from Nepal (only one female available), but it differs from *latipennis* in having vein IA opposite the level of the FRs, and the Scv far beyond the FRs, at the level of the end of the Cu<sub>1</sub>.

*Bittacus taraiensis* PENNY

*Bittacus taraiensis* Penny, 1969: 161-164, figs. 1-3.

This species is very similar to *B. indicus*. The only significant difference is the position of the Scv. In another Indian *Bittacus*, *B. nodosus*, the position of the Scv varies, and this would support synonymizing *indicus* and *taraiensis*. But as emphasized in the redescription of *B. insularis*, some Chinese species that have very similar wings can be recognized only from the male genitalia. Our knowledge of Indian bittacids is very incomplete.

Penny (1969) stated that *taraiensis* also differed from *indicus* in the coloration of the abdomen. Coloration is a somewhat unreliable character, often affected by

method of preservation, age of the specimen when preserved, etc. The types of *taraiensis* are preserved in alcohol and the holotype of *indicus* is a pinned specimen.

The following brief redescription is derived from Penny's (1969) original description:

WINGS: Membrane hyaline, stigma and adjacent cells tawny brown; distal two rows of cross-veins nearly white. Av absent, 1A extending distally beyond first fork of M. Two Pcv. Sc extends beyond FRs. Scv one-fourth distance from ORs to FRs.

ABDOMEN OF MALE: Epiandrial lobes with connecting transverse ridge at base, apices converging and curved dorsad; short, many-spined protuberance on basal, mesal margin directed mesad. Basi-styles with bluntly rounded apices. Aedeagus stout at base, tapering abruptly to fine point. Proctiger projecting dorsally between epiandrial lobes, with long hairs at apex.

FEMALE: UNKNOWN.

LENGTH OF FORE WING: 17.5-18.0 mm.

BODY LENGTH: 14-16 mm.

HOLOTYPE: Male, Pant Nagar, Nainital Dist., India, 5 August 1968, L. J. Stannard; in the Illinois Natural History Survey collection, Urbana, Illinois. Paratype, 1 male, same locality and collector, 26 July 1968.

On the basis of the proctiger, this species is similar to several western Chinese species, especially *B. carpenteri* Cheng and *B. pieli* Navás, in having the 10th segment elongated and extended dorsally between the epiandrial lobes (Penny, 1969). But in *taraiensis*, the aedeagus is not lobed at the base (i.e., has no penunci) as in these species but is similar to those of *B. henryi* and *B. nodosus*. The epiandrial lobes of *taraiensis* are similar to those of some Indian and African species, especially *B. chevalieri* Navás, in having a many spined protuberance on the inner, basal margin. The genitalia of *taraiensis* represent an

intermediate form between certain western Chinese and African species.

In wing venation, *taraiensis* differs from the other Indian species, except *indicus* and an undescribed species (female) from Nepal, in having 1A extending distally beyond FRs.

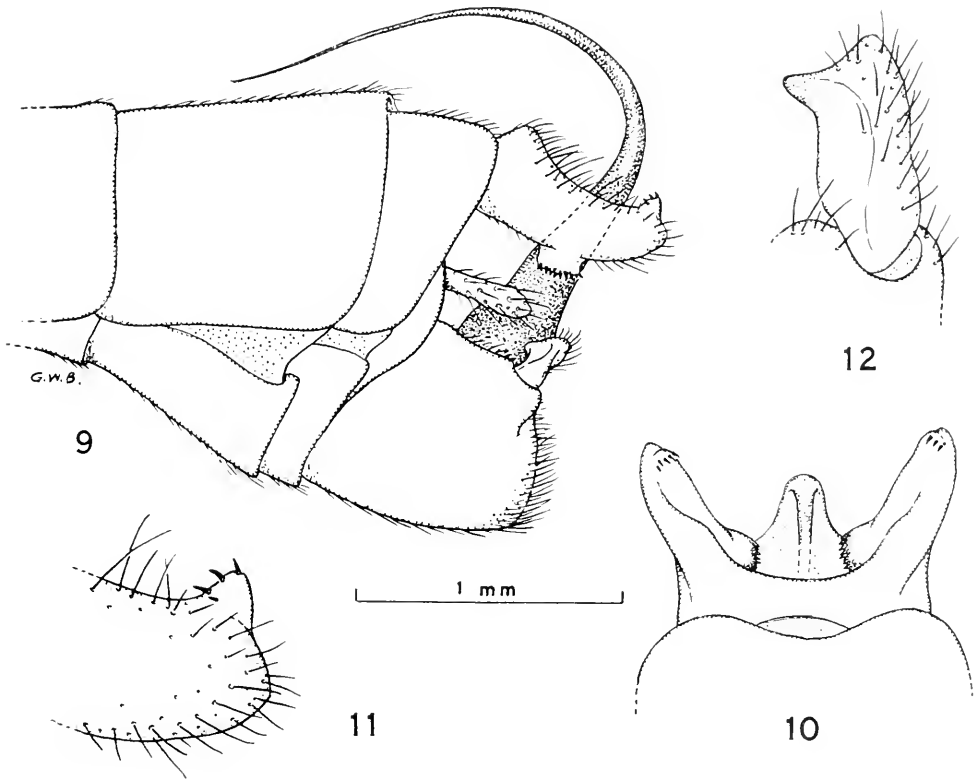
#### *Bittacus nodosus*, NEW SPECIES

Description based on two males and one specimen of unknown sex, pinned.

HEAD: Vertex, frons, and genae light yellowish brown; rostrum light yellowish brown grading into dark yellowish brown at apex; maxillary palpi yellowish brown, except apical segment dark yellowish brown. Ocelli extremely large, on conspicuous black prominence with two spines posterior to median ocellus. Epistomal suture with row of hairs of uniform length. Antennal scape and pedicel light yellowish brown; flagellum light yellowish brown with 14 segments.

THORAX: Pronotum with one long black spine at each side, on both anterior and posterior margins. Several small black setae on meso- and metanotum; two short, black setae on posterior margin of metepimeron. Dorsum, pleural region, and coxae yellowish brown. Anterior surfaces of coxae with long yellowish hairs. Legs yellowish brown, except apices of tarsomeres blackish brown; hind femora not especially enlarged. Wing membrane hyaline, outer margin with faint brownish tinge; longitudinal veins and cross-veins brown. Av absent. One Pcv, except right fore wing (two), in holotype; two Pcv in all wings in paratypes. Scv opposite FRs, in left fore wing, slightly distal to FRs in right fore wing in holotype, midway between FRs and ORs in paratype; Scv basal to FRs in hind wings of both specimens. Vein 1A extends slightly beyond level of ORs. Three cross-veins between  $R_2$  and  $R_1$  in left fore wing of holotype, two in other wings.





FIGS. 9-12. *Bittacus nodosus* n. sp. 9, terminal abdominal segments, male holotype, left lateral aspect; 10, epiandrial lobes, dorsal aspect; 11, tip of left epiandrial lobe, lateral aspect; 12, left dististyle, anterodorsal aspect. Scale figs. 9-10.

**ABDOMEN OF MALE:** Terga and sterna 2-9 sordid yellowish brown. Base of tergum 9 with transverse ridge extending postero-laterally onto epiandrial lobes. Lobes stout, each with 4-5 spines on small protuberance at apex (figs. 10, 11); protuberance on lower mesal margin with many spines (fig. 10). Hind margin of basistyles squarely blunt, with long hairs. Dististyles small, apex abruptly truncate forming a somewhat concave surface (fig. 12). Cerci short, about half as long as epiandrial lobe. Aedeagus stout at base, tapering to fine point.

**FEMALE:** Unknown.

**LENGTH OF FORE WING:** 16.0-17.3 mm. (holotype 17.3 mm.); hind wing, 14.5-16 mm. (holotype, 16 mm.).

**HOLOTYPE:** Male, Karachi, Pakistan, 8 October 1959, R. I. Sailer; in Snow En-

tomological Museum. Paratypes, 1 male, 1 without abdomen, Deesa, India (about 330 mi. E. of Karachi), 8 January 1935, G. G. Nurse; in British Museum (Natural History), London.

In wing venation, this species resembles *B. latipennis* in that the Scv is opposite or slightly distal to the FRs and vein 1A extends slightly beyond ORs. But *nodosus* differs from *latipennis* in having narrower wings (greatest width, *nodosus*, about 2.6 mm.; *latipennis*, about 4.9 mm.) and a shorter Sc. In addition, there is a second basal cross-vein between veins 1A and 2A in *latipennis*, not present in *nodosus*, and it appears from Esben-Petersen's (1921) photograph of the wings of *latipennis* that the longitudinal veins are slightly darkened at their bases.

The male genitalia of *nodosus* closely

resemble those of *B. chevalieri* Navás from Africa, and vaguely those of *B. henryi*, especially in the epiandrial lobes. The absence of penunci from the base of the aedeagus, the small, inconspicuous proctiger, and the spined protuberance on the inner, basal margin of the epiandrial lobes are characters shared by all three of these species. *B. nodosus* differs from the other two in having a short, spined, dorsal protuberance at the apex of each epiandrial lobe. The posterior margins of the basistyles are abruptly truncate, not rounded as in the African and Singhalese species. On the basis of the genitalia, *nodosus* resembles the African species more than it does either *taraiensis* or *henryi*.

#### SPECIES OF *Bittacus* NOT DESCRIBED.

Two bittacids that probably represent new species were examined but not described. The following brief discussion of these specimens is primarily to note their existence, their affinities with other species, and their location. Since the male genitalia provide the most reliable taxonomic characters, we have declined to base descriptions of new species on these individuals.

In the British Museum, there is a single *Bittacus* (abdomen missing) from Hadibu, Socotra Island (12°36' N, 53°59' E), in the Gulf of Aden about 125 miles east of Capo Guardfui, Republic of Somali. The wing venation is similar to that of *B. henryi* and *B. insularis*, but this species differs in having a clear membrane and slightly larger wings (about 16 mm. long).

Another undescribed *Bittacus*, a single female from Simra, Nepal, has distinctive wing venation. The Scv is distal to the FRs and IA extends almost to the level of the FRs (fore wing). Since no other known species from the Indian subcontinent has such a venational pattern, this

may allow recognition of the male when discovered. This specimen is in the collection of the Entomology Research Institute, Canada Department of Agriculture, Ottawa.

#### TAXONOMY OF THE GENUS *NEOPANORPA*

**HEAD:** The head of *Neopanorpa* has the large lateral compound eyes, long prominent rostrum, and three ocelli on a prominence, as commonly found in Panorpidae. In the adult, the ecdysial cleavage line is present but confined to the ocellar region (Hepburn, 1969). Two major components of the rostrum are the clypeus (anterior) and the subgenae (lateral); the elongated maxillary stipites and membranous submentum comprise nearly all of the posterior aspect. The absence of the occipital suture makes it impossible to define the exact extent of the genae and postgenae, but the subgenal suture clearly outlines the postgenal process.

In *Neopanorpa*, the antennae are long and conspicuous. The scape is subcylindrical and the pedicel nearly globular. The flagellum is usually blackish brown to black and consists of numerous (usually 35-45) finely pubescent flagellomeres. There is a whorl of six to eight slightly longer bristles near the apex of each flagellomere.

**THORAX:** In addition to the short hairs that cover most of the thoracic sclerites, the pronotum may possess several long setae along the anterior margin. In the meso- and metathorax, the meron is enlarged and extends nearly the length of the adjacent coxa. The legs are similar on all three thoracic segments, each having the femur and tibia of approximately equal length, and two long spurs at the apex of the tibia. The basitarsus is approximately equal in length to the other four tarsomeres combined. Usually amber colored, the pre-tarsal claws have five pectinations.

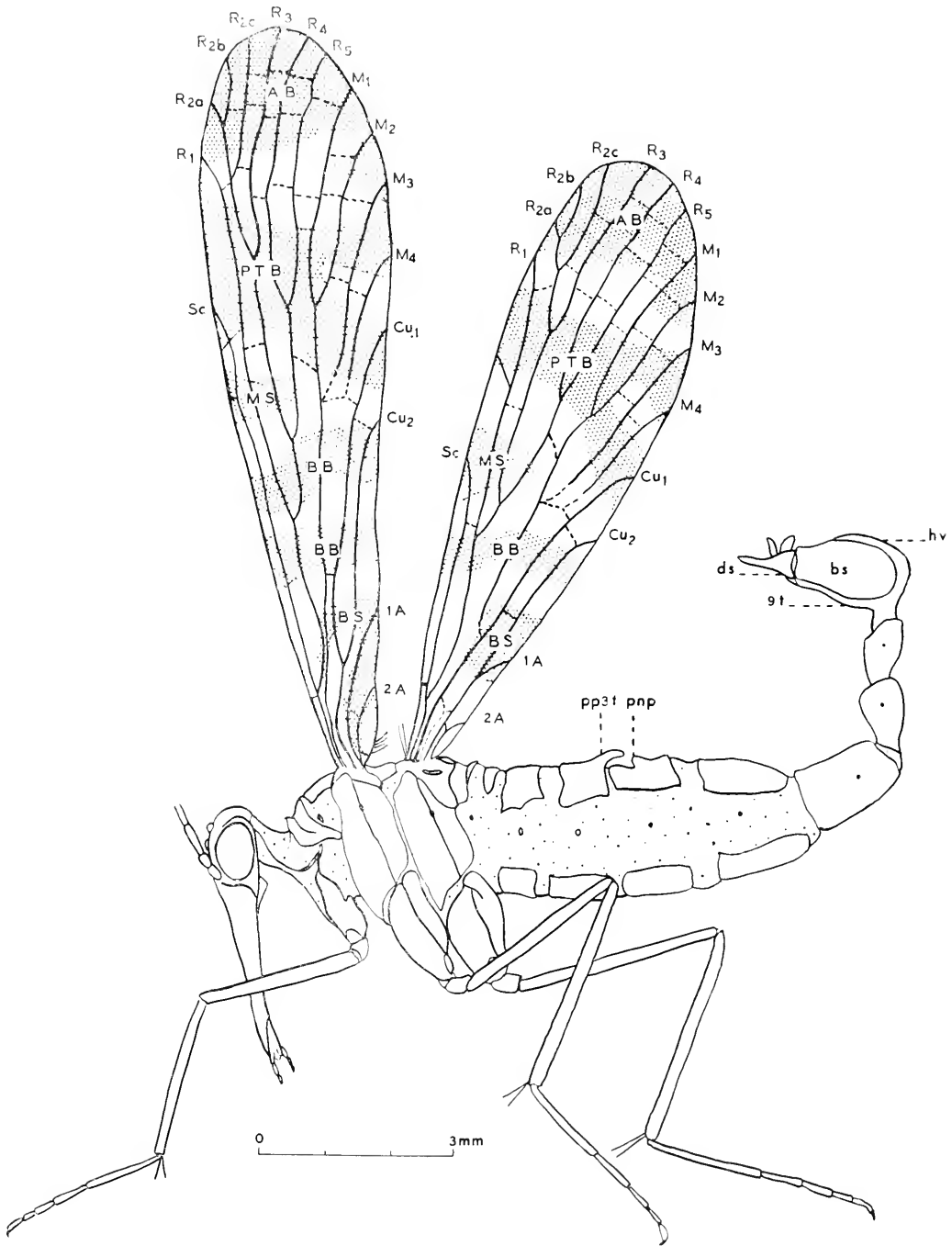


FIG. 13. Left lateral aspect of male of *Neopanorpa denticulata* n. sp. A—anal vein, AB—apical band, BB—basal band, BS—basal spot, bs—basistyle, Cu—cubitus, ds—dististyle, hv—hypovalves, M—media, MS—marginal spot, pnp—posterior notal process, pp3t—posterior process of third tergum, PTB—ptero-stigmal band, R—radius, Sc—subcosta, t—tergum. Note that the basal band is divided, or double, in the fore wing in many individuals of this species.

WINGS: The fore wings are slightly (1 or more mm.) longer than the hind wings. On the proximal hind margin of the fore wing, there are four to eight setae which together with two long setae on the proximal costal margin of the hind wing serve to unite the wings during flight. The venation of the wing (fig. 13) consists of a costa, a subcosta, a five-branched radius, a four-branched media, a two-branched cubitus, and three anal veins. The only significant departure in the venation of the hind wing from that of the fore wing is a consolidation of anal and cubital veins, in which the cubitus forks and converges with both the media and first anal veins; the anal and cubital veins are not independent as in the fore wing. At the first fork of the media, the veins are always pale within a clear spot (thyridium). Vein 1A merges with the hind margin before the origin of the Rs, a generic character differentiating *Neopanorpa* from *Panorpa*.

The wing membrane varies from clear to yellowish brown and may be slightly to extensively marked with spots or bands. The presence or absence of these bands can often be used to differentiate species, although there is some variation within species in their size and shape. Generally, within a species of *Neopanorpa*, the background color and wing markings are somewhat reduced in the hind wings, and the dark coloration is usually more extensive in the female.

If present, the apical band is in the extreme distal portion of the wing; its proximal margin may be irregular or notched. Usually the broadest band, the pterostigmal is proximal to the apical band and has a variety of shapes depending on the species. It may be unbranched or may fork posteriorly. In several species, it is partially fused with adjacent bands. Near the costal margin in the midsection of the wing, the marginal spot may partially fuse

to the pterostigmal band, basal band, or both. The basal band, in the proximal half of the wing, is often incomplete and may appear as a series of spots. In several species, the basal band is complete and may be partially fused to the marginal spot, basal spot or proximal branch of the pterostigmal band. Occasionally there is a distinct basal spot near the base of the wing; but in many heavily marked species, individual spots are difficult to discern.

ABDOMEN OF MALE: In segments 2-5, there is a large membranous pleural area between the terga and sterna. Segments 6-8 are completely sclerotized and roughly cylindrical. On the posterior margin of the third tergum, there is a sclerotized median projection (fig. 13) extending over the fourth tergum for which the terms "notoorganus", "notal organ", or "notorgan" were proposed by Crampton (1931). A small protuberance on the fourth tergum, which Crampton called the "postorganus", is a functional part of the notal organ. Mickoleit (1971) reported that in *Panorpa communis* Linnaeus from Europe the combined structure served as a mechanism for securing the female's wings during mating. This function was also recorded by Issiki (1933) and has been observed by us in several species of North American *Panorpa*. Often neglected in older species descriptions, the shape and length of the notal organ differ from species to species.

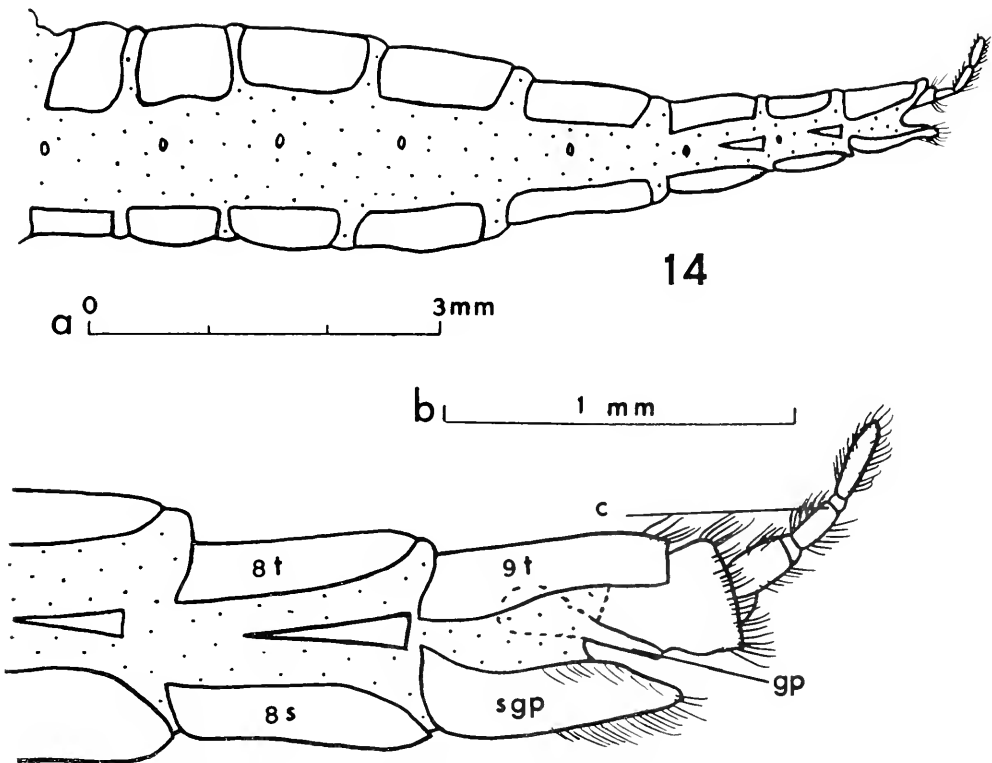
In a few species of *Neopanorpa*, the fifth and sixth terga are modified with projections or protuberances that are excellent taxonomic characters. In several large Himalayan species, the seventh and eighth segments are elongated but are thicker than those of *Leptopanorpa*. The constricted base of the ninth segment is cylindrical; the basally fused ventral and dorsal sclerites diverge to form the hypovalves and ninth tergum respectively. Segments 10-11 are small and weakly sclero-

tized in Panorpidae. The single-segmented cerci are the only portion of the last two segments not normally concealed by the ninth tergum.

The genital bulb (figs. 64, 65) consists of the ninth tergum (epiandrium), ninth sternum (including the hypovalves), basally fused basistyles, dististyles, and aedeagus. At the ventromesal base of each dististyle, there is a single lobe that is usually directed mesad, but occasionally more ventrad. The shape, size, and hairiness of this lobe are useful in the recognition of many species. The basal lobe is almost always single in *Panorpa* and *Neopanorpa*, while in *Leptopanorpa* it is usually divided into two parts.

Located between the basistyles, the aedeagus (figs. 68, 69) has several structures that are useful for taxonomic pur-

poses. The dorsal and ventral valves are on the distal margin of the axial portion of the aedeagus. In *Neopanorpa*, the dorsal valves are generally small, rounded, darkly sclerotized protuberances and relatively unimportant in taxonomy. The shape of the ventral valves varies and may be useful for taxonomic purposes. The ventral and dorsal parameres often have characteristic shapes diagnostic for the species. Arising on the proximal, ventral margin of the aedeagus beside the ventral valves, the ventral parameres extend distally, with the terminal portion having a variety of shapes. In several species, they are reduced to small knobs or hooks; in others, they are blade-shaped or filamentous. If present, the dorsal parameres are above the dorsal valves and are usually short and stout, rarely attaining the length



FIGS. 14-15. Abdomen of female *Neopanorpa denticulata* n. sp. 14, left lateral aspect of entire abdomen; 15, left lateral aspect of terminal segments (c—cercus, gp—genital plate, s—sternum, sgp—subgenital plate, t—tergum). Scale a—fig. 14; b—fig. 15.

and bizarre shapes of the ventral parameres. Extending laterally from the mid-section of the aedeagus, the lateral processes are generally short and somewhat triangular, in *Neopanorpa*. In several species, they are fused with the dorsal parameres, the two structures together modified into long blades.

**ABDOMEN OF FEMALE:** In segments 2-8 (fig. 14), there is a large membranous pleural area separating the terga and sterna. A wedge-shaped sclerite (laterotergite) is situated on each side in the pleuron of the distal half of segments 7-8 in many species. In other species, these sclerites are absent, but hairs outline their position. The subgenital plate is considered to be formed of extensions of the eighth sternum, and the genital plate is the highly modified ninth sternum (Byers, 1954). Rarely visible from the outside, the genital plate (fig. 70) consists of three parts that are variously developed in different species. The distal and basal plates extend laterally from a central body or axial portion. The arms of the distal plate extend posteriorly and are occasionally visible without dissection. There are in most species two divergent apodemes at the anterior end of the axial portion, serving as sites of muscle attachment. The shapes of the subgenital plate and, more importantly, the composite genital plate are useful in the recognition of species. Segments 10-11 are greatly reduced in size as compared to the more anterior segments. Usually blackish brown to black, the two-segmented cerci are covered with many short hairs. The eleventh segment, situated below the cerci, has only weakly developed sclerites.

**KEY TO MALES OF INDIAN SPECIES OF THE GENUS *Neopanorpa***

The males of *flava*, *ocellaris*, and *benaci* are unknown, and not enough is known about the males of *fenestrata* and *sordida*

to determine accurately where they should be placed in the key. Both *fenestrata* and *sordida* should be located somewhere after couplet six.

- 1      Posterior half of sixth abdominal segment greatly modified, either conspicuously thickened and humped dorsally, or with slender projections ..... 2
- Posterior half of sixth segment not so modified ..... 4
- 2(1)   Sixth abdominal segment with thick dorsal hump; seventh segment bearing long dorsal hairs; ninth tergum with median, setose projection near mid-length (fig. 118) ..... *gibbosa*
- Sixth abdominal segment not thickened and humped dorsally; seventh segment without long hairs; ninth tergum without median projection near mid-length ..... 3
- 3(2)   Projections from sixth abdominal segment more than half length of segment (fig. 43); dististyles shorter than basistyles (fig. 40); wings 12-13 mm. long ..... *cornuta*
- Projections from sixth abdominal segment much shorter than half length of segment (fig. 57); dististyles much longer than basistyles (fig. 58); wings 15-17 mm. long .... *jurcata*
- 4(1)   Posterior process of third abdominal tergum extends beyond posterior margin of fifth tergum ..... 5
- Posterior process of third tergum extends at most to posterior margin of fourth tergum ..... 6
- 5(4)   Hypovalues each with single mesal projection (figs. 17, 19) ..... *appendiculata*
- Hypovalues each with one mesal and one ventral, subapical projections (figs. 82, 86) ..... *salai*
- 6(4)   Wing membrane with strong yellowish tinge ..... 7
- Wing membrane not yellowish, with hyaline to brownish gray tinge ..... 8
- 7(6)   Hypovalues widely divergent at base, converging somewhat at tips (fig. 28); basal lobe of dististyles broad, thick blade with convex ventral surface ..... *chillcotti*
- Hypovalues not widely divergent at base, apical half of each deflected ventrad (figs. 48, 49); basal lobe narrow ..... *effusa*
- 8(6)   Wings unmarked except for stigmal spot, or only weakly patterned ..... 9
- Wings distinctly marked with bands, spots, or both ..... 11

- 9(8) Wing membrane hyaline; hypovalves sinuate with spiny, hairy apices curved abruptly mesad (figs. 110, 112) ..... *echinata*  
 Wing membrane with diffuse brownish gray pattern; hypovalves not sinuate, their apices not spiny ..... 10
- 10(9) Hypovalves narrowly separated at base (fig. 136); aedeagus short, not extending between dististyles; ventral parameres inconspicuous, convergent apically (fig. 138) ..... *ochrura*  
 Hypovalves separated by subcircular space at base (fig. 71); aedeagus long, extending between dististyles; ventral parameres long, projecting beyond hypovalves, divergent apically (figs. 71, 74) ..... *nipalica*
- 11(8) Posterior process of third abdominal tergum extending entire length of fourth tergum; ventral parameres broad near base, slender subapically, widened at apex (figs. 36, 39) .... *contracta*  
 Posterior process of third tergum short, rarely extending beyond mid-length of fourth tergum, but never entire length; ventral parameres broader subapically than near base .. 12
- 12(11) Dististyles largely covered with long, dense black hairs, especially near mid-length, their apices glabrous; hypovalves slender, sinuate (fig. 64) *hirsuta*  
 Dististyles without long dense black hairs near mid-length, with hairs longest on basal lobe; hypovalves not sinuate ..... 13
- 13(12) Hypovalves thickest at level of basal separation, tapering toward apices, widely separated basally (as fig. 129) ..... *indica*  
 Hypovalves wider near mid-length than at level of basal separation, not widely separated basally ..... 14
- 14(13) Mesal margins of hypovalves entire, without lobes or spines (fig. 147); ventral parameres two-branched (figs. 145, 152, 153) ..... *ramulata*  
 Mesal margins of hypovalves uneven, with setiferous or spinous lobes; ventral parameres unbranched ..... 15
- 15(14) Mesal margins of hypovalves each with two setiferous lobes before apex (figs. 90, 96) ..... *zebrata*  
 Mesal margins of hypovalves each with two spinous points before apex, another at apex (figs. 101, 104) ..... *denticulata*

KEY TO FEMALES OF INDIAN SPECIES OF THE GENUS *Neopanorpa*

The females of *echinata* n. sp., *fenestrata*, *gibbosa* n. sp., and *nipalica* are unknown. Not enough is known about the female of *sordida* to include this species in the key. The genital plates of *benaci*

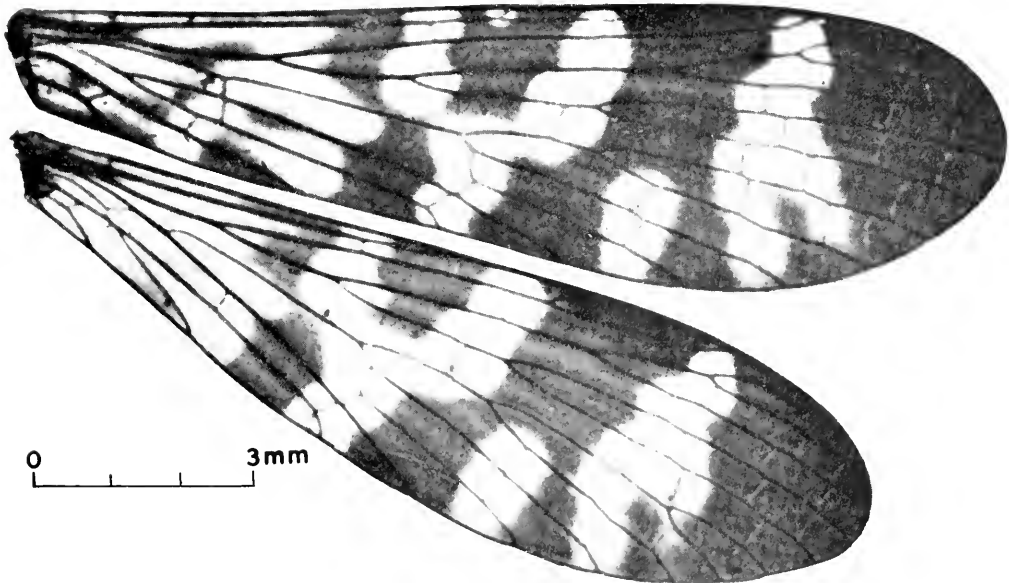


FIG. 16. *Neopanorpa appendiculata* (Westwood), male, right wings (fore wing length 13.8 mm.).

have never been examined and the position of this species in the key is based entirely on external characters.

			Axial portion long, over one-half total length; basal plate and apodemes well developed .....	9
		8(7)	Anterior half of mesonotum dark brown, posterior half yellowish; metanotum yellowish with dark brown semicircular spot on anterior margin; genital plate small, less than .5 mm. long (fig. 45) .....	<i>cornuta</i>
1	Wing membrane with strong yellowish tinge .....	2		
	Wing membrane not yellowish, hyaline to brownish gray .....	5		
2(1)	Proximal margin of apical band oblique to costal edge of wing; proximal and distal branches of pterostigmal band subequal in width; pronotum and anterior half of mesonotum black, posterior half of mesonotum and all metanotum yellowish brown .....	<i>effusa</i>	9(7) Apex of subgenital plate notched, plate ventrally keeled .....	10
	Proximal margin of apical band either perpendicular to costal edge of wing or uneven and notched; branches of pterostigmal band of unequal width .....	3	Apex rounded, plate not keeled .....	13
3(2)	Genital plate broad, nearly as wide as long, its axial portion poorly developed (fig. 60); pronotum black with narrow yellowish band along posterior margin; anterior half of mesonotum black, posterior half and all metanotum yellowish brown .....	<i>furcata</i>	10(9) Apodemes of genital plate long, widely divergent anteriorly (fig. 70); no basal spot in fore wings (fig. 63) .....	<i>hirsuta</i>
	Genital plate not nearly as broad as long, axial portion short but distinct; thoracic nota not as described above .....	4	Apodemes shorter, only slightly divergent and only shallowly separated anteriorly; basal spot in fore wings present or absent .....	11
4(3)	Subgenital plate deeply notched apically (fig. 32); mesonotum and metanotum sordid yellowish brown throughout, without distinct pattern; fore wing 14-16 mm. (fig. 27) ....	<i>chilleotti</i>	11(10) Apodemes of genital plate deflected abruptly ventrad from anterior edge of plate (fig. 155); basal spot absent from fore wings .....	<i>ramulata</i>
	Subgenital plate only shallowly notched apically (fig. 55); anterior two-fifths of mesonotum and anterior one-third of metanotum black, rest of both nota yellowish brown; fore wing about 18 mm. (fig. 52) .....	<i>flava</i>	Apodemes of genital plate deflected gradually dorsad anteriorly; basal spot in fore wings large .....	12
5(1)	Distal half of fore wing heavily patterned, apical band broadly joined to pterostigmal band along hind margin .....	6	12(11) Large clear spot in apical band; distal plate of genital plate dorso-ventrally flattened (figs. 98, 99) ....	<i>zebrata</i>
	Distal half of fore wing less heavily patterned, apical band not connected to pterostigmal band .....	7	Apical band without large clear spot, with notch on proximal margin; lateral margins of genital plate strongly curved ventrad (figs. 108, 109) .....	<i>denticulata</i>
6(5)	Apical and pterostigmal bands of fore wings with distinct included pale areas; cross-veins in apical portion of wing pale (fig. 26) .....	<i>benaci</i>	13(9) Apodemes of genital plate about one-third of total length (fig. 132) ....	<i>indica</i>
	Apical and pterostigmal bands without included pale areas; outermost cross-veins not pale, same color as veins in basal portion of wing .....	<i>ocellaris</i>	Apodemes about one-fourth of total length .....	14
7(5)	Axial portion of genital plate less than one-half total length; basal plate and apodemes of genital plate absent .....	8	14(13) Subgenital plate about 1.5 times as long as greatest width, without setae on triangular anteromedian area (fig. 23); apodemes of genital plate separated from edge of plate forward (fig. 24) .....	<i>appendiculata</i>
			Subgenital plate only slightly longer than its greatest width, covered with setae anteromedially (fig. 89); apodemes diverging from axis well forward of edge of genital plate (fig. 87) .....	<i>salai</i>

DESCRIPTIONS OF SPECIES: GENUS  
*Neopanorpa*

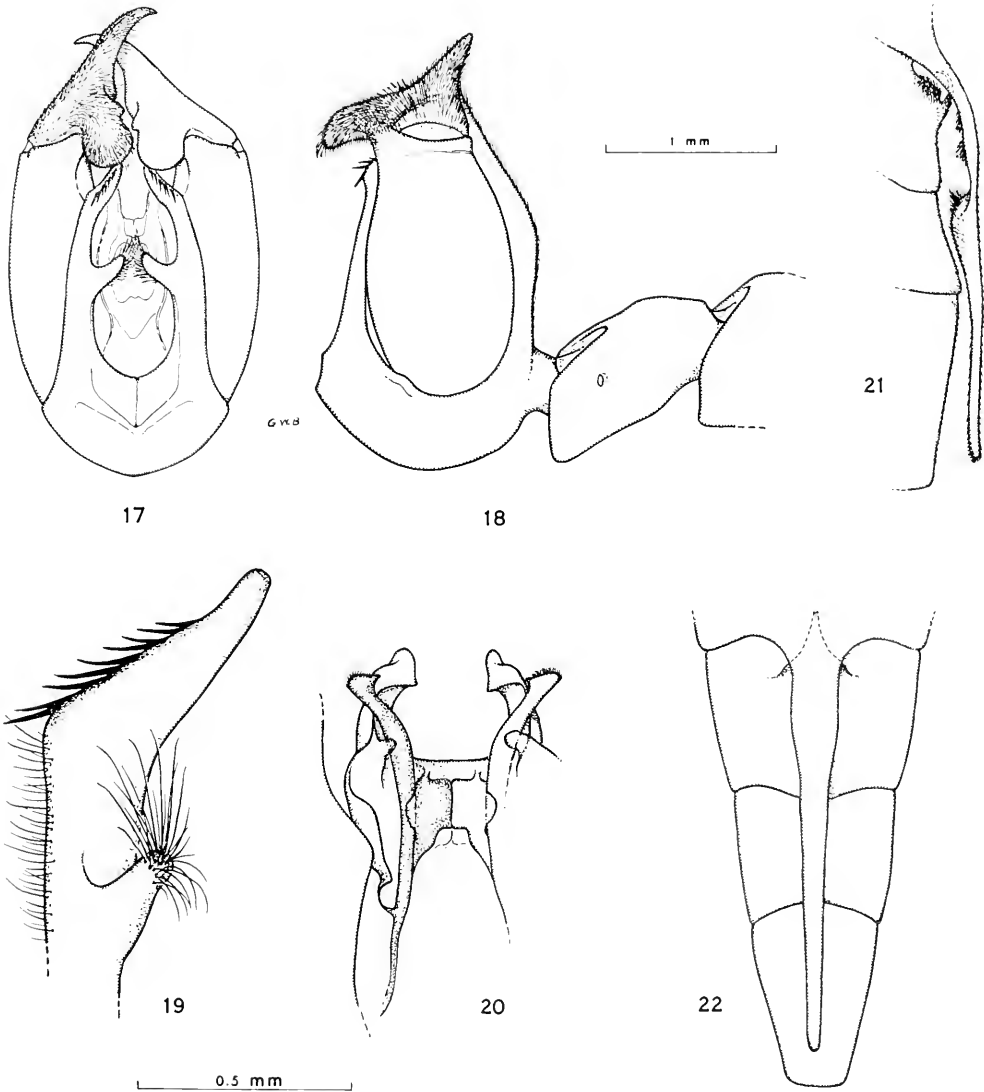
*Neopanorpa appendiculata* (WESTWOOD)  
*Panorpa appendiculata* Westwood, 1846:  
186.



*Neopanorpa appendiculata*; Esben-Petersen, 1915: 229.

Originally described as a *Panorpa*, this species was transferred to *Neopanorpa* by Esben-Petersen (1915), who pointed out that the vein 1A does not extend beyond the ORs. The redescription and photograph in Esben-Petersen's world mono-

graph (1921) are based on a female syntype. This syntype, however, probably represents the female of *N. salai*, which species differs from *appendiculata* in having more extensive wing pigmentation, and in the male an additional projection on each hypovalve and a shorter posterior process of the third abdominal tergum.



FIGS. 17-22. *Neopanorpa appendiculata* (Westwood). 17, genital bulb, male lectotype, ventral aspect; 18, genital bulb, lectotype, right lateral aspect; 19, tip of left hypovalve, male, mesal aspect; 20, aedeagus, male, ventral aspect (part of right side omitted); 21, terga 3-6, lectotype, left lateral aspect; 22, terga 3-6, lectotype, dorsal aspect.

On the basis of wing pattern and body coloration, *appendiculata* closely resembles *N. indica*, n. sp., but the male of *appendiculata* differs in having a much longer posterior process of the third tergum and a larger mesal projection on the hypovalves. The females are not, however, as easily differentiated. Males of both species have been collected at the same locality and on the same date, together with eight females, probably all *N. appendiculata*. In the type series of *appendiculata*, there are two males of *indica* and two females with wing patterns identical to that of these males. The genital plates of these two females differ from those of the eight mentioned females in having longer apodemes and narrower distal plate. These two female syntypes of *appendiculata* are therefore tentatively included in *indica*.

The following composite redescription is based on notes and drawings of the male lectotype, 23 additional males, and 17 females:

**HEAD:** Dorsum, frons, and rostrum sordid yellowish brown. Scape, pedicel and basal half of first flagellomere sordid yellowish brown, antennal color then abruptly changing to black, remaining 37 flagellomeres black.

**THORAX:** Dorsum dark sordid yellowish brown (lectotype) to dark grayish brown. Pleural area and coxae sordid yellowish brown to grayish brown; femora and tibiae sordid yellowish brown; tarsi brownish grading to black on segments 4-5. Wing (fig. 16) membrane hyaline; markings dark smoky brown; cross-veins in distal portion pale, more basal ones brown. Apical band broad. Pterostigmal band forked posteriorly, with narrow distal branch. Marginal spot extends from costal margin to base of vein  $M_{1+2}$ . Basal band large anteriorly, constricted at vein M. Basal spot large.

**ABDOMEN OF MALE:** Terga 2-9 and corresponding sterna black. Posterior proc-

ess of third tergum (figs. 21, 22) extending to hind margin of fifth tergum or beyond, its basal one-third broad and flattened, a broad ventral thickening near mid-length, remaining portion slender; entire process yellowish brown. Process of fourth tergum large dorsal protuberance with a narrow hooked projection directed anteriorly; protuberance covered with long black hairs. Hypovalves (fig. 17) stout, somewhat cylindrical basally; short finger-like protuberance with long hairs on inner margin in distal half, posterior margin straight, apical part deflected into interior of bulb, blade-like, with marginal row of thick black spines. Lateral margins of tergum 9 abruptly convergent in distal half, posterior margin straight. Broad hook-shaped protuberance on anterior margin of sternum 10, with long hairs on posterior margin. Cerci short, extending only to edge of ninth tergum. Dististyles about one-third length of entire bulb. Basal lobe of dististyles (figs. 17, 18) wide, bluntly rounded, directed ventrad, with long hairs on inner margin. Ventral parameres (fig. 20) thin, curved laterally in apical one-fourth, with short hairs on dorsal surface. Ventral valves of aedeagus broad, with thin lateral wings. Lateral processes broad at base, tapering to bluntly rounded point. Dorsal parameres curved ventrad, apex abruptly truncate.

**ABDOMEN OF FEMALE:** Terga 2-11 and corresponding sterna black. Subgenital plate (fig. 23) broad with bluntly rounded apex, with many long hairs on distal side and apex. Genital plate (figs. 24, 25) about 1.1 mm. long; posterior arms of distal plate long, about half of total length, slender, somewhat twisted at base; distal and basal plates broad, about .25 of total length, with lateral margins abruptly curved dorsad; apodemes short, about .25 of total length, with apices twice as broad as base and distinct notch on anterior margin.

LENGTH OF FORE WING: Male, 11.0-13.0 mm. (lectotype, 11.6 mm.); female, 11.3-12.6 mm.

LECTOTYPE: Male, Madras, date unknown; in British Museum (Natural History), London.

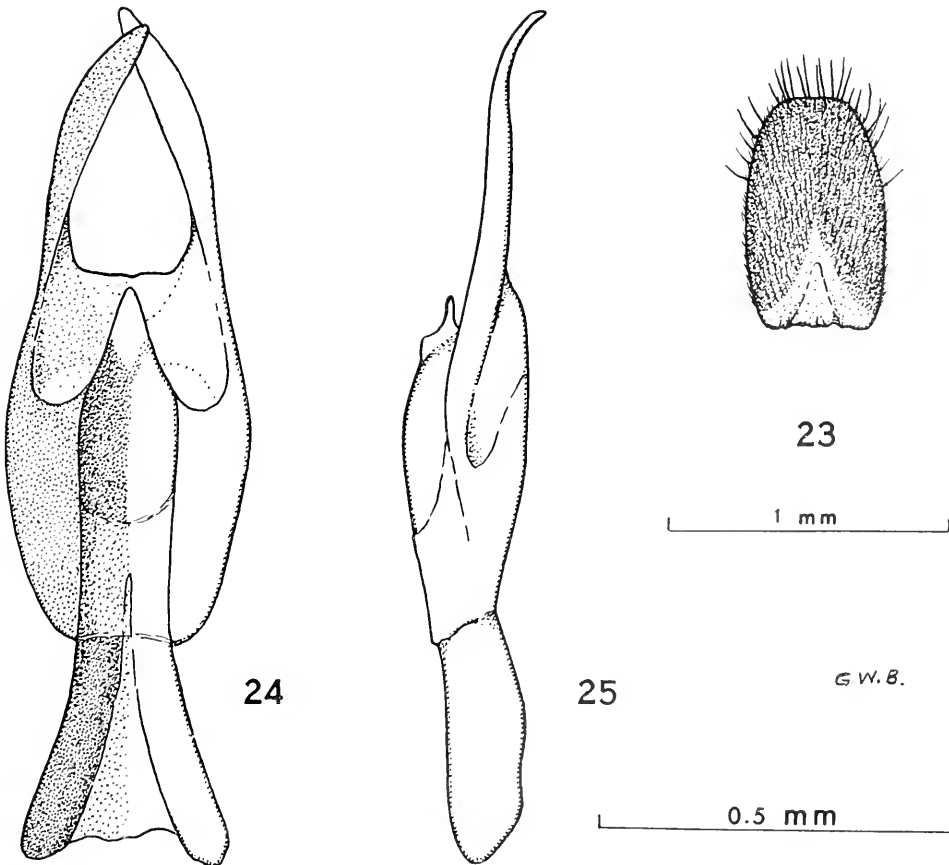
In addition to the types mentioned above, we have examined the following specimens; 9 males, 8 females, Gudalur, Nilgiri Hills, South India, 3,500 feet, September 1960, P. S. Nathan, in the Snow Entomological Museum; 14 males, 9 females, Cherangoda (1200 m.) and Singara (1100 m.), Nilgiri Hills, October 1950 and May 1954, in the Naturhistorisches Museum, Basel, Switzerland.

The similarity of hypovalves, aedeagus, and dististyles in males and the subgenital and genital plates in females are the primary characters used in grouping *appendiculata*, *indica*, and *salai* into the *appendiculata* group. It was called the *appendiculata* group after the first described, included species.

*Neopanorpa benaci* NAVÁS

*Neopanorpa benaci* Navás, 1935: 97-98.

This species was originally described from the female holotype only, from Kurseong, India. The abdomen has been broken off beyond the seventh segment since being described, so nothing is known



FIGS. 23-25. *Neopanorpa appendiculata* (Westwood). 23, subgenital plate, female, ventral aspect (upper scale); 24, genital plate, female, ventral aspect (lower scale); 25, genital plate, right lateral aspect.

about the genitalia. On the basis of wing pattern, *benaci* is very similar to *N. nipalica* and may be a synonym. Another male, holotype of *N. ochrura* n. sp., has a wing pattern similar to that of *benaci* but differs in having paler markings and smaller wings (about 11 mm.).

The following redescription is based on notes and drawings of the holotype and the original description:

**HEAD:** Vertex, frons, and rostrum black. Antennae black, about 8.5 mm. long.

**THORAX:** Pronotum black; anterior half of mesonotum blackish brown, posterior half brownish; metanotum blackish brown. Pleural areas and coxae pale grayish. Legs brownish. Wing pattern complex (fig. 26); membrane with a faint brown-

ish tinge, becoming pale whitish in distal portion of wing; markings light to dark smoky brown; cross-veins in distal portion of wing pale. Apical band widely fused to pterostigmal band along hind margin, with six pale to clear spots surrounding cross-veins. Pterostigmal band complete, forked posteriorly, with a pale spot between  $R_4$  and  $R_5$ . Marginal spot large, extending from costal margin to base of  $M_{1+2}$ . Basal band complete, constricted at vein M.

**ABDOMEN OF FEMALE:** Anterior segments black, posterior segments dark brown to black.

**MALE:** Unknown.

**LENGTH OF FORE WING:** Female holotype, 14.4 mm.

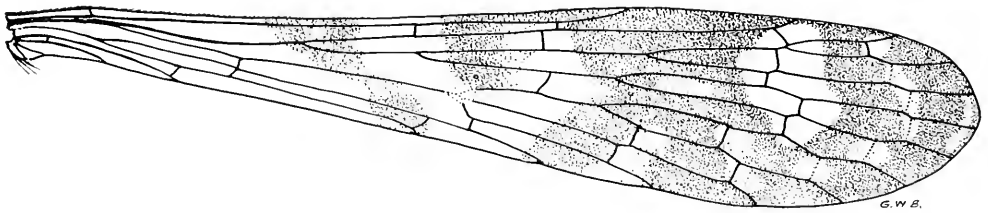


FIG. 26. *Neopanorpa benaci* Navás, female holotype, right fore wing (length about 13.9 mm.).

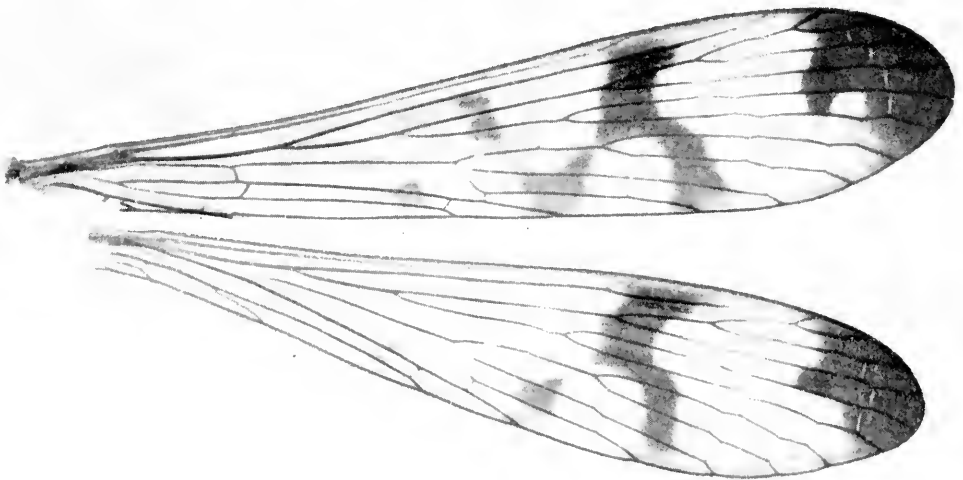


FIG. 27. *Neopanorpa chillcotti* Byers, male paratype, right wings (fore wing length 15.0 mm.).

HOLOTYPE: Female, Kurseong, India, 1932; in the Museum National d'Histoire Naturelle, Paris.

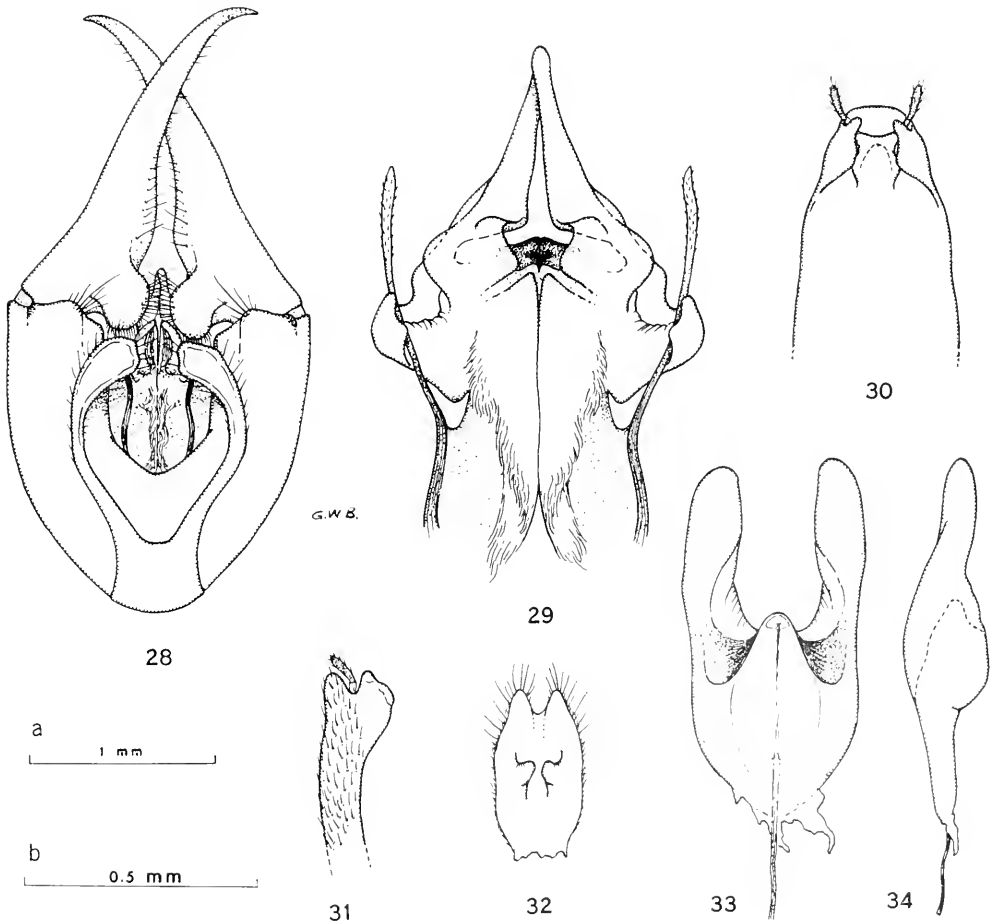
*Neopanorpa chillcotti* BYERS

*Neopanorpa chillcotti*, Byers, 1971: 534-539, figs. 1-10.

Only certain diagnostic characters of this recently described Nepalese species are included in this brief redescription, to provide a basis for comparisons with other species. The following is based on the original description and reexamination of three male and one female paratypes:

WING: (fig. 27): Membrane with strong dark yellowish tinge, markings brown. Apical band complete, its anterior proximal margin with a small projection directed posteriorly. Pterostigmal band variable, usually forked posteriorly. Marginal spot not attaining costal margin. Basal band incomplete, consisting of small spot near hind margin. Basal spot absent.

ABDOMEN OF MALE: Posterior process of third tergum extending to midlength of fourth tergum. Hypovalves (fig. 28) widely divergent at bases, convergent near apices; slender, somewhat wider in apical half. Dorsal parameres elongate,



FIGS. 28-34. *Neopanorpa chillcotti* Byers. 28, genital bulb, male holotype, ventral aspect; 29, aedeagus, ventral aspect; 30, ninth tergum, ventral aspect; 31, ninth tergum, left lateral aspect; 32, subgenital plate, female, dorsal aspect; 33, genital plate, ventral aspect; 34, genital plate, right lateral aspect. Scale a—figs. 28, 30-32; b—figs. 29, 33, 34.

slender, wedge-shaped. Ventral parameres slender, with minute hairs near apices.

**ABDOMEN OF FEMALE:** Subgenital plate deeply notched at apex (fig. 32). Arms of genital plate (figs. 34, 35) broad and stout with bluntly rounded apices, subequal in length to axial portion. Axial portion broad, rounded anteriorly.

**LENGTH OF FORE WING:** Male, 14-16 mm. (holotype, 14.8 mm.).

**HOLOTYPE:** Male, Godavari, 10 mi SE of Katmandu, Nepal, 5,000 feet, 31 July 1967, Canadian Nepal Expedition. Holotype, allotype, and 13 paratopotypes are in the Entomology Research Institute, Canada Department of Agriculture, Ottawa, Ontario, Canada; 4 paratypes are in the Snow Entomological Museum.

*Neopanorpa contracta* CHENG

*Neopanorpa contracta* Cheng, 1953: 122, figs. 4-5, pl. 5.

Cheng's original description was based on two females from Darjeeling, India. It deals adequately with the genitalia and wing pattern, but the drawings lack precise detail. Two males, determined to be *contracta* on the basis of wing pattern and body coloration, are also included in the following brief redescription. The two males were badly damaged in transit from the Illinois Natural History Survey, but fortunately each specimen was pinned in its own sealed container so that genitalia could be associated with certainty.

**HEAD:** Dorsum shiny black, frons grayish brown, with a large median, shiny black spot; rostrum sordid grayish brown. Antennal scape blackish; base of pedicel blackish brown, changing abruptly to dark yellowish brown; flagellum blackish brown.

**THORAX:** Pronotum deep brown (holotype) to shiny blackish brown (males). Anterior half of mesoscutum and narrow band along median line to mesoscutellum

blackish brown; posterolateral areas of mesoscutum light grayish brown. Metanotum similar to mesonotum. Pleural area and coxae pale grayish brown, except vertical brownish streaks on meso- and metamera. Femora and tibiae grayish; basitarsi grayish grading to black on segments 4-5, apices of tarsomeres 1-3 black. Wing membrane hyaline, markings light smoky brown. Apical band wide, with two hyaline spots in cells  $R_5$  and  $M_1$ . Pterostigmal band complete, forked posteriorly. Marginal spot large, extending from costal margin to base of vein  $M_{1+2}$ . Basal band incomplete, reduced to small spot in males, to large spot extending from  $Cu_1$  to hind margin in female (holotype).

**ABDOMEN OF MALE:** Terga 2-3 blackish brown, 4-6 sordid grayish brown (segments 7-11 missing in one male, segment 7 in other), 8-9 sordid yellowish brown. Sterna 2-9 sordid brown. Posterior process of third tergum broadly triangular in basal half, slender in distal half, extending full length of fourth tergum, shiny black. Hypovalves (figs. 35, 36) extending to bases of dististyles, nearly uniform in width with bluntly rounded apices; distal half of each faintly sclerotized, with pale whitish tinge. Dististyles (figs. 35, 39) slender, blackish brown, outer margins concave in basal half; basal lobes directed mesad, dorsal surface shallowly concave, with long yellowish hairs at apices. Ventral parameres (fig. 39) broad at base, slender near mid-length, with apices flattened into blades; distal half of each curved ventrad. Lateral processes complex, mesal margin curved ventrad over ventral parameres, with spines along distal edge. Dorsal parameres long, contiguous, converging to a fine point.

**ABDOMEN OF FEMALE:** Terga 2-7 deep brown, 8-10 light brown. Subgenital plate deeply notched. Arms of genital plate long, 0.6 of total length of genital

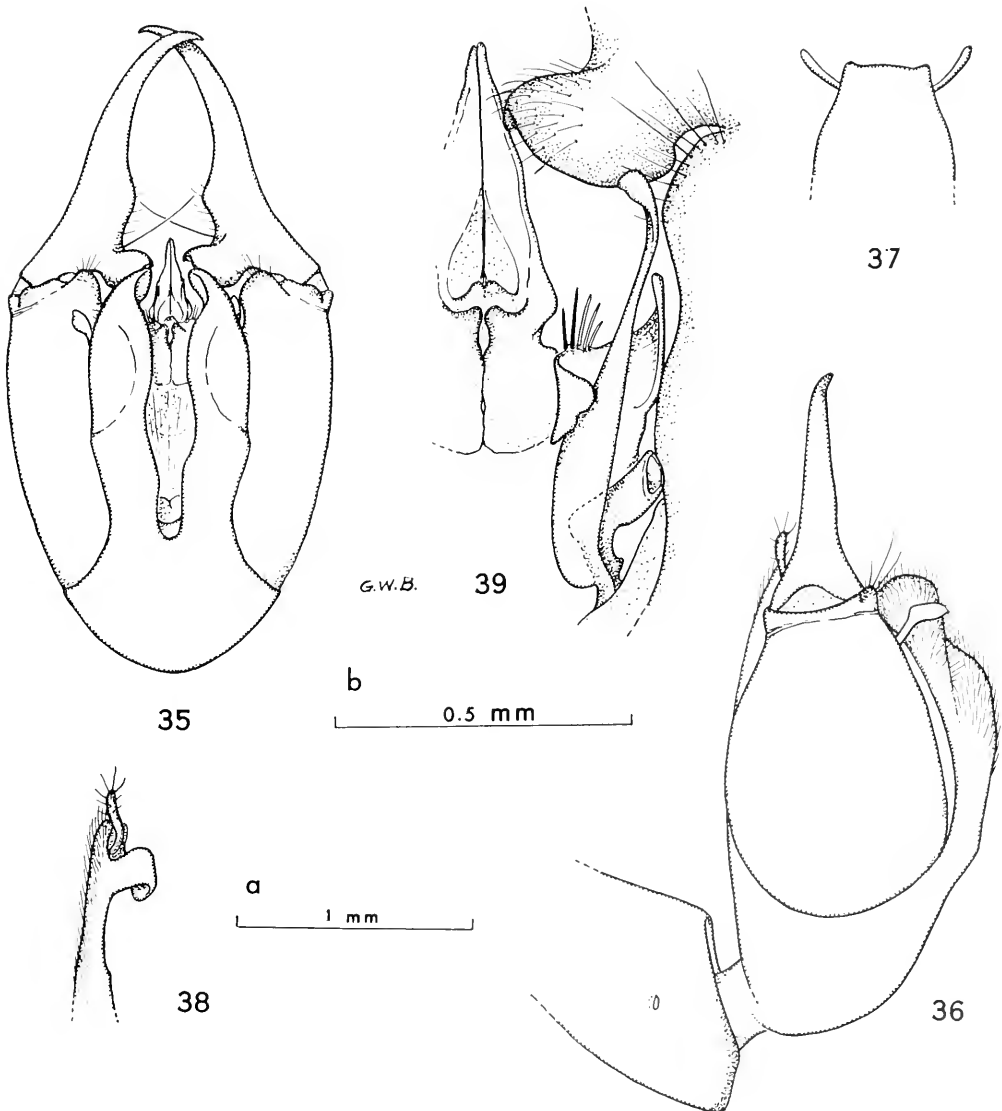
plate, twisted at base. Axial portion slightly broadened anteriorly, slightly notched.

LENGTH OF FORE WING: Female holotype, 14.5 mm.; hind wing, 13.2 mm. Length of fore wing: Male, 14.0 mm.; hind wing, 13.2 mm.

HOLOTYPE: Female, Darjeeling, India, May 1939, T. C. Maa; in the Maa collection, Taipei, Taiwan, China. Paratype,

1 female, same collection data (Cheng collection). We have examined the following individuals: 1 male, Rangiroon, Darjeeling, India, 6,250 feet, 25 May 1966, Kamath; 1 male, same locality, 26 May 1966, Gupta; both males are in the Illinois Natural History Survey collection, Urbana, Illinois.

On the basis of the female genitalia, *contracta* superficially resembles several



FIGS. 35-39. *Neopanorpa contracta* Cheng. 35, genital bulb, male, ventral aspect; 36, genital bulb, left lateral aspect; 37, ninth tergum, dorsal aspect; 38, ninth tergum, left lateral aspect; 39, aedeagus and basal lobe of dististyle, right side, ventral aspect. Scale a—figs. 35-38; b—fig. 39.

regional species of *Neopanorpa* in having a deeply notched subgenital plate and a genital plate in which the posterior arms are longer than the axial portion. The genital plate of *contracta* is similar to that of *N. appendiculata*, especially the posterior arms, but lacks the long, anterior axial portion found in *appendiculata*.

The genital bulb of *contracta* resembles that of *N. nipalica* in having long hypovalves of uniform width, long, contiguous dorsal parameres, and curved ventral parameres. However, *contracta* differs from *nipalica* in having a slightly darker wing pigmentation.

*Neopanorpa cornuta* ESSEN-PETERSEN

*Neopanorpa cornuta* Esben-Petersen, 1915: 227.

This species was originally described from eight males and ten females from the Khasi Hills, Assam. Illustrations of the male abdomen and wings (Esben-Petersen, 1921) show the sixth and seventh abdominal segments apparently in an unnatural position. In the illustration of the genital bulb, there are two forked structures (titillators), which are the ventral parameres.

*N. cornuta* can be recognized by its thoracic coloration and wing pattern. In addition, there are in the male two long projections on the enlarged posterodorsal margin of the sixth abdominal segment. In *N. furcata*, there are two claw-like projections, but the posterior half of the sixth segment is not enlarged in lateral aspect as in *cornuta*. The posterior half of the sixth segment of *N. gibbosa* n. sp. is enlarged, but there are no projections.

The following redescription is based on examination of the male lectotype, one male syntype from which the genital bulb is missing, two female syntypes and the original description:

HEAD: Vertex blackish brown, frons and

rostrum yellowish brown. Antennal scape, pedicel, and proximal half of basal flagellomere yellowish brown, remaining 43 segments blackish brown.

THORAX: Pronotum black. Anterior half of mesoscutum dark brown, posterior half and mesoscutellum yellowish. Metanotum yellowish with semicircular dark brown spot on anterior margin. Pleural areas and coxae yellowish to yellowish brown. Legs yellowish, apices of tarsi dark brown to black. Wing membrane with faint yellowish tinge, markings pale smoky brown. Cross-veins in distal portion of wing whitish, in proximal portion brown. Apical band incomplete, abruptly truncate posteriorly at  $M_1$ . Pterostigmal band narrowly connected to apical band along costal margin, greatly constricted at vein  $R_2$ , forked posteriorly. Marginal spot slender, extending from  $R_1$  to  $M_1$ . Basal band incomplete, comprising faint spot near base of  $R_s$  and wide spot extending from hind margin to  $Cu_2$ .

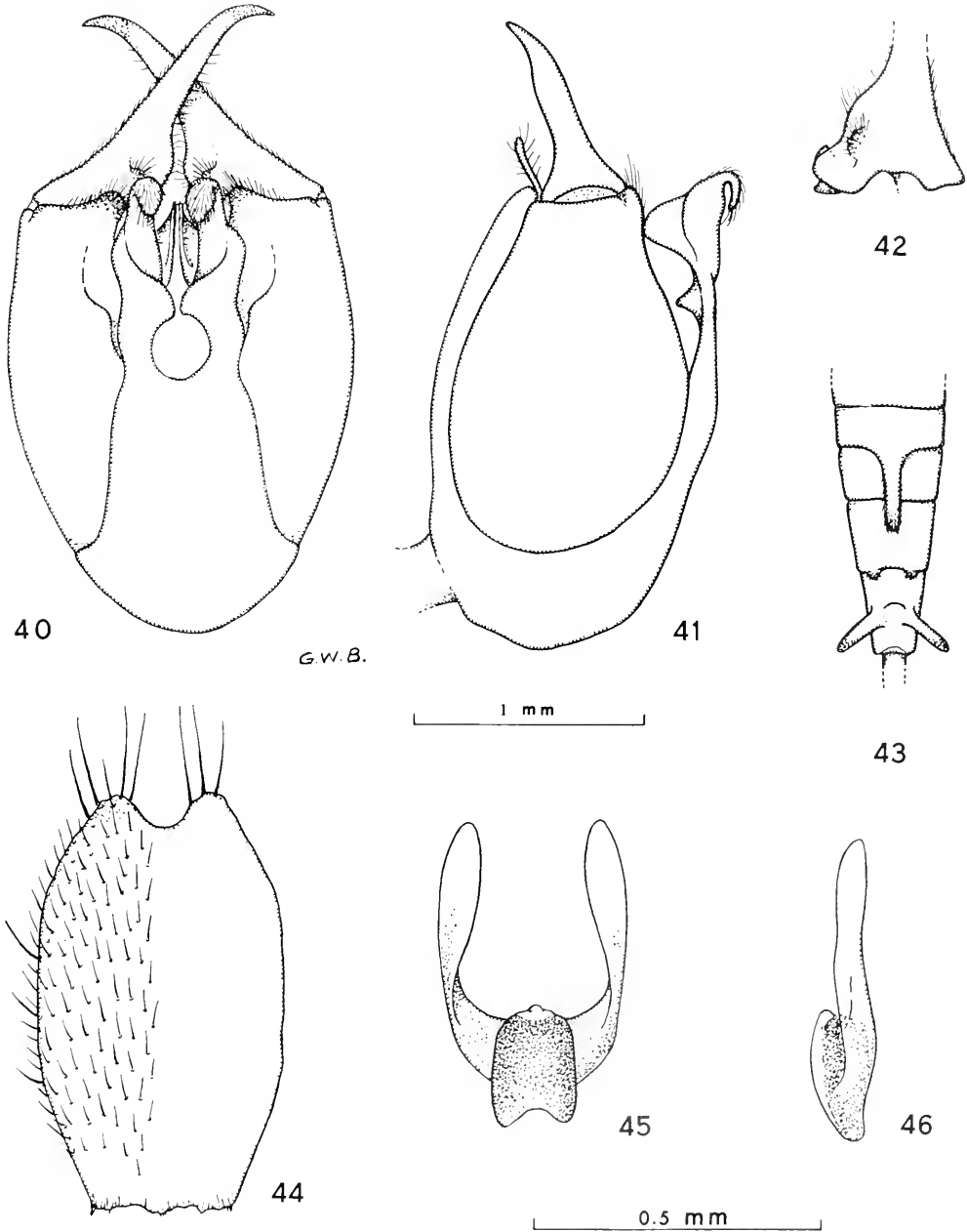
ABDOMEN OF MALE: Terga 2-5 dark brown; anterior half of tergum 6 dark brown, posterior half yellowish brown; segments 7-9 yellowish brown. Sterna 2-9 yellowish brown. Posterior process of third tergum (fig. 43) extends to basal one-third of fifth tergum, slender at base, cylindrical in cross-section entire length. A small protuberance on each side of posterolateral margin of fifth tergum. Posterior half of sixth tergum greatly elevated (lateral aspect), with two diverging, finger-like, yellowish brown projections abruptly blackened at apices. Hypoalves with a large dorsal protuberance at apex, smaller dorsomedian protuberance; inner margin concave in basal half (figs. 40, 41). Lateral margins of dististyles slightly concave in basal half; basal lobes directed mesad, each with a blunt, flattened tooth on anterodorsal margin and a more rounded posterodorsal tooth; adjacent ven-



tral protuberance with stiff hairs (fig. 42). Tergum 9 terminating at base of dististyles.

ABDOMEN OF FEMALE: Terga brown, sterna

yellowish brown. Subgenital plate deeply notched, with several long spines at apex (fig. 44). Arms of genital plate broad, 0.4 of total length. Anterior margin of



FIGS. 40-46. *Neopanorpa cornuta* Esben-Petersen. 40, genital bulb, male lectotype, ventral aspect; 41, genital bulb, left lateral aspect; 42, base of right dististyle, ventral aspect; 43, third to sixth abdominal segments, male lectotype, dorsal aspect; 44, subgenital plate, female syntype, ventral aspect (lower scale); 45, genital plate, ventral aspect (lower scale); 46, genital plate, right lateral aspect.

genital plate shallowly emarginate (figs. 45, 46).

LENGTH OF FORE WING: Both male and female syntypes, 12.5-15 mm.; hind wings: 11.5-13.5 mm.

SYNTYPES: 4 males, 6 females, N. Khasia Hills (N. Khasi Hills), Assam date unknown; in the British Museum (Natural History), London; from the same locality, 2 females in the Museo de Ciencias Naturales, Barcelona, and 1 male, 1 female in the Universitetets Zoologiske Museum, Copenhagen. There is an additional male in the British Museum, the label of which reads "Assam, 1901-262." This may be one of the missing male syntypes. To prevent confusion in the future, the male syntype in the British Museum (Natural History) bearing a white label with a red circle around the word "type" is hereby designated as the lectotype.

In wing pattern, this species somewhat resembles *N. chillcotti* Byers from Nepal and *N. burmana* Byers from Burma, and closely resembles *N. gibbosa* n. sp. from Simla, India. But the wing membrane of *cornuta* is clear, not with a strong yellowish tinge as in *chillcotti*, and the wings are slightly smaller. The basal band in *burmana* is nearly complete, not consisting of two spots as in *cornuta*. The wing pattern of *gibbosa* is nearly identical to that of *cornuta* but slightly lighter in color.

Two Himalayan species, *N. gibbosa* and *N. furcata*, have the posterior part of abdominal segment 6 in the male modified, but in each the shape is diagnostic of the species and quite different from that in *cornuta*. Some undescribed species from northern Burma have hypovalves similar to those of *cornuta* but these can easily be recognized by the absence of prolongations of the sixth segment and by their distinctly yellowish seventh and eighth abdominal segments. Two Chinese species, *N. pielina* Navás and *N. mutabilis* Cheng, have deeply cleft ventral para-

meres similar to those of *cornuta* but are otherwise unlike *cornuta* in genitalia.

The genital plate in *cornuta* closely resembles that of several species from northern Burma (undescribed), western China, and Indo-China in having long, twisted spatulate arms and a short, stout axial portion. The deeply notched subgenital plate of *cornuta* also resembles that of many of these species.

#### *Neopanorpa effusa* (Navás)

*Campodotecnum effusum* Navás, 1914: 429, fig. 7.

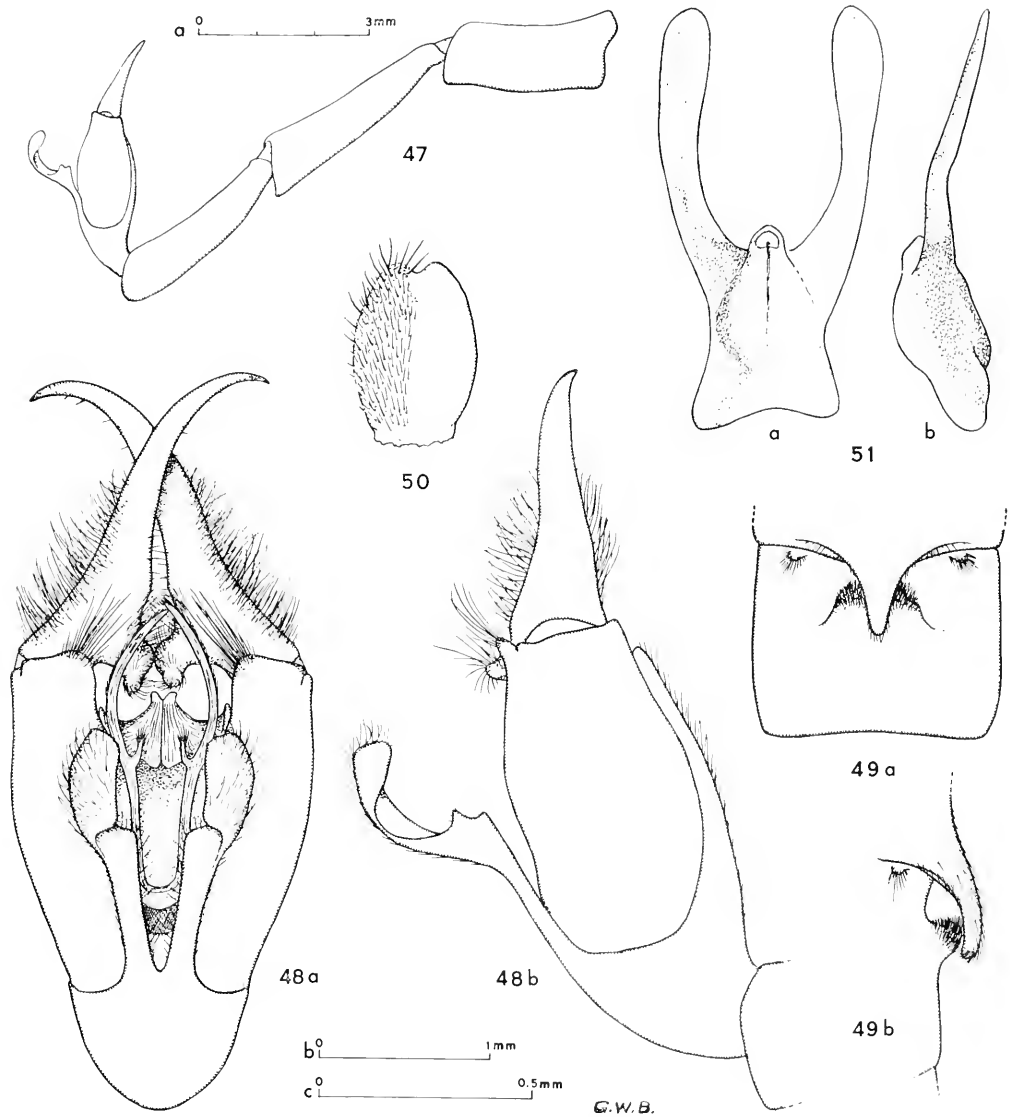
*Leptopanorpa effusa*; Esben-Petersen, 1921: 91-92, fig. 101.

Esben-Petersen (1921) referred to a male type specimen, but mentioned nothing of the female syntype. He was somewhat reluctant to transfer this species to *Leptopanorpa* because of the relatively short, stout seventh and eighth abdominal segments, as compared to those in other species of *Leptopanorpa*, the sessile genital segment, and the long, setose ventral parameres, not found in *Leptopanorpa*. In addition, the single basal lobe of the dististyle and the width of the wings indicate that this species is a *Neopanorpa*.

Navás' (1914) original illustrations are small and lack detail. Esben-Petersen (1921) illustrated only the fore wing of the male syntype. The following composite redescription is based in part on notes and drawings of the male syntype: HEAD: Vertex brownish black; frons and rostrum brown; maxillary palpi yellowish brown. Antennal scape yellowish; pedicel yellowish with dark brown apex; proximal half of basal flagellomere blackish, remaining segments dark brown. THORAX: Pronotum black. Anterior half of mesoscutum black, posterior half of mesoscutum and scutellum yellowish brown. Metanotum yellowish brown. Pleural regions yellowish brown. Legs yellowish, except distal tips blackish.

Wing membrane with strong yellowish tinge; longitudinal veins yellowish, slightly darker than membrane; markings dark brown. Apical band complete, its proximal margin oblique in posterior half. Pterostigmal band complete, forked posteriorly, with branches of sub-equal width. Basal band complete from R<sub>1</sub> to hind margin.

ABDOMEN OF MALE: Terga and sterna 2-6 brown, 7-9 yellowish brown. Posterior process of third tergum (figs. 49a, 49b) somewhat triangular, extending almost to mid-length of fourth tergum. Two small, hair-covered protuberances on anterior margin of fourth tergum. Seventh and eighth segments (fig. 47) each about 3.5 mm. long. Lateral and inner margins



FIGS. 47-51. *Neopanorpa effusa* (Navás). 47, terminal abdominal segments, male syntype, right lateral aspect (scale a); 48a, genital bulb, ventral aspect; 48b, genital bulb, right lateral aspect; 49a, third and fourth terga, dorsal aspect; 49b, third and fourth terga, left lateral aspect; 50, subgenital plate, female ventral aspect; 51a, genital plate, ventral aspect; 51b, genital plate, right lateral aspect.

of proximal two-thirds of hypovalves straight, distal one-third curved and arched ventrad with long hairs on ventral surface (figs. 48a, 48b). Dististyles (fig. 48a) long, nearly equal to length of basistyles; long, dense hairs on proximal two-thirds of lateral margin; basal lobes directed ventrad, not cupped, with long hairs on apices. Ventral parameres setose, slender, long, extending between bases of dististyles. Apices of ventral valves slightly divergent.

**ABDOMEN OF FEMALE:** Subgenital plate (fig. 50) roughly oval, its apex shallowly indented. Genital plate (figs. 51a, 51b) with short, stout axial portion, long broad arms bent angularly dorsad near mid-length, and with short, thick anterior apodemes connected by a sclerotized lamella.

**BODY LENGTH:** Male syntype, 21 mm.; female syntype, 12 mm.

**LENGTH OF FORE WING:** Male and female syntypes, 16 mm.

**LENGTH OF HIND WING:** Male and female syntypes, 14.5 mm.

**SYNTYPES:** Male and female, Sikkim, collected by Felder, date unknown; in the Naturhistorisches Museum, Wien.

In addition, the following specimen has been identified: 1 female, 87 km. N. of Phuntsholing, Bhutan, 22 May 1972, in Naturhistorisches Museum, Basel, Switzerland.

By mistake, the original identification labels of both the male and female syntypes read "*Campodotecnum falcatum* Nav., Navás S. J. det." Additional labels reading "*Campodotecnum effusum* Navás" and "*Leptopanorpa effusa* Navás, Esben-Petersen" appear to have been written by Esben-Petersen.

In wing pattern, this species resembles the other large Himalayan species in having broad apical and pterostigmal bands and the membrane strongly yellowish-tinted. The basal and distal branches of

the pterostigmal band of *effusa* are subequal in width, while the distal branch is narrower in *furcata*. The basal band is nearly complete in *effusa*, not consisting of a large spot along the hind margin as in *furcata* and *flava*.

In *effusa*, the long, slender, setose ventral parameres are very diagnostic and have somewhat the appearance of those found in many species of *Panorpa*. The basal lobes of the dististyles are also unusual in that they are not cupped on either the ventral or mesal surface. Mesonotal-metanotal color pattern will differentiate *effusa* from *flava* (Byers, 1975).

*Neopanorpa fenestrata* (NEEDHAM)

*Panorpa fenestrata* Needham, 1909: 195-196, figs. 13-15.

*Neopanorpa fenestrata*; Esben-Petersen, 1915: 230.

Unfortunately, the male holotype could not be obtained from the Indian Museum, and Needham's original description is not very informative. Esben-Petersen (1915) transferred this species to *Neopanorpa*, but it seems that he did not examine the holotype and in his world monograph (1921) only quoted Needham's description. The genital bulb resembles that of *Neopanorpa*, but the wing venation has never been confirmed.

Needham's (1909) illustrations of the genital bulb are small and lack detail. The following is derived entirely from the original description:

**HEAD:** Dorsum black, lateral margins of rostrum and basal segment of antennae somewhat reddish. Antennae 11 mm. long.

**THORAX:** Dorsum black; pleural areas paler, somewhat reddish. Wing membrane hyaline. Apical band present. Pterostigmal band forked posteriorly. Basal band fused with marginal spot, enclosing a hyaline spot on costal margin. Basal spot present.

**ABDOMEN OF MALE:** Terga and sterna 2-6 black, 7-9 reddish. Posterior process

of third tergum short, extending about one-third length of fourth tergum. Hypovalves long, extending beyond bases of dististyles, their inner margins contiguous in distal half; inner margins folded under lateral margins at base, forming a dorsal protuberance. Aedeagus extends between dististyles.

LENGTH OF BODY: Male holotype, 15 mm.; expanse of fore wings 28 mm.

HOLOTYPE: Male, Assam, date unknown; in the Indian Museum, Calcutta.

*Neopanorpa flava* ESSEN-PETERSEN

*Neopanorpa flava* Esben-Petersen, 1915: 225-226.

This species was originally described from the female holotype only. It is one of the largest *Neopanorpas* known, its fore wings being 18.5 mm. long. This was probably the reason that Esben-Petersen felt that when the male was discovered the species might be transferred to *Leptopanorpa*. But *flava* has not only large but also broad wings, a long but stout abdomen, and a genital plate and bi-colored thorax that are similar to those of *N. furcata* and *N. effusa*.

The original description dealt fairly adequately with coloration. The following

composite redescription is based on notes and drawings of the female holotype and one additional female specimen:

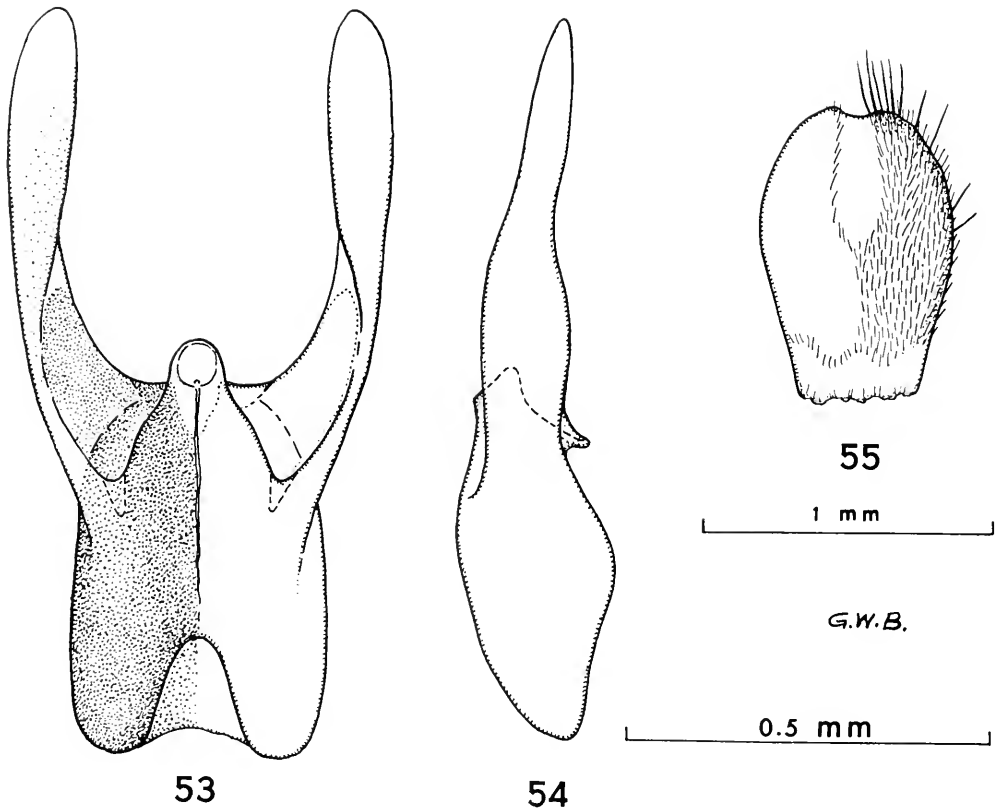
HEAD: Dorsum black; frons and rostrum yellowish brown. Antennal scape, pedicel, and first flagellomere yellowish brown; remaining flagellomeres blackish brown.

THORAX: Pronotum black. Anterior two-fifths of mesonotum black, changing abruptly to yellowish brown posteriorly. Metanotum similar, except only anterior one-third to one-half black. Pleural areas, coxae, and legs yellowish brown. Wing (fig. 52) membrane with strong yellowish tinge, markings dark brown, longitudinal veins brownish through spots and bands, yellowish in uncolored membrane, crossveins in distal portion of wing pale. Apical band complete but uneven, posterior edge deeply and broadly emarginate. Pterostigmal band complete, widely separated along costal and hind margins from apical band, greatly constricted at first fork of  $R_{2+3}$ , forked posteriorly. Marginal spot small, not in contact with costal margin (holotype). Basal band incomplete, comprising small spot near base of  $R_s$  and wide band extending from hind margin of wing almost to M. Basal spot absent.

ABDOMEN OF FEMALE: Terga 2-3 black-



FIG. 52. *Neopanorpa flava* Esben-Petersen, female, right wings (fore wing length 17.8 mm.).



FIGS. 53-55. *Neopanorpa flava* Esben-Petersen. 53, genital plate, ventral aspect; 54, genital plate, right lateral aspect; 55, subgenital plate, ventral aspect (upper scale).

ish brown, 3-4 blackish brown laterally, sordid reddish brown medially, 5-9 sordid reddish brown. Sterna 2-8 sordid reddish brown. Apex of subgenital plate (fig. 55) shallowly emarginate, with long brownish setae in distal one-third. Arms of genital plate (figs. 53, 54) broad, their bases arched dorsad and darkly sclerotized ventrally. Axial portion stout, its anterior apodemes short, thick, rounded at apex, the notch between them mostly closed by a sclerotized lamella.

MALE: Unknown.

LENGTH OF FORE WING: Female holotype, 18.5 mm.

HOLOTYPE: Female, Sikkim, September 1885, Bingham; in the Zoologisches Museum, Humboldt University, Berlin. Additional specimen examined: 1 female,

Sikkim, R. P. Bretaudeau, 1894; in the British Museum (Natural History), London.

This species differs from the other two large Himalayan species, *N. furcata* and *N. effusa*, in having a complete apical band and wide pterostigmal band. The very striking color pattern on the mesonotum and metanotum should also prove useful in the recognition of the male when discovered.

There are five species from China and one (undescribed) from northern Burma that have very large wings (fore wings over 15 mm.) Of these species, *N. caveata* Cheng, *N. cavalieriei* Navás, and the Burmese species have markings on the wings. The wing markings of *cavalieriei* are nearly identical in shape to those of *flava*

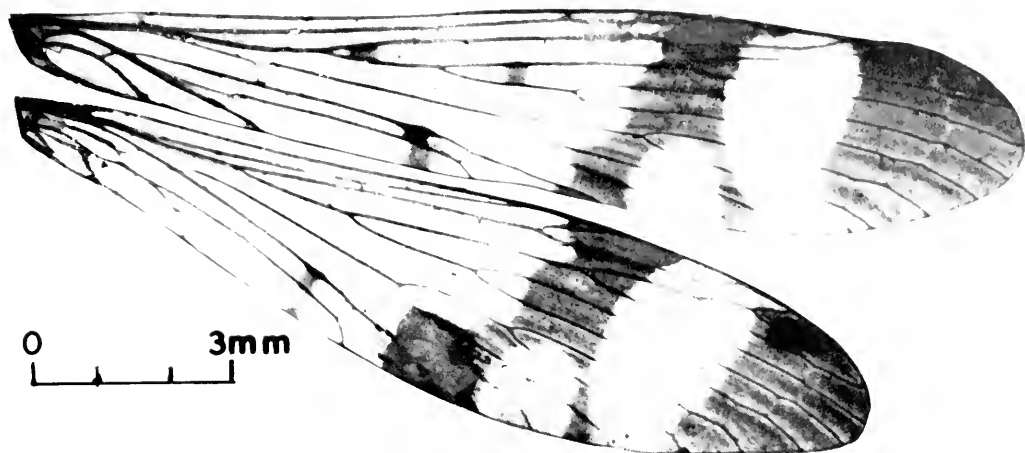


FIG. 56. *Neopanorpa furcata* (Hardwicke), male, right wings (fore wing length 15.4 mm.).

but slightly lighter in color. The fore wings of *cavaleriei* are 16 mm. long, not as long as those of *flava* (18.5 mm.), and the membrane is nearly clear, not strongly tinged with yellow as in *flava*.

On the basis of the genital plate, *flava* resembles *N. translucida* Cheng from China in having long arms and broad axial portion, but it differs from *translucida* in not having the arms of the distal plate twisted.

*Neopanorpa furcata* (HARDWICKE)

*Panorpa furcata* Hardwicke, 1825: 132, figs. 2-6.

*Leptopanorpa furcata*; Esben-Petersen, 1915: 231.

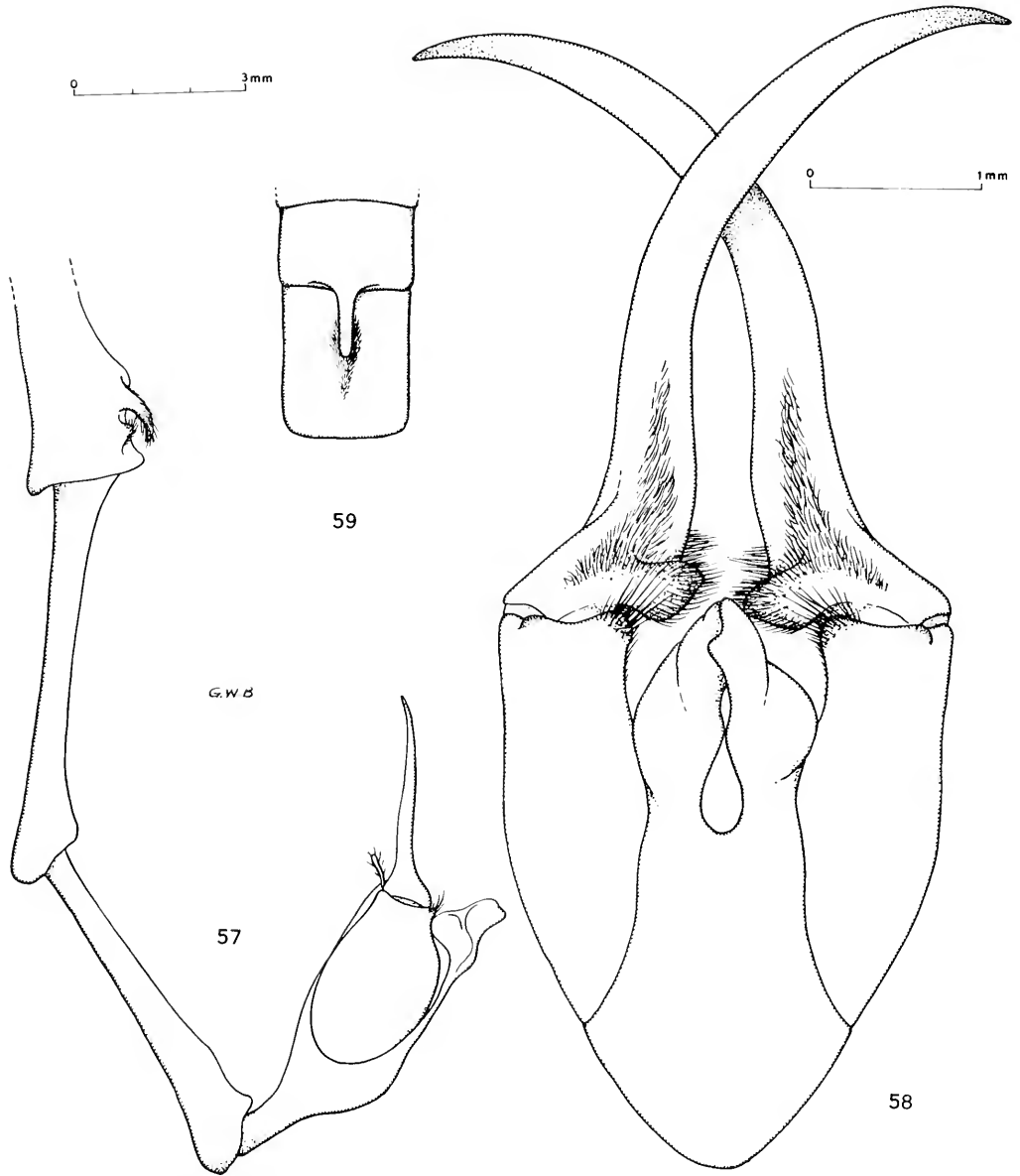
Probably due to its wing length (19.5 mm.) and the elongate seventh and eighth abdominal segments of the male, Esben-Petersen (1915) transferred *furcata* from the genus *Panorpa* to *Leptopanorpa*. The undivided basal lobe of the dististyles, the slightly emarginate ninth tergum, the width of the wings, and the shape of the genital plate of the female, however, warrant transferring *furcata* to *Neopanorpa*.

Several inaccurate statements exist in Hardwicke's original description. Originally reported to extend the entire length of the fourth tergum, the posterior process

of the third tergum is only half that length. The antennal flagella were also reported to consist of "about 52 segments." Unfortunately, the flagella are now missing from both types, but there are only 46 flagellomeres in other male and female specimens examined. Since little mention had been made of the female by Hardwicke, Esben-Petersen (1921) redescribed the female syntype and gave a brief account of the male syntype from the original description, repeating several of Hardwicke's inaccuracies.

The following redescription is a composite from the original description, Esben-Petersen's redescription, drawings of the male syntype, and study of two additional males and seven females:

HEAD: Vertex black with narrow band of yellowish brown along anterior and lateral margins; frons, genae, and rostrum yellowish brown. Antennal scape yellowish brown, pedicel blackish brown, basal flagellomere brown at base grading to black at apex, remaining segments black. THORAX: Pronotum black, except narrow yellowish brown band along hind margin. Anterior half of mesonotum black, posterior half yellowish brown to black (syntypes). Metanotum yellowish brown to grayish brown (syntypes). Legs



Figs. 57-59. *Neopanorpa juvata* (Hardwicke). 57, terminal abdominal segments, left lateral aspect; 58, genital bulb, ventral aspect (upper right scale); 59, third and fourth terga, dorsal aspect.

sordid yellowish. Wing (fig. 56) membrane with a strong yellowish tinge; longitudinal veins brownish black, except basal portion of subcosta and distal portion of radius yellowish; cross-veins paler, especially in distal portion of wing; markings dark smoky brown. Apical band complete, proximal margin nearly straight.

Pterostigmal band wide, forked posteriorly, with distal branch narrow, proximal branch sub-equal in width to anterior part of band. Marginal spot small, between  $R_{2+3}$  and  $R_{4+5}$ . Basal band incomplete, a large spot extending from hind margin to cell M. Basal spot along hind margin.

ABDOMEN OF MALE: Terga and sterna



2-9 yellowish brown. Yellowish hairs along posterodorsal margin of third tergum longer than other abdominal pilosity. Posterior process of third tergum extending half length of fourth tergum, apex bluntly rounded, sides of process subparallel (fig. 59). Hairs along mid-line of fourth tergum slightly longer than other pilosity, directed cephalad. Conspicuous rounded, dorsal protuberance on posterior margin of tergum 4. Posterior margin of sixth tergum (fig. 57) with two claw-like projections with long, yellowish hairs on lateral margins; small protuberance at base of each projection densely covered with long hairs. Segment 7 about 7.5 mm. long; segment 8 about 7 mm. long; both segments abruptly more slender than preceding segments, with long hairs on anterodorsal margin. Genital bulb (fig. 58) large, about 7.5 mm. long, exceeding usual proportion to body size and wing length. Outer (lateral) margins of hypovalves (fig. 58) slightly convex; inner margins overlapped and arched ventrad in distal

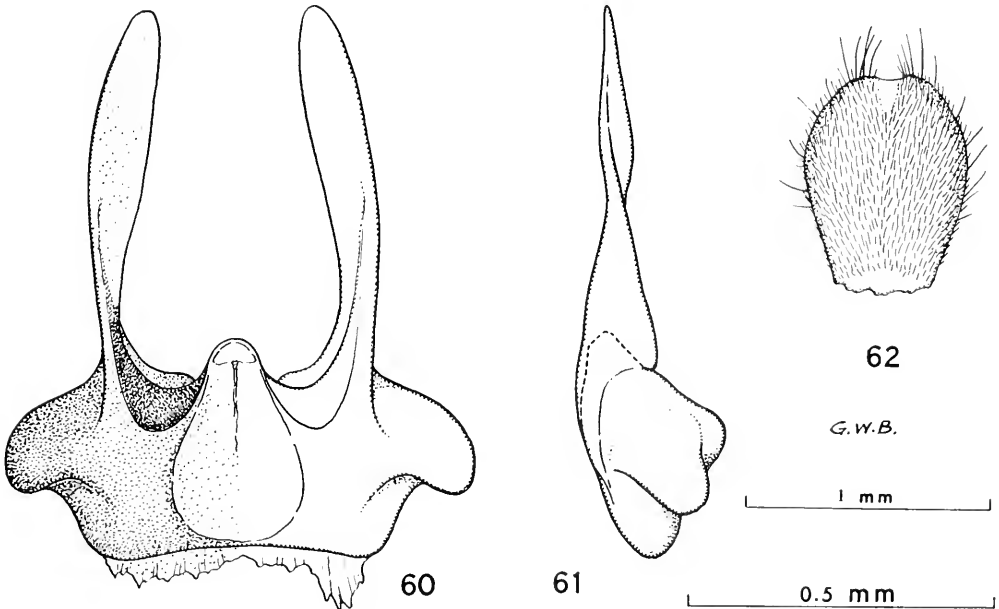
half; large subtriangular projection directed dorsad from mesal margin. Dististyles long, slightly over half length of bulb, slender, with outer margins concave in basal one-third; margins of basal lobe subparallel, apex truncate, lobe directed mesad, covered with long hairs.

ABDOMEN OF FEMALE: Terga 2-9 dark yellowish brown to blackish brown (syntype). Sterna 2-8 yellowish brown. Subgenital plate (fig. 62) slightly emarginate at apex, with long yellowish hairs on distal sides and apex. Arms of genital plate (figs. 60, 61) long, two-thirds of total length, twisted at base, spatulate at apex, with inner basal surface darkly sclerotized. Lateral margins of distal plate projecting, thickened, curved cephalad; anterior margin shallowly emarginate.

LENGTH OF FORE WING: Male, 17.0-19.5 mm. (syntype, 19.5 mm.).

LENGTH OF FORE WING: Female, 15.6-19.0 mm. (syntype, 19.0 mm.).

SYNTYPES: One male and one female,



FIGS. 60-62. *Neopanorpa furcata* (Hardwicke). 60, genital plate, female, ventral aspect (lower scale); 61, genital plate, right lateral aspect; 62, subgenital plate, ventral aspect.

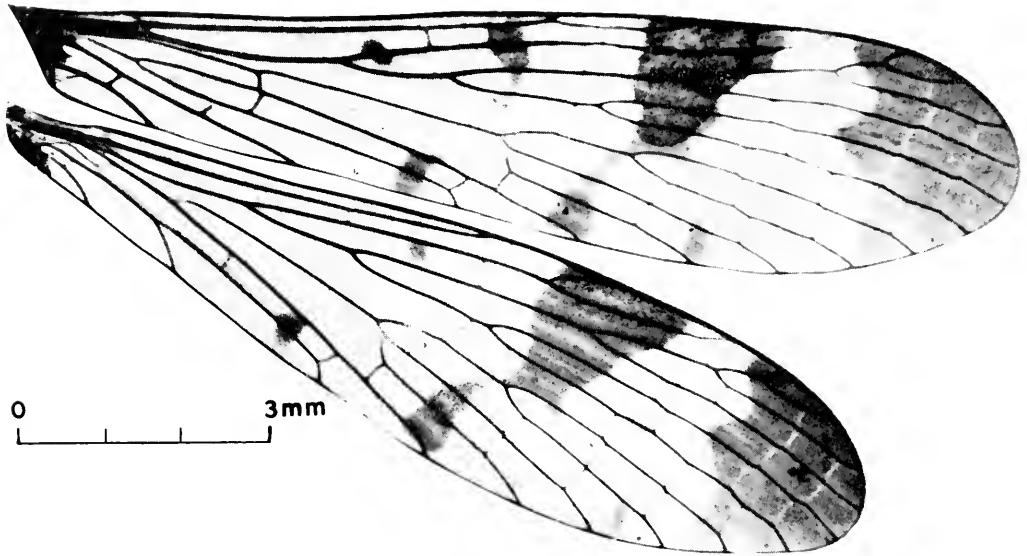


FIG. 63. *Neopanorpa hirsuta* (Crampton), male, right wings (fore wing length 12.4 mm.).

Nepal, no other data; in the British Museum (Natural History), London.

In addition, we have examined the following specimens: 1 male and 2 females, 1 mi. S of Ulleri, Nepal, 5,000-7,000 feet, 16 May 1954, J. Quinlan; 1 male and 1 female, S of Baron River, East Nepal, 11 June 1954, 7,000 feet, L. Swan; all of these are in British Museum (Natural History), London; 1 female, Namdu, Nepal, 1450 m., 18 June 1961; 2 females, Manga Deorati, Nepal, 2300-2500 m., 19 June 1961; 1 female, Solu, Nepal, 2700-2900 m., 11 June 1961; all are in the collection of Dr. H. Janetshek, Innsbruck, Austria.

On the basis of the female genitalia, this species resembles several Chinese species, especially *N. claripennis* Carpenter, in having a broad genital plate, darkly sclerotized inner, basal surface of the arms of the genital plate, and no apodemal processes. Body size and wing pattern of *furcata* are similar to those of another large Himalayan species, *N. flava*, but the genital plate of *flava* lacks the large transverse distal plate and the darkened basal surface of the arms and has a somewhat elongate axial portion.

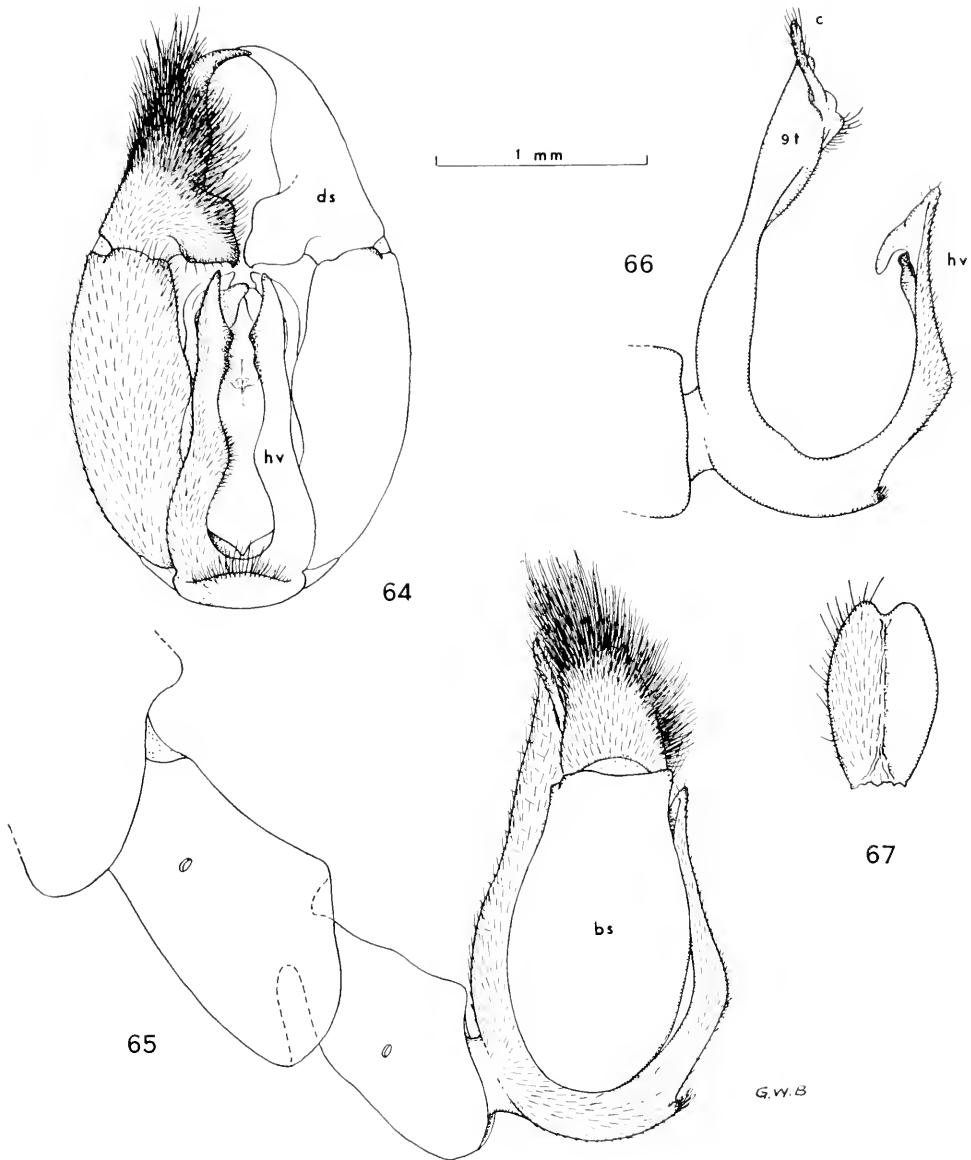
The male of *furcata* can easily be recognized by the modifications of the sixth abdominal tergum and by its genital bulb, which is over twice the size of that of most species of *Neopanorpa*. The seventh and eighth abdominal segments are extremely elongated, but they are of greater diameter than their similarly elongate counterparts in some species of *Leptopanorpa*, and the entire body of *N. furcata* is more robust than that of any typical *Leptopanorpa*.

*Neopanorpa hirsuta* (CRAMPTON)

*Panorpa hirsuta* Crampton, 1931: 10, fig. 23.

*Neopanorpa hirsuta*; Carpenter, 1931: 184-185, fig. 1.

In a paper concerning the morphology and phylogeny of *Notiothauma reedi*, Crampton published a sketch of the genital bulb of an Indian species, suggesting that if it proved to be undescribed it should be called *Panorpa hirsuta*. Carpenter's (1931) redescription of this single specimen is somewhat brief, and his drawing of the genital bulb lacks certain de-



FIGS. 64-67. *Neopanorpa hirsuta* (Crampton). 64, genital bulb, ventral aspect; 65, terminal abdominal segments, male, left lateral aspect; 66, ninth and tenth segments (basistyles and dististyles removed); 67, subgenital plate, female, ventral aspect; bs—basistyle, c—cercus, ds—dististyle, hv—hypovalve, t—tergum.

tails; in addition, the notal process is not described.

The following redescription is based on 12 males and 13 females. Eight of the females were collected together with ten males at Naduvatam in the Nilgiri Hills,

in May 1958. In wing pattern and body coloration, the females agree with all known males of *hirsuta*.

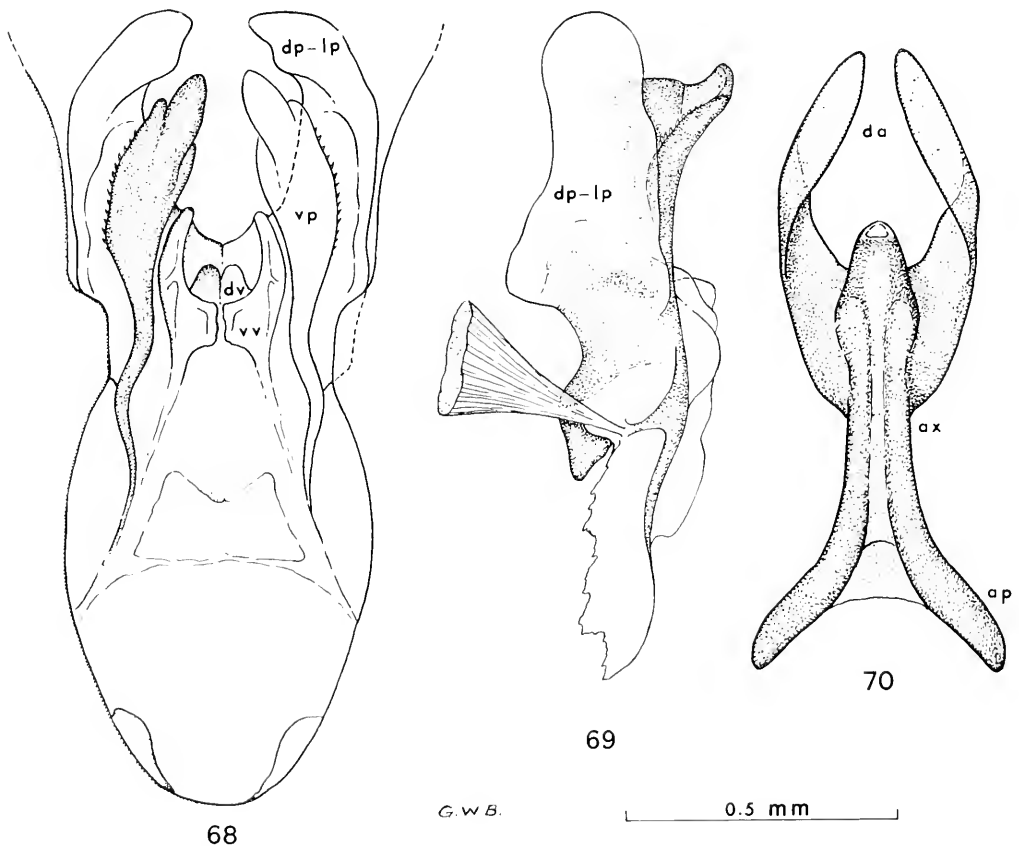
HEAD: Dorsum, rostrum, and genae light reddish brown to reddish brown. Antennal scape light reddish brown; pedicel

blackish brown; flagellum black, with 42-43 segments in females, 44-45 segments in males.

**THORAX:** Anterior edge of pronotum with short pilosity, no setae. Dorsum, pleural areas and coxae light to dark reddish brown. Femora and tibiae light reddish brown; basitarsi blackish brown grading to black on tarsomeres 4-5. Wing (fig. 63) membrane hyaline, markings light brown (holotype) to dark smoky brown; cross-veins pale in distal portion of wing, brown in proximal portion. Apical band ending posteriorly at tip of  $M_1$  in male, at tip of  $M_2$  in female; clear notch extending from proximal margin almost to tip of  $M_2$  in female. Pterostig-

mal band wide, forked posteriorly. Marginal spot present, ending near base of  $M_{4+5}$ . Basal band incomplete. Basal spot absent.

**ABDOMEN OF MALE:** Terga 2-5 blackish brown to black, 6 blackish brown fading posteriorly and laterally to light reddish brown. Posterior process of third tergum (notal organ) half length of fourth tergum, bent downward over process of fourth tergum. Basistyles deeply separated. Hypovalves (figs. 65, 66) extend full length of basistyles, with distinct transverse ridge at base, lateral margins slightly convex at base and near mid-length; hook-shaped dorsal protuberance at apex lightly sclerotized, nearly trans-



FIGS. 68-70. *Neopanorpa hirsuta* (Crampton). 68, aedeagus, ventral aspect; 69, aedeagus, left lateral aspect; 70, genital plate, female, ventral aspect; ap—apodemal process, ax—axial portion, da—distal arms, dp-lp—fused dorsal parameres and lateral processes, dv—dorsal valve, vp—ventral paramere, vv—ventral valve.

parent. Tergum 9 extends nearly entire length of bulb, some hairs perpendicular to surface (fig. 64). Tenth sternum with long hairs. Cerci pale at base gradually darkening apically. Dististyles densely set with long black hairs, only tips exposed; basal lobe directed mesad; prominence at dorsal base of lobe bearing tuft of stout black hairs. Aedeagus (figs. 68, 69) elongate, lateral processes and ventral parameres becoming wide, inwardly concave blades, toward apex. Outer lateral margins of ventral parameres with short, thick pale hairs. Lateral processes and dorsal parameres fused, longer than ventral parameres.

ABDOMEN OF FEMALE: Terga 2-6 blackish brown to black, 7-10 dark reddish brown, cerci black. Sterna 2-6 blackish brown to black, 7-8 dark reddish brown. Subgenital plate (fig. 67) deeply notched and ventrally keeled. Arms of genital plate (fig. 70) long, blade-like, twisted  $180^\circ$ , with tips narrowly rounded. Anterior axial portion of genital plate forming two strongly divergent, large apodemes.

LENGTH OF FORE WING: Males, 11.0-14.0 mm. (holotype, 14.0 mm.).

LENGTH OF FORE WING: Females, 11.4-12.1 mm.

HOLOTYPE: Male, Mysore, India, date unknown; in the Museum of Comparative Zoology, Harvard University.

In addition to the holotype, we have seen the following specimens, all collected in South India by P. S. Nathan: 2 males, Chembra Peak area, Kerala State, 3500 feet, May 1970; 10 males, 8 females, Naduvatum, Nilgiri Hills, 6000 feet, May 1958; 1 female, Devala, Nilgiri Hills, 3200 feet, October 1960; 2 females, Gudalur, Nilgiri Hills, 3500 feet, September 1960; all in the Snow Entomological Museum; 1 female, Cherangoda, 1200 m., Nilgiri Hills, November 1950, 1 female, same locality but without date, both in Naturhistorisches Museum, Basel.

This species is aptly named. Males may be recognized from all other species of *Neopanorpa* by the long, dense hairs on the dististyles. The long, narrow, sinuate hypoalves with the dorsal protuberance at the apex are also diagnostic. On the basis of wing pattern, this species closely resembles *N. cantonensis* Cheng from Kwantung, China, but differs in not having a basal spot. The genital plate of the female holotype of *cantonensis* differs from that of *hirsuta* in not having anterior apodemes or a large basal plate.

The aedeagus of *hirsuta* superficially resembles that of other southern Indian species in having long, blade-like ventral parameres and fused dorsal parameres and lateral processes. The short, thick, pale hairs on the outer margin of the apically lobed ventral parameres are diagnostic of *hirsuta*. The aedeagus of *hirsuta* also differs from those of *N. zebrata* and *N. denticulata* in lacking the large mesal extensions of the fused dorsal parameres and lateral processes.

#### *Neopanorpa nipalica* (Navás)

*Panorpa nipalica* Navás, 1910: 288, fig. 1.

*Aulops suffusa* Navás, 1914: 427, fig. 5.

*Neopanorpa nipalica*; Esben-Petersen, 1915: 230.

Esben-Petersen (1915) transferred this species from *Panorpa* to *Neopanorpa* and synonymized *Aulops suffusa* with it without stating the reasons. Navás had described *Aulops suffusa* from a single male that was somewhat teneral and badly mashed, especially part of the genital bulb. The wing coloration and processes on the third and fourth abdominal terga of these two male holotypes are nearly identical (figs. 77, 78). Even though the genital bulb of the type of *suffusa* is badly damaged, the shapes of the hypoalves, dististyles, and parts of the aedeagus are recognizable and are very similar to the corresponding structures in *nipalica*.

Esben-Petersen's (1921) redescription of *nipalica* deals adequately with body coloration and wing pattern; however, the process of the third abdominal tergum and the genital bulb were not described in detail. The genital bulb of the male holotype of *nipalica* has not been dissected, and the hypovalves conceal most of the aedeagus. The following redescription is based on examination of the holotypes of *nipalica* and *suffusa* and one additional male specimen:

**HEAD:** Antennae about as long as fore wing, comprising scape, pedicel, and 45-46 flagellomeres.

**THORAX:** Dorsum blackish brown. Wing membrane tinged with brownish gray, unmarked except for light brownish stigma.

**ABDOMEN OF MALE:** Terga 2-9 black, corresponding sterna yellowish brown. Posterior process of third tergum (figs. 76, 77, 78) slender, with apex bent downward, extending nearly entire length of fourth tergum. Dorsal process of fourth tergum mid-length of segment in type of *suffusa*, slightly further caudad in type of *nipalica*. Hypoalves (figs. 71, 72) extend to base of dististyles, lateral margins straight, apices bluntly rounded; inner margins concave in basal one-fourth, separating gradually in distal half. Basal portions of dististyles blackish; basal lobe directed mesad, cupped on dorsal surface; tips of dististyles directed slightly dorsad (lateral view). Aedeagus (fig. 74) with long conspicuous dorsal parameres; ventral parameres slender, somewhat bulbous at apices (fig. 75), which project from genital chamber (fig. 72).

**FEMALE:** UNKNOWN.

**LENGTH OF FORE WING:** Male, 12.8-13.8 mm. (holotype, *nipalica*, 12.8 mm.).

**HOLOTYPE:** Male, Sikkim, 1890, Harmand; in the Museum National d'Histoire Naturelle, Paris. Additional specimens examined: 1 male (holotype of *suffusa*),

Sikkim, H. Fruhstorfer, in the Naturhistorisches Museum, Wien; 1 male, Darjeeling, Rangiroon, India, 6250 feet, 25 May 1966, Kamath, in the Illinois Natural History Survey collection, Urbana, Illinois.

If the female is similar to the holotype in color, the unmarked wings, black dorsum of the thorax and abdomen and yellowish brown sterna should permit its recognition when discovered. There are several species from the Himalayan region known only from female holotypes, but these differ from the holotype of *nipalica* in having distinct wing markings. On the basis of wing markings, the male of *nipalica* from Darjeeling is closely similar to the female holotype of *N. benaci*. There is a possibility that *benaci* is a synonym.

The genital bulb of *nipalica* superficially resembles that of *N. claripennis* Carpenter from China, but the hypoalves of *claripennis* are slightly wider and the notal organ of *claripennis* is short and semicircular in shape, not long and narrow as in *nipalica*. The dorsal parameres of *claripennis* are not as long or narrow as in *nipalica*, and the ventral parameres of *claripennis* are short and filamentous. Several clear-winged species (undescribed) from northern Burma have hypoalves similar to those of *nipalica* but differ in having distinctly yellowish seventh and eighth abdominal segments.

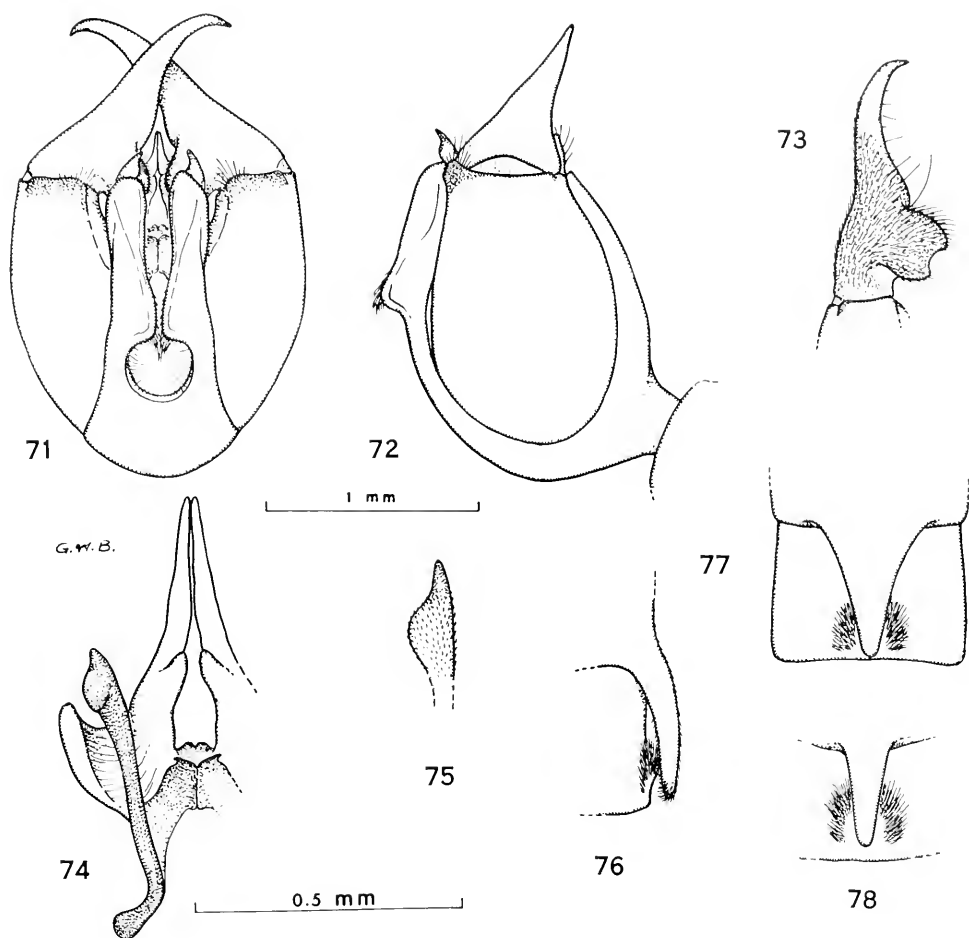
#### *Neopanorpa ocellaris* (NAVÁS)

*Panorpa ocellaris* Navás, 1908: 417.

*Neopanorpa ocellaris*; Esben-Petersen, 1921: 82-83, fig. 92.

This species is known only from the female holotype from Sikkim. In his redescription, Esben-Petersen (1921) dealt adequately with general body coloration and improved the illustration of the wing characters.

The terminal segments of the female holotype were dissected and the following



FIGS. 71-78. *Neopanorpa nipalica* (Navás). 71, genital bulb, holotype of *nipalica*, ventral aspect; 72, genital bulb, holotype of *nipalica*, right lateral aspect; 73, left dististyle, holotype of *suffusa*, ventral aspect; 74, aedeagus, male, ventral aspect (lower scale); 75, tip of right ventral paramere, male, lateral aspect (lower scale); 76, third and fourth terga, holotype of *suffusa*, left lateral aspect; 77, third and fourth terga, holotype of *suffusa*, dorsal aspect; 78, third and fourth terga, holotype of *nipalica*, dorsal aspect.

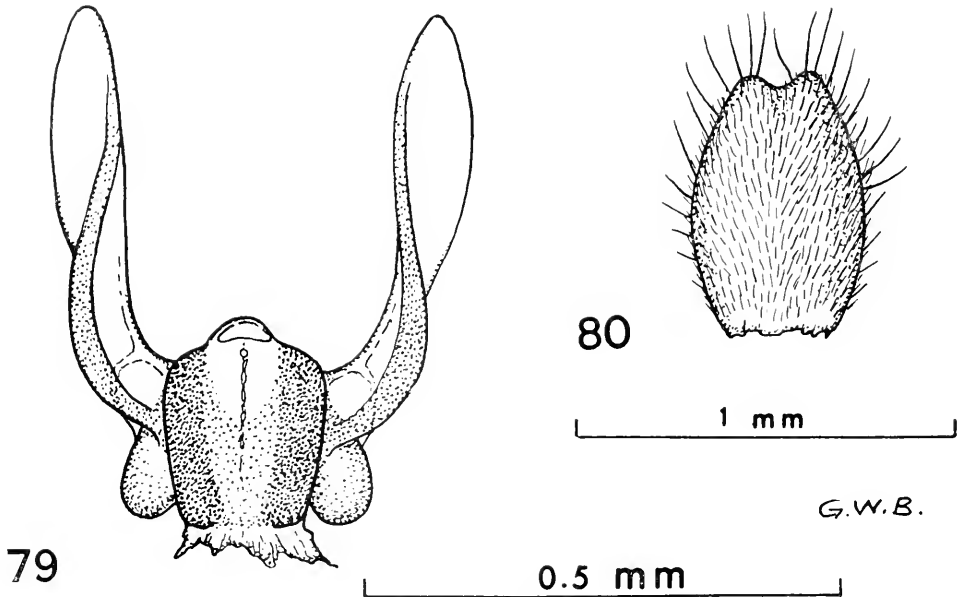
brief redescription is based on the notes and drawing this specimen:

**HEAD:** Dorsum shiny black; rostrum shiny black, except lateral margins reddish brown. Antennal flagella missing.

**THORAX:** Dorsum shiny black. Pleural areas and coxae pale grayish brown, except a lateral black stripe on each coxa. Femora and tibiae yellowish brown, except apices of tibiae brown; tarsi light yellowish brown at base, grading to brown at apex. Wing membrane hyaline; mark-

ings dark smoky brown. Apical band complete, unusually wide. Pterostigmal band wide, forked posteriorly, distinctly fused to apical band along costal and hind margins. Marginal spot broadly fused to proximal fork of pterostigmal band. Basal band complete, unusually wide. Basal spot large, extending from costal margin to  $Cu_2$ .

**ABDOMEN OF FEMALE:** Terga 2-11 shiny black. Sterna 2-8 pale grayish brown. Apex of subgenital plate slightly notched



FIGS. 79-80. *Neopanorpa ocellaris* (Navás). 79, genital plate, female holotype, ventral aspect (lower scale); 80, subgenital plate, ventral aspect.

(fig. 80). Arms of genital plate twisted, spatulate (fig. 79). Axial portion of genital plate short, thick, with large rounded lobes at base on each side, giving it a broadly triangular shape.

MALE: Unknown.

LENGTH OF FORE WING: Female holotype, 14 mm.; hind wing 13 mm.

HOLOTYPE: Female, Sikkim, 1890, Harmand; in the Museum National d'Histoire Naturelle, Paris.

When the male is discovered, the pattern of the wing markings, the uniformly shiny black dorsum of the thorax, and the black abdomen should permit recognition. On the basis of broad, interconnected

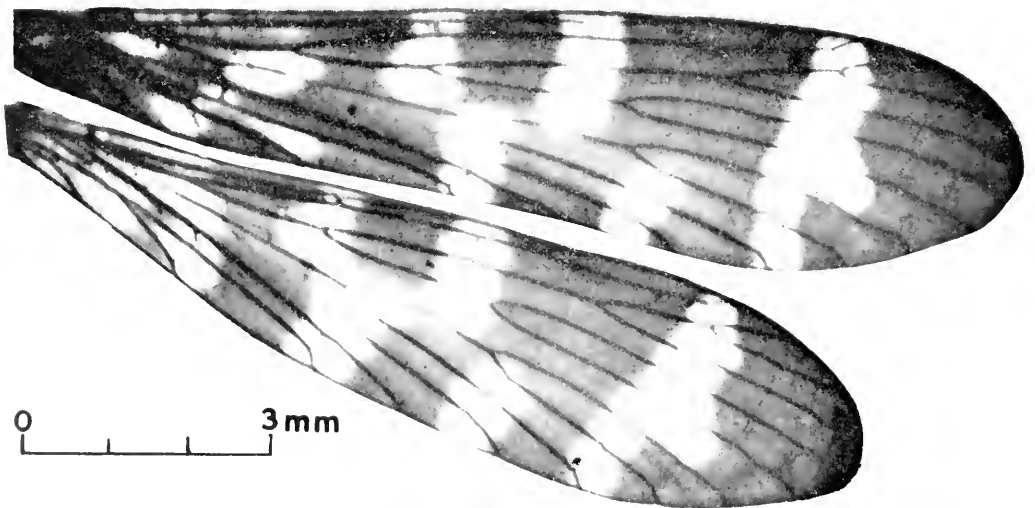


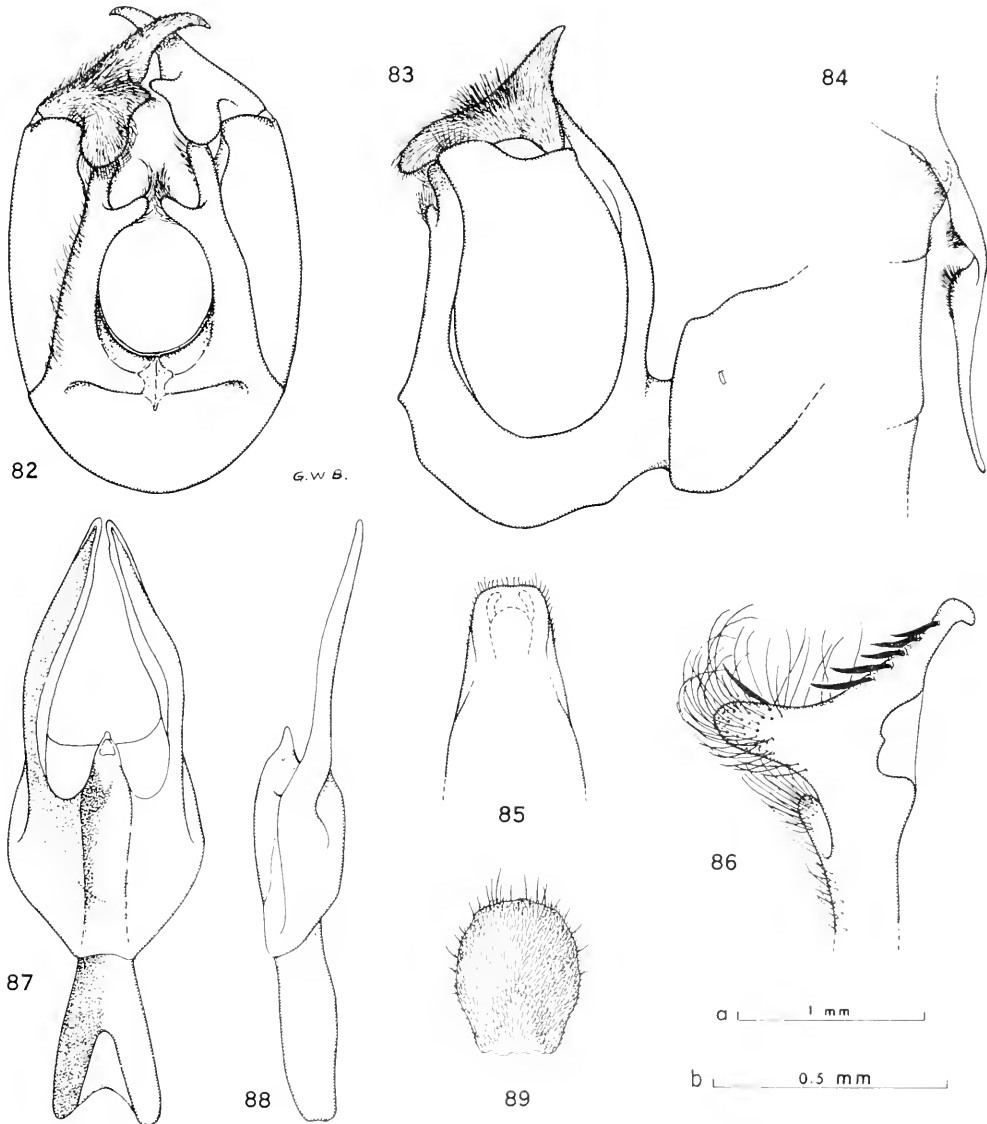
FIG. 81. *Neopanorpa salai* Navás, male, right wings (fore wing length 12.0 mm.).



bands of the wing pattern, this species somewhat resembles *N. ornata* Byers from Vietnam and superficially *N. harmandi* Navás from Vietnam and Thailand (see Byers, 1965). But *ornata* differs from *ocellaris* in having a distinctly bi-colored

thorax and brownish abdominal terga. The notched apical band and the unbranched pterostigmal band of *harmandi* differ from those of *ocellaris*.

In *ocellaris*, the genital plate resembles those of some Indo-Chinese species in hav-



FIGS. 82-89. *Neopanorpa salai* Navás. 82, genital bulb, male holotype, ventral aspect; 83, genital bulb, male holotype, right lateral aspect; 84, third and fourth terga, male, left lateral aspect; 85, ninth tergum, male, dorsal aspect (cerci, shown by dashed lines, do not extend beyond margin of ninth tergum); 86, tip of right hypovalve, male, right lateral aspect; 87, genital plate, female, ventral aspect; 88, genital plate, female, right lateral aspect; 89, subgenital plate, female, ventral aspect. Scale a—figs. 82-85, 89; b—figs. 86-88.

ing long spatulate arms and rounded lateral lobes, and in lacking basal (anterior) apodemes. In several Chinese species of *Neopanorpa*, the anterior apodemes are absent, but the shape and size of the basal plate differ from those of *ocellaris*.

*Neopanorpa salai* NAVÁS

*Neopanorpa salai* Navás, 1929: 196.

Navás described *salai* from the male holotype only. This species very closely resembles *N. appendiculata* and *N. indica* in general appearance. Until another male and a female of *salai* were discovered among specimens identified as *N. appendiculata*, few characters were known that separated them. There are noticeable differences in the shape of the basal lobes of the dististyles, hypovalves, and posterior process of the third tergum between males of *salai* and *appendiculata*.

This composite redescription is based on notes and drawings of the holotype, one other male, and two females:

**HEAD:** Vertex, frons, genae, and rostrum dark yellowish brown. Antennal scape and pedicel dark brown, flagellum blackish brown with 37-38 segments (holotype, 38).

**THORAX:** Dorsum dark sordid brown. Pleural areas and legs sordid yellowish brown. Wing (fig. 81) membrane hyaline; longitudinal veins brownish, except in distal hyaline spot pale; cross-veins brownish; markings dark brown. Apical band complete, notched in proximal margin or margin straight and hyaline spot included (holotype). Pterostigmal band wide, forked posteriorly with branches sub-equal in width. Marginal spot large, extending from costal margin to first fork of media, fused to pterostigmal and basal bands. Basal band wide, complete. Basal spot large.

**ABDOMEN OF MALE:** Terga 2-9 and corresponding sterna blackish brown. Posterior process of third tergum (fig. 84) long, extending one-third distance across

sixth tergum; basal one-third wide, dorsoventrally flattened with ventral tuft of hairs; abruptly becoming cylindrical and tapering to a point. A low sharp ridge across base of hypovalves (figs. 82, 83) with distinct notch at midpoint. Hypo- valves somewhat rounded with two long projections (of length sub-equal to width of hypovalves at base) in distal one-half; both proximal, mesal projection and distal ventromesal projection covered with black hairs longest at apex; tips of hypovalves flattened, tapered, directed posterodorsad (into interior of genital bulb), with row of flattened black spines along outer (posteroventral) margin (fig. 86). Entire dististyle covered with blackish hairs longest on basal lobe; basal lobe broad, its bluntly rounded apex directed ventrad.

**ABDOMEN OF FEMALE:** Terga and sterna 2-6 blackish brown, 7-9 dark sordid reddish brown. Subgenital plate (fig. 89) broad, about three-fourths as wide as long, with long hairs along margin. Genital plate (figs. 87, 88) about 1.25 mm. long; arms of genital plate twisted near base, about one-half total length; anterior apodemal process short, about one-fourth of total length.

**LENGTH OF FORE WING:** Male, 11.3-13.0 mm. (holotype, 13.0 mm.); female, 12.8 mm.

**HOLOTYPE:** Male, Khandala, India, date unknown; in the Museum National d'Histoire Naturelle, Paris. In addition, the following specimens were examined: 1 male, Bombay, India, and 1 female, India, place and date unknown, both in the British Museum (Natural History), London; 1 female, Coimbatore, Madras, South India, October 1951, in the Naturhistorisches Museum, Basel.

*Neopanorpa sordida* (NEEDHAM)

*Panorpa sordida* Needham, 1909: 196, figs. 16, 17.

*Neopanorpa sordida*; Esben-Petersen, 1915: 230.

This species is still known only from one male and two female syntypes from Assam. The original description is somewhat vague, and unfortunately the syntypes could not be obtained from the Indian Museum for further study. According to Needham, the male and one of the female syntypes have unmarked wings. The other female has diffuse bands near the middle of the wing, posterior to the stigma, and distal to the stigma. It seems likely that the more darkly marked female represents a second species.

The following is based entirely on the original description:

**HEAD:** Dorsum pale brown. Antennae about 10 mm. long (female), their bases tawny yellow.

**THORAX:** Pronotum pale brown. Mesonotum and metanotum reddish yellow. Femora, tibiae, and tarsi tawny yellow with brownish apices. Wing membrane smoky-tinged, hyaline, unmarked (1 male and 1 female), longitudinal veins brown; or diffuse pterostigmal band forked posteriorly, oblique apical spot beyond stigma (1 female).

**ABDOMEN OF MALE:** Basal segments pale brown, terminal segments tawny. Posterior process of third tergum extends half length of fourth tergum. Hypovalves extend to bases of dististyles (apices broken off).

**LENGTH OF BODY:** Male, 11 mm.; female, 10 mm. Expanse of wings 22 mm.

**SYNTYPES:** 1 male and 2 females, Khasi Hills, Assam, 5000 feet, May (year unknown); in the Indian Museum, Calcutta.

*Neopanorpa zebrata* ESBEN-PETERSEN

*Neopanorpa zebrata* Esben-Petersen, 1915: 228.

This species was originally described from a single female from Travancore,

India. A photograph of the wings of the holotype appears in Esben-Petersen's world monograph (1921). With permission of Mr. D. E. Kimmins of the British Museum, the terminal abdominal segments of the holotype were dissected. Several male specimens in the British Museum, tentatively determined to be *zebrata*, are from Periyar Dam, Travancore State, India.

The distal wing markings of the male examined are somewhat smaller and paler but clearly correspond in position to those of the female. In addition, the body coloration of this male is nearly identical to that of the female holotype. This male was collected together with several females of *zebrata*. The following redescription is based on the original description, notes on the female holotype, and one male:

**HEAD:** Dorsum, frons, and rostrum sordid light yellowish brown. Antennal scape and pedicel sordid yellowish brown; flagellum (broken in holotype) blackish brown, with 38 flagellomeres (male).

**THORAX:** Short pilosity and four long, black setae on anterior margin of pronotum. Dorsum, pleural areas, and coxae sordid yellowish brown. Femora, tibiae, and tarsi yellowish, with apices of tarsi brown. Wing membrane with light yellowish tinge; markings light brown (male) to smoky brown (holotype); crossveins pale in distal portion of wing, brown in proximal portion. Apical band complete, with a large clear spot extending from  $R_1$  to  $M_1$  in female, absent in male; large notch on proximal posterior margin (holotype), absent in male. Pterostigmal band complete, forked posteriorly, with basal fork constricted at base of  $M_1$  and  $M_2$  (holotype), or incomplete, with posterior branches reduced to two spots (male). Marginal spot large, fused with pterostigmal band in holotype, but not so fused and extending to vein  $M$  in male. Basal band complete, constricted at vein

M (holotype). Basal spot large (holotype), absent in male.

ABDOMEN OF MALE: Terga 2-4 blackish brown, 5-6 brown, 7-9 sordid yellowish brown. Sterna 2-9 sordid yellowish brown. Posterior process of third tergum (figs. 93, 94) approximately half length of fourth tergum, subquadrate in dorsal aspect, somewhat bulbous at apex; base blackish brown fading to yellowish brown posteriorly. Lateral margins of hypovalves (figs. 90, 96) convex in distal one-fourth; distal half of inner margin with two mesal protuberances, one near mid-length with two setae at apex and one more distal with minute nodules on surface, both with long hairs on mesal surface (fig. 96). Tergum 9 (fig. 92) abruptly narrower in distal portion, apex truncate. Dististyles slightly concave on outer surface near mid-length; basal lobe directed ventromesad, its outer surface with long hairs; prominence at inner base of dististyle (dorsal aspect, fig. 95) with tuft of stout, black setae. Aedeagus (fig. 95) with mesally concave blades extending caudad from lateral processes; blades broad basally, tapering to bluntly rounded apex. Ventral parameres extend between lateral processes and ventral valves, apex of ventral paramere truncate. Dorsal parameres compressed oval blades, narrowly connected at base to lateral processes, posterior edges divergent (fig. 95).

ABDOMEN OF FEMALE: Terga blackish brown, except apical segments brown. Sterna brown. Subgenital plate (fig. 97) strongly keeled ventrally and notched at apex. Arms of genital plate (figs. 98, 99) short, tips bluntly rounded; basal plate somewhat depressed. Apodemes long, nearly straight, slightly divergent near anterior apex.

LENGTH OF FORE WING: Female holotype, 13 mm.; male, 11.6 mm.

LENGTH OF HIND WING: Female, 12 mm.

HOLOTYPE: Female, Travancore, date un-

known, Hampson; in the British Museum (Natural History), London.

In addition to the holotype, the following specimens are in the British Museum: 3 males, 7 females, Thekkadi, Periyar Dam, Travancore, India, 6-10 May 1937; 1 male, 1 female, Naraikadu, Tinnevely District, South India, 2500-3000 feet, 3-8 May 1938; 1 male, 1 female, Pirmed, Travancore, 3400 feet, 4-6 May 1937. The illustrations of the male were made from one of the series from Thekkadi, Periyar Dam, now in the Snow Entomological Museum, by exchange.

This species can easily be recognized by the large, clear spot in the apical band, especially evident in the female, and by the mesal projections of the inner margins of the hypovalves in the male. The distal wing markings of two Chinese species, *N. chelata* Carpenter (1938) and *N. pielina* Navás (1936), superficially resemble those of *zebrata* in having a large, clear spot in the apical band, but the spot is not nearly as large or centrally situated as in *zebrata*. In addition, these Chinese species lack the extensive basal spots that are present in the holotype of *zebrata*.

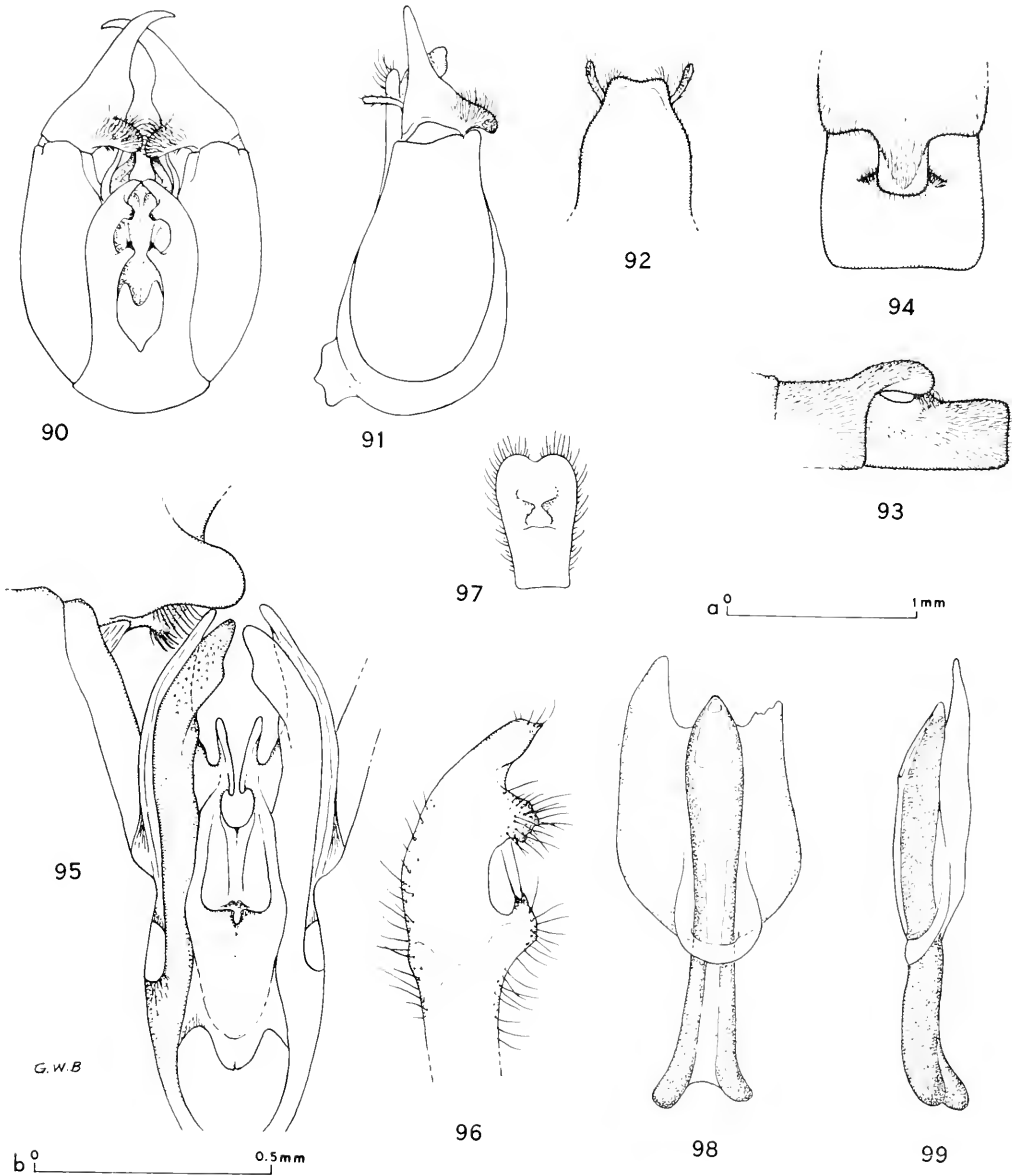
On the basis of male and female genitalia, *zebrata* closely resembles the other southern Indian species, especially *N. denticulata* n. sp. In both of these species, the aedeagus bears long, blade-like ventral parameres and fused lateral processes and dorsal parameres. Aside from the southern Indian species, *N. burmana* Byers (1965) from southern Burma is the only known species in which the lateral processes and dorsal parameres have fused, but the ventral parameres of *burmana* (Byers, 1965) are not evident, while they are large in the southern Indian species.

Usually the basal lobes of the dististyles are directed mesad, in *Neopanorpa*, but in *zebrata*, *appendiculata*, and *indica*, they are directed ventrad; but those of *appen-*

*diculata* and *indica* are nearly as broad as long, not slender and bluntly rounded as in *zebrata*.

In *zebrata*, the female genital plate superficially resembles that of *denticulata*,

but differs in having shorter distal arms and in being more dorsoventrally flattened. The apodemal processes of *zebrata* are not as long or divergent as those of *appendiculata* and *N. hirsuta*.



FIGS. 90-99. *Neopanorpa zebrata* Esben-Petersen. 90, genital bulb, male, ventral aspect; 91, genital bulb, left lateral aspect; 92, ninth tergum, dorsal aspect; 93, third and fourth terga, left lateral aspect; 94, third and fourth terga, dorsal aspect; 95, aedeagus and basal lobe of left dististyle, ventral aspect; 96, tip of left hypovalve, ventral aspect; 97, subgenital plate, female holotype, dorsal aspect; 98, genital plate, holotype, ventral aspect; 99, genital plate, right lateral aspect. Scale a— figs. 90-94, 97; b— figs. 95, 96, 98, 99.

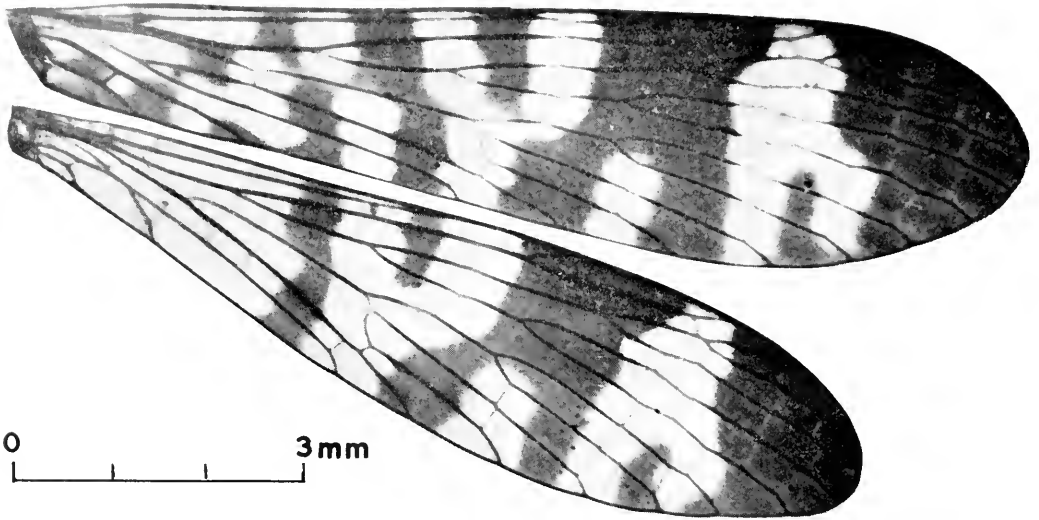


FIG. 100. *Neopanorpa denticulata* n. sp., male paratype, right wings (fore wing length 10.8 mm.).

*Neopanorpa denticulata* NEW SPECIES

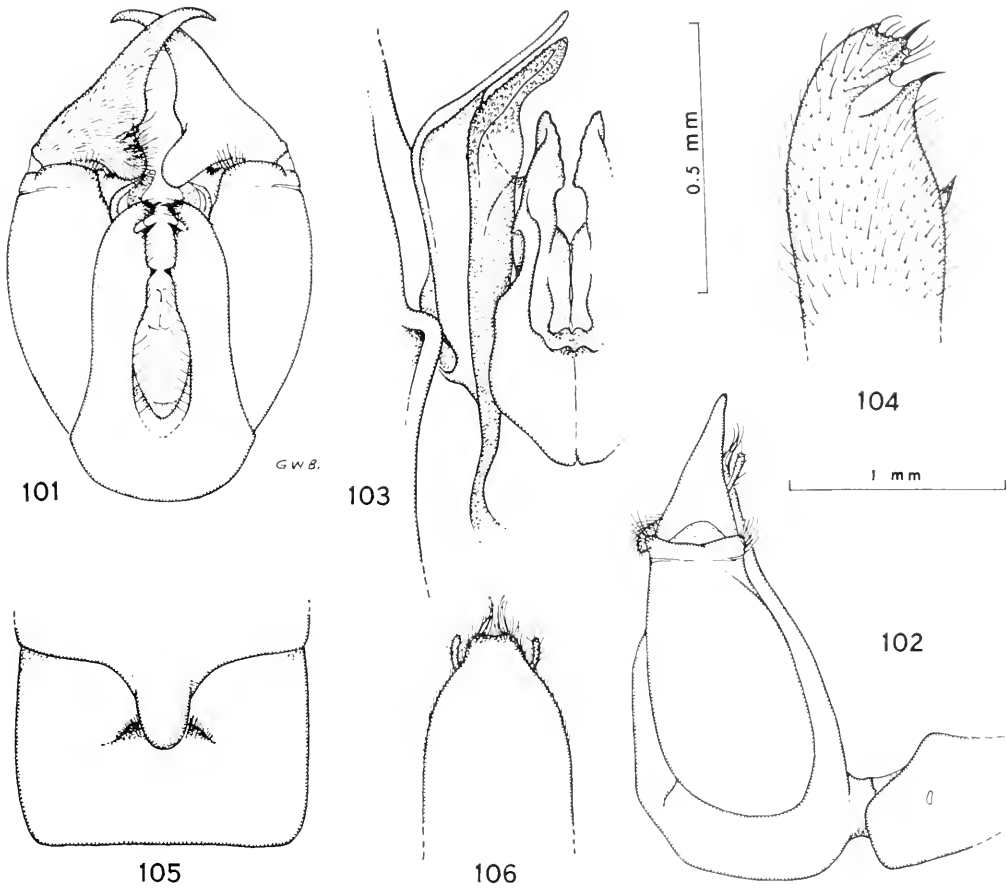
Description based on 150 males and 121 females pinned, 1 male and 13 females in alcohol.

**HEAD:** Dorsum, rostrum, frons, and genae sordid yellowish brown (holotype) to dark yellowish brown. Antennal scape yellowish brown; pedicel yellowish brown to dark yellowish brown (holotype); basal portion of first flagellomere dark yellowish brown, remaining flagellum black, with 39-42 flagellomeres (holotype, 42).

**THORAX:** Short pilosity but no setae on anterior edge of pronotum. Dorsum sordid yellowish brown (holotype) to sordid dark brown; pleural region and coxae yellowish brown (holotype) to dark yellowish brown. Femora and tibiae sordid yellowish brown; tarsi sordid yellowish brown grading to black on segments 4-5. Wing (fig. 100) membrane hyaline, markings brown (holotype) to dark smoky brown. Apical band complete with clear spot or notch at  $M_1$  and  $M_2$  on proximal hind margin (holotype). Pterostigmal band complete, forked posteriorly. Marginal spot variable, sometimes fused with pterostigmal band or with basal band. Basal band variable, partially or com-

pletely divided (holotype) into two transverse bands in fore wing (figs. 13, 100). Basal spot present.

**ABDOMEN OF MALE:** Terga 2-5 black; anterior one-third of sixth tergum black, fading posteriorly to dark yellowish brown; terga 7-9 sordid yellowish brown. Sterna 2-8 sordid yellowish brown. Posterior process of third tergum (fig. 105) somewhat triangular, rounded apically, extending half length of fourth tergum. Hypovalves (figs. 101, 104) slightly widened in apical half, then narrowed and abruptly thickened at apex; a mesal thick brown spine on apical enlargement, another on mesal margin just before apex, and a third on dorsomesal margin just beyond mid-length of hypovalves; hypovalves with uniform brown pilosity. Ninth tergum (fig. 106) abruptly narrowed in distal one-fourth, terminating in shallowly emarginate apex with numerous long, brownish hairs. Basal lobes of dististyles directed ventrad (fig. 102), shallowly cupped on dorsomesal surface, with bluntly rounded apices; ventral posterior surface with long blackish hairs; tuft of stout black setae at the dorsal base of lobe. Aedeagus complex (fig. 103), with blade-



FIGS. 101-106. *Neopanorpa denticulata* n. sp. 101, genital bulb, male paratype, ventral aspect; 102, genital bulb, right lateral aspect; 103, aedeagus, ventral aspect (vertical scale); 104, tip of left hypovalve, ventral aspect (vertical scale); 105, third and fourth terna, dorsal aspect; 106, ninth tergum, dorsal aspect.

like ventral parameres and fused lateral processes and dorsal parameres extending between bases of dististyles. Dorsal parameres enlarged, blade-like, directed dorsad. ABDOMEN OF FEMALE: Terga 2-6 black, 7-9 dark yellowish brown. Sterna 2-8 yellowish brown. Subgenital plate (fig. 107) notched apically, with elongate hairs along margins and at apex. Arms of genital plate (figs. 108, 109) short, about one-fifth of total length, slightly curved inward. Apodemes about .3 total length of plate, fused for about half their length, diverging anteriorly. Basal and distal plates broad, with lateral margins of distal plate folded ventrad.

LENGTH OF FORE WING: Male, 10.0-12.0 mm. (holotype, 11.0 mm.); female, 10.3-12.6 mm. (allotype, 12.4 mm.).

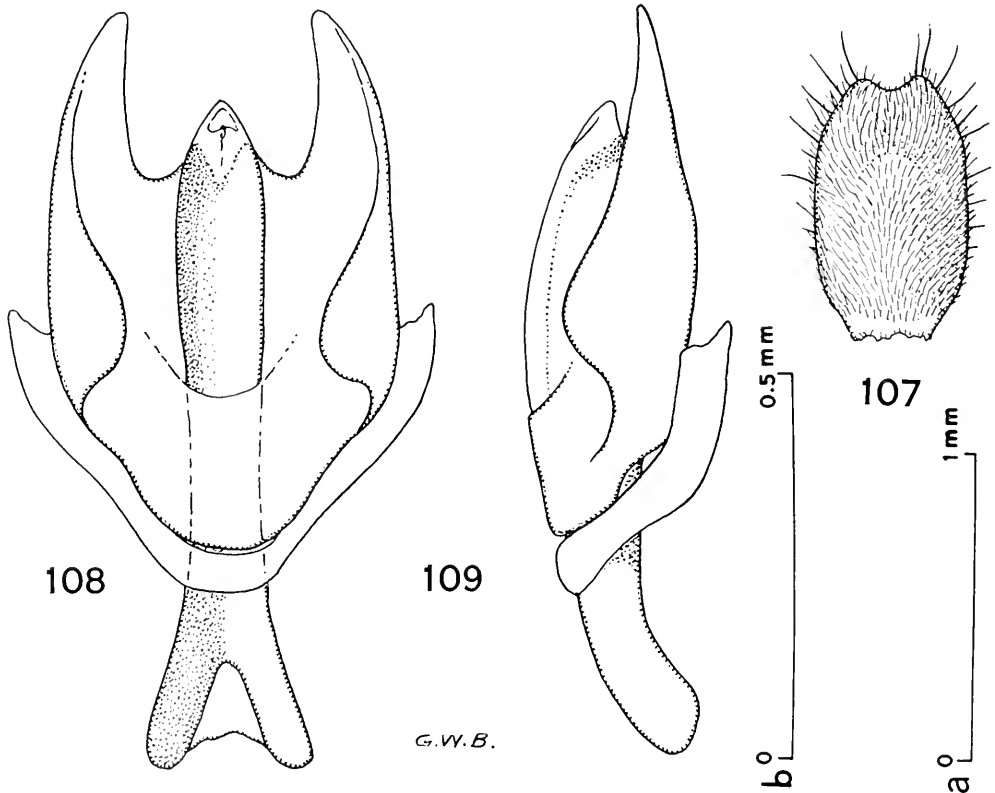
LENGTH OF HIND WING: Male, 9.3-10.6 mm (holotype, 10.0 mm.); female, 10.0-11.0 mm.

HOLOTYPE: Male and allotype, female, Devala, Nilgiri Hills, India, 3200 feet, May 1961, P. S. Nathan. Paratypes, 150 males, 133 females: at type locality, May 1961 (120 males, 63 females); type locality, October 1960 (5 males, 6 females); Walayar Forest, Kerala, India, 700 feet, P. S. Nathan, September 1959 (2 males, 9 females), 15 September 1959 (1 male), October 1959 (4 males, 13 females),

August 1960 (2 males), September 1965 (1 female); at Chembra Peak area, India, 3500 feet, T. R. S. Nathan, May 1970 (5 males, 6 females), October 1970 (1 female); all in the Snow Entomological Museum; Walayar Forest, S. Malabar, India, 1000 feet, P. S. Nathan, August 1957 (1 male, 9 females), November 1957 (4 females), in the Illinois Natural History Survey collection, Urbana, Illinois; Muthikolam, Coimbatore Dist., India, 3000 feet, 23-26 September 1938 (1 male, 1 female); Siruvani, 1700 feet, 23-26 September 1938 (1 male), in the British Museum (Natural History), London; Cherangoda, Nilgiri Hills, 1200 m., November 1954 (7 males, 14 females), October 1954 (1 male, 3 females), October 1950 (1 male), no

date (1 male); Coimbatore, Madras, South India, October 1951 (1 male), in the Naturhistorisches Museum, Basel, Switzerland.

This species superficially resembles in general appearance two regional species, *N. zebra* and *hirsuta*; and the aedeagus resembles those of *hirsuta*, *echinata* n. sp., and especially *zebrata*, in having long, blade-like ventral parameres and fused dorsal parameres and lateral processes. The lateral processes and dorsal parameres are also fused in *N. burmana* Byers (1965) from Indo-China, but *burmana* differs from these Indian species in lacking the long, blade-like ventral parameres. In *denticulata*, the dorsal parameres are large, slightly divergent, vertical plates similar



Figs. 107-109. *Neopanorpa denticulata* n. sp. 107, subgenital plate, female paratype, ventral aspect; 108, genital plate, ventral aspect; 109, genital plate, right lateral aspect. Scale a—fig. 107; b—figs. 108, 109.



to those of *zebrata*, but these plates have a broader connection to the body of the aedeagus than in *zebrata*. The structure of the aedeagus is the primary character used in grouping *hirsuta*, *echinata* n. sp., *denticulata*, and *zebrata* into the *denticulata* group. It is called the *denticulata* group after the commonest included species.

The basal markings of the wing, the solidly-colored, complete apical band, and the three tooth-like projections on the inner margin of the hypovalves permit easy recognition of *denticulata*. The specific name refers to the three projections of the hypovalves (Latin *denticulus*=small tooth). Some variation in wing pattern, especially the fusion of the two basal bands, was observed in the paratypes from the Walayar Forest.

On the basis of female genitalia, *denticulata* superficially resembles *N. zebrata* in having large, broad basal and distal plates and apodemes subequal in length to the basal and distal plates; but it differs from *zebrata* in having longer arms of the distal plate and a somewhat flattened subgenital plate, not strongly keeled as in *zebrata*.

#### *Neopanorpa echinata* NEW SPECIES

Description based on 2 males, pinned.

**HEAD:** Dorsum sordid yellowish brown; frons sordid yellowish brown, with dark brown medial spot; rostrum sordid yellowish brown, edges becoming translucent yellowish brown. Antennal scape sordid yellowish brown; pedicel dark yellowish brown; flagellum blackish brown, with 41-42 flagellomeres (holotype, 42).

**THORAX:** Short pilosity but no setae on anterior margin of pronotum. Pronotum blackish brown. Medial portion of mesoscutum sordid grayish brown, color extending along midline to scutellum; lateral margins of scutum dark brown. Meta-

notum similar to mesonotum. Pleural areas and coxae light grayish brown. Femora and tibiae sordid light brown. Basitarsi sordid brown grading to dark brown on segments 4-5. Wings hyaline, except light yellowish brown stigmal spot. Longitudinal veins brownish; cross-veins brown in proximal portion of wing, pale in distal portion.

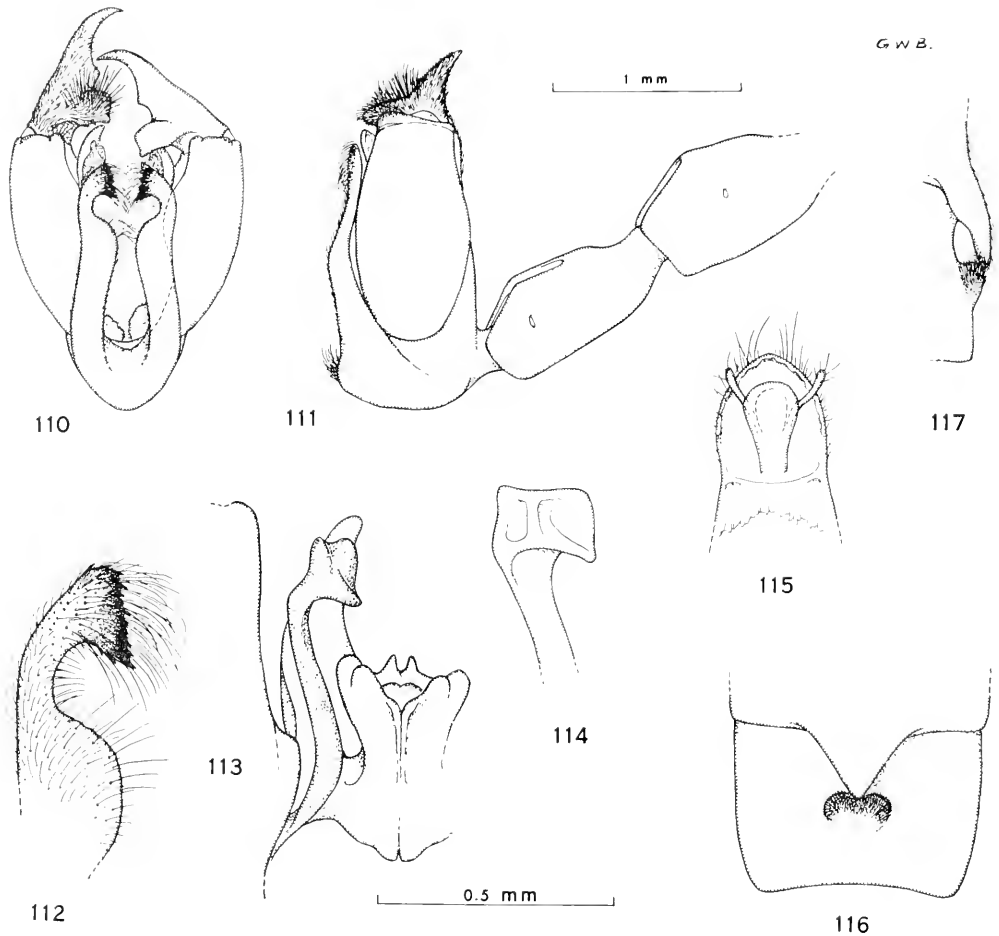
**ABDOMEN OF MALE:** Terga 2-5 blackish brown, 6 dark yellowish brown, 7-9 sordid grayish brown. Sterna 2-9 sordid grayish brown. Posterior process of third tergum (figs. 116, 117), triangular, extending across one-third to one-half length of fourth tergum. Notal process of tergum 4 with short black hairs on anterior two-thirds. Segments 7 and 8 short (fig. 111), each with a dorso-medial trough in its posterior one-half to one-third. Base of hypovalves broad, forming a U-shaped ridge, bearing blackish hairs; hypovalves sinuous (figs. 110, 112), apices with numerous small black spines and long black hairs. Basal lobe of dististyles with concave dorsal surface and long hairs on ventral, posterior surface. Ventral parameres (fig. 113) slender, wedge-shaped apices directed ventrad. Dorsal parameres short, rounded protuberances. Lateral processes of aedeagus long, concave, blade-shaped.

**FEMALE:** UNKNOWN.

**LENGTH OF FORE WING:** Male, 11.0 mm. (holotype); hind wings, 9.7-10.0 mm. (holotype, 10.0 mm.).

**HOLOTYPE:** Male, Naduvatam, Nilgiri Hills, India, 6000 feet, May 1958, P. S. Nathan. Holotype and 1 male paratopotype are in the Snow Entomological Museum.

This species can be easily recognized from other regional species by the absence of wing markings, except for a faint stigmal spot, and the narrow, sinuous hypovalves with spiny apices. The specific name (Latin *echinatus*=spiny, prickly)



FIGS. 110-117. *Neopanorpa echinata* n. sp. 110, genital bulb, male holotype, ventral aspect; 111, terminal abdominal segments, right lateral aspect; 112, tip of left hypovalve, ventral aspect (lower scale); 113, aedeagus, ventral aspect, part of right side omitted (lower scale); 114, tip of left ventral paramere, lateral aspect (lower scale); 115, ninth tergum, ventral aspect; 116, third and fourth terga, dorsal aspect; 117, third and fourth terga, left lateral aspect.

refers to the spiny apices of the hypovalves.

On the basis of the aedeagus, this species was placed in the *denticulata* species group. The lateral processes are elongated as in all the other species in this group, but the dorsal parameres of *echinata* are not fused with the lateral processes as in *denticulata* and *zebrata*. The dorsal parameres are not distinguishable in *hirsuta*. The posterior process of the third tergum of *echinata* is triangular, not narrow with subparallel sides as in the other species of

the group. The broad, thick base of the hypovalves and the ventral parameres of *echinata* are similar in appearance to those found in several species of the *appendiculata* group.

#### *Neopanorpa gibbosa* NEW SPECIES

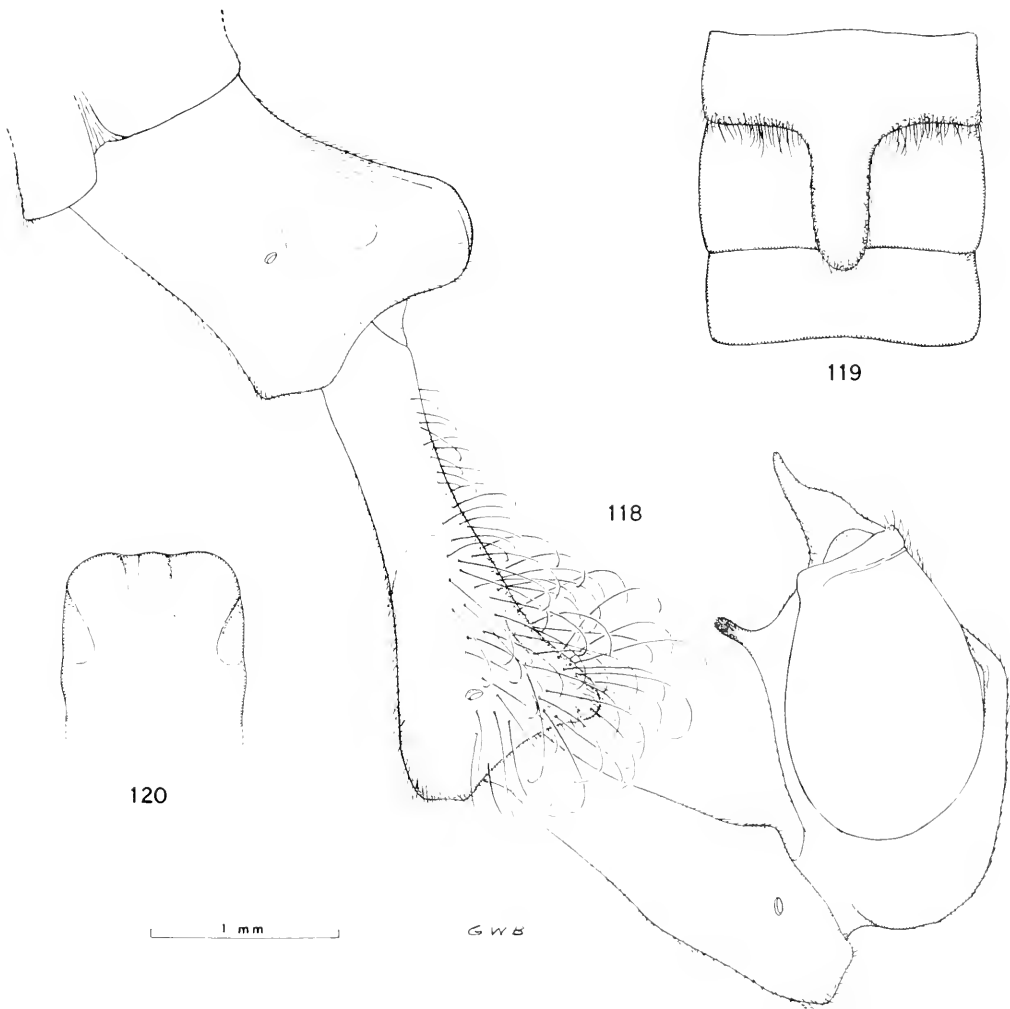
Description is based on one male, pinned.

HEAD: Vertex black, rostrum dark sordid yellowish brown, frons and antennal scape and pedicel sordid yellowish brown; antennal flagellum blackish brown, with

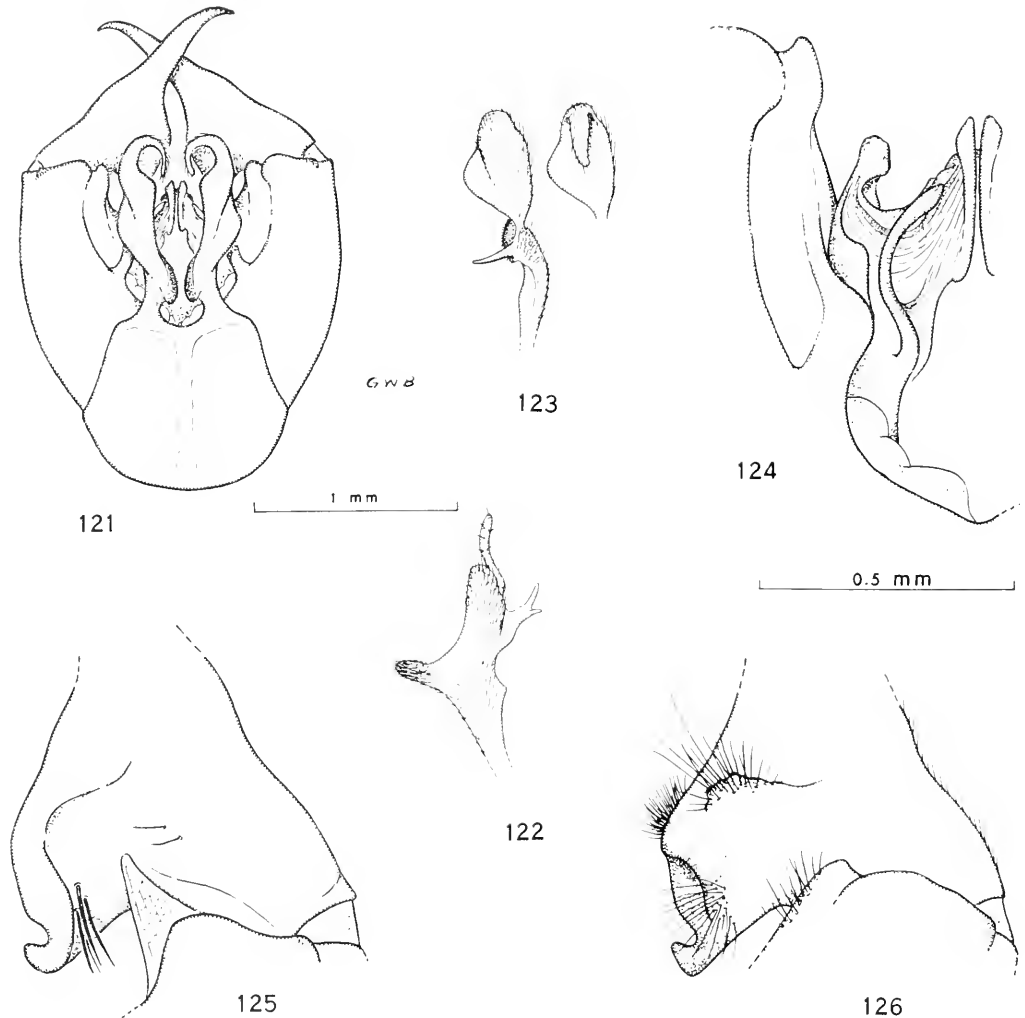
43 flagellomeres (left flagellum missing). THORAX: Pronotum blackish brown. Meso- and metanotum blackish brown (metanotum partly obscured by pin), pleural areas grayish brown. Wing membrane hyaline; longitudinal veins brownish, cross-veins brown in proximal half and pale in distal half of wing; markings light brown. Apical band complete. Pterostigmal band constricted near mid-length, forked posteriorly. Marginal spot a narrow band extending from costal margin

to basal branch of pterostigmal band. Basal band a small spot near the base of  $R_s$ . Basal spot absent.

ABDOMEN OF MALE: Terga 2-3 blackish brown, posterior margin of third tergum and base of posterior process of third tergum with long yellowish hairs, 4-9 yellowish brown. Sterna 2-9 yellowish brown. Posterior process of third tergum (fig. 119) blackish brown, curved downward on fourth tergum, extending across entire length of fourth tergum. Posterior



FIGS. 118-120. *Neopanorpa gibbosa* n. sp. 118, terminal abdominal segments, male holotype, left lateral aspect; 119, terga 3-5, dorsal aspect; 120, posterior portion of sixth abdominal segment, dorsal aspect.



FIGS. 121-126. *Neopanorpa gibbosa* n. sp. 121, genital bulb, male holotype, ventral aspect; 122, distal portion of ninth tergum, left lateral aspect; 123, left hypovalve, left lateral aspect, and apical portion (mesal aspect); 124, aedeagus, left half, ventral aspect (right scale); 125, base of left dististyle, dorsal aspect (right scale); 126, base of right dististyle, ventral aspect.

half of sixth tergum enlarged, curved dorsad into large, broad hump (figs. 118, 120). Posterior half of seventh segment somewhat enlarged with long hairs near posterior margin. Ninth tergum with a median projection extending dorsad near mid-length, with short black pilosity; apex bluntly truncate (figs. 118, 122). Basal petiole of each hypovalve with heavily sclerotized, rounded mesal projection and narrowly triangular dorsal projection; hypovalves broad, thin, laterally flattened

lobes. Inner ventral margin of basistyle forms a distinct ridge with a branch leading into interior of bulb. Basal lobe of dististyles cupped mesally, with hair-covered protuberance on posteroventral surface (fig. 126) and 3-4 thick black, dorsal spines (fig. 125). Ventral parameres of aedeagus short, slender, sinuate, convergent at apices. Ventral valves large, thin blades. Dorsal parameres, long, narrow, bluntly pointed blades.

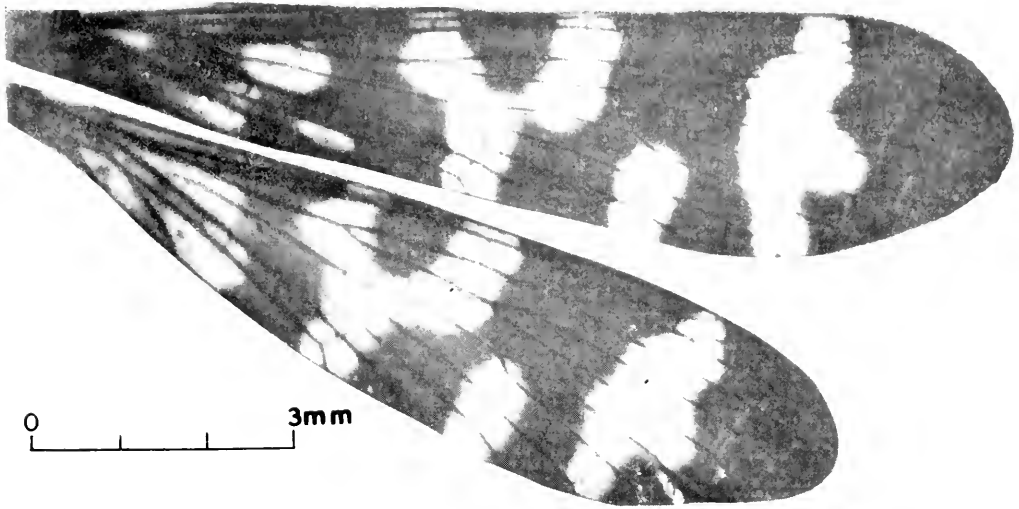


FIG. 127. *Neopanorpa indica* n. sp., male paratype, right wings (fore wing length 11.3 mm.).

LENGTH OF FORE WING: Male holotype, 12.3 mm.; hind wing, 11.0 mm.

HOLOTYPE: Male, Simla, India, from the McLachlan collection in the British Museum (Natural History), London.

On the basis of wing pattern and body coloration, the female should be recognized when discovered. The modification of the sixth tergum and the dorsal projection of the ninth tergum of the male are diagnostic of this species. The specific name (Latin *gibber*, humped, hump-backed, protuberant) refers to this modification. The projection on the ninth tergum is unique among known species of Panorpidae. *N. cornuta* and *N. furcata* have a modified sixth tergum, but in both species it is extremely different from that of *gibbosa*. The aedeagus of *gibbosa*, especially the ventral valves, is similar to that of other northern Indian and Indo-Chinese species.

#### *Neopanorpa indica* NEW SPECIES

Description is based on 14 males and 2 females, pinned.

HEAD: Vertex, rostrum, genae, and frons sordid yellowish brown. Dorsum of antennal scape yellowish brown, venter

brown; pedicel blackish brown; flagellum black with 39 flagellomeres.

THORAX: Short pilosity, no setae on anterior margin of pronotum. Dorsum sordid dark brown. Pleural areas black. Coxae and femora blackish brown, tibiae pale yellowish brown, tarsi yellowish brown grading to black on segments 3-5. Wing (fig. 127) membrane hyaline; markings smoky brown. Apical band complete with small notch on proximal margin. Pterostigmal band complete, forked posteriorly. Marginal spot large, extending from costal margin to behind  $R_{4+5}$ . Basal band complex and variable. Basal spot large.

ABDOMEN OF MALE: Terga 2-9 and corresponding sterna black. Posterior process of third tergum narrow (figs. 130, 131), extending half to three-fourths length of fourth tergum, sordid yellowish brown to dark brown, with bluntly rounded apex. Notal process of fourth tergum (fig. 130) with a tuft of short black hairs. Sternum 9 broad at base (fig. 129), forming interrupted transverse ridge. Hypovalves (fig. 129) stout, rounded basally becoming compressed laterally in distal one-third; small protuberance on mesal

margin sparsely covered with long black hairs; posteroventral edge of apex with a row of flattened black setae. Dististyles (fig. 129) about .3 of total length of genital bulb, with large basal lobes directed ventrad; apices of basal lobes bluntly rounded, dorsal surface strongly convex, covered with long, dense black hairs. Ventral parameres of aedeagus narrow, darkly sclerotized, diverging and becoming somewhat compressed laterally in distal one-fourth; apices with short white pilosity. Posterior margin of lateral process forming a thin, finger-like process. Dorsal parameres stout, apices curved mesad. Cerci short, extending to posterior margin of ninth tergum.

**ABDOMEN OF FEMALE:** Terga 2-9 and corresponding sterna black. Subgenital plate (fig. 134) broad, nearly as wide as long, with shallowly notched apex, ventral keel, and long hairs along periphery. Genital plate (figs. 132, 133) long, about 1.3 mm.; arms of distal plate twisted, slightly narrowed basally; apodemes about one-third total length of plate, diverging anteriorly, with thick interconnecting lamella.

**LENGTH OF FORE WING:** Male, 12.2-13.4 mm. (holotype, 13.4); female, 13.7-14.9 mm. (allotype, 13.7).

**HOLOTYPE:** Male, Gudalur, Nilgiri Hills, 3500 feet, September 1960, P. S. Nathan. Allotype, 3 male and 1 female paratypes. Bombay, India, date and collector unknown; in the British Museum (Natural History), London. Eight male paratypes: Nilgiri Hills, May 1954 (5 males), October 1950 (1 male), Cherangoda, 1200 m., no date (2 males), also 26 females not paratypes (same dates), in Naturhistorisches Museum, Basel. Holotype and 3 male paratypes in the Snow Entomological Museum.

In wing pattern, this species closely resembles *N. appendiculata* and *N. salai*, but it differs from those species in the

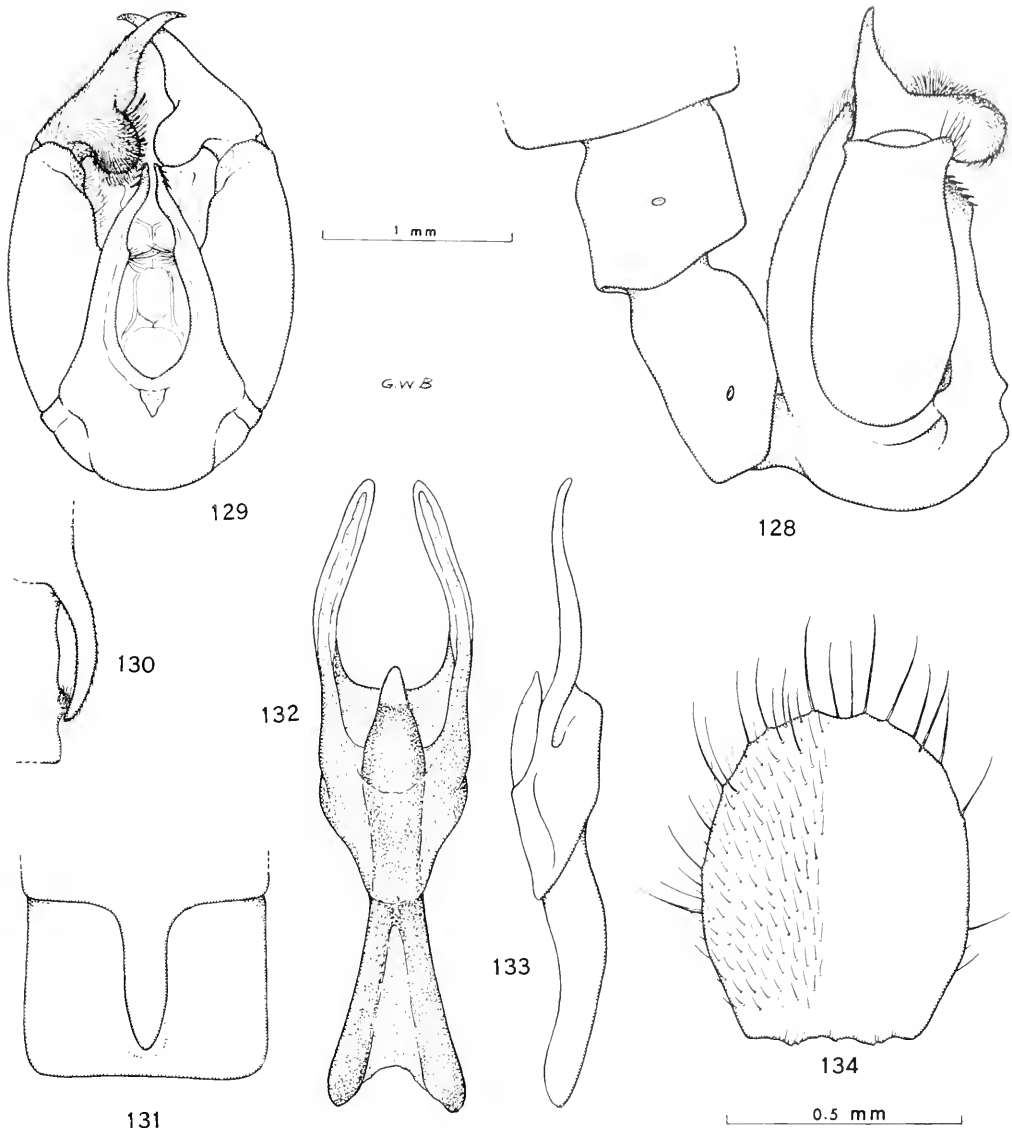
shape of the hypovalves and the posterior process of the third tergum. The mesal projection of the hypovalves is short in *indica*, not long as in *appendiculata* and *salai*. The posterior process of the third tergum in *indica* extends midway or a little more across the fourth tergum, not beyond the posterior margin of the fifth tergum as in *appendiculata* and *salai*. The position and shape of the dorsal parameres of *indica* and *appendiculata* are very similar to those of *N. burmana* Byers (1965) from Burma, especially in dorsal aspect.

The genital plates of the females of *appendiculata*, *indica*, and *salai* are similar, and these females have been identified in most cases by their association in collections with males. The heavily pigmented wing of *salai* distinguishes that species from *appendiculata* and *indica*. The relative length of the apodemes to the total genital plate length in *indica* is longer than in *appendiculata* and *salai* and may be used to separate the species.

#### *Neopanorpa ochrura* NEW SPECIES

Description based on 1 male and 1 female, pinned.

**HEAD:** Vertex black; frons black medially, sordid yellowish brown beneath antennal sockets; rostrum blackish brown with lateral margins brown (holotype) to dark sordid yellowish brown (allotype). Antennal scape and pedicel brownish black (flagella missing from both types). **THORAX:** Pronotum black. Anterior half of mesoscutum and wide median streak, including mesoscutellum, black; postero-lateral areas of mesoscutum brown. Metanotum similar to mesonotum. Pleural areas grayish brown to blackish brown. Femora, tibiae, and tarsi brownish with apices dark brown. Wing (fig. 135) membrane hyaline, markings light brown (holotype) to brown (allotype), stigma slightly darker; longitudinal veins brown, cross-veins brown in basal portion of



FIGS. 128-134. *Neopanorpa indica* n. sp. 128, terminal abdominal segments, male holotype, left lateral aspect; 129, genital bulb, holotype, ventral aspect; 130, third and fourth terga, left lateral aspect; 131, third and fourth terga, dorsal aspect; 132, genital plate, female allotype, ventral aspect (lower scale); 133, genital plate, right lateral aspect; 134, subgenital plate, ventral aspect (lower scale).

wing, pale in distal portion. Apical band complete, with several hyaline spots surrounding cross-veins, broadly joined to distal branch of pterostigmal band along hind margin. Pterostigmal band wide, forked posteriorly. Marginal spot not attaining costal margin. Basal band nearly complete.

ABDOMEN OF MALE: Terga 2-6 blackish brown, 7-9 yellow ocher. Sterna 2-5 brown, 6 blackish brown, 7-9 yellow ocher. Posterior process of third tergum (fig. 141) short, extending across one-third length of fourth tergum; pale area on fourth tergum beneath process of third. Basistyles not deeply divided. Hypovalves

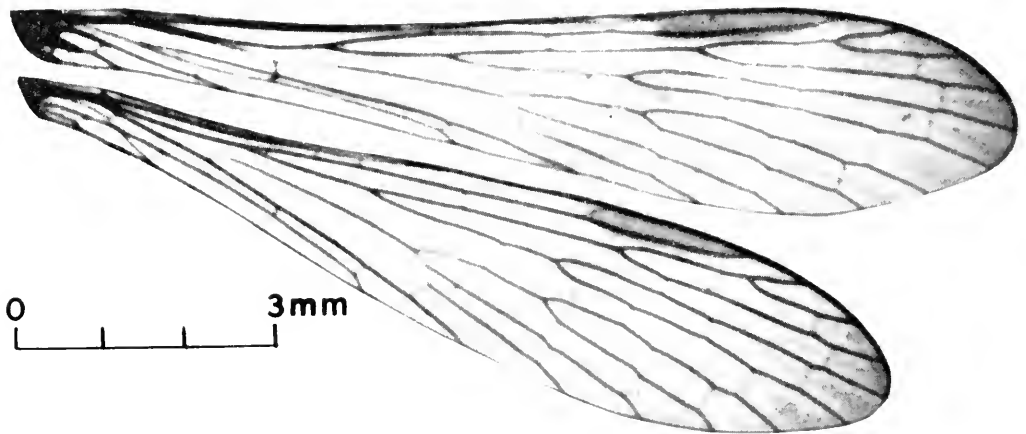


FIG. 135. *Neopanorpa ochrura* n. sp., male holotype, right wings (fore wing length 11.3 mm.).

(figs. 136, 139) narrow at base, broadest near mid-length, apices narrowed and arched ventrad. Basal lobe of dististyles (fig. 138), strongly convex on dorsomesal surface, covered with long hairs ventrally. Basal one-half of ventral parameres (fig. 138) concealed under basistyles, tips bent mesad and converging, apical one-fourth contiguous. Ventral aedeagal valves small, projected ventrad. Lateral processes short. Dorsal parameres absent.

**ABDOMEN OF FEMALE:** Terga 2-7 blackish brown, 8-10 yellow ocher, cerci black. Sterna 2-6 grayish brown, 7-8 light ocher. Apex of subgenital plate (fig. 142) deeply notched, with many long yellowish hairs along margin and at apex. Axial portion of genital plate (figs. 143, 144) about .4 of total length of genital plate, stout, about .5 width of genital plate. Distal arms of genital plate broad, spatulate, twisted at base.

**LENGTH OF FORE WING:** Male holotype, 11.3 mm.; female allotype, 11.6 mm.

**LENGTH OF HIND WING:** Male holotype, 10.0 mm.; female allotype, 10.6 mm.

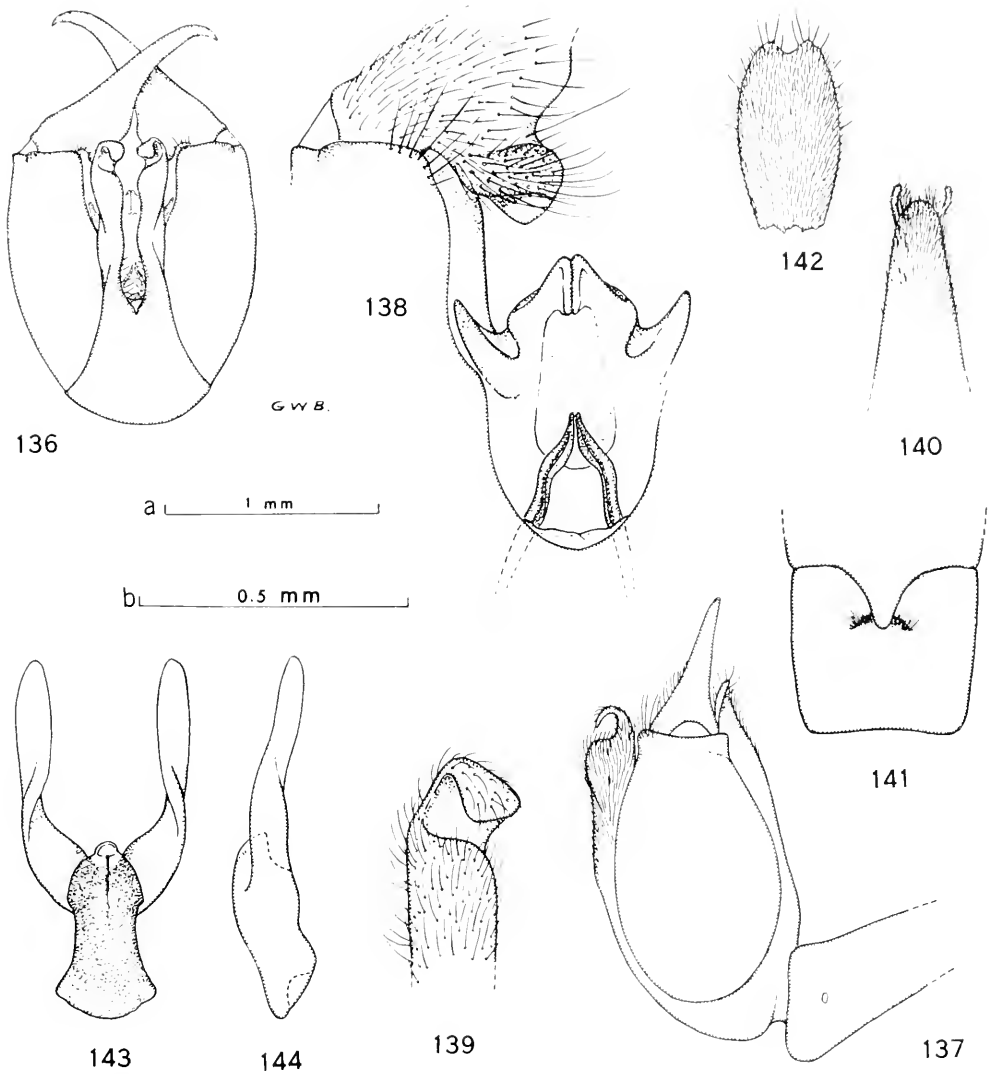
**HOLOTYPE:** Male, Simla, India, date and collector unknown. Allotype, female, same data as for holotype; both types in the British Museum (Natural History), London.

The wing pattern of this species closely resembles that of *N. cornuta*, but *ochrura* has a different color pattern on the nota and no modification of the sixth tergum in the males. The nota are especially useful in distinguishing the females of these two species. The anterior half of the mesonotum of *cornuta* is dark brown and the posterior half is yellowish, without a median blackish stripe as in *ochrura*. In *cornuta*, there is a small blackish semi-circular spot along the anterior margin of the metanotum and no median stripe as in *ochrura*.

In *ochrura*, the female genitalia, especially the genital plate, resemble those of several Indo-Chinese and northern Indian species in having large spatulate distal arms and lacking elongate apodemes. The genital plate of *ochrura* resembles that of *cornuta* but differs in being larger (about 0.7 mm.) and having a proportionately longer axial portion.

The aedeagus of *ochrura* is similar to that of many Indo-Chinese species, but the ventral parameres are much longer. The specific name (from Greek *ochra*, a yellowish brown or ochre color + *oura*, tail) refers to the color of the posterior abdominal segments in both the female and male.





FIGS. 136-144. *Neopanorpa ochruva* n. sp. 136, genital bulb, male holotype, ventral aspect; 137, genital bulb, right lateral aspect; 138, aedeagus and base of left dististyle, ventral aspect; 139, tip of left hypovalve, ventral aspect; 140, ninth tergum, dorsal aspect; 141, third and fourth terga, dorsal aspect; 142, subgenital plate, female, ventral aspect; 143, genital plate, ventral aspect; 144, genital plate, right lateral aspect. Scale a—figs. 136, 137, 140-142; b—figs. 138, 139, 143, 144.

*Neopanorpa ramulata* BYERS

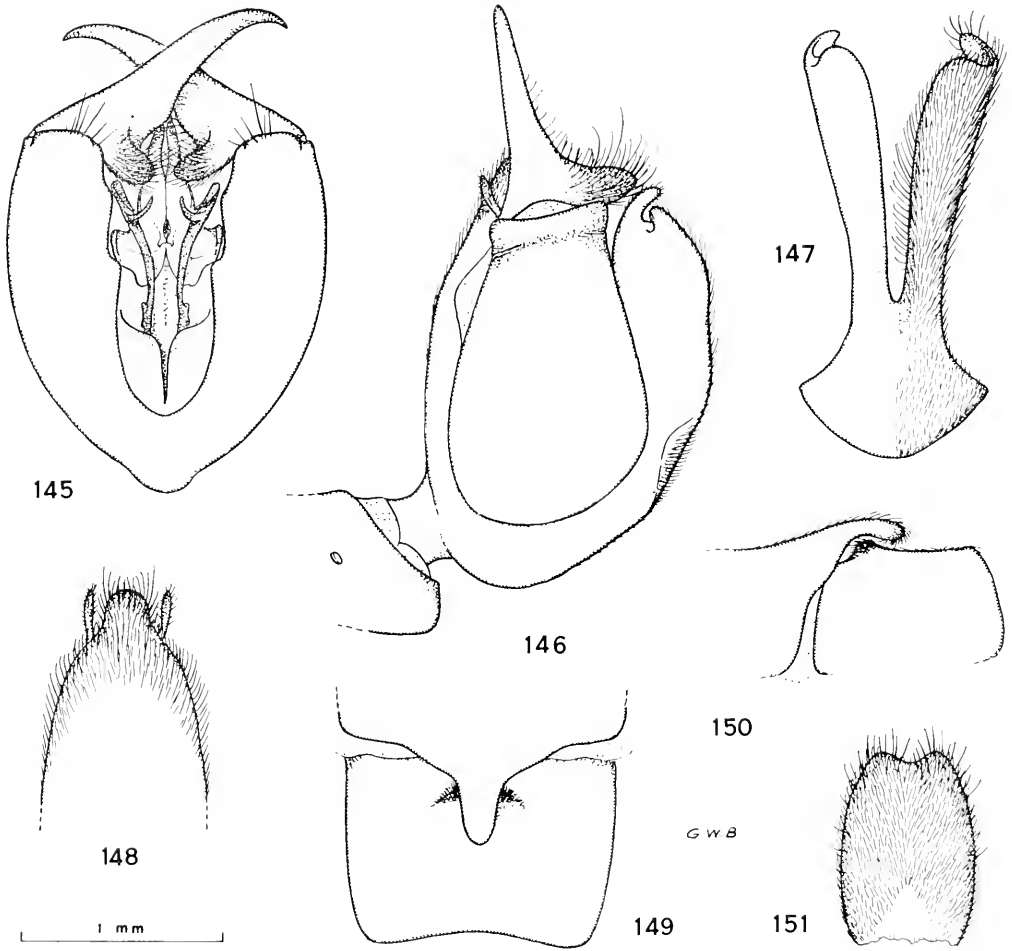
*Neopanorpa ramulata* Byers, 1975: 87-91, figs. 1-11.

Since this species from Bhutan was recently described, only its more important and diagnostic characteristics are re-described here, to permit comparison with other regional species. The following

paragraphs are based upon the original description:

HEAD: Dorsum shiny black, rostrum pale brown with two diffuse longitudinal stripes. Antennae about 14 mm. long in male, 12 mm. in female, with 47-48 flagellomeres.

THORAX: Pronotum dark brownish black throughout, with only very short hairs



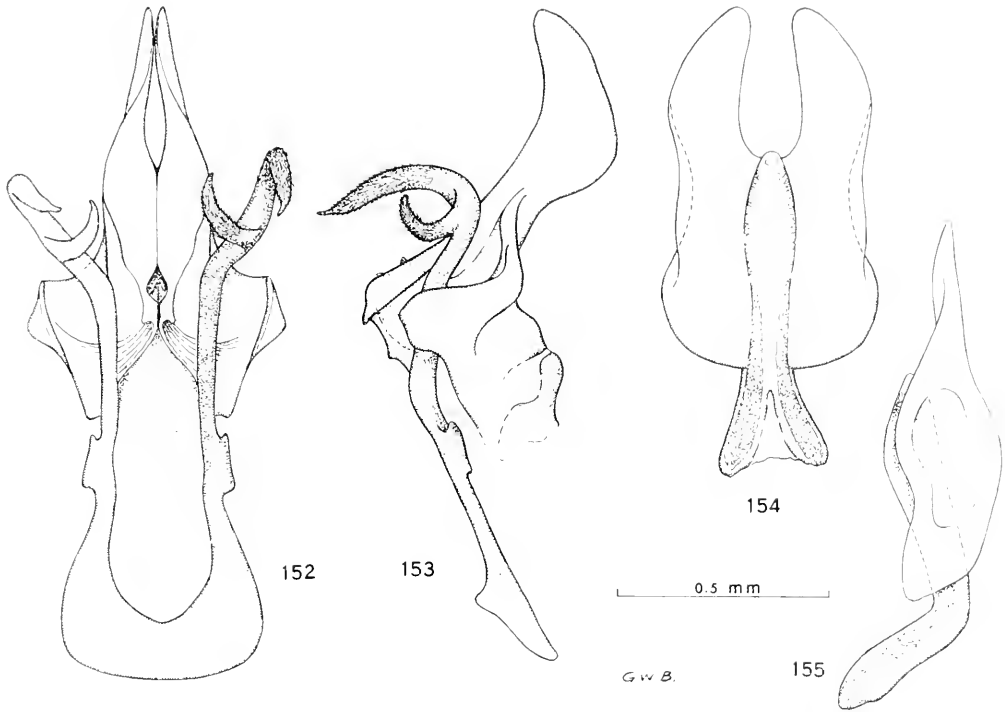
FIGS. 145-151. *Neopanorpa ramulata* Byers. 145, genital bulb, male paratype, ventral aspect, hypovalves removed; 146, genital bulb, male holotype, left lateral aspect; 147, hypovalves, male paratype, ventral aspect; 148, apex of ninth tergum, paratype, dorsal aspect; 149, third and fourth terga, dorsal aspect; 150, third and fourth terga, left lateral aspect; 151, subgenital plate, female allotype, ventral aspect.

on anterior margin. Mesonotum and metanotum dark brownish black on anterior half, along mid-line and on scutellum; dark yellowish brown spot adjacent to each wing base.

WINGS: Lightly tinged with brown; bands and spots light to dark smoky brown. Apical band darkest anteriorly, fading or absent behind vein  $R_5$ . Pterostigmal band nearly black over stigma, entire and forked, the branches fading toward posterior edge of wing. Marginal spot from

near C to slightly behind  $R_{4+5}$ . Basal band absent, or rarely faintly indicated by diffuse spots.

ABDOMEN OF MALE: Terga 1-5 black, segment 6 dark brown anteriorly, yellowish brown on posterior one-third, segments 6-9 yellowish brown except dististyles dark brown. Posterior process of third tergum (figs. 149, 150) broad at base, slender and curved downward apically. Hypovalves (figs. 146, 147) somewhat rolled, convex ventrolaterally, concave



FIGS. 152-155. *Neopanorpa ramulata* Byers. 152, aedeagus, male paratype, ventral aspect; 153, aedeagus, right lateral aspect; 154, genital plate, female allotype, ventral aspect; 155, genital plate, right lateral aspect.

mesally, pale at tips, with lateral apical corner slightly extended and curled over ventral apex (fig. 146). Tergum 9 (fig. 148) narrowed and rounded at apex. Outer margins of dististyles slightly concave near mid-length (fig. 145); basal lobe of each dististyle prolonged ventrad, rounded and somewhat flattened, bearing numerous long hairs. Ventral parameres elongate, slender, darkly sclerotized, forked near apex, one branch curving ventrad, the other caudad, both covered with fine, short hairs (figs. 152, 153). Dorsal parameres greatly enlarged, expanded dorsad and caudad as subparallel pale blades. ABDOMEN OF FEMALE: Terga 1-5 black, 6 dark brown, 7-9 yellowish brown, cerci black. Subgenital plate (fig. 151) slightly narrowed toward apex, broadly and shallowly notched at tip. Genital plate (figs. 154, 155) weakly sclerotized, with elongate anterior apodemes strongly deflected ventrad.

LENGTH OF FORE WING: Male, 15.2-15.8 mm., female 14.2-15.0 mm.

HOLOTYPE: Male, Tongsa (Tongsa Dzong, 27°33'N, 90°30'E), Bhutan, 2150 m., 24 June 1972, Naturhistorisches Museum Basel Bhutan Expedition. Allotype and 1 female paratype, same data as for holotype. One male, 1 female paratypes, Changra, 18 km. south of Tongsa, 1900 m., 22 June 1972. Holotype, allotype and 1 female paratype in Naturhistorisches Museum, Basel; 1 male, 1 female paratypes in Snow Entomological Museum, University of Kansas.

*Neopanorpa ramulata* resembles *N. chillcotti* Byers and *N. nipalica* (Navás) in having slender ventral parameres and conspicuously developed dorsal parameres, in the male, and in the female a large genital plate, the axial portion of which is strongly sclerotized and bears divergent anterior apodemes. From these species, males of *ramulata* may be differentiated

by the peculiar, antler-like branched ventral parameres, by the shape of the hypovalves, and shape of the basal lobe of the dististyles. In aedeagal structure of males and genital plate of females, *ramulata* approaches some species of *Panorpa*.

#### SPECIES OF NEOPANORPA NOT DESCRIBED

Since most of the reliable taxonomic characters in females are on the subgenital and genital plates, dissections are usually necessary to identify species, especially to differentiate those having similar wing patterns. On the other hand, males have several excellent external taxonomic structures. Association of males and females of a species has been based mainly on body coloration, wing pattern, body size, and date and place of collection.

Six female specimens, probably representing four new species, were not described because of lack of associated males. Two males, probably representing two additional new species, were not described because they were so badly damaged. Following is a summary of information concerning these specimens:

Two large-winged female specimens from Nepal externally resemble *N. furcata*, but the genital plates and color pattern of the thorax differ from those of *furcata*. These two females are in the collection of Canada Department of Agriculture.

One badly damaged male specimen (missing genital bulb) from Darjeeling, India, generally resembles *N. nipalica*. Another male from Darjeeling (missing hypovalves) has distinctly shaped dististyles. Both males are in the Illinois Natural History Survey collection.

One female from India (no more detailed locality) resembles *N. effusa* but is smaller than *effusa* (wings about 14 mm.). It is in the British Museum (Natural History).

One female specimen from Chinchona,

Anaimalai Hills, southern India, resembles *N. appendiculata*, but the basal half of the wing is much paler. This specimen is in Snow Entomological Museum.

Two additional females from Changra, Bhutan, somewhat resemble *N. ramulata* but have yellow-tinged wings with more extensive markings and reduced genital plate more typical of other Neopanorpas of the Himalayan region. For further details, see Byers (1975).

#### DESCRIPTIONS OF SPECIES: GENUS *Panorpa*

##### *Panorpa davidi* NAVÁS

*Panorpa davidi* Navás, 1908: 415.

Originally *P. davidi* was described from one male and one female. The female syntype is now the holotype of *P. guttata*. The distinctive apical, pterostigmal, and incomplete basal bands may allow recognition of the female when discovered. Rarely is body coloration helpful in the recognition of a species, but the blackish head with reddish brown rostrum in *davidi*, and the blackish thorax with a reddish brown median streak, may be diagnostic.

The original label on the holotype reads "David, Moupin, Thibet," and a later one "Museum Paris, Mou-Pin, A. David 1870." Since 1908, the borders of Tibet have shifted westward from about 102° E to their present position, about 95° E. No such locality as Mou-Pin appears in detailed gazetteers of Tibet proper, today, but in southwestern Szechwan, at 28° 48' N, 103° 39' E, about 50 kilometers east of the 1908 Tibetan border, there is the town of Mapien, whose pronunciation would resemble that of "Mou-Pin" in French. At an elevation of 2000 feet, it is in a more likely habitat for *Panorpa* than the higher, colder regions in modern Tibet.

Esben-Petersen (1921), illustrated in the ventral aspect of the genital bulb, two separate appendages between the ventral

parameres. These, however, are merely basal thickenings of the ventral parameres. The following redescription is based in part on drawings of the holotype:

HEAD: Dorsum black, rostrum reddish brown. Antennal scape and pedicel reddish brown; both flagella missing.

THORAX: Dorsum black, with longitu-

dinal median reddish streak; pleural areas black. Legs testaceous. Wing membrane with a faint yellowish tinge; longitudinal veins brownish; cross-veins in apical portion pale. Apical band incomplete, ending at margin between  $R_5$  and  $M_1$ ; large spot extending from hind margin to cell  $R_5$  (fore wing only). Pterostigmal band con-

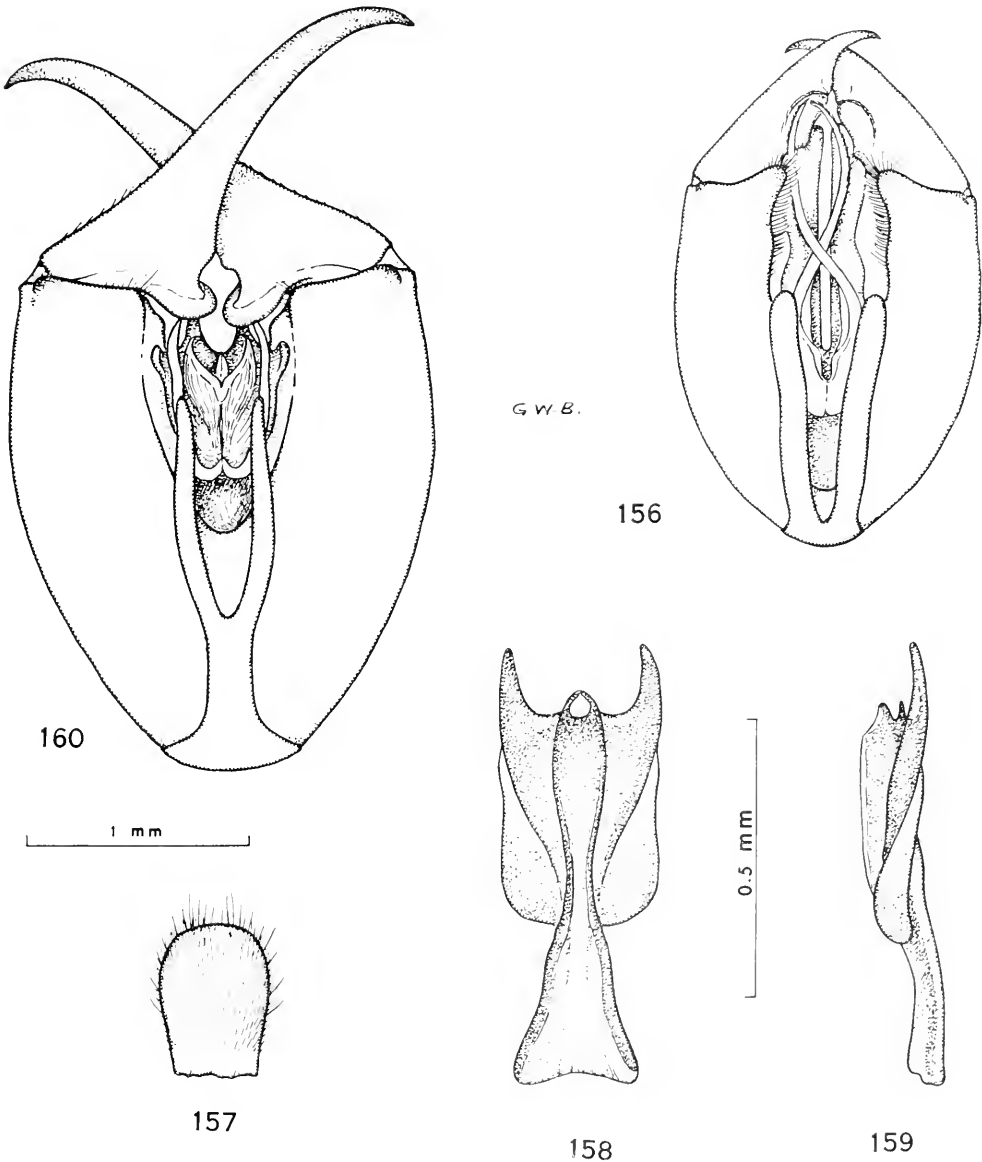


FIG. 156. *Panorpa darvii* Navás, male holotype, genital bulb, ventral aspect. FIGS. 157-159. *Panorpa guttata* Navás, 157, subgenital plate, female holotype, ventral aspect; 158, genital plate, ventral aspect (vertical scale); 159, genital plate, right lateral aspect. FIG. 160. *Panorpa stigmalis* Navás, male holotype, genital bulb, ventral aspect.

tinuous, diagonal, not forked; distal branch not present. Marginal spot absent. Basal band incomplete, comprising three spots.

**ABDOMEN OF MALE:** Terga and sterna 2-6 black, 7-9 testaceous. Virtually no modification of terga 3-4 (i.e., notal organ poorly developed). No anal horn on sixth tergum. Basistyles (fig. 156) deeply separated ventrally; distal mesal margin of each with dense fringe of hairs. Dististyles slightly more than half length of basistyles; basal "lobe" shallowly cup-shaped, one-half length of inner margin of dististyle. Hypovalves narrow, strap-like, with rounded apices; extending to about two-thirds length of basistyles. Ventral parameres long, thick at base but tapering to sharp tips, setose on outer margins, extending to distal ridge of basal concavity of dististyle, sinuate, crossing near mid-length. Dorsal parameres thin, flattened dorsoventrally, strap-like, extending beyond bases of dististyles.

**FEMALE:** UNKNOWN.

**LENGTH OF FORE WING:** Male holotype, 13 mm.; hind wing 11.5 mm.

**HOLOTYPE:** Male, Mou-Pin, Thibet (Tibet), 1870, A. David; in the Museum National d'Histoire Naturelle, Paris.

Cheng (1957) based the *dauidi* group, in which there is no anal horn on the sixth abdominal segment, on this species. The structure of the genital bulb, however, is not similar to that of any other species assigned to this group. According to Cheng (1957), the wing markings resemble those of *P. chenii* Cheng from Chekiang, China; but the genital bulbs of these two species are quite different. Several Chinese species have extremely elongate dorsal parameres, especially *P. waongkehzenqi* Cheng from Kiangsi, China. The dorsal parameres in that species are somewhat similar to those of *dauidi*, but the ventral parameres and hypovalves are much shorter in *waongkehzenqi*.

Unfortunately, 12 Chinese species are

known only from their female holotypes. Eight of these can be eliminated from consideration as the possible female of *dauidi* because they have forked pterostigmal bands, and several of them also have basal spots. The pattern of the wings of *P. leei* Cheng and *P. semifasciata* Cheng is similar to that of *dauidi* but differs in having the apical band somewhat reduced and the basal band absent. From the original description (Cheng, 1957), it seems that *P. grahamana* Cheng and *P. carpenteri* Cheng have wing patterns nearly identical to that of *dauidi*. The wing membrane in these two females is hyaline, not with a faint yellowish tinge as in *dauidi*. Due to a somewhat vague description of overall body coloration of these two females, it is impossible to compare them accurately with the male type of *dauidi*.

Cheng (1957) states that the only differences between *grahamana* and *carpenteri* are the coloration of the rostrum and the bent apices of the two distinct apodemes of the genital plate of *carpenteri*. Future investigation may indicate that these two nominal species, both collected in Szechwan, are synonymous. And we think there is some likelihood that both are synonyms of *dauidi*.

*Panorpa guttata* Navás

*Panorpa guttata* Navás, 1908: 416.

*Panorpa dauidi* Navás, 1908: 415 (in part).

Navás originally described the holotype of *guttata* as the female of *P. dauidi* (1908). In his closing statements, he suggested that the female be called *guttata* if the differences in the wing markings were significant; therefore, Esben-Petersen (1915) recognized the female as the holotype of *guttata*. The indistinct apical and pterostigmal bands of *guttata* differ from those of *dauidi* in being paler in color and much smaller. In *guttata*, the thorax and abdomen are grayish brown, not reddish brown and black as in *dauidi*.

The locality data on the original label are the same as for *P. davidi*: Mou-Pin, Tibet (see *P. davidi* for discussion). The following redescription is based on previous descriptions and on notes and drawings of the holotype:

**HEAD:** Dorsum and rostrum grayish brown, except ocelli on blackened prominence. Antennal scape grayish brown, pedicel brownish black; flagellum pale grayish brown grading to dark brown towards apex.

**THORAX:** Dorsum pale brown, pleural regions pale grayish yellow. Legs brownish yellow, except apices of tibiae and tarsomeres brown. Wing membrane hyaline with a faint yellowish tinge, longitudinal veins brownish. Apical band incomplete, reduced to several spots in front wings. Pterostigma yellowish; pterostigmal band incomplete.

**ABDOMEN OF FEMALE:** Terga and sterna pale yellowish brown. Blackish pigmented spot on each side of basal part of eighth sternum. Subgenital plate evenly rounded at apex, with numerous long hairs on margin (fig. 157). Arms of genital plate (figs. 158, 159) short, slightly longer than one-sixth of total length; basal plate large; apodemes long, projecting cephalad about two-fifths of total length of plate, divergent from anterior edge of basal plate but connected by pale, sclerotized lamella.

**MALE:** UNKNOWN.

**LENGTH OF FORE WING:** Female holotype, 12 mm.; hind wing 11 mm.

**HOLOTYPE:** Female, Mou-Pin, Thibet, 1870, A. David; in the Museum National d'Histoire Naturelle, Paris.

Nine species of Chinese *Panorpa* are known only from male holotypes. They differ from *guttata* in having darkly colored thoracic and abdominal sclerites and more extensive markings on the wings, except for *P. obtusa* Cheng. The color pattern of the wings of *obtusa* resembles that of *guttata*, but the stigma is grayish

brown, not with a yellowish tinge as in *guttata*.

Cheng (1957) was unable to assign *guttata* to any one of his groups of Chinese *Panorpa*. He noted similarities in the pterostigmal band and differences in the apical band between *guttata* and *P. tjederi* Carpenter from Yunnan. Comparison of the subgenital and genital plates of these two species indicates no particular relationship of *guttata* with the *dicerus* group to which *tjederi* belongs. The genitalia of *guttata* resemble those of the *centralis* group, especially *P. leei* Cheng and *P. emarginata* Cheng. But the genital plate of *guttata* also resembles that of some eastern North American species in having a sclerotized lamella between the apodemes and the basal and distal plates broad.

#### *Panorpa stigmalis* Navás

*Panorpa stigmalis* Navás, 1908: 416, fig. 20.

When Byers examined the probable male holotype in 1964, it did not have a type label. The labels read "Museum Paris, Mou-Pin, A. David 1870," "*Panorpa stigmalis* Navás," and "*Panorpa stigmalis* Navás, Longin Navás det. 1907." Since there was no mention of any other specimen in the original description, this male may be regarded as the holotype, and a label reading "probably holotype, G. W. Byers '64" was added. Cheng (1957) stated the type locality of *stigmalis* to be Mou-Pin, Sikang. The collecting labels are the same as those of *P. davidi* and *P. guttata*, except in the latter two species the type locality is Mou-Pin, Tibet (see *P. davidi* for complete discussion).

Esben-Petersen's redescription (1921) is adequate; however, he did not present any additional information concerning the genitalial characters. The following redescription is based in part on notes and a drawing of the holotype:

**HEAD:** Dorsum and rostrum brown, ocelli enclosed by blackish spot. Antennal scape and pedicel brown; flagellum brown grad-

ing to dark brown at apex, with 42 flagellomeres.

**THORAX:** Dorsum, pleural areas, and coxae black. Femora, tibiae, and tarsi brown; apices of tarsi blackish. Wings long and narrow, membrane with sordid yellowish tinge; bands and spot smoky brown, stigma red. Longitudinal veins yellowish brown. Apical band complete but ending on outer margin at  $M_1$ . Pterostigmal band narrowly connected to apical band along costal margin. Marginal spot absent. Faint spot extending from  $M_3$  to hind margin (fore wings only). A narrow band extending from  $Cu_1$  to hind margin (fore wings only).

**ABDOMEN OF MALE:** Terga 2-3 black, 4-9 reddish brown. Sternum 2 black, sterna 3-9 reddish brown. Posterior process of third tergum two-thirds length of fourth tergum. Hairs on dorsal and ventral posterior margins of sixth segment twice as long as other pilosity. Apex of tergum 9 bearing a pair of lobes. Basistyles (fig. 160) separated only to about mid-length, with sharp ridge along ventral mesal margins of each. Hypovalves short, narrow, strap-like, borne on slender pedicel. Basal lobes of dististyles (fig. 160) rounded, with thickened edge, not noticeably cupped on inner surfaces. Ventral parameres slender, slightly curved mesad at apices. Dorsal parameres elongate, extending between dististyles; lateral processes short, fully exposed in ventral aspect.

**FEMALE:** Unknown.

**LENGTH OF FORE WING:** Male holotype, 17.4 mm.; hind wing 16.0 mm.

**HOLOTYPE:** Male, Mou-Pin, 1870, A. David; in the Museum National d'histoire Naturelle, Paris.

The sordid yellowish wing membrane and distinctly red stigmal spot should allow recognition of the female when discovered. In addition, such body coloration as the solidly black thorax and the black and reddish brown abdomen may prove

helpful. The absence of the anal horn from the sixth abdominal segment of the male places *stigmalis* in the *dauidi* group as defined by Cheng (1957). The narrow hypovalves, simple aedeagus, and the hairs on the sixth segment separate *stigmalis* from the other members of this group.

Cheng (1957) noted the similarity of the genital bulb (hypovalves) of *stigmalis* to those of the *kongosana* group of Korea but also the differences in the wing markings. The illustrations of *P. kongosana* by Okamoto (1925) are not usefully detailed; the hypovalves of *kongosana* are similar to those of *stigmalis* but somewhat longer.

#### LOCALITIES AND HABITATS OF MECOPTERA IN THE INDIAN SUBCONTINENT

Previously published distributional information has usually consisted of locality name, date and occasionally elevation. To aid in the location of collection localities, we have included the name of the state, district, and geographic coordinates. Since we found no detailed gazetteers of India, it was necessary to estimate the coordinates of several localities. Names of localities are in alphabetical order, and other data appear in the following sequence:

1. Name of locality from pin label.
2. Synonyms or variant spellings of name, in parentheses.
3. State, district, and country if all pertain to locality.
4. Geographic coordinates of locality. There may be a slight difference between the site used for identification and actual collecting site.
5. Elevation, if known. Elevation derived from maps are stated as ranges.
6. Reference for locality data, if previously published.

Anaimalai Hills (Anamalai Hills), Kerala and Madras, India; about  $10^{\circ}15'$  N,  $77^{\circ}00'$  E; 1950-5750 feet (600-1750 m.).



Bombay, Maharashtra, India; about 18°56' N, 72°51' E; 0-330 feet (0-100 m.).

Changra (village 18 km. S of Tongsa), Bhutan; 1900 m.; (Byers, 1975).

Chembra Peak, Kerala State, India; summit 3500 feet (1070 m.).

Chinchona, Kerala, Anaimalai Hills, India; 10°22' N, 77°55' E; 3500 feet (1070 m.).

Coimbatore, Madras, India; 11°00' N, 76°58' E; 1400 feet (430 m.).

Darjeeling, West Bengal, India; 27°05' N, 88°16' E; 6500 feet (1980 m.); (Cheng, 1953).

Deesa, Gujarat, India; 24°14' N, 72°13' E; 330-660 feet (100-200 m.).

Devala, Madras, India; 11°29' N, 76°22' E; 3500 feet (1070 m.).

Godavari (a village 10 mi. SE of Katmandu), Nepal; about 27°45' N, 85°19' E; 5000 feet (1530 m.); (Byers, 1971).

Gudalur (in Nilgiri Hills), Madras, India; 11°30' N, 76°30' E; 3200 feet (975 m.).

Hambantota, Hambantota Dist., Ceylon; 6°15' N, 81°16' E; 100-150 feet (30-45 m.), numerous forests in surrounding area.

Igatpuri, Maharashtra, India; 19°41' N, 73°38' E; about 1640-3280 feet (500-1000 m.).

Karachi, Pakistan; 24°52' N, 67°03' E; 0-330 feet (0-100 m.).

Katmandu, Nepal; 27°45' N, 85°19' E; 5000-6000 feet (1520-1830 m.).

Khandala, Maharashtra, India; 18°45' N, 73°25' E; 660-3280 feet (200-1000 m.); (Navás, 1928).

Khasi Hills (N. Khasia), Assam, India; about 25°30' N, 93°00' E; 5000 feet (1520 m.); (Needham, 1909).

Kurseong, Bihar, India; 26°52' N, 88°17' E; 4860 feet (1480 m.).

Ma-pien (Mou-Pin), Szechwan, China; 28°48' N, 103°39' E; 3280-4920 feet (1000-1500 m.); there are a river and a town by the same name; (Navás, 1908).

Muthikolam, Coimbatore Dist., India; no additional data.

Naduvatam (in Nilgiri Hills), Madras, India; 11°30' N, 76°34' E; 6000 feet (1830 m.).

Naga Hills, Assam, India; about 26°00' N, 94°30' E; 3000-12000 feet (910-3660 m.).

Nagarkot, Nepal; 27°42' N, 85°31' E; 7000 feet (2130 m.).

Nainital, Uttar Pradesh, India; 29°23' N, 79°30' E; 4920-6560 feet (2000-3000 m.); (Penny, 1969).

Naraikadu, Tinnevely Dist., India; 2500-3000 feet (760-910 m.).

Nilgiri Hills, Madras, India; 11°30' N, 76°30' E; summits up to 8650 feet (2640 m.).

Peermade (Pirmed), Kerala, India; 9°31' N, 77°02' E; 3400 feet (1040 m.).

Periyar Dam, Kerala, India; 9°30' N, 72°20' E; approximately 1075 m.

Pondicherry, Madras, India; 11°59' N, 79°50' E; 0-330 feet (0-100 m.).

Shillong, Assam, India; 25°34' N, 91°53' E; 5000 feet (1520 m.).

Simla, Himachal Pradesh, India; 31°07' N, 77°09' E; 6560-9840 feet (2000-3000 m.).

Simra, Nepal; 27°37' N, 84°16' E; 330-660 feet (100-200 m.).

Thanikudi, Kerala, India; 9°30' N, 77°16' E; town in valley, surrounding hills 4000 feet.

Tongsa (Tongsa Dzong), Bhutan; 27°33' N, 90°30' E; 2150 m.; (Byers, 1975).

Vavuniya, Vavuniya Dist., Ceylon; 8°45' N, 80°30' E; 200-600 feet (60-180 m.).

Walayar Forest, Kerala, India; about 10°48' N, 76°48' E; about 700 feet (215 m.).

Wattegama, Monaragala Dist., Ceylon; 6°48' N, 81°30' E; 0-330 feet (0-100 m.).

Yala, Yala Dist., Ceylon; 6°22' N, 81°31' E; town is on coast, many small forest reserves nearby inland.

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