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THE AMBLYCERAN MALLOPHAGA (BITING LICE) FOUND ON THE BUCEROTIDAE (HORNBILLS)

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THE AMBLYCERAN MALLOPHAGA (BITING LICE) FOUND ON THE BUCEROTIDAE (HORNBILLS)

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THE AMBLYCERAN MALLOPHAGA (BITING LICE) FOUND ON THE BUCEROTIDAE (HORNBILLS)

INTRODUCTION

Mallophaga of the genera Chapinia and Bucerophagus of the amblyceran family Menoponidae are found only on Hornbills. The purpose of this paper is to redescribe and illustrate the known species in these genera, describe new species encountered, and compare the classification of these lice with that of the Hornbills. Menoponidae have been examined from 50 species or subspecies of Hornbills (see Table 13). Presented are descriptions and illustrations of 16 species of Chapinia of which 11 are new, three species of Bucerophagus, and two new species in a new genus, Bucerocolpocephalum.

No previous attempt has been made to examine all the Menoponidae from the Hornbills. Clay (1947) included Chapinia and Bucerophagus in her key to the genera of the Menoponidae, but her figures 8 and 9 of the antennae of these genera were accidently transposed. The genus Chapinia was described by Ewing (1927) for his species C. robusta; and later by Bedford (1930) for Menopon bucerotis Kellogg, 1908 and M. lophocerus Bedford, 1920. Hopkins and Clay (1952) included in the genus Chapinia the additional species, Colpocephalum hirtum Rudow, 1866, Menopon acutovulvatum Piaget, 1881, and Allomenopon mjöbergi Eichler, 1947; but they considered the generic position of C. hirtum doubtful. In the present study C. hirtum is

shown to be a Chapinia, and a neotype is designated; A. mjöbergi is shown to be a synonym of M. acutovulvatum. Hopkins (1941) designated a lectotype for Chapinia lophocerus (Bedford), Clay (1949 a) designated a lectotype for C. acutovulvata (Piaget), and a lectotype is designated here for C. bucerotis (Kellogg). Piaget (1880) identified a female from Rhyticeros cassidix (Temminck, 1823) as C. hirtum, but Piaget's specimen is shown here to be the new species Chapinia lydae. The genus Bucerophagus was described by Bedford (1929) for his species B. africanus and for Colpocephalum productum Burmeister, 1838. For the latter species a neotype was erected by Conci (1950), and a lectotype was designated by Clay (1951 a). Eichler (1947) described a new genus for Menopon forcipatum Nitzsch, 1874; but Hopkins and Clay (1952) put M. forcipatum in the genus Bucerophagus. A neotype for B. forcipatus (Nitzsch) is designated here from Eichler's material. Clay (1951 a) stated that Bucerophagus africanus and B. productus both infest the two hosts, Bucorvus abyssinicus (Boddaert, 1783) and B. leadbeateri (Vigors, 1825). No morphological or statistical means were found in the present study to separate the populations of each species on each host so that only one species of Bucerophagus productus and one species of B. africanus can be recognized. Similarly, Clay (1955) recognized only one species of Bucorvellus docophorus from these two hosts.

The phylogenetic arrangement of the Hornbills (Peters, 1945) shows scant regard for the geographical regions, and the list winds back and forth between the Ethiopian, Oriental, and Australasian Regions. (see Table 13). However, the mallophagan genera studied here fall into definite species-groups confined to the Ethiopian Region or to the Oriental and Australasian Regions. It is believed, therefore, that the arrangement of

the Mallophaga gives more insight into the origin of the Hornbills than study of the host skins.

Classification of the hosts is that proposed by Deignan (1963) except for species not discussed by him for which Peters (1945) has been followed. Skins of the hosts collected in Thailand are in the United States National Museum and were identified by Mr. H. G. Deignan. Collections were made possible by assistance from the U. S. Operations Mission to Thailand and the USNM.

EXPLANATION OF TERMS AND ABBREVIATIONS

The terminology used in this paper agrees with that of Clay (1947) except as noted below.

1. Combs of setae are rows of short stout setae, each with the alveoli lying close together and approximately in a straight line, on the venter of the third femora and the posterolateral areas of one or more abdominal sternites (see Figs. 64-65).

2. Brushes of setae are concentrations of setae on the venter of the third femora and the posterolateral areas of one or more abdominal sternites. These may take the form of a few widely spaced setae called small scattered brushes (see Figs. 23-24), or a large number of closely set setae called large thick brushes (see Figs. 68-69). The setae of the brushes are normal if approximately the same length and thickness as the surrounding setae, or small if the majority are considerably smaller than the surrounding setae.

3. The preocular slit is an emargination with approximately equal and parallel margins in the dorsal-lateral margin of the head immediately anterior to the eye (see Figs. 23-24).

4. The preocular notch is a similar emargination with triangular or semi-circular margins (see Figs. 25-26, 64-69).

5. The metasternal plate on the metasternum was first described by

Bedford (1920) as a four-sided plate which was normally expanded anteriorly (see Figs. 26 c, 64 c, 66 c, 68 c, and 70).

6. The male and female each possess a complete complement of abdominal segments from the first to the tenth (Cope, 1941).

7. The pleurites (paratergal plates of some authors) are sclerites which pass around the lateral margin of the abdomen, and are separated from the tergites and sternites by clear divisions (Clay, 1954) (see Figs. 23-24).

8. The post-spiracular seta on each side of abdominal tergites III-VIII is posterior to the spiracle; and is always associated with two small setae, the alveoli of the three setae being contiguous (Clay, 1954). A similar group of three setae is present on abdominal tergite II although there is no functional spiracle on this tergite. In most Amblycera the post-spiracular setae are the most laterad setae of the posterior marginal row (see Fig. 25 p).

9. The male terminal abdominal tergites, IX and X, are almost completely fused. Abdominal sternite VIII is fragmented into two parts which have moved laterad. Abdominal sternite IX strengthens the anterior lip of the genital and anal opening (cloaca), and there is no apparent tenth sternite (Cope, 1941).

10. The basal plate (basal apodeme of Clay, 1956) of the male genitalia supports posteriorly the slender parameres laterally and the endomeres centrally (Ewing, 1927).

11. The sclerite of the male genital sac is the sclerite on the walls of the genital sac which is articulated to the basal plate (Clay, 1956)

(see Figs. 18-19, s).

12. The lateral horns of the male genitalia are structures on each side of the large, curved, plate-like endomeres (Ewing, 1927) (see Figs. 1-3, 6-7).

13. The female terminal abdominal tergites, IX and X, are single plates. Abdominal sternite VIII has a pair of gonopods, lying side by side medianally, which are fused at their apices to cover the genital opening (vulva) between segments VIII and IX; and on each lateral side of the gonopods is a fragment of sternite VIII (Cope, 1941).

14. The internal sclerite of female abdominal sternite VIII is the sclerite that Clay (1961) calls the internal structure of the female genital chamber (see Figs. 35 i, 38 i, 39 i, and 49 i).

15. Sclerital hooks are hook-like processes in the female arising on either side of the mid-line of the ventral sclerite between the vulva and anus (see Fig 27 h).

16. The anal fringe (anal corona of Ferris, 1923) surrounds the female anus on abdominal segment X (see Figs. 28, 45, and 52).

17. Species-groups are groups of similar species within a genus.

18. Fresh material indicates that Mallophaga were obtained from the host that was collected in the field as contasted to mallophagan dried material which was obtained from dried museum skins either personally, (REE), or by my wife, Lyda (LE).

19. The following abbreviations indicate sources from which fresh or dried material was loaned for study:

BL - Dr. Boonsong Lekagul, Bangkok, Thailand.

BM(NH) - British Museum (Natural History), London, England.

BPBM - Bernice P. Bishop Museum, Honolulu, Hawaii.

CNHM - Chicago Natural History Museum, Chicago, Illinois.

GHEH - Mr. G. H. E. Hopkins, Zoological Museum, Tring, Hertfordshire, England.

JT - Dr. João Tendeiro, Centro de Zoologia, Lisboa, Portugal.

KCE - Dr. K. C. Emerson, Stillwater, Oklahoma.

Meinertzhagen - R. Meinertzhagen collection in BM(NH).

MMZ - Michigan University Museum of Zoology, Ann Arbor, Michigan.

Piaget - E. Piaget collection in BM(NH).

SMRL - SEATO Medical Research Laboratory, Bangkok, Thailand

USNM - United States National Museum, Washington, D. C.

METHODS

Fresh material was obtained in Thailand by placing the shot Hornbills in individual cloth bags. Prior to preparing the skins, the bags were placed into a chloroform-saturated chamber to kill the ectoparasites. After 10-15 minutes the bird feathers were fluffed lightly over a white surface, and all ectoparasites were placed with the host debris and host-catalog number into a vial of 70% ethyl alcohol.

Dried material was obtained from museum skins by lightly fluffing the bird feathers, particularly around the neck and lower belly, over a white surface. All ectoparasites and host debris found on a Hornbill skin were placed either into a vial of 95% ethyl alcohol with the host-locality information or dry into an envelope on which the host-locality information was was written. Emerson (1954) stated that contamination that occurred on museum skins was well known and that records of Mallophaga so obtained should be considered questionable. Edwards (1961) stated that if skins of a host species were found with a few lice of one species only, some doubt existed concerning the true host. Mallophaga that were obtained from museum skins were here considered to be stragglers unless they belonged to recognized Hornbill genera, and unless they were represented by other specimens obtained from additional skins of the same host species. Correspondingly, about 20% of the dried material was considered to be stragglers.

The USNM mounted most of the dried material obtained from the museum as well as some of the fresh material obtained from Thailand. Wanit Songprakob helped mount the remaining dried material from the museum and some fresh material from Thailand. The dried material obtained from other museums was mounted personally. The mounting procedure was suggested by Dr. K. C. Emerson (personal correspondence): Mallophaga were placed in 10% potassium hydroxide overnight, transferred to distilled water, and after one hour the body contents were teased out. Specimens were placed into fresh 10% potassium hydroxide for 6-12 hours after which they again were transferred to distilled water. Approximately one-half hour later specimens were put into 40% ethyl alcohol, to which after 15 minutes several drops of carbol fuchsin (Ziehl Nielson) were added, and allowed to act for one-half hour. Specimens were placed in 70% ethyl alcohol for one-half hour, followed by 95% ethyl alcohol for 15 minutes; when specimens were too dark, a few drops of glacial acetic acid were added to the 95% ethyl alcohol to decolorize the non-chitinous parts. Next, specimens were washed in 100% ethyl alcohol for a few minutes, and placed in Beechwood Creosote for one hour to overnight, after which they were mounted in Gum Damar or other dried resin media. Mallophaga were mounted ventral side up, posterior end forward, in the center of the slide. Males and females of the same species were mounted on the same slide, the male on the left. The host data was placed on a label on the right and the parasite identification label on the left of the cover slip.

Drawings were prepared from holotypes and allotypes except as noted in the test. All drawings were prepared with the aid of a 300 watt 35 milli-

meter slide projector as suggested by Dr. K. C. Emerson (personal correspondence). The monocular microscope with the mounted Mallophaga was turned on it's side, the ocular and mirror removed, and the slide projector placed at the lower end of the microscope so that the light projected the image onto a vertical surface from which the outline was traced on Bristol board or drawing velum. Measurements were obtained by projecting a millimeter scale from a stage micrometer onto the surface. Details of the Mallophaga were added after the microscope was uprighted.

Measurements for the tables are in millimeters and were made with the aid of an ocular micrometer.

Because of variation in setal number, setae recorded in species descriptions represent the range in numbers of setae from representative specimens from the material examined.

Characters described under genera or species-groups have not been repeated for individual specific descriptions. In each genus or species-group the arrangement of the species is based first on morphological similarity and second on the phylogenetic arrangement of their hosts.

KEY TO THE GENERA AND SPECIES

A. Terminal segment of antenna showing definite signs of division either by transverse line or marginal indentation (see Figs. 64 a, 66 a, and 68 a).....B

Terminal segment of antenna without signs of division (see Figs. 23 a and 25 a).....Chapinia.....F

B. Venter of third femora and posterolateral margins of fourth abdominal sternite each with three full rows of combs (see Figs. 64-65).....Bucerocolpocephalum.....C

Venter of third femora and fourth abdominal sternite without combs.....Bucerophagus.....D

C. Male genitalia with parameres anteriorly slender, having points that reach endomeres; female abdominal sternite VIII with internal triangular sclerite (Figs. 49 and 57).Bucerocolpocephalum emersoni.....17

Male genitalia with parameres anteriorly enlarged, lacking points that reach endomeres; female abdominal sternite VIII without internal sclerite (Figs. 50 and 58).....Bucerocolpocephalum deignani.....18

D. Venter of third femora and posterolateral margins of abdominal sternites IV-V each with brushes of normal setae (see Figs. 68-69).....E

Venter of third femora and abdominal sternite IV-V without brushes (Figs. 66-67).....Bucerophagus forcipatus.....19

E. Metasternal plate trapezoidal, expanded anteriorly (Fig. 68 c)..
.....Bucerophagus africanus.....21

Metasternal plate triangular, expanded anteriorly (Fig. 70).....
.....Bucerophagus productus.....20

F. Dorsal-lateral margins of head with a preocular slit (see Figs. 23-24).....lophocerus species-group.....G

Dorsal-lateral margins of head with a preocular notch (see Figs. 25-26).....K

G. Each lateral margin of abdominal tergites III-VI with a short seta between the spiracle and post-spiracular seta (see Fig. 64 1).....H

Abdominal tergites without such short setae.....
.....Chapinia robusta.....5

H. Abdominal sternite II with three median rows of setae.....
.....Chapinia bucerotis.....4

Abdominal sternite II with one median row of setae on posterior margin.....I

I. Male genitalia with each lateral horn possessing two sharp posterior points; female anal fringe with fewer than 58 setae (Figs. 2 and 28).....Chapinia lophocerus.....2

Male genitalia with each lateral horn possessing one or two rounded posterior points; female anal fringe with more than 58 setae....J

J. Male genitalia with each lateral horn possessing two rounded posterior points; female anal fringe with more than 70 setae (Fig. 1)....
.....Chapinia fasciatus.....1

Male genitalia with each lateral horn possessing one rounded poster-

ior point; female anal fringe with 60-64 setae (Fig. 3).....

.....Chapinia camurus.....3

K. Each lateral margin of abdominal tergites III-VI with a short seta between the spiracle and post-spiracular seta (see Fig. 64 1).....T

Abdominal tergites without such short setae.....L

L. Abdominal sternite II with at least two median rows of setae....M

Abdominal sternite II with one median row of setae on posterior margin.....acutovulvatum species-group.....P

M. Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with brushes of normal setae.....N

Venter of third femora and abdominal sternites IV-VI without brushes (Figs. 25-26).....Chapinia traylori.....13

N. Male genitalia with parameres anteriorly enlarged; female terminal abdominal tergite with the two median setae on posterior margin as widely spaced as four times the distance between the other 3-4 long setae each side of mid-line (Figs. 20 and 46).....

.....Chapinia lydae.....14

Male genitalia with parameres anteriorly slender.....

.....hirtum species-group.....O

O. Sclerite of male genital sac large, nearly twice as long as wide (Fig. 18 s).....Chapinia muesebecki.....15

Sclerite of male genital sac small, about as wide as long; female terminal abdominal tergite with five long evenly spaced setae on posterior margin (Figs. 19 s and 48).....

.....Chapinia hirta.....16

P. Male abdominal sternite II with more than 46 total setae; female anal fringe with more than 48 setae.....Q

Male abdominal sternite II with fewer than 44 total setae; female anal fringe with fewer than 46 setae.....R

Q. Male genitalia with endomeres consisting only of paired outer rims which are curved inwardly; female abdominal sternite VIII with internal sclerite almost as wide as long (Figs. 13 and 38 i).....

.....Chapinia hoplai.....9

Male genitalia with endomeres consisting only of paired outer rims which are straight and nearly parallel; female abdominal sternite VIII with internal sclerite much longer than wide (Figs. 14 and 39 i)....

.....Chapinia boonsongi.....10

R. Male genitalia with endomeres consisting of paired plates having posterior extension split; female venter of third femora and abdominal sternite IV-VI without brushes (Figs. 17 and 25).....

.....Chapinia traylori.....13

Male genitalia with endomeres either lacking paired plates or if present, posterior extension not split; female venter of third femora and posterolateral margins of abdominal sternites IV-VI each with brushes of normal setae.....S

S. Male venter of third femora and posterolateral margins of abdominal sternites IV-VI each with brushes of normal setae; female abdominal sternite VIII without internal sclerite (Fig. 40).....

.....Chapinia wenzeli.....11

Male venter of third femora and abdominal sternite IV-VI without

brushes; female abdominal sternite VIII with internal sclerite having slender posteriorly divergent margins (Fig. 43).....

.....Chapinia blakei.....12

T. Male genitalia with endomeres possessing outer rim and large shield-like inner plate with paired lateral flanges and central terminal point; female abdominal sternite VIII with more than 32 setae on posterior margin (Figs. 12 and 37).....Chapinia malayensis.....8

Male genitalia with endomeres possessing outer rim and small inner plate that is not shield-like; female abdominal sternite VIII with fewer than 32 setae on posterior margin.....U

U. Male genitalia with each outer rim of endomeres possessing a triangular internal knob longer than wide; female terminal abdominal tergite with at least six long setae each side of mid-line on posterior margin (Figs. 9 and 35).....Chapinia acutovulvata.....7

Male genitalia with each outer rim of endomeres possessing a triangular internal knob wider than long; female terminal abdominal tergite with at most five long setae each side of mid-line on posterior margin (Figs. 8 and 33).....Chapinia clayae.....6

GENUS CHAPINIA EWING

Chapinia Ewing, 1927, J. Wash. Acad. Sci., 17: 88.

Genotype: Chapinia robusta Ewing, 1927.

Allomenopon Bedford, 1930. Rep. vet. Res. S. Africa, 16: 153.

Genotype: Menopon bucerotis Kellogg, 1908.

Examples illustrated in Figs. 23-26. Head triangular, width 1 1/2 - 2 times that of length. Forehead much narrower anteriorly. Temples expanded. Antennae four-jointed, third segment constricted at base, and terminal segment capitate without signs of division. Antennary fossa deep, covered above by expansion of lateral margin of head, posterior margin of which bears eye with double cornea. Dorsal-lateral margin of forehead anterior to eye with preocular slit or shallow notch. Gular region with 3-7 setae varying in length on each lateral margin. Pronotum large, expanded anteriorly, with four short median setae, and posterior marginal row of long setae. Metanotum expanded posteriorly, with four short median setae, posterior marginal row of long setae, and two short setae on each lateral margin. Metanotum separated from mesonotum and from pleurites. Thoracic sternal plates as shown in Fig. 23 b, 25 b, and 26 c. Prosternum with two median setae. Metasternal plate trapezoidal, expanded anteriorly, with 6-22 setae. Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with or without brushes of normal setae. Abdominal

segments consist of tergites, sternites, and pleurites, the latter without prolongation of posteroventral angles. Abdominal tergites each with a posterior marginal row of setae, the most laterad being the post-spiracular seta. Each lateral margin of abdominal tergites II-VI with or without a short seta between the spiracle and post-spiracular seta. Sternites and pleurites each with a posterior marginal row of long setae and with numerous shorter setae. Male terminal abdominal sternites VIII and IX fused with partial division only from sternite VII (see Figs. 4, 10, and 22). Male genitalia as illustrated for each species with parameres either expanded anteriorly or split posteriorly or both. Female terminal abdominal segments as illustrated for each species with lateral processes arising from ventral sclerite between vulva and anus with long stout setae but never strong spines. Females larger than males usually with more abdominal sternal setae, but general shape and chaetotaxy similar to that of males except for terminal abdominal segments.

Both Ewing (1927) and Bedford (1930) stated that the pterothorax was undivided. As noted by Cope (1941), the sclerotized median button behind the prothorax (see Fig. 25 m) is a vestige of the mesonotum; and the supposed mesonotum, the narrow sclerotized band posterior to this button, is a mere extension of the subcoxae. Ewing (1927) stated that the abdomen consisted of nine segments in the female and ten segments in the male, but as shown by Cope (1941) the abdomen of both the male and female each has ten segments.

Chapinia resembles most closely Bucerophagus (Figs. 66-69), but differs in several characters: The terminal segment of the antenna shows no

sign of division in Chapinia, but there are definite signs of division into two parts either by transverse line or marginal indentation in Bucerophagus. The venter of the third femora may have brushes of normal setae in Chapinia and Bucerophagus; similar brushes are present on posterolateral margins of abdominal sternites IV-VI in Chapinia, but abdominal sternites IV-V in Bucerophagus. Each lateral margin of abdominal tergites II-VI may have a short seta between the spiracle and post-spiracle seta in Chapinia, but 1-5 short setae may be present on margins of abdominal tergites II-VIII in Bucerophagus. Male terminal abdominal sternites VIII and IX are fused in Chapinia with partial division only from abdominal sternite VII, but abdominal sternites VIII and IX may be fused in Bucerophagus with a complete division from abdominal sternite VII. Male genitalia have parameres slender or expanded anteriorly in Chapinia, but branched anteriorly in Bucerophagus. Lateral processes arising from the ventral sclerite between the female vulva and anus have long stout setae in Chapinia but long stout setae and strong spines in Bucerophagus.

The male genitalia and details of the male and female terminal abdominal segments are the best characters for separating species of Chapinia. Other characters useful in species separation are: the presence or absence of brushes of normal setae on the venter of the third femora and posterolateral margins of abdominal sternites IV-VI; the presence or absence of a short seta on each lateral margin of abdominal tergites III-VI between the spiracle and post-spiracular seta; the number of median rows of setae, and the total number of setae on abdominal sternite II. The number and length of setae on the lateral margins of the gular region are too variable to be

of much use in separating species.

For convenience of classification the species of Chapinia have been arranged into species-groups.

Hosts: Species of Chapinia have been found on the genera Tockus, Penelopides, Rhyticeros, Anthracocerus, Bycanistes, Ceratogymna, and Buceros of the avian family Bucerotidae.

LOPHOCERUS SPECIES-GROUP

Species similar in shape to Chapinia robusta (see Figs. 23-24). Differing from other species-groups in the following combination of characters: dorsal-lateral margins of head with preocular slit; venter of third femora and posterolateral margins of abdominal sternites IV-VI each with brushes of normal setae; each lateral margin of abdominal tergites II-VI with or without a short seta between the spiracle and post-spiracular seta; females with more abdominal sternal setae than in males; abdominal sternite II with either one or three median rows of setae; male genitalia with lateral horns on each side of endomeres, and with parameres swollen anteriorly, not split posteriorly; female with sclerital hooks on each side of midline of ventral sclerite between vulva and anus; female abdominal sternite VIII with most of setae similar in size to setae on posterior margin.

Hosts: Species of the lophocerus species-group have been found on the genera Tockus, Bycanistes, and Ceratogymna of the avian family Bucerotidae.

1. Chapinia fasciatus n. sp.

(Fig. 1)

Male: Smaller than Chapinia robusta in all measurements; slightly larger than C. lophocerus in width of metathorax (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each

with small scattered brushes of normal setae. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and postspiracular seta. Abdominal sternite II with 32-42 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. lophocerus. Geritalia as shown in Fig. 1, each lateral horn with two rounded posterior points.

Female: Larger than Chapinia robusta in all measurements except for width of metathorax; slightly larger than C. lophocerus in width of prothorax (see Table 2). Resembles the male except that abdominal sternite II has 54 total setae. Terminal abdominal segments similar to those of C. lophocerus. Ventral sclerite between vulva and anus elevated medianally between sclerital hooks. Anal fringe with 72-86 setae.

Discussion: Chapinia fasciatus resembles most closely C. lophocerus. The male genitalia have each lateral horn possessing two posterior points which are rounded in C. fasciatus, but sharp in C. lophocerus. The ventral sclerite between female vulva and anus is elevated medianally between the sclerital hooks in C. fasciatus, but not elevated in C. lophocerus. The female anal fringe has more than 70 setae in C. fasciatus, but fewer than 58 setae in C. lophocerus.

Material examined: 27 males and 34 females from fresh and dried material collected in the Ethiopian Region.

Type host: Tockus fasciatus fasciatus (Shaw, 1811).

Type material: Holotype male and allotype female from Eden, French Cameroons, Africa, collected by J. Mouchet, are in the British Museum (Natural History). Paratypes: 18 males and 15 females from French

Cameroons, Africa, collected by J. Mouchet, BM(NH); 1 male from Kasongo, Belgin Congo, Africa, 13 November 1959, collected by P. L. G. Benuit, JT; 3 males and 10 females from CNHM skins from Entebbe, Uganda, Africa, 1895-1916, collected by F. J. Jackson and others (REE); 2 males and 1 female from CNHM skins from Bitya, Cameroons, Africa, 1924-1927, collected by O. L. Bates (REE); 1 female from CNHM skin from Yokadouma, French Cameroons, Africa, 19 October 1946, collected by A. I. Good (REE); 1 female from CNHM skins from Bwamba, Ruwenzori, Uganda, Africa, 1944-1946, collected by V. Someren (REE); 1 male from CNHM skins from Ebolowa, French Cameroons, Africa, 1952-1953, collected by A. I. Good (REE); 1 male and 3 females from USNM skins from Congo, Africa, 1917, collected by C. R. Aschemeier (REE); from Tockus alboterminatus suahelicus (Neumann, 1905): 1 female from CNHM skins from Sokoke Forest, Kenya, Africa, June 1932, collected by V. Someren (REE); 1 female from USNM skins from Nairobi, Kenya, Africa, 1909, collected by Loring and Mearns (REE).

2. Chapinia lophocerus (Bedford)

(Figs. 2, 4, 27-28)

Menopon lophocerus Bedford, 1920. Rep. vet. Res. S. Africa, 7-8: 717, pl. 1, fig. 1; pl. 3, fig. 1.

Type host: Lophoceros leucomelas = Tockus flavirostris leucomelas (Lichtenstein, 1842).

Chapinia lophocerus (Bedford). Hopkins and Clay, 1952. Checklist Mallophaga: 67.

Bedford did not designate a type from his material which contained a pair of Mallophaga from Lophoceros leucomelas = Tockus flavirostris leucomelas

(Lichtenstein, 1842), a pair from L. epirhinus = Tockus nasutus caffer (Sundevall, 1851), and 2 males and 1 female from L. erythrorhynchos = Tockus e. erythrorhynchus (Temminck, 1823). A lectotype was designated by Hopkins (1941) from the host, Lophoceros leucomelas, since the male from that host agreed best with Bedford's figure of the male genitalia.

Male: Smaller than Chapinia robusta in all measurements (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 28-42 total setae and one median row of setae on posterior margin. Terminal abdominal segments as shown in Fig. 4. Genitalia as shown in Fig. 2, each lateral horn with two sharp posterior points which do not reach the slender endomeres.

Female: Larger than Chapinia robusta in all measurements except for width of prothorax and width of metathorax (see Table 2). Resembles the male except that abdominal sternite II has 34-54 total setae. Terminal abdominal tergite with 22-30 setae, short setae alternating with long, on posterior margin; ventral sclerite between vulva and anus not elevated medianally between sclerital hooks (Fig. 27). Anal fringe with 42-56 setae. (Fig. 28).

Discussion: Measurements given by Bedford (1920) are:

	Male (mm)	Female (mm)
Length of head	0.25	0.33
Width of head	0.53	0.60
Width of prothorax	0.38	0.43

	Male (mm)	Female (mm)
Width of metathorax	0.55	0.71
Width of abdomen	0.85	1.15
Total length	1.74	2.36

Except for females being larger in abdominal width and total length, these measurements fall within the ranges of Chapinia lophocerus (see Tables 1-2). C. lophocerus resembles most closely C. fasciatus. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae in C. lophocerus, C. fasciatus, and C. camurus; but large thick brushes of normal setae in C. bucerotis. Abdominal sternite II of both sexes has fewer than 58 total setae and one median row of setae in C. lophocerus, C. fasciatus, and C. camurus; but more than 58 total setae and three median rows of setae in C. bucerotis. The male genitalia have each lateral horn possessing posterior points that do not reach the slender endomeres in C. lophocerus, C. fasciatus, and C. camurus; but one sharp point that crosses the broad endomeres in C. bucerotis; the posterior two points are sharp in C. lophocerus, but rounded in C. fasciatus, and there is only one rounded posterior point in C. camurus. The ventral sclerite between female vulva and anus is not elevated medianally between the sclerital hooks in C. lophocerus, is elevated slightly in C. camurus, but is more elevated in C. fasciatus and C. bucerotis. The female anal fringe has fewer than 58 setae in C. lophocerus, at least 72 setae in C. fasciatus, and 58-72 setae in G. camurus and C. bucerotis.

Material examined: 6 males and 13 females from fresh and dried material

collected in the Ethiopian Region; lectotype male and syntype female from Transvaal, South Africa, September 1917, collected by G. A. H. Bedford, are in the collection of G. H. E. Hopkins; from the type host: 1 male and 4 females from Pretoria Zoo, South Africa, 10 February 1938, collected by G. A. H. Bedford, GHEH; from Tockus n. nasutus (Linnaeus, 1766): 1 male and 1 female from Maroua, North French Cameroons, Africa, 1959, collected by J. Mouchet, BM(NH) 1960-105; 1 male and 2 females from Mansôa, Portuguese Guinea, Africa, 14 February 1951, collected by J. Tendeiro, JT; from Tockus e. erythrorhynchus (Temminck, 1823): 1 male and 4 females from Somaliland, Africa, February 1949, Meinertzhagen 18708, BM(NH); 1 male from USNM skins from Ethiopia, Africa, 1912, collected by Childs Frick (REE); from Tockus f. flavirostris (Rüppell, 1835): 1 female from USNM skins from Ethiopia, Africa, 1912, collected by Childs Frick (REE).

Drawings were made of the lectotype male and a female collected in the Pretoria Zoo. Specimens are in the collection of GHEH.

3. Chapinia camurus n. sp.

(Fig. 3)

Male: Smaller than Chapinia robusta in all measurements; smaller than C. lophocerus in all measurements except for length of head and width of prothorax (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 37-38 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. lophocerus. Genitalia as

shown in Fig. 3, each lateral horn with one rounded posterior point.

Female: Smaller than other Chapinia in all measurements except for length of head and width of abdomen (see Table 2). Resembles the male except that abdominal sternite II has 44-56 total setae. Terminal abdominal segments similar to those of C. lophocerus. Ventral sclerite between vulva and anus slightly elevated medianally between sclerital hooks. Anal fringe with 60-64 setae.

Discussion: Although smaller in size, Chapinia camurus resembles most closely C. lophocerus. The male genitalia have each lateral horn possessing one rounded posterior point in C. camurus, but two sharp posterior points in C. lophocerus. The ventral sclerite between female vulva and anus is slightly elevated medianally between the sclerital hooks in C. camurus, but is not elevated in C. lophocerus. The female anal fringe has more than 58 setae in C. camurus, but fewer than 58 setae in C. lophocerus.

Material examined: 2 males and 2 females from fresh material collected in the Ethiopian Region.

Type host: Tockus camurus camurus Cassin, 1857.

Type material: Holotype male and allotype female from Ambam, French Cameroons, Africa, 1955, collected by J. Mouchet, are in the British Museum (Natural History). Paratypes: 1 male and 1 female with same data.

4. Chapinia bucerotis (Kellogg)

(Figs. 5-6, 29-30)

Menopon bucerotis Kellogg, 1908. Wiss. Ergebn. schwed. zool. Exped. Kilimandjaro, 15, 4: 54, pl. 7, fig. 12. Menopon bucerotis Kellogg, 1908.

Bedford, 1920. Rep. vet. Res. S. Africa, 7-8: pl. 3, fig. 2 (male genitalia).

Type host: Bycanistes cristatus = Bycanistes brevis omissus Peters, 1945.

Chapinia bucerotis (Kellogg). Hopkins and Clay, 1952. Checklist Mallophaga: 67.

Kellogg did not designate a type from his material which contained 1 male and 1 female syntypes on slides, and about 40 syntypes in alcohol. The slide specimens were remounted and the male is designated hereby as a lectotype; the slide has been so labeled. Approximately one half of the syntype material formerly in alcohol was mounted.

Male: Smaller than Chapinia robusta in all measurements (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with large thick brushes of normal setae. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 60-82 total setae and three median rows of setae. Terminal abdominal segments as shown in Fig. 5. Genitalia as shown in Fig. 6, each lateral horn with two sharp posterior points, one of which crosses the broad endomeres.

Female: Approximately the same size as Chapinia robusta (see Table 2). Resembles the male except that abdominal sternite II has 68-104 total setae. Terminal abdominal tergite with 22-32 setae, short setae alternating with long, on posterior margin; ventral sclerite between vulva and anus elevated medianally between sclerital hooks (Fig. 29). Anal fringe with 58-72 setae (Fig. 30).

Discussion: Measurements given by Kellogg (1908) are:

	Male (mm)	Female (mm)
Length of head	0.33	0.40
Width of head	0.65	0.72
Width of abdomen	0.80	1.10
Total length	2.00	2.80

These measurements are slightly larger than those given here for Chapinia bucerotis (see Tables 1-2). C. bucerotis resembles most closely C. lophocerus. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have large thick brushes of normal setae in C. bucerotis, but small scattered brushes of normal setae in other species of the lophocerus species-group. Each lateral margin of abdominal tergites II-VI has a short seta between the spiracle and post-spiracular seta in C. bucerotis, but not in C. robusta. Abdominal sternite II of both sexes has more than 58 total setae in C. bucerotis, but fewer than 58 total setae in C. lophocerus; this sternite has three median rows of setae in C. bucerotis, but one median row of setae on posterior margin in other species of the lophocerus species-group. The male genitalia have each lateral horn possessing two sharp posterior points in C. bucerotis and C. lophocerus, but one point crosses the broad endomeres in C. bucerotis, and the points do not reach the slender endomeres in C. lophocerus; each lateral horn in C. robusta has one sharp median point that crosses the broad endomeres. The ventral sclerite between female vulva and anus is elevated medianally between the sclerital hooks in C. bucerotis almost as much as in C. robusta, but is not elevated in C. lophocerus. The female anal fringe has at least 58 setae in C. bucerotis, but at most 56 setae in C. lophocerus.

Material examined: 33 males, 29 females, and approixmately 20 specimens in alcohol from fresh and dried material collected in the Ethiopian Region; lectotype male and syntypes, 12 males, 13 females, and about 20 syntypes in alcohol from Kilimanjaro, Tanganyika, Africa, collected by Sjöstedt, are in the Swedish Museum of Natural History; from Bycanistes bucinator sharpii (Elliot, 1873): 1 female from CNHM skin from Mt. Tandan, Mouila, Gabon, Africa, 9 June 1951, collected by H. A. Beatty (REE); 1 female from USNM skins from Congo, Africa, 1917-1918, collected by C. R. Aschemeier (REE); from Bycanistes bucinator duboisi x sharpii: 1 female from CNHM skin from Yaounde, French Cameroons, Africa, 12 July 1948, collected by A. I. Good (REE); from Bycanistes bucinator duboisi W. Sclater, 1884: 1 male from CNHM skins from Elat, French Cameroons, Africa, collected by Rev. M. Fraser (REE); from Bycanistes b. bucinator (Temminck, 1824): 1 male and 1 female from Pietermaritzburg, South Africa, 1917, GHEH; 3 male and 2 females from CNHM skins from Kenya, Africa, 1918-1922, collected by V. Someren (REE); from Bycanistes c. cylindricus (Temminck, 1831): 1 male and 1 female from CNHM skins from Liberia, Africa, February-June 1948, collected by H. A. Beatty (REE); from Bycanistes cylindricus albotibialis (Cabanis and Reichenow, 1877): 2 males and 1 female from Mbalmayo, French Cameroons, Africa, collected by J. Mouchet, BM(NH); 1 male from CNHM skin from French Cameroons, Africa, 8 July 1907 (REE); 1 male from CNHM skin from French Cameroons, Africa, 25 June 1940, collected by A. I. Good (REE); 1 male from CNHM skin from Uganda, Africa, 15 July 1945, collected by V. Someren (REE); from Bycanistes subcylindricus subquadratus Cabanis, 1880: 6 males and 6 females from Uganda, Africa, April 1936,

Meinertzhagen 7674, 7708-7709, BM(NH); 1 male from CNHM skin from Kampala, Uganda, Africa, 2 September 1918, collected by V. Someren (REE); 1 male and 2 females from USNM skins from Uganda, Africa, June 1920, collected by H. C. Raven (REE); from Bycanistes b. brevis Friedmann, 1929: 2 males from CNHM skin from Mt. Kenya, Kenya, Africa, November 1946, collected by V. Someren (REE).

Drawings were made of the lectotype male and the syntype female mounted on the same slide. Specimens are in the Swedish Museum of Natural History.

5. Chapinia robusta Ewing

(Figs.. 7, 23-24, 31-32)

Chapinia robusta Ewing, 1927. J. Wash. Acad. Sci., 17: 89.

Type host: Ceratogymna atrata (Temminck, 1835).

Chapinia robusta Ewing. Hopkins and Clay, 1952. Checklist Mallophaga: 68.

Through the courtesy of Dr. K. C. Emerson, BM(NH) specimens from the type host, here examined, were determined to be conspecific with the USNM holotype and allotype (USNM 40137, Nytonga, Congo, Africa, 3 November 1917, collected by E. A. Chapin).

Male: As illustrated in Fig. 24. Larger than other species of the lophocerus species-group in all measurements except for width of abdomen; approximately the same size as Chapinia traylori (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-

spiracular seta. Abdominal sternite II with 48-66 total setae and one median row of setae on posterior margin. Terminal abdominal segments as shown in Fig. 24 c. Genitalia as shown in Fig. 7, each lateral horn with one large sharp point which crosses the broad endomeres.

Female: As illustrated in Fig. 23. Larger than Chapinia camurus in all measurements except for length of head; approximately the same size as other species of the lophocerus species-group; slightly smaller than C. traylori in all measurements except for length of head (see Table 2). Resembles the male except that abdominal sternite II has 56-68 total setae. Terminal abdominal tergite with 20-24 setae, short setae alternating with long, on posterior margin; ventral sclerite between vulva and anus elevated medianally between sclerital hooks (Fig. 31). Anal fringe with 56-62 setae (Fig. 32).

Discussion: Measurements given by Ewing (1927) are:

	Male (mm)	Female (mm)
Width of abdomen	0.70	0.95
Total length	1.59	2.00

These measurements are not as great as those given here for Chapinia robusta (see Tables 1-2). C. robusta resembles most closely C. bucerotis. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae in C. robusta which are slightly more numerous than for other species of the lophocerus species-group except for C. bucerotis which has large thick brushes of normal setae. Each lateral margin of abdominal tergites II-VI lacks the short seta between the spiracle and post-spiracular seta in C. robusta that is

present in all other species of the lophocerus species-group. Abdominal sternite II has one median row of setae in C. robusta, but three median rows of setae in C. bucerotis. Male genitalia have each lateral horn possessing one sharp median point that crosses the broad endomeres in C. robusta; but two sharp posterior points, one of which crosses the broad endomeres in C. bucerotis. The ventral sclerite between female vulva and anus is elevated medianally between the sclerital hooks slightly more in C. robusta than in C. bucerotis.

Material examined: 4 males and 5 females from fresh and dried material collected in the Ethiopian Region; from the type host: 3 males and 3 females from Ambam, French Cameroons, Africa, 1955, collected by J. Mouchet, BM(NH); 1 female from CNHM skin from Fougamou, Gabon, Africa, 4 August 1951, collected by H. A. Beatty (REE); from Ceratogymna elata (Temminck, 1831): 1 male and 1 female from Konn, French Cameroons, Africa, 26 April 1947, collected by V. Aellen BM(NH) 1954-487.

Drawings were made of a male and a female from the type host collected in Ambam, French Cameroons, Africa. Specimens are in the BM(NH).

Figs. 1-7. Dorsal-ventral view of male terminal abdominal segments and ventral view of male genitalia of lophocerus species-group, drawn to the same scale, as indicated.

Fig. 1. Chapinia fasciatus n. sp., genitalia of holotype.

Fig. 2. Chapinia lophocerus (Bedford), genitalia of lectotype.

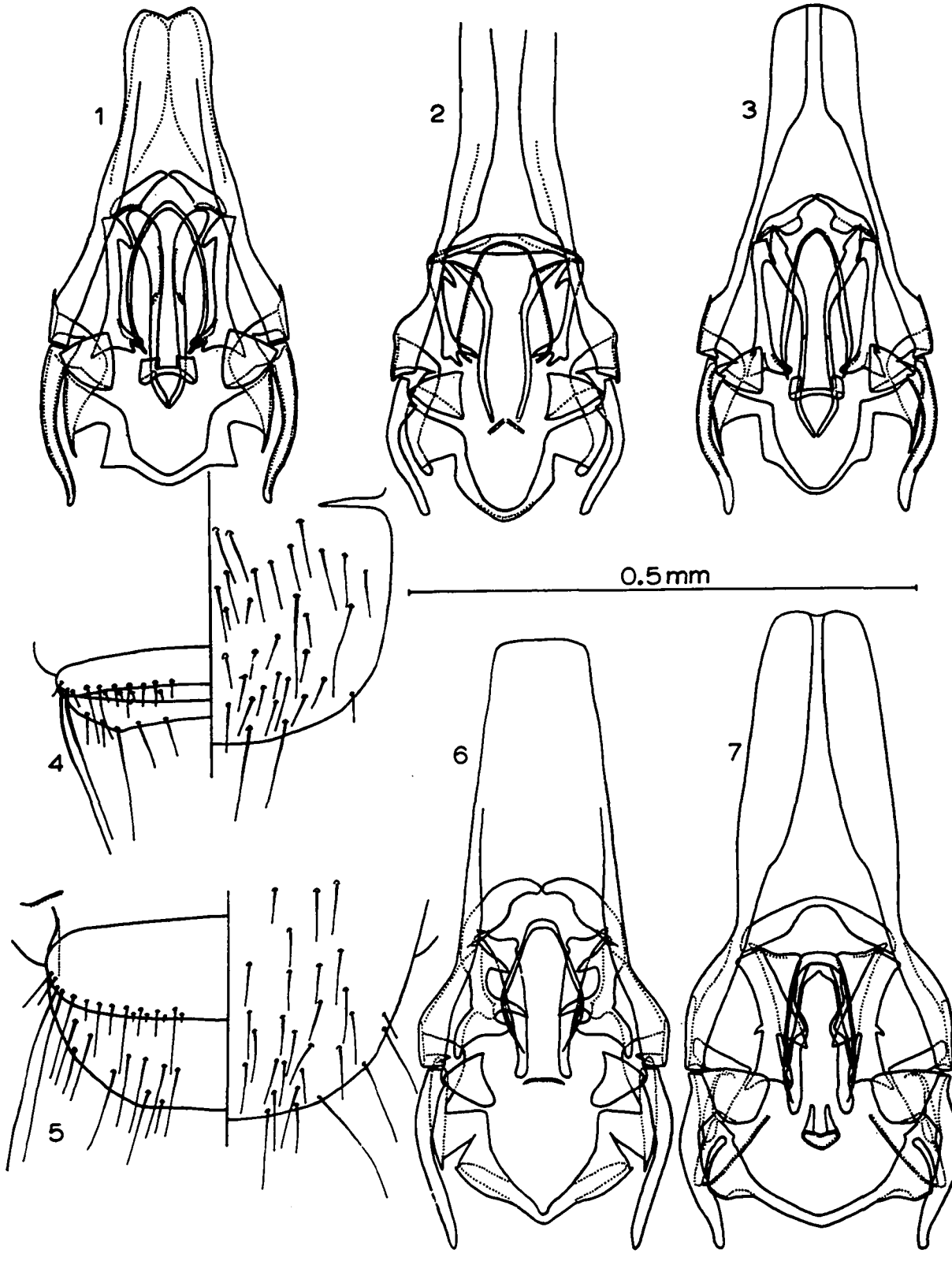
Fig. 3. Chapinia camurus n. sp., genitalia of holotype.

Fig. 4. Chapinia lophocerus (Bedford), terminal abdominal segments of lectotype.

Fig. 5. Chapinia bucerotis (Kellogg), terminal abdominal segments of lectotype..

Fig. 6. Chapinia bucerotis (Kellogg), genitalia of lectotype.

Fig. 7. Chapinia robusta Ewing, genitalia.


1
2
3
0.5mm
4
5
6
7

DISCUSSION: LOPHOCERUS SPECIES-GROUP

Species of the lophocerus species-group are all similar in size except that both sexes of Chapinia camurus are smaller than corresponding sexes of other species, and males of C. robusta are larger than other males. The small size of C. camurus might be expected since its host, the 15-inch Tockus camurus, is the smallest know Hornbill. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have large thick brushes of normal setae in C. bucerotis, but small scattered brushes of normal setae in other species of the lophocerus species-group. although the brushes are slightly thicker in C. robusta. Each lateral margin of abdominal tergites II-VI has a short seta between the spiracle and postspiracular seta in all species except in C. robusta. Abdominal sternite II has more total setae in both sexes of C. bucerotis and C. robusta than in corresponding sexes of C. fasciatus, C. lophocerus, and C. camurus; this sternite has one median row of setae in all species except C. bucerotis which has three median rows. The male genitalia have each lateral horn possessing posterior points in all species except C. robusta which has one sharp median point crossing the broad endomeres; the posterior points are sharp in C. bucerotis and C. lophocerus, but rounded in C. fasciatus and C. camurus, and these species have two posterior points except C. camurus which has only one; the two points do not reach the slender endomeres in C. lophocerus but one point crosses the broad endomeres in

C. bucerotis (see Figs. 1-7). The female ventral sclerite between vulva and anus is elevated medianally between the sclerital hooks in C. fasciatus, C. bucerotis, and C. robusta, is only slightly elevated in C. camurus, and is not elevated in C. lophocerus. The female anal fringe has the most setae in C. fasciatus, and the fewest in C. lophocerus.

Clay (1958) treated populations of the ischnoceran genus Degeeriella as subspecies when the male genitalia were apparently identical or differed only in a minor degree, and when there were other minor morphological differences. Because of similarity of the genitalia, Chapinia fasciatus and C. camurus could be considered subspecies of C. lophocerus. This would express the similarity of their six host species which are all members of the Ethiopian genus Tockus. Clay (1958) pointed out that the genitalia, particularly in the Amblycera, might show only minor differences throughout a genus or species group and great differences in other groups. She, therefore, concluded that differentiation of the genitalia has taken place at different rates in different groups. Similarly, Johnson (1960) stated that evolution and morphological divergence would not be expected to proceed at the same rate for all free-living species. It would seem that the similarity in the genitalia of C. fasciatus, C. lophocerus, and C. camurus would indicate either that evolution has not proceeded as rapidly in these species or that they have not been isolated as long as other species of Chapinia. Clay (1958) stated that if subspecies were populations that would interbreed under natural conditions if they occurred sympatrically, any morphological differences which might prevent interbreeding should be considered as specific characters. Johnson (1960) believes that there is

little possibility of finding interbreeding populations among lice which are isolated on their hosts. She stated that it would be desirable to treat all stable recognizable forms of Anoplura and Mallophaga as species. Clay (1962) consequently stated that the subspecific category might be useful in some of the ischnoceran genera, but its application in the Amblycera is less satisfactory, and should not be used until more is known about the relationships between populations in this superfamily.

The members of the lophocerus species-group are arranged according to the phylogeny of their hosts since this order agrees with the morphological similarities of the parasites.

ACUTOVULVATUM SPECIES-GROUP

Species similar in shape to Chapinia traylori (see Figs. 25-26). Differing from other species-groups in the following combination of characters: dorsal-lateral margins of head with a preocular notch; venter of third femora and posterolateral margins of abdominal sternites IV-VI each with or without brushes of normal setae; each lateral margin of abdominal tergites II-VI with or without a short seta between the spiracle and post-spiracular seta; females usually with more abdominal sternal setae than in males; abdominal sternite II usually with one median row of setae on posterior margin; male genitalia without lateral horns on each side of endomeres, and with parameres swollen anteriorly, split posteriorly; female without sclerital hooks on each side of mid-line of ventral sclerite between vulva and anus; female abdominal sternite VIII with most of setae much shorter than those on the posterior margin.

Hosts: Species of the acutovulvatum species-group have been found on the genera Tockus, Penelopides, Rhyticeros, Anthracoceros, and Buceros of the avian family Bucerotidae.

6. Chapinia clayae n. sp.

(Figs. 8, 33-34)

Both sexes are smaller than corresponding sexes of Chapinia traylori in all measurements except for length of head (see Tables 1-2).

Male: Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 38-50 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. acutovulvata. Genitalia as shown in Fig. 8, endomeres with small inner plate and paired outer rims.

Female: Resembles the male except that abdominal sternite II has 66-76 total setae. Terminal abdominal tergite with 12 long and 12 short setae on posterior margin; abdominal sternite VIII with 22-30 setae on posterior margin (Fig. 33). Anal fringe with 38-44 setae (Fig. 34).

Discussion: Although smaller in size, Chapinia clayae resembles most closely C. acutovulvata. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae in C. clayae, but large thick brushes of normal setae in C. acutovulvata. The male genitalia have on each outer rim of endomeres a triangular internal knob that is wider than long in C. clayae, but longer than wide in C. acutovulvata. The female terminal abdominal tergite has on the posterior margin at most 24 setae in C. clayae of which approximately one-half are long and one-half are short, but at least 26 setae in C. acutovulvata of which approximately two-thirds are long and one-third are short. In addition this margin has on each side of the mid-line at most four long setae in C. clayae, but at least six long setae in C. acutovulvata. The female anal fringe has at most 44 setae in C. clayae, but at least 44 setae in C. acutovulvata.

Material examined: 19 males and 29 females from fresh and dried material collected in India and Nepal.

Type host: Tockus birostris (Scopoli, 1786).

Type material: Holotype male, allotype female, and 2 male and 4 female paratypes on one slide from Rajputana, India, March 1937, are in the British Museum (Natural History) Meinertzhagen 8855-8856. The holotype and allotype are each the second from the right in the rows of males and females as seen under the microscope. Paratypes: 5 males and 12 females with same data except Meinertzhagen 8932, BM(NH); 1 male from Nepal, December 1935, Meinertzhagen 4859, BM(NH); 4 males and 5 females from Nepal, February 1936, Meinertzhagen 4858, BM(NH); 1 female from CNHM skins from Kotla, Kangra, East Punjab, India, 1946 and 1948, collected by W. Koelz (REE); 1 male and 1 female from CNHM skins from Bheraghat, Central Provinces, India, March-April 1946, collected by W. Koelz and R. Chand (REE); 1 male from CNHM skins from Belwani, Kisli, Central Provinces, India, July-August 1946, collected by W. Koelz (REE); 1 female from CNHM skin from Kanha, Central Provinces, India, 29 August 1946, collected by R. Chand (REE); 2 males from CNHM skins from Kalnali, United Provinces, India, February 1947, collected by W. Koelz (REE); 1 male and 1 female from CNHM skins from Nichland, United Provinces, India, February 1947, collected by W. Koelz (REE); 1 female from CNHM skins from Simra, Nepal, 4 March 1947, collected by W. Koelz and R. Chand (REE); 1 female from CNHM skins from Baihar, Balaghat, India, January-February 1949, collected by R. L. Flemming (REE); 1 female from USNM skins from India, 1898, 1946-1948 (REE); from Tockus g. griseus (Latham, 1790): 1 male from CNHM skins from Nilambus, Madras, India, February-March 1937, collected by W. Koelz (REE).

Chapinia clayae is named for Dr. Theresa Clay of the British Museum (Natural History) in appreciation for her continuous assistance throughout the study, for the loan of Hornbill Menoponidae from the BM(NH); and for helping to obtain the loan of Hornbill Menoponidae from other museums.

7. Chapinia acutovulvata (Piaget)

(Figs. 9-10, 35-36)

Menopon acutovulvatum Piaget, 1881. Tijdschr. Ent., 24: 5, pl. 1, fig. 4.

Type host: Buceros malabaricus = Antracoceros a. albirostris (Shaw, 1808).

Menopon acutovulvatum Piaget, 1885. Les Pédiculines Supplément: 106, pl. 11, fig. 8.

Allomenopon mjöbergi Eichler, 1947. Ark. Zool., 39 A: 2 and 20, figs. 1-2 (New synonym).

Type host: Antracoceros convexus (Temminck, 1831).

Chapinia mjöbergi Eichler. Hopkins and Clay, 1952. Checklist Mallophaga: 68.

Chapinia acutovulvata (Piaget). Hopkins and Clay, 1952. Checklist Mallophaga: 67.

Dr. Eichler's specimens of Chapinia mjöbergi from Anthracoceros convexus in the Zoological Museum, Humboldt University, Berlin, were loaned through the courtesy of Dr. von Keler. Comparison of these lice with specimens of Chapinia acutovulvata from Anthracoceros a. albirostris discloses no morphological differences between the two series.

A lectotype male for Chapinia acutovulvata was designated by Clay

(1949 a) from the Piaget collection, and it is now in the British Museum (Natural History), BM 777, with 6 syntype females, BM 774 and 776.

Male: Approximately the same size as Chapinia traylori (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with large thick brushes of normal setae. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 42-54 total setae and one median row of setae on posterior margin. Terminal abdominal segments as shown in Fig. 10. Genitalia as shown in Fig. 9, endomeres with small inner plate and paired outer rims.

Female: Smaller than Chapinia traylori in all measurements except for length and width of head which is larger than for other Chapinia (see Table 2). Resembles the male except that abdominal sternite II has 76-86 total setae. Terminal abdominal tergite with 16-22 long and 10-12 short setae on posterior margin; abdominal sternite VIII with 18-30 setae on posterior margin (Fig. 35). Anal fringe with 44-54 setae (Fig. 36).

Discussion: Although larger in size, Chapinia acutovulvata resembles most closely C. clayae. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have large thick brushes or normal setae in C. acutovulvata, but small scattered brushes of normal setae in C. clayae. Abdominal sternite II of both sexes has more total setae in C. acutovulvata than in corresponding sexes of C. malayensis. The male genitalia have on each outer rim of endomeres a triangular internal knob that is longer than wide in C. acutovulvata, but wider than long in C. clayae. These internal knobs are absent in other Chapinia. The female

terminal abdominal tergite has on the posterior margin at least 26 setae in C. acutovulvata of which approximately two-thirds are long and one-third are short, but at most 24 setae in C. clayae and C. malayensis of which approximately one-half are long and one-half are short in C. clayae, but approximately two-thirds are long and one-third are short in C. malayensis. In addition this margin has on each side of mid-line at least six long setae in C. acutovulvata, but at most five long setae in C. clayae. The female abdominal sternite VIII has on the posterior margin fewer than 32 setae in C. acutovulvata, but more than 34 setae in C. malayensis. The female anal fringe has at least 44 setae in C. acutovulvata, but at most 44 setae in C. clayae.

Material examined: 33 males and 35 females from fresh and dried material collected in the Oriental Region; from the type host: 2 females, Piaget, BM(NH) 1953-21; 2 males and 2 females from Nepal, December 1935, BM(NH), 4872; from Anthracoceros albirostris leucogaster (Blyth, 1841): 2 males and 2 females from Myitkyina, Burma, 26 March 1945, collected by the U. S. Typhus Commission, BM(NH); and 3 males, 1 female with same data, USNM; 2 males and 1 female from Stillwell Road, Myitkyina, Burma, 26 September 1945, collected by H. S. Fuller, BM(NH) 1947-321(164); and 2 males, 2 females with same data, USNM; 2 males from Hin Laem, Tha Khanun, Kanchanaburi, Thailand, 27 November 1952, collected by Robert E. Elbel and H. G. Deignan, USNM; 2 males from Ban Khlua Klang, Prachuap Khiri Khan, Thailand, December 1952, collected by Robert E. Elbel and H. G. Deignan, USNM; 2 males and 1 female from Ban Nam Phu, Phu Khieo, Chaiyaphum, Thailand, 22 December 1952, collected by Robert E. Elbel, USNM; 1 male and 1 female from

Ban Thung Chuak, Salok Bat, Khanu, Kamphaeng Phet, Thailand, 25 June 1953, collected by Robert E. Elbel, USNM; 1 female from Tha Din Daeng, Pa Bon, Pak Pha Yun, Phatthalung, Thailand, 30 July 1962, collected by Wichit Suwan Laong, BPBM; 6 males and 6 females from Muang Kluang, Ka Poe, Ranong, Thailand, 1962-1963, collected by Wichit Suwan Laong, BPBM; from Anthracoceros coronatus (Boddaert, 1783): 6 males and 11 females from Pa Dong Lan, Chumphae, Khon Kaen, Thailand, 2 December 1962, collected by Kitti Thonglongya, SMRL; 2 females from CNHM skins from Kanha, Central Provinces, India, August 1946, collected by Rup Chand (REE); 2 females from CNHM skins from Nawadeh, Bihas, India, 11 November 1947, collected by W. Koelz (REE); 1 male from USNM skins from India and Ceylon, 1874 and 1944, collected by B. H. Swales and S. D. Ripley (REE); from Anthracoceros convexus (Temminck, 1831): 1 male and 1 female from lot 1584 (TMRN), Zoological Museum, Humboldt University, Berlin; according to Eichler (1947), the Mallophaga from this later named host were collected in Sumatra by E. Mjöberg; from Anthracoceros marchei Oustalet, 1885: 1 male from Puerto Princesa, Palawan, Philippines, 12 May 1962, collected by Max Thompson, USNM BPM-PI 2313.

Drawings were made of a male and a female from Anthracoceros albirostris leucogaster collected in Myitkyina, Burma. Specimens are in the BM(NH).

8. Chapinia malayensis n. sp.

(Figs. 12 and 37)

Male: Approximately the same size as Chapinia traylori (see Table 1). Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with large thick brushes of normal setae which are not as numerous

on abdominal sternite VI. Each lateral margin of abdominal tergites II-VI with a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 34 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. acutovulvata. Genitalia as shown in Fig. 12, endomeres with large inner plate and paired outer rims.

Female: Slightly smaller than Chapinia traylori in all measurements except for length of head (see Table 2). Resembles the male except that abdominal sternite II has 64 total setae. Terminal abdominal tergite with 20 long and 4 short setae on posterior margin; abdominal sternite VIII with 24 long and 12 short setae on posterior margin (Fig. 37). Anal fringe similar to that of C. acutovulvata with 50 setae.

Discussion: Chapinia malayensis resembles most closely C. acutovulvata. Abdominal sternite II of both sexes has fewer total setae in C. malayensis than in corresponding sexes of C. acutovulvata. Male genitalia have the large inner plate of endomeres possessing paired lateral flanges and a central terminal point in C. malayensis, but a small inner plate in C. acutovulvata. The female terminal abdominal tergite has on the posterior margin at most 24 setae in C. malayensis, but at least 26 setae in C. acutovulvata. The female abdominal sternite VIII has on the posterior margin more than 34 setae in C. malayensis, but fewer than 32 setae in C. acutovulvata.

Material examined: 1 male and 1 female from fresh material collected in Borneo.

Type host: Anthracoceros malayanus (Raffles, 1822).

Type material: Holotype male and allotype female from Borneo are in the British Museum (Natural History) Meinertzhagen 10910.

9. Chapinia hoplai n. sp.

(Figs. 13 and 38)

Both sexes are slightly smaller than corresponding sexes of Chapinia traylori in all measurements except for length of head (see Tables 1-2).

Male: Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with large thick brushes of normal setae. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 66-68 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. acutovulvata. Genitalia as shown in Fig. 13, endomeres with paired outer rims only.

Female: Resembles the male except that abdominal sternite II has 80-88 total setae. Terminal abdominal tergite with 14 long and 12 short setae on posterior margin; abdominal sternite VIII with 16 long and 4 short setae on posterior margin (Fig. 38). Anal fringe similar to that of C. acutovulvata with 50-54 setae.

Discussion: Although slightly larger in size, Chapinia hoplai resembles most closely C. boonsongi. The venter of the third femora and posterolateral margins of abdominal sternite IV-VI each have large thick brushes of normal setae in C. hoplai, but small scattered brushes of normal setae in C. boonsongi. Abdominal sternite II of both sexes has more total setae in C. hoplai than in corresponding sexes of C. boonsongi. The male genitalia have paired outer rims of endomeres curved inwardly in C. hoplai,

but straight and nearly parallel in C. boonsongi. The female terminal abdominal tergite has on the posterior margin more than 24 setae of which approximately one-half are long and one-half are short in C. hoplai, but fewer than 22 setae of which approximately two-thirds are long and one-third are short in C. boonsongi.

Material examined: 3 males and 2 females from dried material collected in the Philippines.

Type host: Anthracoceros montani (Oustalet, 1880).

Type material: Holotype male and allotype female from USNM skins from Sulu, and Tawi Tawi, Philippines, 1891, collected by D. C. Worchester and F. S. Bourns (REE) are in the United States National Museum. Paratypes: 2 males and 1 female with same data.

Chapinia hoplai is named for Dr. Cluff E. Hopla, Department of Zoology, University of Oklahoma, in appreciation for his thoughtful advice while directing this study.

10. Chapinia boonsongi n. sp.

(Figs. 11, 14, and 39)

Both sexes are smaller than corresponding sexes of Chapinia traylori in all measurements except for length of head (see Tables 1-2).

Male: Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae which are not as numerous on abdominal sternite VI. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 48-62 total setae and one median row of setae on posterior margin. Terminal abdominal segments as shown in Fig. 11.

Genitalia as shown in Fig. 14, endomeres with paired outer rims only.

Female: Resembles the male except that abdominal sternite II has 62-70 total setae. Terminal abdominal tergite with 14-16 long and 4 short setae on posterior margin; abdominal sternite VIII with 18-20 setae on posterior margin (Fig. 39). Anal fringe similar to that of C. acutovulvata with 50-56 setae.

Discussion: Although slightly smaller in size, Chapinia boonsongi resembles most closely C. hoplai. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae in C. boonsongi, but large thick brushes of normal setae in C. hoplai. Abdominal sternite II of both sexes has fewer total setae in C. boonsongi than in corresponding sexes of C. hoplai. The male genitalia have paired outer rims of endomeres straight and nearly parallel in C. boonsongi, but curved inwardly in C. hoplai. The female terminal abdominal tergite has on the posterior margin fewer than 22 setae of which approximately two-thirds are long and one-third are short in C. boonsongi, but more than 24 setae of which approximately one-half are long and one-half are short in C. hoplai.

Material examined: 5 males and 8 females from fresh and dried material collected in Thailand.

Type host: Rhyticeros undulatus ticehursti Deignan, 1941.

Type material: Holotype male from USNM skin from Ban Hai Huai, Thailand, 15 June 1936, collected by H. G. Deignan (REE), is in the United States National Museum. Additional types from: Rhyticeros u. undulatus (Shaw, 1811): Allotype female from Khao Phap Pha Mt., Ban Na, Phatthalung,

Thailand, 7 February 1955, collected by Boonsong Lekagul, is in the United States National Museum. Paratypes: 3 males and 3 females with same data; 1 male from BL skin from Nong Ko, Siracha, Chon Buri, Thailand, August 1953, collected by Boonsong Lekagul (REE); 4 females from Lamo, Muang, Trang, 5 March 1963, collected by Wichit Suwan Laong, BPBM.

Chapinia boonsongi is named for Dr. Boonsong Lekagul, Bangkok physician and naturalist, in appreciation for the fresh material he collected from Thailand and for permission to examine his Hornbill skins for Mallophaga.

11. Chapinia wenzeli n. sp.

(Figs. 15, 40-41)

Both sexes are smaller than corresponding sexes of Chapinia traylori in all measurements except for length of head in females (see Tables 1-2).

Male: Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae which are not as numerous on abdominal sternite VI. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 30-36 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. boonsongi. Genitalia as shown in Fig. 15, endomeres with paired outer rims only, the posterolateral margins of which are split.

Female: Resembles the male except that abdominal sternite II has 50-60 total setae. Terminal abdominal tergite with 12-14 long and 6-8 short setae on posterior margin; abdominal sternite VIII with 18-24 setae on posterior margin (Fig. 40). Anal fringe with 40-44 setae (Fig. 41).

Discussion: Chapinia wenzeli resembles most closely C. blakei. The

venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae in both sexes of C. wenzeli, but only in the female of C. blakei. The male genitalia have endomeres with outer rims in C. wenzeli, but paired plates in C. blakei. However, the paired plates may be split in C. blakei giving the appearance of paired outer rims and inner plate; but the inner plate in this case is unsymmetrical. The female abdominal sternite VIII has on the posterior margin at least 18 setae in C. wenzeli, but at most 18 setae in C. blakei; and the internal sclerite, absent in C. wenzeli, is present in C. blakei. The female anal fringe has at least 40 setae in C. wenzeli, and at most 40 setae in C. blakei.

Material examined: 20 males and 23 females from fresh and dried material collected in the Philippines.

Type host: Penelopides panini samarensis Steere, 1890.

Type material: Holotype male and allotype female from CNHM skins from Sandayong, Sierra Bullones, Bohol Island, Philippines, April 1955, collected by D. S. Rabor (REE) are in the Chicago Natural History Museum. Paratypes: 2 females with same data; 2 males from CNHM skins from Matuguinao, Samar Island, Philippines, April 1957, collected by D. S. Rabor (REE); from Penelopides panini manilloe (Boddaert, 1783): 1 male and 1 female from CNHM skin from Bataan, Luzon Island, Philippines, 17 January 1905, collected by Celestino and Canton (REE); from Penelopides panini mindorensis Steere, 1890: 1 male from CNHM skin from Balete, Rio Baca, Mindanao, Philippines, 1 April 1905, collected by McGregor, Celestino, and Canton (REE); from Penelopides panini affinis Tweeddale, 1877: 8 males and 2 females from

CNHM skins from Mindanao, Philippines, 1946 and 1947, collected by Werner and Alcasid (REE); 3 males and 8 females from Davao, Mindanao, Philippines, 18 January 1947, KCE; 4 males and 9 females from Mindanao, Philippines.

Chapinia wenzeli is named for Dr. Rupert L. Wenzel, Curator of Insects, Chicago Natural History Museum, in appreciation for the loan of Hornbill Menoponidae from that Museum.

12. Chapinia blakei n. sp.

(Figs. 16, 42-43)

Male: Slightly smaller than Chapinia traylori in all measurements except for length of head and width of metathorax (see Table 1). Venter of third femora and abdominal sternites IV-VI each without brushes. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 32-42 total setae and one median row of setae on posterior margin. Terminal abdominal segments similar to those of C. boonsongi. Genitalia as shown in Fig. 16, endomeres with paired plates.

Female: Smaller than Chapinia traylori in all measurements except for length of head (see Table 2). Resembles the male except that the venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae which are not as numerous on abdominal sternite VI. Abdominal sternite II with 52-64 total setae. Terminal abdominal tergite with 10-16 long and 8-14 short setae on posterior margin; abdominal sternite VIII with 14-18 setae on posterior margin (Fig. 43) and with internal sclerite having slender posterior diverging margins. Anal fringe with 34-40 setae (Fig. 42).

Discussion: Chapinia blakei resembles most closely C. wenzeli. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have small scattered brushes of normal setae in females of C. blakei, and in both sexes of C. wenzeli. The male genitalia have endomeres with paired plates in C. blakei, but paired outer rims in C. wenzeli. However, the paired plates may be split in C. blakei giving the appearance of paired outer rims and inner plate; but the inner plate in this case is unsymmetrical. The male genitalia of C. traylori also have endomeres with paired plates, but the posterior extension of the endomeres is split in C. traylori, and not split in C. blakei. The female abdominal sternite VIII has on the posterior margin at most 18 setae in C. blakei, but at least 18 setae in C. wenzeli; and the internal sclerite with slender posterior diverging margins, present in C. blakei, is absent in both C. wenzeli and C. traylori. The female anal fringe has at most 40 setae in C. blakei and at least 40 setae in C. wenzeli.

Material examined: 13 males and 16 females from fresh and dried material collected in the Philippines.

Type host: Rhyticeros l. leucocephalus (Vieillot, 1816).

Type material: Holotype male and allotype female from CNHM skins from Zamboanga, Mindanao Island, Philippines, 1948 and 1956, collected by D. S. Rabor (REE) are in the Chicago Natural History Museum. Paratypes: 11 males and 12 females from Mutya, Canon, Mindanao Island, Philippines, December 1961, collected by Rabor and Gonzales, BPBM; 1 female from Davao, Tagum, Mindanao Island, Philippines, 13 October 1946, collected by H. Hoogstraal, CNHM; from Rhyticeros leucocephalus waldeni (Sharpe, 1877): 1 male and 2

females from CNHM skins from Tolong, Negros Island, Philippines, November-December 1948, collected by D. S. Rabor (REE).

Chapinia blakei is named for Dr. Emmet R. Blake, Curator of Birds, Chicago Natural History Museum, in appreciation for permission to examine Hornbill skins for Mallophaga in that Museum.

13. Chapinia traylori n. sp.

(Figs. 17, 25-26, 44-45)

Male: As illustrated in Fig. 26. Slightly larger than Chapinia wenzeli, C. clayae, C. hoplai, C. boonsongi, C. lydae, and C. blakei in all measurements except for length of head in C. clayae, C. hoplai, C. boonsongi, C. lydae, and C. blakei, and for width of metathorax in C. blakei; approximately the same size as C. robusta (see Table 1). Venter of third femora and abdominal sternites IV-VI each without brushes. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 24-42 total setae and two median rows of setae although the anterior row has widely separated setae. Terminal abdominal segments as shown in Fig. 26 e. Genitalia as shown in Fig. 17, endomeres with paired plates.

Female: As illustrated in Fig. 25. Larger than Chapinia acutovulvata in all measurements except for length and width of head; slightly larger than other Chapinia in all measurements except for length of head (see Table 2). Resembles the male except that abdominal sternite II has 38-58 total setae. Terminal abdominal tergite with 10 long and 6-10 short setae on posterior margin; abdominal sternite VIII with 14-20 setae on posterior margin and with small triangular internal sclerite; each lateral projection of the

sclerite between abdominal sternite VIII and anus with 2-3 thick, posteriorly directed setae (Fig. 44). Anal fringe with 34-40 setae (Fig. 45).

Discussion: Chapinia traylori resembles most closely C. blakei. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI lack brushes in both sexes of C. traylori and in the male of C. blakei, but these margins have small scattered brushes of normal setae in females of C. blakei. The male genitalia have endomeres with paired plates in both C. traylori and C. blakei, but the posterior extension of the endomeres is split in C. traylori, and not split in C. blakei; the paired plates may be split in C. blakei giving the appearance of paired outer rims and inner plate, but the inner plate in this case is unsymmetrical. The female abdominal sternite VIII has a small triangular internal sclerite in C. traylori, but a much larger sclerite with slender posterior diverging margins in C. blakei. There are fewer than four thick, posteriorly directed setae on each lateral projection of the sclerite between female abdominal sternite VIII and anus in C. traylori, but more than four in all other Chapinia.

Material examined: 73 males and 52 females from fresh and dried material collected in the Philippines.

Type host: Buceros hydrocorax semigaleatus Tweeddale, 1878.

Type material: Holotype male, allotype female, and paratype female on 1 slide from CNHM skins from San Isidro, Samar Island, Philippines, April-May 1957, collected by D. S. Rabor (REE) are in the Chicago Natural History Museum. The allotype female is the largest female and is next to the male. Paratypes: 1 male and 1 female from CNHM skins from Cantaub, Sierra Bul-

lones, Bohol Island, Philippines, April-May 1955, collected by D. S. Rabor (REE); 2 males from CNHM skins from Matuguinao, Samar Island, Philippines, April 1957, collected by D. S. Rabor (REE); 15 males and 9 females from CNHM skins from Mt. Capato-an, Samar Island, Philippines, May 1957, collected by D. S. Rabor (REE); from: Buceros hydrocorax mindanensis Tweeddale, 1877: 11 males and 12 females from Mutya, Canon, Mindanao Island, Philippines, 23 December 1961, collected by Rabor and Gonzales, BPBM; 9 males and 7 females from Mt. McKinley, Davao, Mindanao Island, Philippines, August 1946, collected by H. Hoogstraal, CNHM; 2 males and 3 females from CNHM skins from Taglawig, Tagum, Davao, Mindanao Island, Philippines, October 1946, collected by Celestino (REE); 13 males and 7 females from Mt. Apo, Todaya, Mindanao Island, Philippines, 25 October 1946, collected by Hoogstraal and Hey, CNHM; 2 males and 1 female from CNHM skins from Kidapawan, Cotabata, Mindanao Island, Philippines, 2 December 1946, collected by Alcasid (REE); 1 male and 1 female from CNHM skins from Burungkot Upi, Cotabata, Mindanao Island, January 1947, collected by Werner and Alcasid (REE); 9 males and 4 females from CNHM skins from Mt. Malindang, Zamboanga, Mindanao Island, Philippines, March-May 1956, collected by D. S. Rabor (REE); 2 males and 1 female from USNM skins from Mindanao Island, Philippines, August-September 1903, collected by E. A. Mearns (REE); 5 males and 4 females from Mindanao Island, Philippines.

Chapinia traylori is named for Dr. M. A. Traylor, Division of Birds, Chicago Natural History Museum, in appreciation for assistance in examination of Hornbill skins for Mallophaga in that Museum.

14. Chapinia lydae n. sp.

(Figs. 20 and 46)

"Colpocephalum hirtum Rudow, 1866." Piaget, 1880. Les Pédiculines: 530, pl. xliv, fig. 3 (nec Rudow, 1866).

Type host: Buceros cassidix = Rhyticeros cassidix (Temminck, 1823).

Clay (1951 b) stated that it was impossible to say whether or not Piaget's specimens of a headless female and 2 nymphs from Buceros cassidix = Rhyticeros cassidix (Temminck, 1823) were conspecific with Rudow's hirtum from Buceros ruficollis = Rhyticeros plicatus ruficollis (Vieillot, 1816). Through the courtesy of Dr. Clay, Piaget's specimens have been examined; and they do not appear to be conspecific with Chapinia hirta (Rudow, 1866). Therefore, they are described herewith and illustrated as part of the type material from Rhyticeros cassidix.

Both sexes are smaller than corresponding sexes of Chapinia traylori in all measurements except for length of head, but this measurement in the male is larger than in males of other Chapinia (see Tables 1-2).

Male: Venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae which are not as numerous on abdominal sternite VI. Each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta. Abdominal sternite II with 62-64 total setae and three median rows of setae. Terminal abdominal segments similar to those of C. boonsongi. Genitalia as shown in Fig. 20, endomeres with inner plate and paired outer rims.

Female: Resembles the male except that abdominal sternite II has 54-68 total setae. Terminal abdominal tergite with 14 long and 8 short setae on posterior margin; abdominal sternite VIII with 20-24 setae on posterior margin (Fig. 46). Anal fringe similar to that of C. hirta with 46-50 setae.

Discussion: Chapinia lydae superfically resembles C. hirta. Abdominal sternite II in both species has approximately the same number of total setae in females as in males, and three median rows of setae. Abdominal sternite II of other members of the acutovulvatum species-group has more setae in the females than in the males and 1-2 median rows of setae. The male genitalia in C. lydae are wider than in C. hirta, and the parameres are swollen anteriorly only in C. lydae; the endomeres have an inner plate and paired outer rims in C. lydae, and paired outer rims only in C. hirta. The female terminal abdominal tergite has on the posterior margin 3-4 long setae on each side of the mid-line in C. lydae, but five evenly spaced long setae in C. hirta; the two median setae in C. lydae are as widely spaced as four times the distance between the other 3-4 long setae on each side of the mid-line.

Material examined: 3 males and 5 females from dried skins collected in the Celebes.

Type material: Holotype male and allotype female from USNM skins from Palaleh River, Celebes, 9 August 1914, collected by H. C. Raven (LE) are in the United States National Museum. Paratypes: 2 males and 3 females with same data; 1 female, Piaget, BM(NH) 1928-325.

Chapinia lydae is named for my wife, Lyda, in appreciation for the dried material from Rhyticeros cassidix and other hosts in the USNM, and for much help in preparation of the manuscript.

Figs. 8-14. Dorsal-ventral view of male terminal abdominal segments and ventral view of male genitalia of acutovulvatum species-group, drawn to the same scale, as indicated.

Fig. 8. Chapinia clayae n. sp., genitalia of holotype.

Fig. 9. Chapinia acutovulvata (Piaget), genitalia.

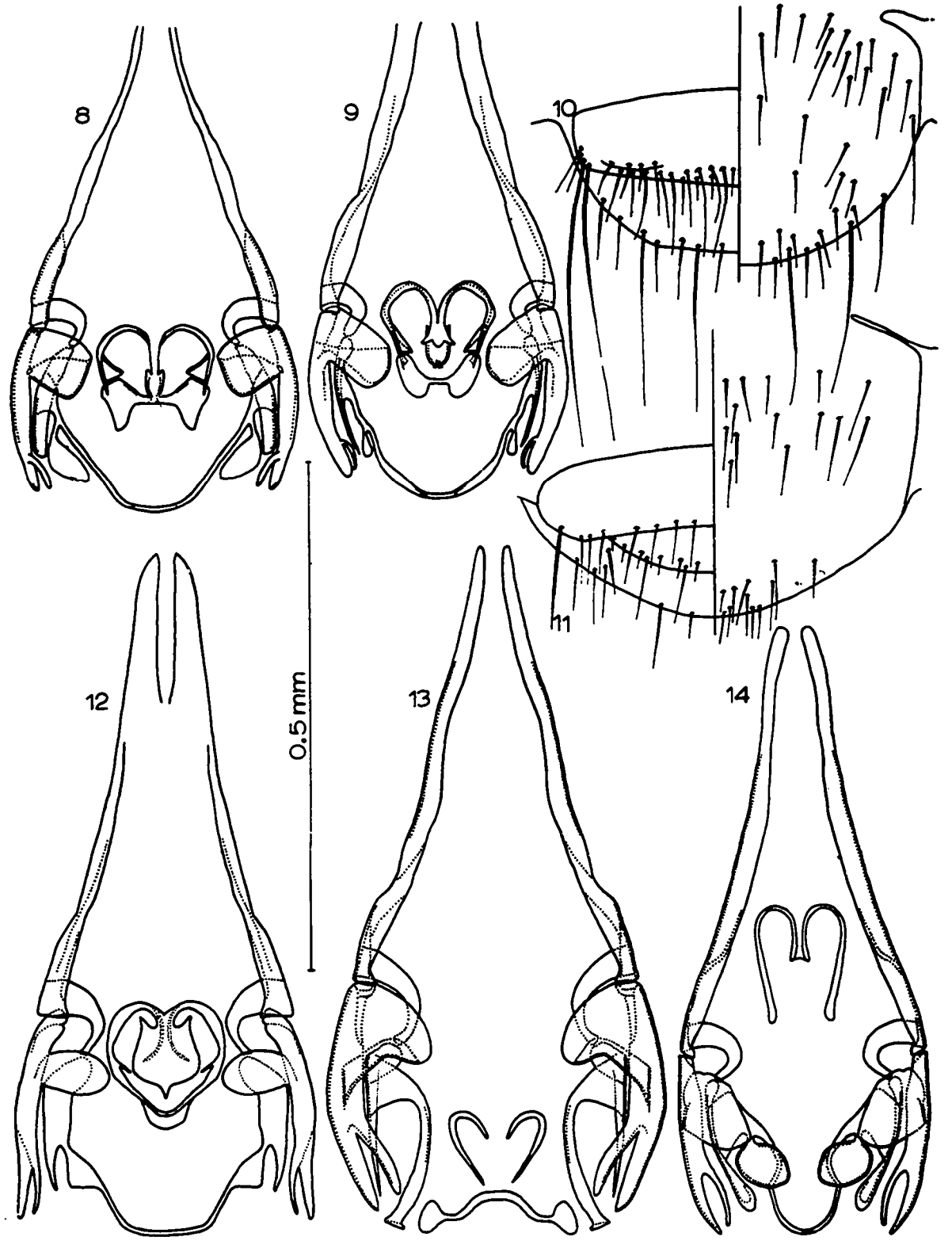
Fig. 10. Chapinia acutovulvata (Piaget), terminal abdominal segments.

Fig. 11. Chapinia boonsongi n. sp., terminal abdominal segments of holotype.

Fig. 12. Chapinia malayensis n. sp., genitalia of holotype.

Fig. 13. Chapinia hoplai n. sp., genitalia of holotype.

Fig. 14. Chapinia boonsongi n. sp., genitalia of holotype.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DISCUSSION: ACUTOVULVATUM SPECIES-GROUP

Species of the acutovulvatum species-group are all similar in size except that males of Chapinia wenzeli are smaller than other males, and females of C. traylori are larger than other females. The venter of the third femora and posterolateral margins of abdominal sternites IV-VI each have large thick brushes of normal setae in both sexes of C. acutovulvata, C. malayensis, and C. hoplai; small scattered brushes of normal setae in females of C. blakei, and in both sexes of C. clayae, C. boonsongi, C. wenzeli, and C. lydae; and brushes are absent in the male of C. blakei, and in both sexes of C. traylori. Each lateral margin of abdominal tergites II-VI has a short seta between the spiracle and post-spiracular seta in C. clayae, C. acutovulvata, and C. malayensis. Abdominal sternite II has more total setae in both sexes of C. acutovulvata and C. hoplai than in corresponding sexes of C. malayensis, C. wenzeli, C. blakei, and C. traylori; more total setae in females than in males except in C. lydae; and setae are arranged in one median row except for two median rows in C. traylori and three median rows in C. lydae. The male genitalia have endomeres with an inner plate and paired outer rims in C. clayae, C. acutovulvata, C. malayensis, and C. lydae, the paired outer rims possessing internal knobs only in C. clayae and C. acutovulvata, the inner plate possessing paired lateral flanges and central terminal point only in C. malayensis; only

paired outer rims in C. hoplai, C. boonsongi, and C. wenzeli, the postero-lateral margin being split in C. wenzeli; and only paired plates in C. blakei and C. traylori. The female terminal abdominal tergite has on the posterior margin at most 24 setae except for C. acutovulvata and C. hoplai with at least 26 setae; of these setae approximately two-thirds are long and one-third are short in C. acutovulvata, C. malayensis, C. boonsongi, and C. lydae; but approximately one-half are long and one-half are short in C. clayae, and C. hoplai; these setae are arranged with at least 5 long setae on each side of the mid-line in C. acutovulvata and C. malayensis, but at most 6 setae in all other species of the acutovulvatum species-group. In the female the sclerite between the vulva and anus is curved sharply on the anterior margin in C. clayae and C. acutovulvata, but is only slightly curved in the other species of the group; on each lateral projection of this sclerite there are 4-6 thick, posteriorly directed setae except in C. traylori which has 2-3. The female abdominal sternite VIII has on the posterior margin the most setae in C. malayensis with more than 34 setae, and the fewest in C. blakei with at most 18 setae. The female anal fringe has at least 44 setae in C. acutovulvata, C. malayensis, C. hoplai, C. boonsongi, and C. lydae; but at most 44 setae in C. clayae, C. wenzeli, C. blakei, and C. traylori.

Were the species of the acutovulvatum species-group arranged according to the phylogeny of their hosts (see Peters, 1945), the order would be: C. clayae, C. wenzeli, C. blakei, C. lydae, C. boonsongi, C. malayensis, C. acutovulvata, C. hoplai, and C. traylori, rather than C. clayae, C. acutovulvata, C. malayensis, C. hoplai, C. boonsongi, C. wenzeli, C. blakei, C. traylori, and C. lydae, which is based on morpholgical similarities of the lice.

Figs. 15-22. Dorsal-ventral view of male terminal abdominal segments and ventral view of male genitalia of acutovulvatum and hirtum species-groups, drawn to the same scale, as indicated.

Fig. 15. Chapinia wenzeli n. sp., genitalia of holotype.

Fig. 16. Chapinia blakei n. sp., genitalia of holotype.

Fig. 17. Chapinia traylori n. sp., genitalia of holotype.

Fig. 18. Chapinia muesebecki n. sp., genitalia of holotype.

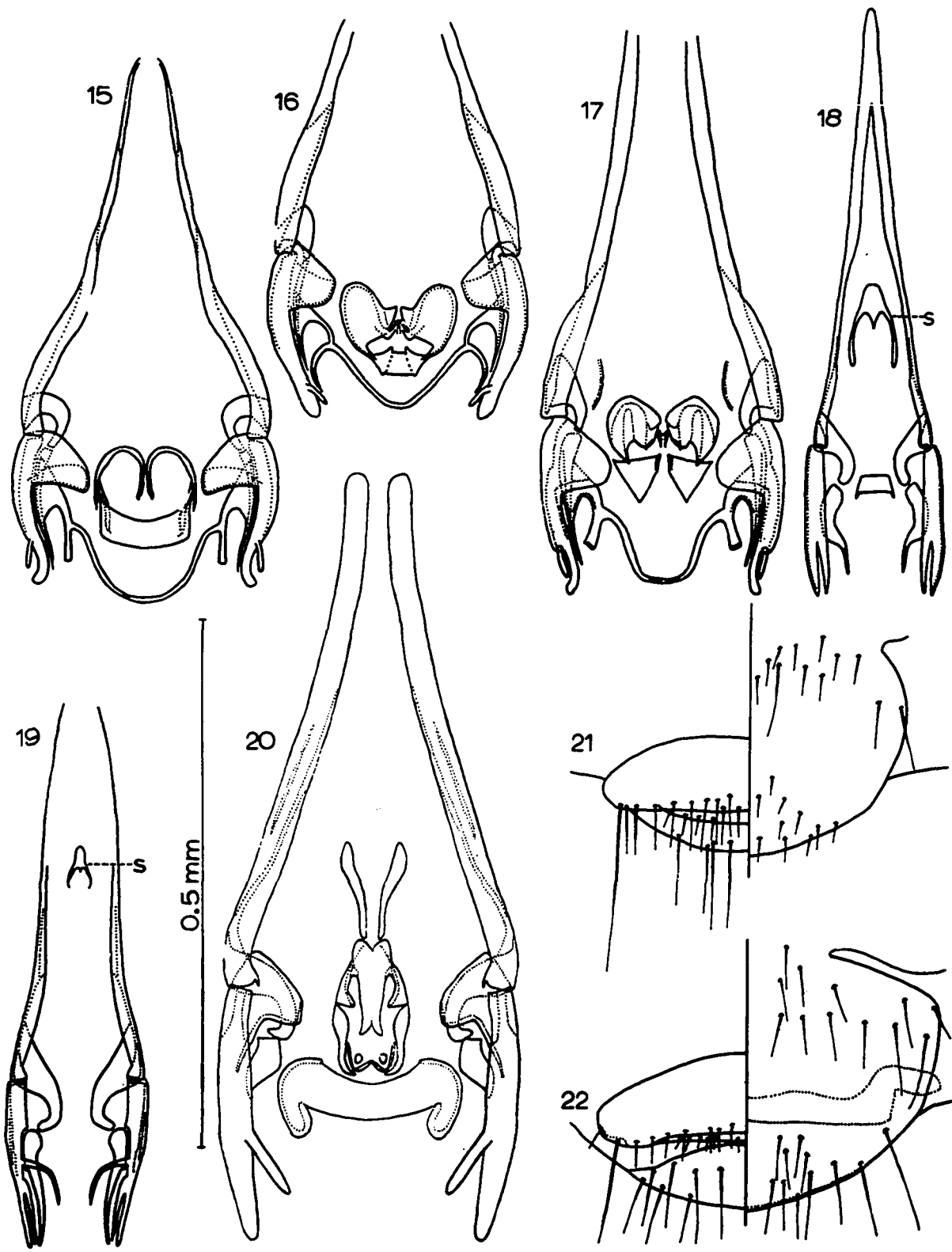
Fig. 19. Chapinia hirta (Rudow), genitalia of neotype.

Fig. 20. Chapinia lydae n. sp., genitalia of holotype.

Fig. 21. Chapinia muesebecki n. sp., terminal abdominal segments of holotype.

Fig. 22. Chapinia hirta (Rudow), terminal abdominal segments of neotype.

s - sclerite of genital sac.


15
16
17
18
s
19
s
0.5 mm
20
21
22

HIRTUM SPECIES-GROUP

Species similar in shape to Chapinia traylori (see Figs. 25-26). Differing from other species-groups in the following combination of characters: dorsal-lateral margins of head with a preocular notch; venter of third femora and posterolateral margins of abdominal sternites IV-VI each with small scattered brushes of normal setae which are not as numerous on abdominal sternite VI; each lateral margin of abdominal tergites II-VI without a short seta between the spiracle and post-spiracular seta; females with approximately the same number of abdominal sternal setae as in males; abdominal sternite II with three median rows of setae; male genitalia much narrower than for other species-groups, without lateral horns on each side of endomeres, and with parameres not swollen anteriorly but split posteriorly; female without sclerital hooks on each side of mid-line of ventral sclerite between vulva and anus; female abdominal sternite VIII with most of setae much shorter than those on posterior margin.

Hosts: Species of the hirtum species-group have been found only on the genera Penelopides and Rhyticeros of the avian family Bucerotidae.

15. Chapinia muesebecki n. sp.

(Figs. 18 and 21)

Male: Smaller than Chapinia traylori in all measurements except for length of head (see Table 1). Abdominal sternite II with 58-62 total setae.

Terminal abdominal segments as shown in Fig. 21. Genitalia as shown in Fig. 18.

Female: Unknown.

Discussion: Chapinia muesebecki resembles most closely C. hirta. Male terminal abdominal segments are shorter in C. muesebecki than in C. hirta, and the partial division between abdominal sternites VII and VIII is not as pronounced in C. muesebecki as in C. hirta. The sclerite of male genital sac is nearly twice as long as wide in C. muesebecki, but approximately as wide as long in C. hirta, and this sclerite is approximately three times as long in C. muesebecki as in C. hirta.

Material examined: 2 males from dried skins collected in the Celebes.

Type host: Penelopides e. exarhatus (Temminck, 1823).

Type material: Holotype male from USNM skins from Celebes, 1914-1916, collected by H. C. Raven (REE) is in the United States National Museum. Paratype male with same data.

Chapinia muesebecki is named for Mr. C. F. W. Muesebeck, Division of Insects, United States National Museum, in appreciation for the loan of Mallophaga from that Museum.

16. Chapinia hirta (Rudow)

(Figs. 19, 22, 47-48)

Colpocephalum hirtum Rudow, 1866. Z. ges. NatWiss., 27: 474.

Type host: Buceros ruficollis = Rhyticeros plicatus ruficollis (Vieillot, 1816).

Colpocephalum hirtum Rudow, 1869. Z. ges. NatWiss., 34: 399.

Chapinia hirta (Rudow). Hopkins and Clay, 1952. Checklist

Mallophaga: 67.

Hopkins and Clay state that the generic position of hirtum is doubtful. Examination of specimens from the type host shows them to be Chapinia. Therefore, the male, BM 13376, is designated hereby as neotype of C. hirta. The slide has been so labeled.

Both sexes are smaller than corresponding sexes of Chapinia traylori in all measurements except for length of head (see Tables 1-2).

Male: Abdmoninal sternite II with 60-64 total setae. Terminal abdominal segments as shown in Fig. 22. Genitalia as shown in Fig. 19.

Female: Resembles the male except that terminal abdominal segments have a tergite with 12 long and 10 short setae on posterior margin; abdominal sternite VIII has 18-22 setae on posterior margin (Fig. 48). Anal fringe with 46-48 setae (Fig. 47).

Discussion: Chapinia hirta resembles most closely C. muesebecki. Also, C. hirta superficially resembles C. lydae. Abdominal sternite II in these three species has approximately the same number of total setae in females as in males, and three median rows of setae. Male terminal abdominal segments are longer in C. hirta than in C. muesebecki, and the partial division between abdominal sternites VII and VIII is more pronounced in C. hirta than in C. muesebecki. The sclerite of male genital sac is approximately as wide as long in C. hirta, but nearly twice as long as wide in C. muesebecki, and this sclerite is approximately one-third as long in C. hirta as in C. muesebecki. The male genitalia in C. hirta are narrower than in C. lydae; and the parameres, straight-sided in C. hirta, are swollen anteriorly in C. lydae; the endomeres apparently are absent in C. hirta,

but have an inner plate and paired outer rims in C. lydae. The female terminal abdominal tergite has on the posterior margin five evenly spaced long setae on each side of mid-line in C. hirta; but 3-4 in C. lydae, the two median setae being as widely spaced as four times the distance between the other 3-4 long setae on each side of the mid-line.

Material examined: 3 males and 2 females from fresh and dried material collected in the Oriental and Australasian Regions; neotype male, BM 13376, and female, BM 13375, from New Guinea are in the British Museum (Natural History); from Rhyticeros plicatus subruficollis (Blyth, 1843): 1 female from USNM skins from Domel Island, Mergui Archipelago, 1904, collected by W. L. Abbott (REE); from Rhyticeros plicatus mendanae (Hartert, 1924): 1 male from CNHM skins from Guadalcanal, Solomon Islands, August-October 1944, collected by W. J. Beecher (REE); 1 male from MMZ skin from Gudalcanal, Solomon Islands, 20 January 1944, collected by K. W. Prescott (REE).

Drawings were made of the neotype male and the female, BM 13375. Specimens are in the BM(NH).

TABLE 1

Measurements in millimeters of Chapinia males.

Chapinia:	Length		Width			
	Head	Total *	Head	Pro-thro.	Meta-thor.	Abdomen *
1. fasciatus.	0.283	1.655	0.544	0.391	0.588	0.786
2. lophocerus.	.276	1.764	.529	.384	.565	.895
a. T. nasutus.	.304	-	.551	.398	.558	-
b. T. e. erythrorhynchus.	.290	-	.536	.362	.522	-
3. camurus.	.304	1.302	.485	.370	.464	.732
4. bucerotis.	.304	2.010	.581	.435	.602	.786
a. B. b. bucinator.	.304	-	.565	.413	.588	-
b. B. c. cylindricus.	.290	-	.558	.406	.544	-
c. B. c. albotibialis.	.286	-	.544	.398	.540	-
d. B. sc. subquadratus.	.290	-	.572	.413	.551	-
e. B. b. brevis.	.308	-	.559	.409	.576	-
5. robusta.	.348	2.222	.602	.471	.682	.868
a. C. elata.	.326	-	.595	.450	.652	-
6. clayae.	.312	1.600	.544	.370	.551	.760
7. acutovulvata.	.333	1.818	.616	.427	.652	.840
a. A. coronatus.	.348	-	.623	.442	.616	-
8. malayensis.	.312	1.655	.602	.478	.630	.950
9. hoplai.	.362	1.845	.572	.442	.623	.868
10. boonsongi.	.355	1.764	.544	.435	.581	.840
11. wenzeli.	.304	1.410	.529	.391	.551	.705
a. P. p. manilloe.	.297	-	.478	.370	.485	-
b. P. p. mindorensis.	.304	-	.478	.362	.492	-
c. P. p. affinis.	.283	-	.515	.355	.522	-
12. blakei.	.333	1.790	.572	.450	.652	.786
a. R. l. waldeni.	.355	-	.544	.420	.572	-
13. traylori.	.340	1.980	.609	.492	.689	.868
a. B. h. mindanensis.	.312	-	.595	.464	.630	-
14. lydae.	.375	1.850	.531	.437	.625	.825
15. muesebecki.	.333	1.790	.536	.398	.572	.814
16. hirta.	.348	1.710	.529	.427	.609	.868
a. R. p. mendanae.	.344	-	.522	.435	.605	-

* Measured only for specimens from which drawings were made.

a-e, from other hosts than type hosts.

TABLE 2

Measurements in millimeters of Chapinia females.

Chapinia:	Length		Width			
	Head	Total *	Head	Pro-thor.	Meta-thor.	Adbomen *
1. fasciatus.	0.340	2.222	0.630	0.485	0.689	1.004
a. T. alboterminatus.	.333	-	.609	.478	.674	-
2. lophocerus.	.304	2.170	.623	.450	.689	1.085
a. T. nasutus.	.348	-	.630	.471	.738	-
b. T. e. erythrorhynchus.	.318	-	.602	.427	.667	-
3. camurus.	.333	1.926	.544	.406	.602	0.950
4. bucerotis.	.362	2.715	.660	.522	.811	1.112
a. B. b. bucinator.	.340	-	.630	.478	.745	-
b. B. c. cylindricus.	.326	-	.630	.478	.745	-
c. B. c. albotibialis.	.377	-	.623	.492	.768	-
d. B. sc. subquadratus.	.311	-	.623	.450	.768	-
5. robusta.	.362	2.550	.652	.508	.803	1.112
a. C. elata.	.333	-	.630	.485	.775	-
6. clayae.	.326	2.118	.602	.435	.717	1.085
7. acutovulvata.	.406	2.550	.703	.492	.782	1.250
a. A. coronatus.	.362	-	.717	.529	.761	-
8. malayensis.	.333	2.010	.652	.515	.789	1.085
9. hoplai.	.333	2.280	.595	.464	.745	0.976
10. boonsongi.	.376	2.150	.563	.469	.719	1.006
11. wenzeli.	.311	1.980	.581	.450	.660	1.004
a. P. p. manilloe.	.333	-	.551	.435	.660	-
b. P. p. affinis.	.304	-	.581	.420	.696	-
12. blakei.	.362	2.010	.595	.485	.689	0.976
a. R. l. waldeni.	.355	-	.599	.486	.711	-
13. traylori.	.333	2.770	.696	.551	.861	1.194
a. B. h. mindanensis.	.318	-	.667	.544	.854	-
14. lydae.	.375	2.155	.544	.482	.712	1.006
15. hirta.	.377	2.035	.551	.464	.674	0.976
a. R. p. subruficollis.	.348	-	.565	.427	.667	-

* Measured only for specimens from which drawings were made.

a-d, from other hosts than type hosts.

Figs. 23-24. Dorsal-ventral view of male and of female, drawn to the same scale, as indicated; a-c, enlarged views, drawn to the same scale, as indicated.

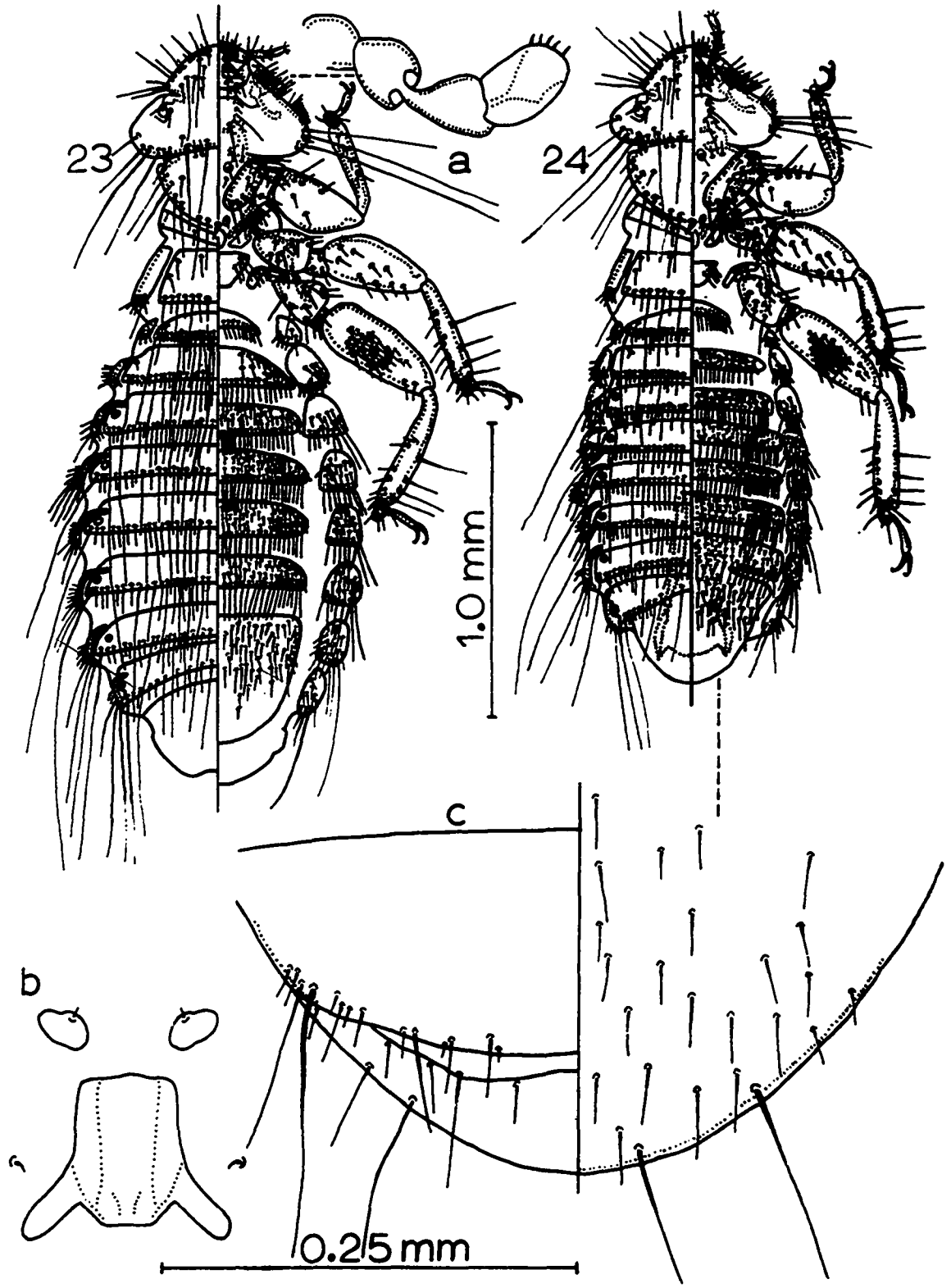
Fig. 23. Chapinia robusta Ewing, female.

Fig. 24. Chapinia robusta Ewing, male.

a - antenna of female.

b - prosternal plate of female.

c - terminal abdominal segments of male.


23
a
24
1.0 mm
c
b
0.25 mm

Figs. 25-26. Dorsal-ventral view of male and of female, drawn to the same scale, as indicated; a-e, enlarged views, drawn to the same scale, as indicated.

Fig. 25. Chapinia traylori n. sp., allotype female.

Fig. 26. Chapinia traylori n. sp., holotype male.

a - antenna of female.

b - prosternal plate of female.

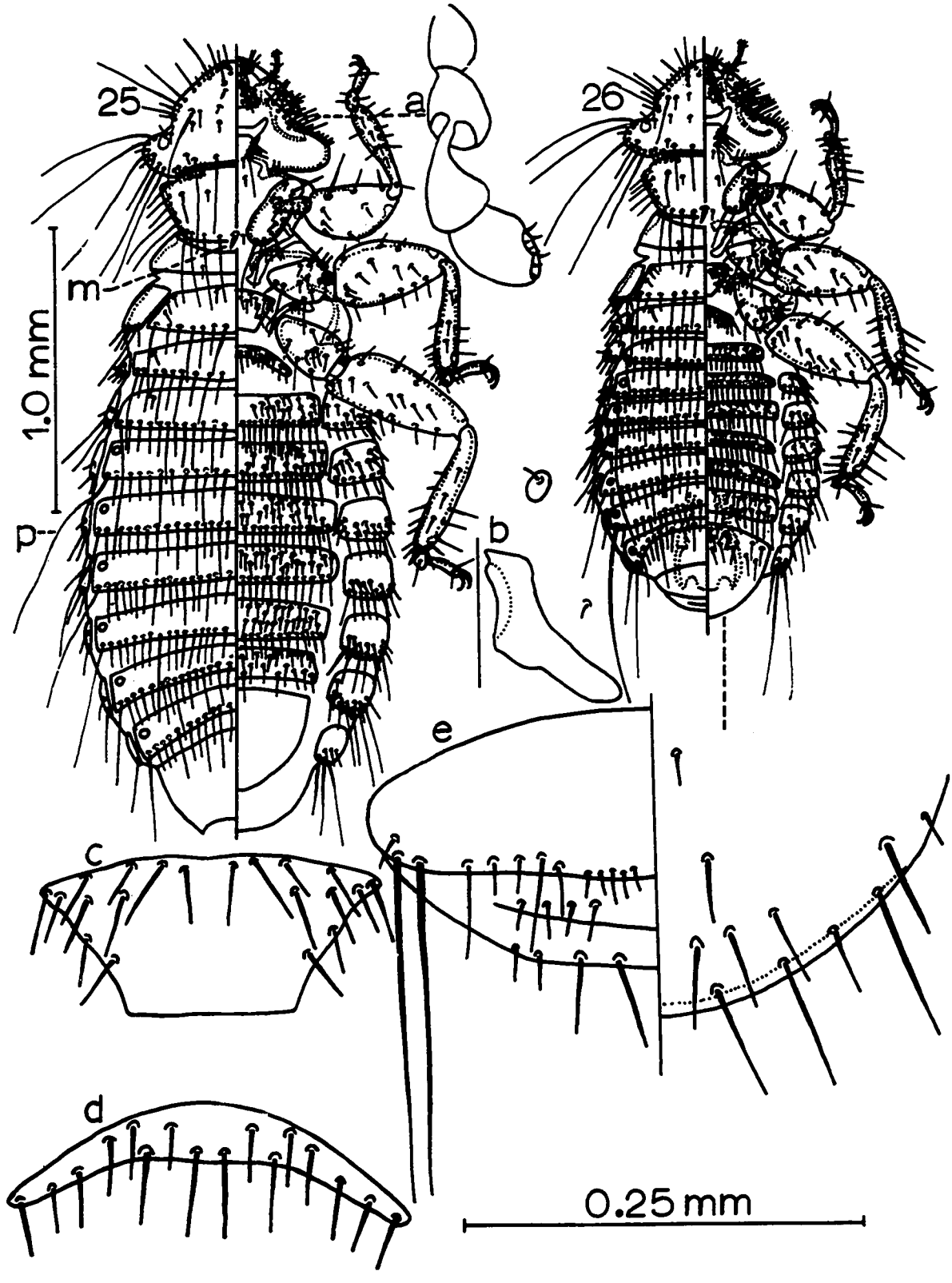
c - metasternal plate of male.

d - first abdominal sternite of male.

e - terminal abdominal segments of male.

m - mesonotum.

p - post-spiracular seta.


25
a
26
m
1.0 mm
p
♂
b
r
e
f
c
d
0.25 mm

Figs. 27-34. Dorsal-ventral view of female terminal abdominal segments and ventral view of female anal fringes of lophocerus and acutovulvatum species-groups, drawn to the same scale, as indicated.

Fig. 27. Chapinia lophocerus (Bedford), terminal abdominal segments.

Fig. 28. Chapinia lophocerus (Bedford), anal fringe.

Fig. 29. Chapinia bucerotis (Kellogg), terminal abdominal segments.

Fig. 30. Chapinia bucerotis (Kellogg), anal fringe.

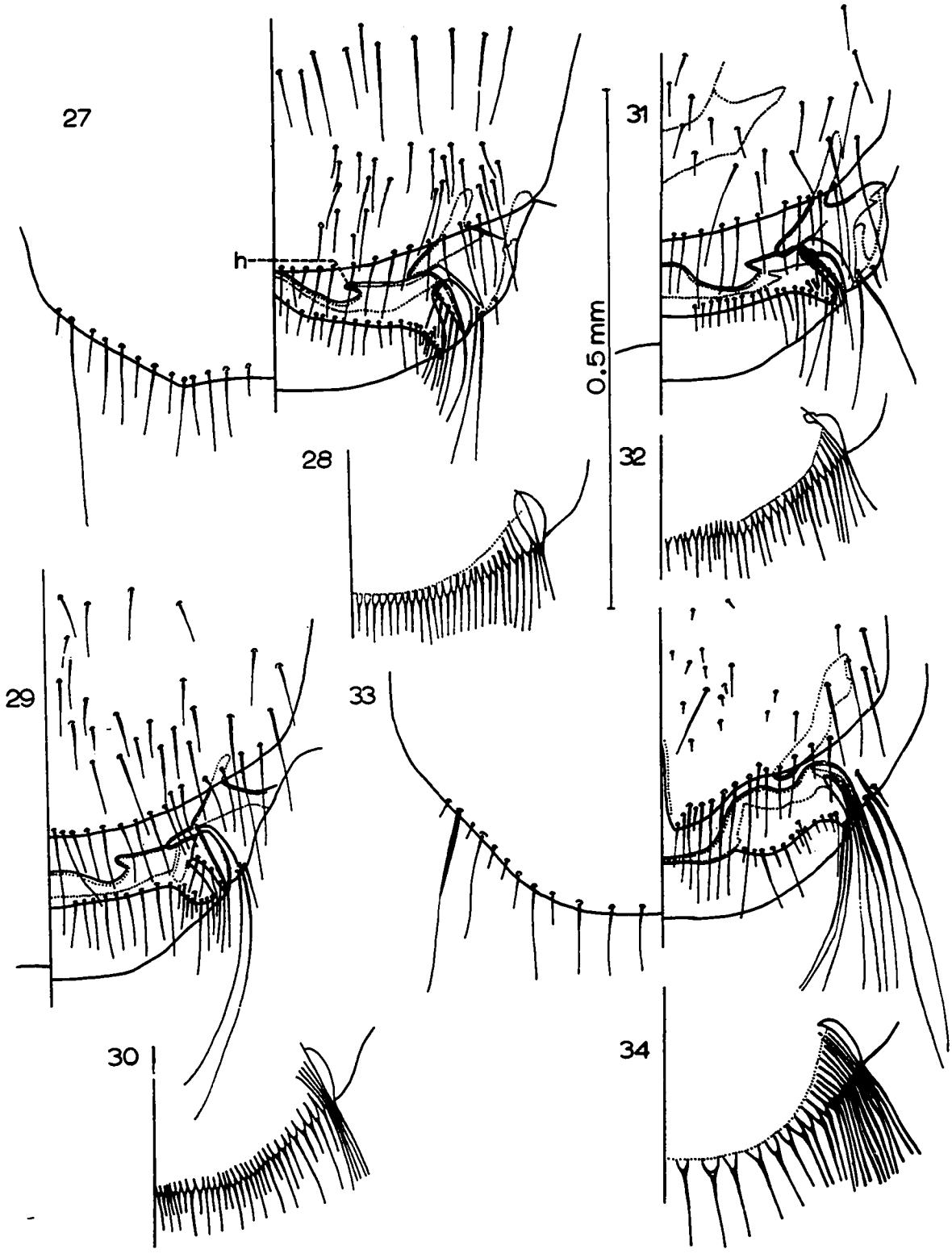
Fig. 31. Chapinia robusta Ewing, terminal abdominal segments.

Fig. 32. Chapinia robusta Ewing, anal fringe.

Fig. 33. Chapinia clayae n. sp., terminal abdominal segments. of allotype.

Fig. 34. Chapinia clayae n. sp., anal fringe of allotype.

h - sclerital hooks.


27
h
28
29
30
31
32
33
34
0.5 mm

Figs. 35-39. Dorsal-ventral view of female terminal abdominal segments and ventral view of female anal fringes of acutovulvatum species-group, drawn to the same scale, as indicated.

Fig. 35. Chapinia acutovulvata (Piaget), terminal abdominal segments.

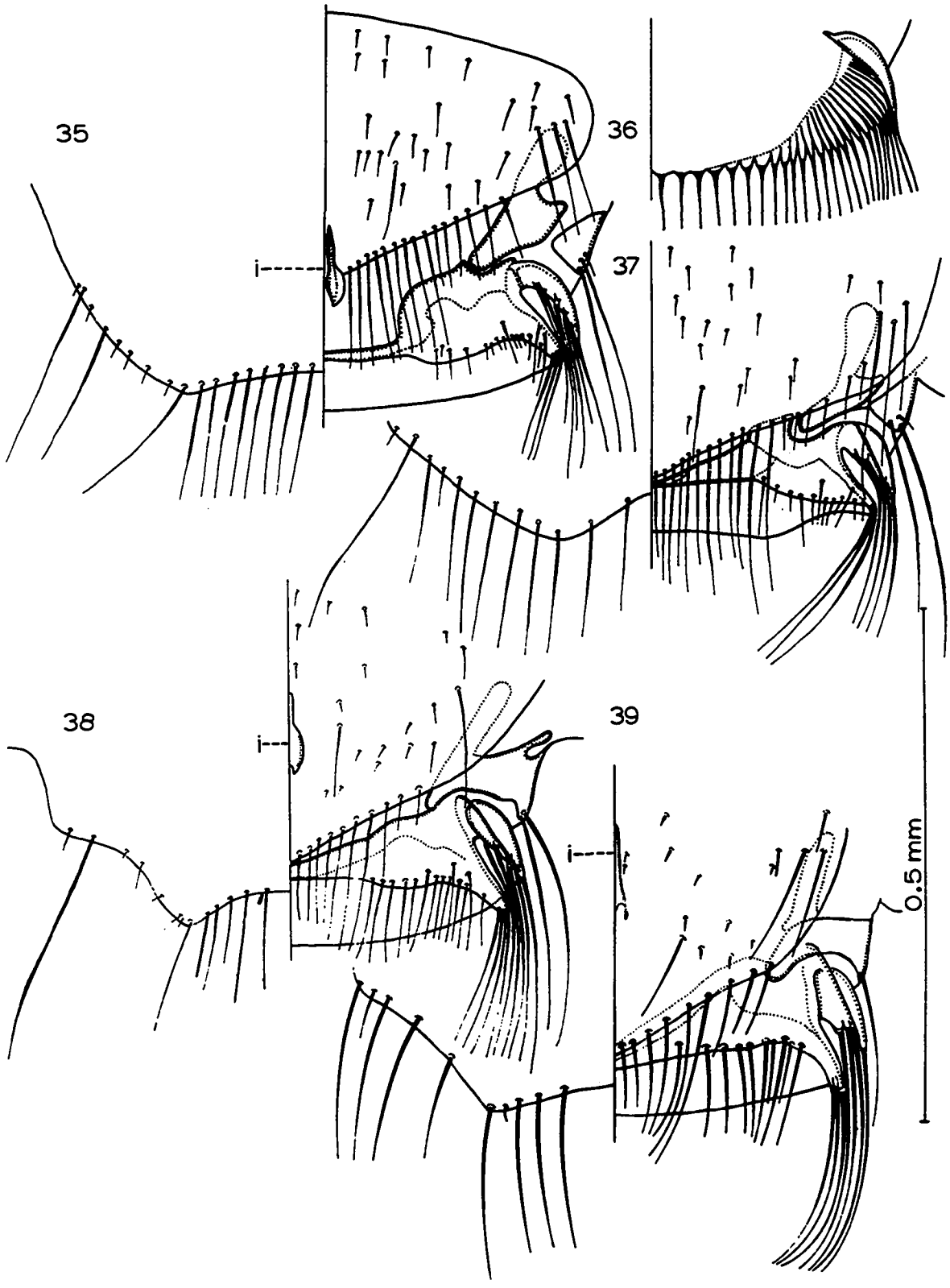
Fig. 36. Chapinia acutovulvata (Piaget), anal fringe.

Fig. 37. Chapinia malayensis n. sp., terminal abdominal segments of allotype.

Fig. 38. Chapinia hoplai n. sp., terminal abdominal segments of allotype.

Fig. 39. Chapinia boonsongi n. sp., terminal abdominal segments of allotype.

i - internal sclerite of abdominal sternite VIII.


35
36
37
38
39
i
i
i
0.5 mm

Figs. 40-45. Dorsal-ventral view of female terminal abdominal segments and ventral view of female anal fringes of acutovulvatum species-group, drawn to the same scale, as indicated.

Fig. 40. Chapinia wenzeli n. sp., terminal abdominal segments of allotype.

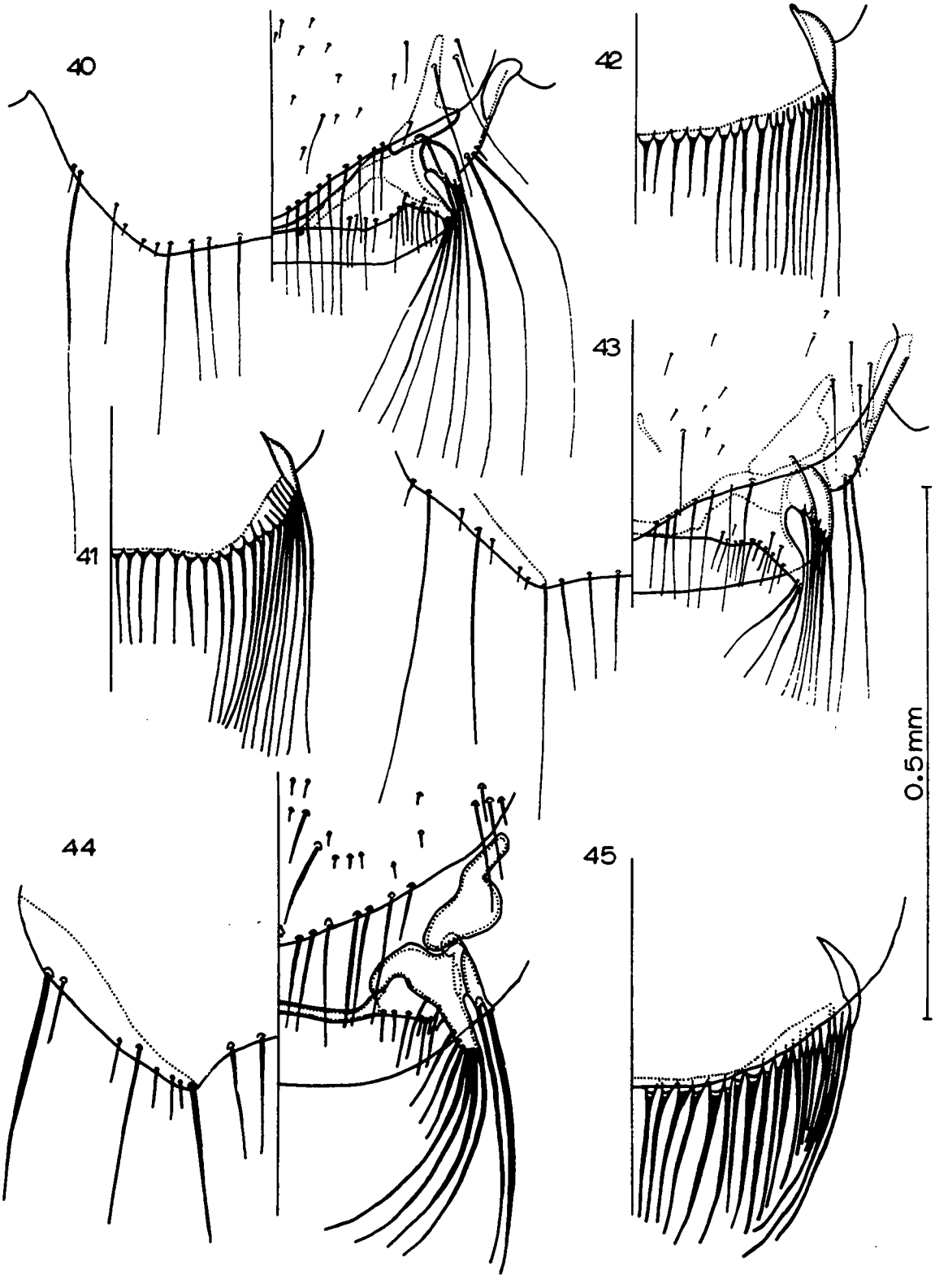
Fig. 41. Chapinia wenzeli n. sp., anal fringe of allotype.

Fig. 42. Chapinia blakei n. sp., anal fringe of allotype.

Fig. 43. Chapinia blakei n. sp., terminal abdominal segments of allotype.

Fig. 44. Chapinia traylori n. sp., terminal abdominal segments of allotype.

Fig. 45. Chapinia traylori n. sp., anal fringe of allotype.


40
41
42
43
44
45
0.5mm

BUCEROCOLPOCEPHALUM N. GEN.

Examples illustrated in Figs. 64-65. Head triangular, width 1 1/4-1 3/4 times that of length. Forehead slightly narrower anteriorly. Temples expanded. Antennae four-jointed, third segment constricted at base, and terminal segment capitate with definite signs of division into two parts, either by transverse line or marginal indentation. Antennary fossa deep, covered above by expansion of lateral margin of head, posterior margin of which lacks an eye. Dorsal-lateral margin of forehead above antennary fossa with shallow notch. Gular region narrow with a ridge on each lateral margin from which 8-11 setae extend. Pronotum large, expanded anteriorly, with four short median setae, and posterior marginal row of long setae. Metanotum expanded posteriorly, with six short median setae, posterior marginal row of long setae, and 4-7 short setae on each lateral margin. Metanotum separated from mesonotum and from pleurites. The sclerotized median button behind the prothorax (see Fig. 25 m) is a vestige of the mesonotum; and the supposed mesonotum, the narrow sclerotized band posterior to this button, is a mere extension of the subcoxae (see Cope, 1941). Thoracic sternal plates as shown in Figs. 64 b and 64 c. Prosternum with four median setae. Metasternal plate oval with 14-24 setae. Venter of third femora and posterolateral margins of abdominal sternite IV each with combs of setae. Abdominal segments consist of tergites, sternites, and pleurites, the latter

without prolongation of posteroventral angles. Abdominal tergites each with a posterior marginal row of setae, the most laterad being the post-spiracular seta. Each lateral margin of abdominal tergites II-VIII with 1-4 short setae between the spiracle and post-spiracular seta. Sternites and pleurites each with a posterior marginal row of long and short setae and with numerous short usually thick setae. Male terminal abdominal sternites VIII and IX fused with complete division from sternite VII (Fig. 65). Male genitalia as illustrated for each species with parameres branched anteriorly and split posteriorly. Female terminal abdominal segments as illustrated for each species with lateral processes arising from ventral sclerite between vulva and anus with long stout setae and strong spines. Females similar to males in size, general shape, and chaetotaxy except for terminal abdominal segments.

Bucerocolpocephalum resembles most closely Bucerophagus (Figs. 66-69), but differs in several characters: the posterior margin of the expansion of the lateral margin of the head covering the antennary fossa lacks an eye in Bucerocolpocephalum, but an eye with a double cornea is present in Bucerophagus. The gular region has on each lateral ridge 8-11 setae in Bucerocolpocephalum, but the ridge is absent, and each lateral margin has at most eight setae in Bucerophagus. The metasternal plate is oval in Bucerocolpocephalum, but trapezoidal or triangular in Bucerophagus. The venter of the third femora has combs of setae in Bucerocolpocephalum, but may have large thick brushes of normal setae in Bucerophagus; similar combs are present on posterolateral margins of abdominal sternite IV in Bucerocolpocephalum, and similar brushes are present on posterolateral mar-

gins of abdominal sternites IV-V in Bucerophagus. Male genitalia of Bucerocolpocephalum are shorter than in Bucerophagus. The female anal fringe is weak in Bucerocolpocephalum, and prominant in Bucerophagus.

The male genitalia and details of the male and female terminal abdominal segments are the best characters for separating species of Bucerocolpocephalum.

Hosts: Species of Bucerocolpocephalum have been found only on the genera Ptilolaemus and Anorrhinus of the avian family Bucerotidae.

Genotype: Bucerocolpocephalum emersoni n. sp.

17. Bucerocolpocephalum emersoni n. sp.

(Figs. 49, 57, 64-65)

Both sexes are approximately the same size as corresponding sexes of Bucerocolpocephalum deignani (see Table 3).

Male: As illustrated in Fig. 65. Metasternal plate with 16-20 setae. Abdominal sternite II with 40-48 total setae. Terminal abdominal segments as shown in Fig. 65 e. Genitalia as shown in Fig. 57.

Female: As illustrated in Fig. 64. Resembles the male except that metasternal plate has 16-24 setae. Terminal abdominal tergite with 30-36 setae on posterior margin; abdominal sternite VIII with 32-42 setae on posterior margin and with internal triangular sclerite; anal fringe with 44-48 weak setae (Fig. 49).

Discussion: Bucerocolpocephalum emersoni resembles most closely B. deignani. Male terminal abdominal sternites VIII and IX have a lateral notch in B. emersoni, but not in B. deignani. Male genitalia have parameres not enlarged anteriorly, but curved inwardly with each lateral point reaching

endomeres in B. emersoni; and enlarged anteriorly, not curved inwardly in B. deignani; endomeres have a pair of posterior points in B. emersoni which are absent in B. deignani. The female terminal abdominal tergite has thick setae along the entire posterior margin in B. emersoni, but thick setae are absent medianally in B. deignani. The female abdominal sternite VIII has an internal triangular sclerite in B. emersoni that is absent in B. deignani.

Material examined: 13 males and 19 females from fresh and dried material collected in the Oriental Region.

Type host: Ptilolaemus tickelli austeni (Jerdon, 1872).

Type material: Holotype male and allotype female from Phu Lom Lo Mt., Kok Sathon, Dan Sai, Loei, Thailand, 23 March 1954, collected by Robert E. Elbel, are in the United States National Museum. Paratypes: 8 males and 15 females with same data; from Ptilolaemus tickelli indochinensis Delacour and Jabouille, 1928: 4 males and 3 females from CNHM skins from Muong Yo, Laos, and Muong Maun, Tonkin, Indo China, March-May 1929, collected by Van Tyne (REE).

Bucerocolpocephalum emersoni is named for Dr. K. C. Emerson, Stillwater, Oklahoma, in appreciation for his untiring help and advice throughout this study, particularly in the preparation of the manuscript and illustrations, and in other studies on Oriental Mallophaga.

18. Bucerocolpocephalum deignani n. sp.

(Figs. 50, 58-59)

Both sexes are approximately the same size as corresponding sexes of Bucerocolpocephalum emersoni (see Table 3).

Male: Metasternal plate with 14-18 setae. Abdominal sternite II with

44-46 total setae. Terminal abdominal segments as shown in Fig. 59. Genitalia as shown in Fig. 58.

Female: Resembles the male except that abdominal sternite II has 42-58 total setae. Terminal abdominal tergite with 28-34 setae on posterior margin; abdominal sternite VIII with 34 setae on posterior margin; anal fringe with 24-40 weak setae (Fig. 50).

Discussion: Bucerocolpocephalum deignani resembles most closely B. emersoni. Male terminal abdominal sternites VIII and IX lack the lateral notch in B. deignani that is present in B. emersoni. Male genitalia have parameres enlarged anteriorly, but not curved inwardly in B. deignani; and not enlarged anteriorly, but curved inwardly with each lateral point reaching endomeres in B. emersoni; endomeres lack the pair of posterior points in B. deignani that are present in B. emersoni. The female terminal abdominal tergite lacks thick setae medianally on the posterior margin in B. deignani, but thick setae are present along this entire margin in B. emersoni. The female abdominal sternite VIII lacks the internal triangular sclerite in B. deignani that is present in B. emersoni.

Material examined: 40 males and 27 females from fresh and dried material collected in the Oriental Region.

Type host: Anorrhinus g. galeritus (Temminck, 1831).

Type material: Holotype male from CNHM skin from Kinabatangan, North Borneo, 18 May 1950, collected by D. D. Davis (REE), is in the Chicago Natural History Museum. Paratypes: 2 males with same data. Additional types: from Anorrhinus g. carinatus (Blyth, 1845): Allotype female from USNM skins from Trang, Thailand, 1896 and 1899, collected by W. L. Abbott

(REE) is in the United States National Museum. Paratypes: 1 male and 1 female with same data; 28 males and 17 females from Lamo and Chong, Muang, Trang, Thailand, March 1963, collected by Wichit Suwan Laong, BPBM; 8 males and 7 females from Na Wong, Ban Na, Muang, Phatthalung, Thailand, 6 March 1963, collected by Wichit Suwan Laong; 1 female from BL skin from Khao Phap Pha, Ban Na, Phatthalung, Thailand, 4 September 1954, collected by B. Lekagul (REE).

Bucerocolpocephalum deignani is named for Mr. H. G. Deignan, Division of Birds, United States National Museum, in appreciation for the fresh material he collected in Thailand, for supplying identifications and information on hosts, and for permission to examine Hornbill skins for Mallophaga in the USNM.

TABLE 3

Measurements in millimeters of Bucerocolpocephalum.

Bucerocolpocephalum:	Length		Width			
	Head	Total *	Head	Pro-thor.	Meta-thor.	Abdomen *
	Male.					
17. emersoni	0.304	1.954	0.435	0.384	0.471	0.548
a. P. t. indochinensis.	.318	-	.435	.398	.485	-
18. deignani.	.312	1.800	.437	.362	.444	.581
a. A. g. carinatus.	.304	-	.464	.398	.471	-
	Female.					
17. emersoni.	.318	2.010	.450	.406	.544	.786
a. P. t. indochinensis.	.300	-	.442	.399	.519	-
18. deignani.	.318	1.960	.481	.418	.531	.800

* Measured only for specimens from which drawings were made.

a, from other hosts than type hosts.

Figs. 46-52. Dorsal-ventral view of female terminal abdominal segments and ventral view of female anal fringes, drawn to the same scale, as indicated.

Fig. 46. Chapinia lydae n. sp., terminal abdominal segments of allotype.

Fig. 47. Chapinia hirta (Rudow), anal fringe.

Fig. 48. Chapinia hirta (Rudow), terminal abdominal segments.

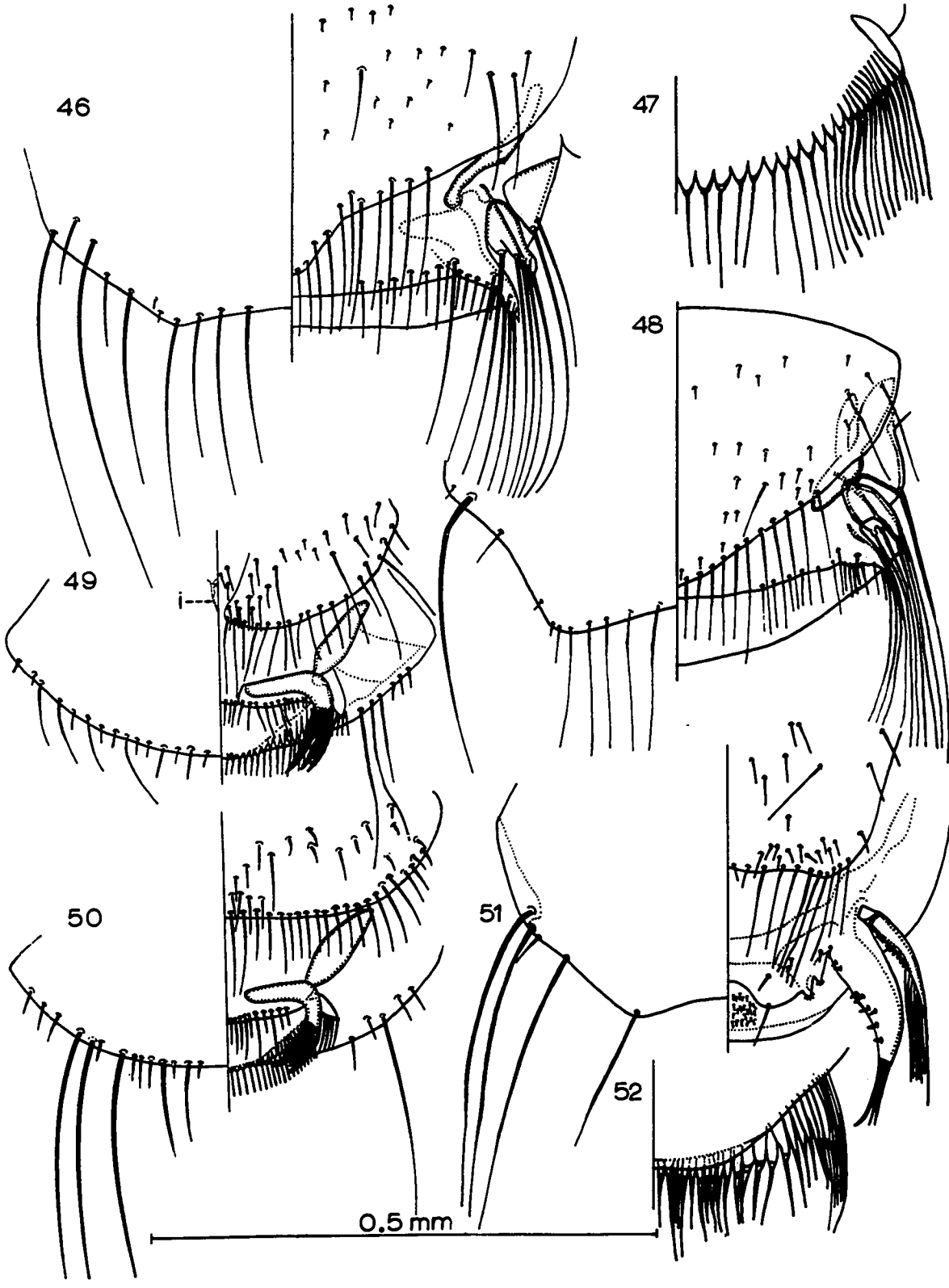
Fig. 49. Bucerocolpocephalum emersoni n. sp., terminal abdominal segments of allotype.

Fig. 50. Bucerocolpocephalum deignani n. sp., terminal abdominal segments of allotype.

Fig. 51. Bucerophagus forcipatus (Nitzsch), terminal abdominal segments.

Fig. 52. Bucerophagus forcipatus (Nitzsch), anal fringe.

i - internal sclerite of abdominal sternite VIII.


46
47
48
49
i
50
51
52
0.5 mm

GENUS BUCEROPHAGUS BEDFORD

Bucerophagus Bedford, 1929. Rep. vet. Res. S. Africa, 15: 509, figs. 11-12.

Genotype: Bucerophagus africanus Bedford, 1929.

Antimenopon Eichler, 1947. Ark. Zool., 39 A: 3, figs. 3-5.

Genotype: Menopon forcipatum Nitzsch, 1874.

Examples illustrated in Figs. 66-69. Head triangular, width 1 1/4-1 3/4 times that of length. Forehead narrower anteriorly. Temples expanded. Antenna four-jointed, third segment constricted at base, and terminal segment capitate with definite signs of division into two parts, either by transverse line or marginal indentation. Antennary fossa deep, covered above by expansion of lateral margin of head, posterior margin of which bears eye with double cornea. Dorsal-lateral margin of forehead anterior to eye with shallow notch. Gular region with 2-8 setae varying in length on each lateral margin. Pronotum large, expanded anteriorly, with four short median setae, and posterior marginal row of long setae. Metanotum expanded posteriorly, with four short median setae, posterior marginal row of long setae, and 2-5 short setae on each lateral margin. Metanotum separated from mesonotum and from pleurites. The sclerotized median button behind the prothorax (see Fig. 25 m) is a vestige of the mesonotum; and the supposed mesonotum, the narrow sclerotized band posterior to this button is

a mere extension of the subcoxae (see Cope, 1941). Thoracic sternal plates as shown in Figs. 66 b, 66 c, 68 b, 68 c, and 70. Prosternum with four median setae. Metasternal plate trapezoidal or triangular, expanded anteriorly, with 6-34 setae. Venter of third femora and posterolateral margins of abdominal sternites IV-V each with or without large thick brushes of normal setae. Abdominal segments consist of tergites, sternites, and pleurites, the latter without prolongation of posteroventral angles. Abdominal tergites each with a posterior marginal row of setae, the most laterad being the post-spiracular seta. Each lateral margin of abdominal tergites II-VIII with or without 1-5 short setae between the spiracle and post-spiracular seta. Sternites and pleurites each with a posterior marginal row of long setae and with numerous shorter setae. Male terminal abdominal sternites VIII and IX either fused or not but with complete division from abdominal sternite VII (see Figs. 67 and 69). Male genitalia as illustrated for each species with parameres branched anteriorly, and either split or unsplit posteriorly. Female terminal abdominal segments as illustrated for each species with lateral processes arising from ventral sclerite between vulva and anus with long stout setae and strong spines. Females larger than males usually with more abdominal sternal setae, but general shape and chaetotaxy similar to that of males except for terminal abdominal segments.

Bucerophagus resembles both Chapinia (Figs. 23-26) and Bucerocolpocephalum (Figs. 64-65), but differs in several characters: The terminal segment of the antenna shows definite signs of division into two parts either by transverse line or marginal indentation in Bucerophagus and Bucerocolpocephalum, but there is no sign of division in Chapinia. The posterior margin of the expansion of the lateral margin of the head covering the antennary fossa

has an eye with a double cornea in Bucerophagus and Chapinia; but an eye is absent in Bucerocolpocephalum. The gular region lacks a lateral ridge, and each lateral margin has at most eight setae in Bucerophagus and Chapinia, but each lateral ridge has 8-11 setae in Bucerocolpocephalum. The metasternal plate is trapezoidal or triangular in Bucerophagus and Chapinia, but oval in Bucerocolpocephalum. The venter of the third femora may have brushes of normal setae in Bucerophagus and Chapinia, but has combs of setae in Bucerocolpocephalum; similar brushes are present on posterolateral margins of abdominal sternites IV-V in Bucerophagus and abdominal sternites IV-VI in Chapinia, but combs of setae are present on posterolateral margins of abdominal sternite IV in Bucerocolpocephalum. Each lateral margin of abdominal tergites II-VIII may have 1-5 short setae between the spiracle and post-spiracular seta in Bucerophagus and Bucerocolpocephalum, but one short seta may be present on margins of abdominal tergites II-VI in Chapinia. Male terminal abdominal sternites VIII and IX may be fused in Bucerophagus and Bucerocolpocephalum with a complete division from abdominal sternite VII; but abdominal sternites VIII and IX are fused in Chapinia with a partial division only from abdominal sternite VII. Male genitalia of Bucerophagus are longer than in Bucerocolpocephalum; parameres are branched anteriorly in Bucerophagus and Bucerocolpocephalum, but slender or expanded anteriorly in Chapinia. Lateral processes arising from the ventral sclerite between the female vulva and anus have long stout setae and strong spines in Bucerophagus and Bucerocolpocephalum, but only long stout setae in Chapinia. The female anal fringe, prominent in Bucerophagus and Chapinia, is weak in Bucerocolpocephalum.

The male genitalia and details of the male and female terminal abdominal segments are the best characters for separating species of Bucerophagus. Other characters useful in species separation are: the shape of the metasternal plate and the number of setae present; the presence or absence of brushes of normal setae on the venter of the third femora and posterolateral margins of abdominal sternites IV-V; the number present or absent of short setae on each lateral margin of abdominal tergites II-VIII between the spiracle and post-spiracular seta; the total number of setae on each of abdominal sternites I and II. The number and length of setae on the lateral margins of the gular region are too variable to be of much use in separating species.

Eichler (1947) believed that the lack of brushes, the rounded projected lobe on the posterior end of the male abdomen, the specific male genital apparatus, and the female anal ring of setae was enough to place Menopon forcipatum Nitzsch in a separate genus. Hopkins and Clay (1952) correctly placed M. forcipatum in the genus Bucerophagus. Since there are several characters separating B. forcipatus from the complex B. productus and B. africanus, it is believed here that the relationship can be shown best by species-groups.

Hosts: Species of Bucerophagus have been found only on the genera Buceros, Rhinoplax, and Bucorvus of the avian family Bucerotidae.

FORCIPATUM SPECIES-GROUP

As illustrated in Figs. 66-67. Differing from the productum species-group in the following combination of characters: Head width 1 1/2-1 3/4 times that of length; metanotum with two short setae on each lateral margin and without setae on anterior margin; metasternal plate with less than 14 setae; venter of third femora and abdominal sternites IV-V without brushes; each lateral margin of abdominal tergites II-VIII without short setae between the spiracle and post-spiracular seta; females with approximately the same number of abdominal sternal setae as in males; both sexes having abdominal sternite I with fewer than 20 total setae and abdominal sternite II with fewer than 44 total setae; male terminal abdominal sternite IX projecting posteriorly as rounded lobe and with complete division from abdominal sternite VIII; male genitalia with parameres curved inwardly and split posteriorly; female terminal abdominal tergite with fewer than 12 setae on posterior margin; female abdominal sternite VIII with fewer than 24 setae on posterior margin.

Hosts: Bucerophagus forcipatus has been found only on the genera Buceros and Rhinoplax of the avian family Bucerotidae.

19. Bucerophagus forcipatus (Nitzsch)

(Figs. 51-52, 60, 66-67)

Menopon forcipatum "Nitzsch," Giebel, 1874. Insecta Epizoa: 289,

pl. xv, figs. 7-8.

Type host: Buceros rhinoceros = Buceros rhinoceros sumatranus Schlegel and Müller, 1840.

Antimenopon forcipatum "Nitzsch in Giebel" Eichler, 1947. Ark. Zool., 39 A: 3 and 20, figs. 3-5.

Bucerophagus forcipatus (Nitzsch). Hopkins and Clay, 1952. Checklist Mallophaga: 64.

Eichler's description and figures are not recognizable. He designated specimens from Buceros rhinoceros from Sumatra as neotype material, but he did not select a neotype. His slide specimens have been remounted and examined; the male, 2275 ji, is designated hereby as neotype. The slide has been so labeled. The female, 2275 jf, is mounted on the same slide with the neotype.

Male: As illustrated in Fig. 67. Smaller than Bucerophagus africanus in all measurements except for length of head and width of metathorax (see Table 12). Metasternal plate trapezoidal, expanded anteriorly, with 6-12 setae (Fig. 66 c). Abdominal sternite I with 6-18 total setae and abdominal sternite II with 30-36 total setae. Terminal abdominal segments as shown in Fig. 67 d. Genitalia as shown in Fig. 60.

Female: As illustrated in Fig. 66. Smaller than Bucerophagus africanus in all measurements except for width of metathorax (see Table 12). Resembles the male except that abdominal sternite II has 34-42 total setae. Terminal abdominal tergite with 8 long and 2 short setae on posterior margin; abdominal sternite VIII with 18-22 long and 4 short setae on posterior margin (Fig. 51). Anal fringe with 44-54 setae (Fig. 52).

Material examined: 49 males and 66 females from fresh and dried material collected in the Oriental Region; neotype male and specimens from the same series, 1 male and 4 females, from WEC 2275 are in the Swedish Museum of Natural History. According to Eichler (1947), WEC 2275 was collected in Sumatra by E. Mjöberg; from the type host: 23 males and 29 females from USNM skins from Tarussan Bay, West Sumatra, 1904-1905, collected by W. L. Abbott (REE); from Buceros rhinoceros borneoensis Schlegel and Müller, 1840: 1 male and 6 females from Serabang Bay, Sarawak, Borneo, 11 January 1958, BM(NH) 1958-737; 4 females from Borneo, BM(NH) 10890; 2 males and 5 females from CNHM skin from Sapagayo Forest Reservation, Sandakan, North Borneo, 27 July 1950, collected by R. F. Inger and D. D. Davis (REE); from Buceros bicornis homrai Hodgson, 1832: 7 males and 5 females from Ban Khlua Klang, Prachuap Khiri Khan, Thailand, December 1952, collected by Robert E. Elbel, and H. G. Deignan, USNM; 11 males and 8 females from Khlong Khlung, Kamphaeng Phet, Thailand, 7 April 1953, collected by Robert E. Elbel and H. G. Deignan, USNM; 1 male and 3 females from Ban Muang Khai, Tha Li, Loei, Thailand, 7 December 1953, collected by Robert E. Elbel, USNM; 2 males and 1 female from Banghin, Kapoe, Ranong, Thailand, 6 February 1963, collected by Wichit Suwan Laong, BPBM; from Rhinoplax vigil (J. R. Forster, 1781): 1 female from Borneo, BM(NH) 10888.

Drawings were made from a male and a female from Buceros bicornis homrai collected in Khlong Khlung, Thailand. Specimens are in the USNM.

Figs. 53-56. Dorsal-ventral view of female terminal abdominal segments and ventral view of female anal fringes of productum species-group, drawn to the same scale, as indicated.

Fig. 53. Bucerophagus productus (Burmeister), terminal abdominal segments.

Fig. 54. Bucerophagus productus (Burmeister), anal fringe.

Fig. 55. Bucerophagus africanus Bedford, terminal abdominal segments.

Fig. 56. Bucerophagus africanus Bedford, anal fringe.

Figs. 57-63. Dorsal-ventral view of male terminal abdominal segments and ventral view of male genitalia, drawn to the same scale, as indicated.

Fig. 57. Bucerocolpocephalum emersoni n. sp., genitalia of holotype.

Fig. 58. Bucerocolpocephalum deignani n. sp., genitalia of holotype.

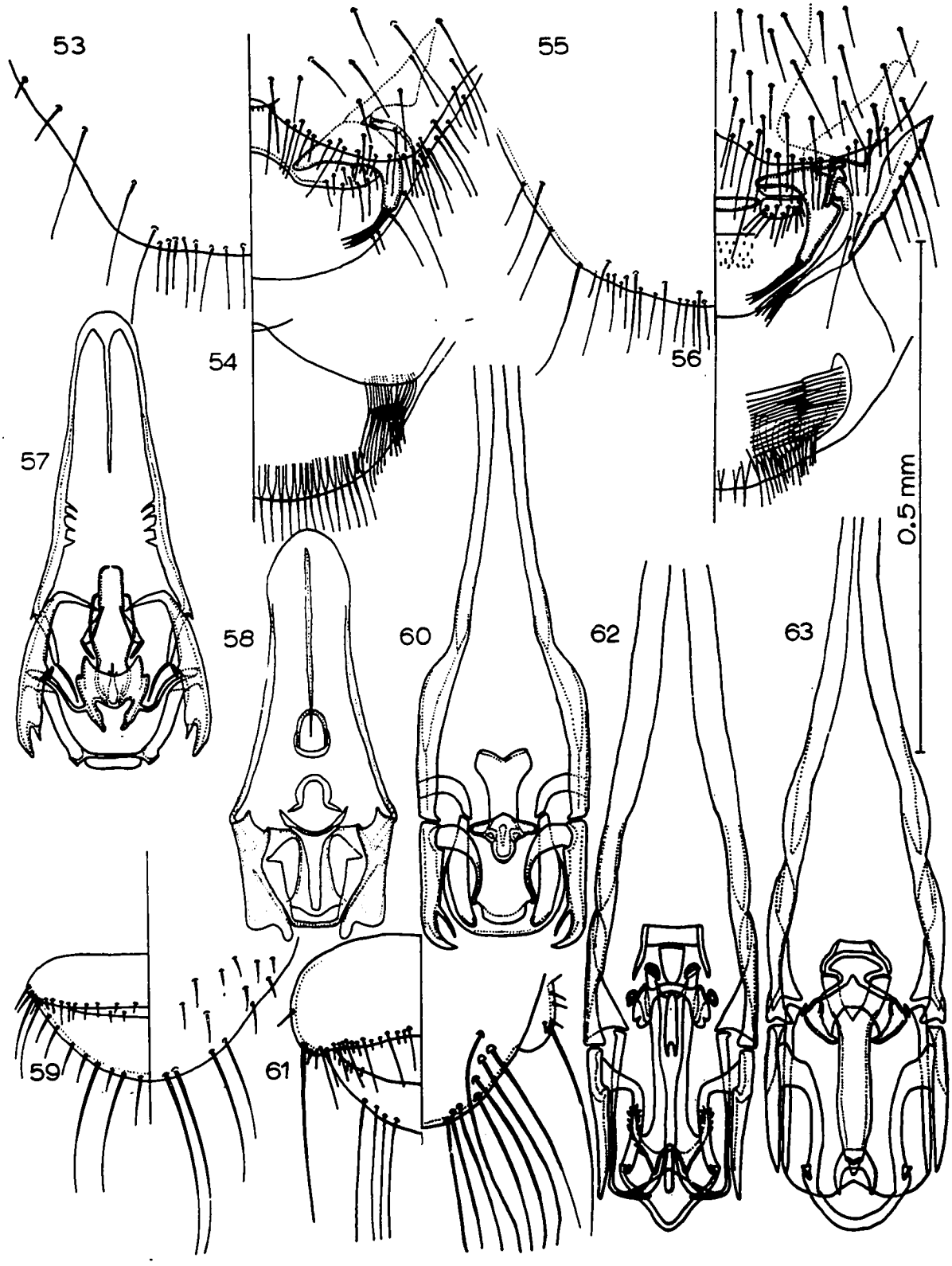
Fig. 59. Bucerocolpocephalum deignani n. sp., terminal abdominal segments of holotype.

Fig. 60. Bucerophagus forcipatus (Nitzsch), genitalia.

Fig. 61. Bucerophagus productus (Burmeister), terminal abdominal segments.

Fig. 62. Bucerophagus productus (Burmeister), genitalia.

Fig. 63. Bucerophagus africanus Bedford, genitalia.


53
54
55
56
57
58
60
62
63
59
61
0.5 mm

Figs. 64-65. Dorsal-ventral view of male and of female, drawn to the same scale, as indicated; a-e, enlarged views, drawn to the same scale, as indicated.

Fig. 64. Bucerocolpocephalum emersoni n. sp., allotype female.

Fig. 65. Bucerocolpocephalum emersoni n. sp., holotype male.

a - antenna of female.

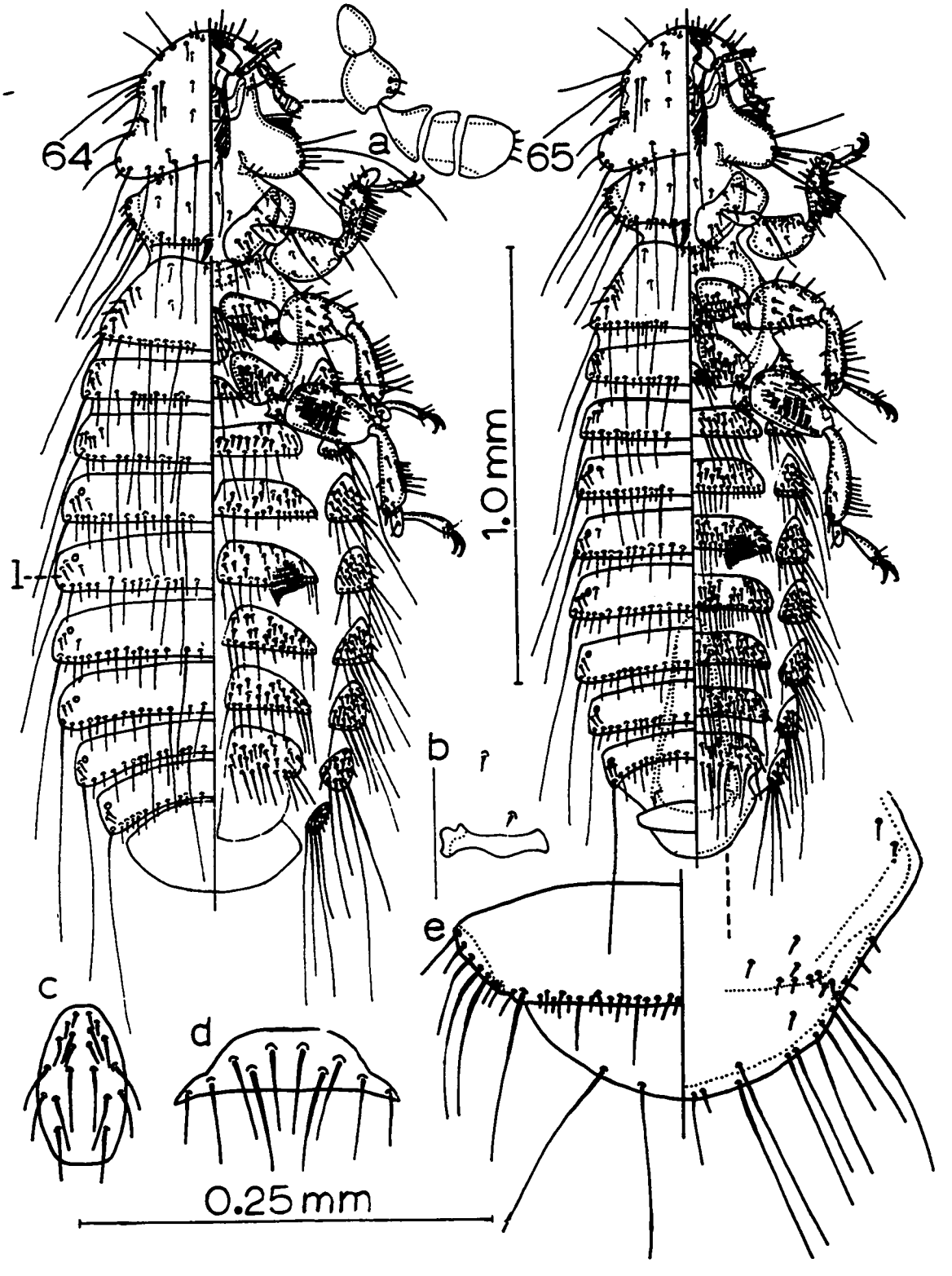
b - prosternal plate of female.

c - metasternal plate of female.

d - first abdominal sternite of female.

e - terminal abdominal segments of male.

l - short lateral setae between spiracle and post-spircular seta.


64
a
65
1
1.0 mm
b
e
c
d
0.25 mm

Figs. 66-67. Dorsal-ventral view of male and of female, drawn to the same scale, as indicated; a-d, enlarged views, drawn to the same scale, as indicated.

Fig. 66. Bucerophagus forcipatus (Nitzsch), female.

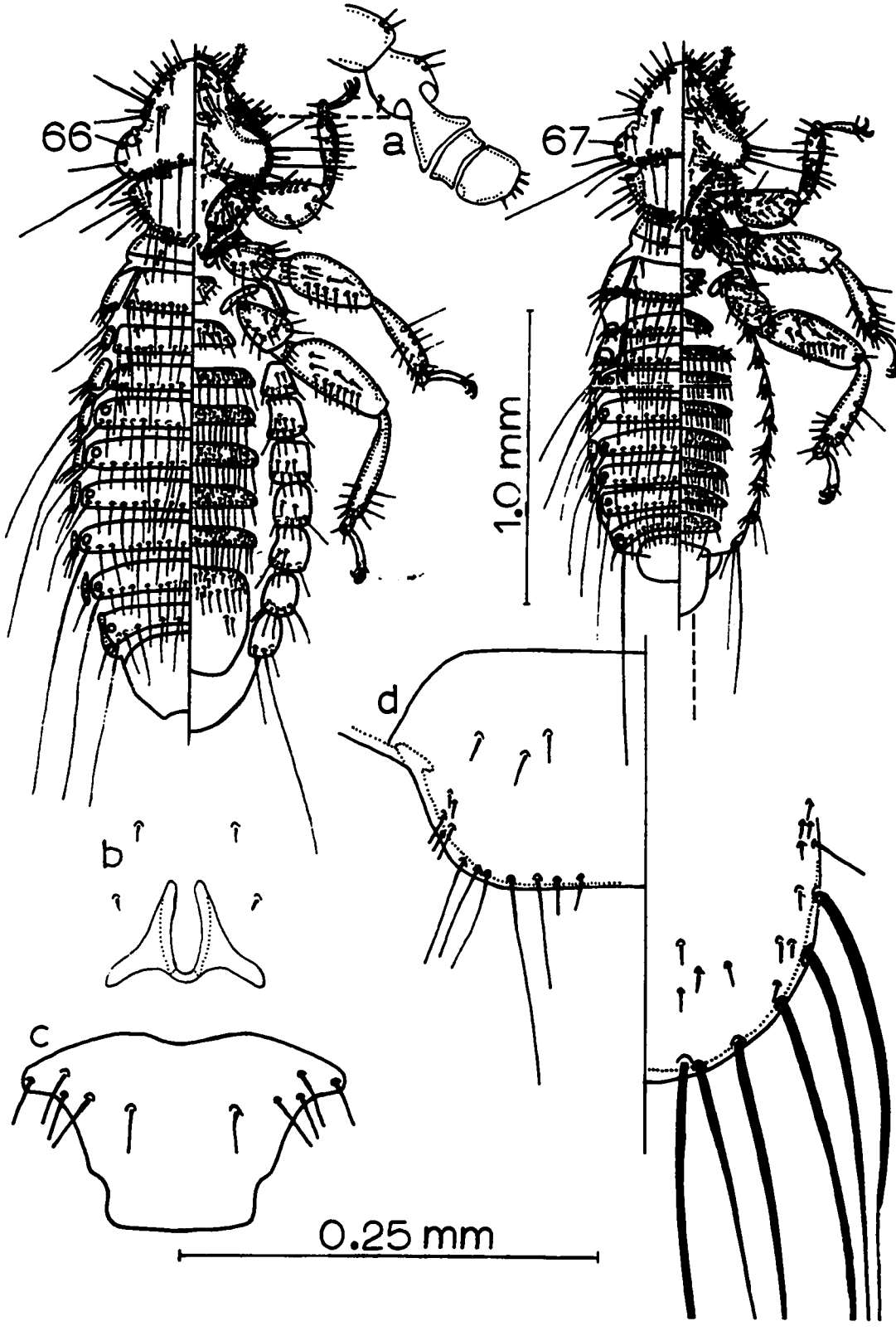
Fig. 67. Bucerophagus forcipatus (Nitzsch), male.

a - antenna of female.

b - prosternal plate of female.

c - metasternal plate of female.

d - terminal abdominal segments of male.


66
a
67
1.0 mm
d
b
c
0.25 mm

PRODUCTUM SPECIES-GROUP

Species similar in shape to Bucerophagus africanus (see Figs. 68-69). Differing from the forcipatum species-group in the following combination of characters: head width 1 1/4 - 1 1/2 times that of length; metanotum with 3-5 short setae on each lateral margin and with 6-8 setae on anterior margin; metasternal plate with more than 20 setae; venter of third femora and posterolateral margins of abdominal sternites IV-V each with thick brushes of normal setae; each lateral margin of abdominal tergites II-VIII with 1-5 short setae between the spiracle and post-spiracular seta; females with more abdominal sternal setae than in males; both sexes having abdominal sternite I with more than 20 total setae and abdominal sternite II with more than 60 total setae; male terminal abdominal sternites VIII and IX neither projecting posteriorly as rounded lobe nor with division but with complete division from abdominal sternite VII; male genitalia with parameres straight and not split posteriorly; female terminal abdominal tergite with more than 24 setae on posterior margin; female abdominal sternite VIII with more than 28 setae on posterior margin.

Hosts: Species of the productum species-group have been found only on the genus Bucorvus of the avian family Bucerotidae.

20. Bucerophagus productus (Burmeister)

(Figs. 53-54, 61-62, and 70)

Colpocephalum productum Burmeister, 1838. Handb. Ent., 2: 439.

Type host: Buceros abyssinicus = Bucorvus abyssinicus (Boddaert, 1783).

Colpocephalum vittatus Giebel, 1866. Z. ges. NatWiss., 28: 394. Nomen nudum.

Colpocephalum productum "Nitzsch," Giebel, 1874. Insecta Epizoa: 266, pl. xiv, figs. 2-3.

Colpocephalum eurygaster Piaget, 1888. Tijdscr. Ent., 31: 162, pl. 4, fig. 5.

Type host: Leptoptilus argala error = Bucorvus abyssinicus.

Bucerophagus productus "Nitzsch in Burmeister." Conci, 1950. Riv. Biol. Colon., 10: 77-82, figs. 1-7.

Bucerophagus productus (Burmeister). Hopkins and Clay, 1952. Checklist Mallophaga: 64.

A neotype, in the Zoologischen Institute der Universität Halle, Germany, was erected by Conci who redescribed and figured Bucerophagus productus from specimens from Bucrovus abyssinicus collected in East Africa by Prof. E. Zavattari. A male from the same series is in the collection of Mr. G. H. E. Hopkins, Zoological Museum, Tring, Hertsfordshire, England.

A lectotype male was designated by Clay (1951 a) from the Colpocephalum eurygaster syntypes in the Piaget Collection, and it is now in the British Museum (Natural History), BM 1157 a, with 3 syntype males and 1 syntype female, BM 1157-1158.

Clay (1951 a) stated that Bucerophagus productus also seemed to occur naturally on Bucorvus leadbeateri (Vigors).

Male: Smaller than Bucerophagus africanus in all measurements except for length of head; approximately the same size as B. forcipatus (see Table 12). Metasternal plate triangular, expanded anteriorly, with 22-26 setae (Fig. 70). Each lateral margin or abdominal tergites III-VIII with 2-4 short setae between the spiracle and post-spiracular seta except for tergite VII with 1-2 setae and tergite VIII with 1 seta. Abdominal sternite I with 22-24 total setae and abdominal sternite II with 66-68 total setae. Terminal abdominal segments as shown in Fig. 61. Genitalia as shown in Fig. 62, with branch connecting parameres posterior to endomeres pointed medianally.

Female: Approximately the same size as Bucerophagus africanus; larger than B. forcipatus in all measurements except for width of head and width of metathorax (see Table 12). Resembles the male except that metasternal plate has 26-34 setae. Abdominal sternite I with 28 total setae and abdominal sternite II with 74-76 total setae. Terminal abdominal tergite with 26-38 setae on posterior margin; abdominal sternite VIII with 30-36 setae on posterior margin (Fig. 53). Anal fringe with 42-56 setae (Fig. 54).

Discussion: Bucerophagus productus resembles most closely B. africanus which, however, is much more pigmented than B. productus. Males of B. productus are much smaller than females, but males of B. africanus are only slightly smaller than females. The metasternal plate is triangular in B. productus, and trapezoidal in B. africanus; this plate has fewer setae in both sexes of B. productus than in corresponding sexes of B. africanus. Each lateral margin of abdominal tergites III-VI between the

spiracle and post-spiracular seta has more short setae in males and fewer in females of B. productus than in corresponding sexes of B. africanus. Abdominal sternite I has approximately one-half the number of setae in both sexes of B. productus as in corresponding sexes of B. africanus; abdominal sternite II has slightly more setae in males and slightly fewer setae in females of B. productus than of B. africanus. The male abdominal sternite VIII lacks the central T-shaped plate in B. productus which is present in B. africanus (Fig. 69 d). The male genitalia has the internal branch connecting the parameres posterior to the endomeres pointed medianally in B. productus, but rounded in B. africanus. The female anal fringe has fewer than 58 setae in B. productus, but more than 58 setae in B. africanus.

Comparison on different hosts: No morphological differences were found between specimens of Bucerophagus productus found on the two hosts, Bucorvus abyssinicus and B. leadbeateri, so standard measurements were tested against the null hypothesis that there were no differences in measurements (see Tables 4-7).

Terminology and formulae are as follows:

$\bar{x}_1$ = mean measurement of B. productus specimens on host 1, Bucorvus abyssinicus.

$\bar{x}_2$ = mean measurement of B. productus specimens on host 2, Bucorvus leadbeateri.

D = difference in mean measurements, $(\bar{x}_1 - \bar{x}_2)$ or $(\bar{x}_2 - \bar{x}_1)$.

s^2 = variance $= \frac{S(x - \bar{x})^2}{N - 1} = \frac{Sx^2 - (Sx)^2/N}{N - 1}$

s_1^2 = variance of measurements of B. productus specimens on host 1, B. abyssinicus.

s_2^2 = variance of measurements of B. productus specimens on host 2, B. leadbeateri.

F = the ratio of the larger variance divided by the smaller =

$$\frac{s_1^2}{s_2^2} \text{ or } \frac{s_2^2}{s_1^2} = \frac{N_n}{N_d}$$

SE = Standard Error of D = $$\sqrt{\frac{S(x - \bar{x}_1)^2 + S(x - \bar{x}_2)^2}{N_n + N_{d-2}} \left(\frac{1}{N_n} + \frac{1}{N_d}\right)}$$

CL = Confidence Limits for $D = D \pm (SE)\ (t.05)$

TABLE 4

Measurements in millimeters and computations for Bucerophagus productus males on host 1, Bucorvus abyssinicus.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 8	0.350	0.507	0.436	0.586	0.707	1.914
	.371	.5285	.457	.586	.771	2.071
	.371	.514	.457	.586	.714	1.914
	.386	.5285	.464	.543	.771	2.0785
	.436	.550	.464	.543	.750	2.0785
	.486	.550	.486	.5785	.750	2.100
	.400	.514	.414	.571	.721	2.114
	.400	.507	.414	.571	.7285	2.057
Sx_1 =	3.200	4.199	3.592	4.5645	5.9125	16.327
$\bar{x}_1$ =	0.400	0.525	0.449	0.5705	0.739	2.041
Sx_1^2 =	1.293	2.206	1.617	2.607	4.374	33.366
$(Sx_1)^2$ =	10.240	17.632	12.902	20.835	34.958	266.571
$(Sx_1)^2/N$ =	1.280	2.204	1.613	2.604	4.370	33.321
$S(x-\bar{x}_1)^2$ =	0.0130	0.0020	0.0040	0.0030	0.0040	0.0450
s_1^2 =	.00186	.000286	.000571	.000428	.000571	.00643

TABLE 5

Measurements in millimeters and computations for Bucerophagus productus males on host 2, Bucorvus leadbeateri.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 28	0.414	0.521	0.443	0.521	0.7285	1.750
	.414	.521	.443	.521	.7285	1.700
	.414	.521	.443	.521	.7285	1.743
	.414	.5285	.443	.471	.7285	1.743
	.414	.5285	.443	.5285	.7285	1.714
	.414	.5285	.443	.5285	.686	1.850
	.414	.5285	.443	.5285	.707	1.929
	.414	.5285	.457	.5285	.707	2.029
	.414	.5285	.457	.5285	.707	1.700
	.414	.5285	.457	.557	.764	1.807
	.400	.5285	.457	.557	.764	1.821
	.400	.536	.457	.557	.714	1.979
	.400	.536	.457	.557	.714	2.136
	.386	.536	.457	.557	.736	2.129
	.386	.536	.457	.557	.743	2.271
	.3785	.536	.457	.514	.771	2.171
	.393	.514	.421	.543	.757	1.857
	.407	.514	.450	.543	.757	1.857
	.4285	.550	.450	.543	.786	2.243
	.4285	.550	.450	.543	.786	1.579
	.4285	.550	.436	.564	.800	2.021
	.4285	.543	.436	.564	.750	1.964
	.443	.543	.471	.536	.750	2.079
	.443	.543	.471	.536	.750	1.900
	.421	.543	.471	.536	.750	1.900
	.457	.557	.464	.500	.814	1.814
	.371	.500	.464	.550	.821	1.786
	.3285	.500	.414	.571	.700	1.914
Sx_2 =	11.468	14.878	12.612	15.0615	20.8765	53.386
$\bar{x}_2$ =	0.4095	0.531	0.450	0.538	0.746	1.907
Sx_2^2 =	4.714	7.911	5.686	8.114	15.597	102.629
$(Sx_2)^2$ =	131.515	221.355	159.063	226.849	435.828	2850.065
$(Sx_2)^2/N$ =	4.697	7.906	5.681	8.102	15.565	101.788
$S(x-\bar{x}_2)^2$ =	0.0170	0.0050	0.0050	0.0120	0.0320	0.841
s_2^2 =	.00060	.000180	.000180	.000444	.001185	.0311

TABLE 6

Measurements in millimeters and computations for Bucerophagus productus females on host 1, Bucorvus abyssinicus.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 8	0.464	0.636	0.536	0.714	1.036	3.250
	.443	.614	.5285	.714	1.050	3.171
	.507	.650	.543	.686	1.043	2.607
	.443	.657	.543	.686	1.136	2.736
	.4785	.657	.543	.6785	1.143	3.100
	.493	.657	.543	.6785	1.193	3.114
	.500	.671	.543	.6785	1.100	2.621
	.457	.614	.543	.693	1.0785	3.171
Sx_1 =	3.7855	5.156	4.3225	5.5285	8.7795	23.770
$\bar{x}_1$ =	0.473	0.6445	0.540	0.691	1.097	2.971
Sx_1^2 =	1.796	3.326	2.336	3.822	9.657	71.132
$(Sx_1)^2$ =	14.330	26.584	18.684	30.564	77.080	565.013
$(Sx_1)^2/N$ =	1.791	3.323	2.3355	3.820	9.635	70.627
$S(x-\bar{x}_1)^2$ =	0.0050	0.0030	0.00050	0.0020	0.0220	0.505
s_1^2 =	.000714	.000428	.0000714	.000286	.00714	.0721

TABLE 7

Measurements in millimeters and computations for Bucerophagus productus females on host 2, Bucorvus leadbeateri.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 34	0.471	0.600	0.500	0.621	0.914	2.843
	.471	.600	.500	.621	.914	3.000
	.471	.600	.500	.636	.957	3.229
	.500	.600	.500	.636	.957	3.229
	.500	.600	.500	.636	.957	2.793
	.500	.600	.500	.636	.971	3.164
	.500	.614	.529	.671	.971	3.250
	.500	.614	.529	.671	.979	3.250
	.500	.614	.529	.671	.979	2.957
	.500	.614	.529	.671	.986	2.521
	.500	.614	.529	.671	.986	2.500
	.500	.614	.529	.671	.986	3.057
	.500	.571	.529	.600	.986	3.136
	.500	.607	.486	.600	1.007	2.393
	.514	.607	.486	.614	0.893	3.086
	.514	.607	.493	.614	.900	2.329
	.486	.607	.479	.614	.900	3.171
	.486	.593	.479	.614	.886	2.971
	.486	.593	.521	.657	.857	2.729
	.486	.621	.521	.657	1.086	2.914
	.486	.621	.521	.657	1.029	2.771
	.486	.621	.521	.657	0.964	3.264
	.486	.621	.514	.657	1.014	2.950
	.464	.621	.514	.643	1.036	2.857
	.464	.621	.514	.643	1.036	2.857
	.457	.579	.514	.643	0.907	2.507
	.457	.629	.507	.629	.950	2.821
	.493	.629	.507	.607	.921	2.650
	.493	.629	.543	.607	1.100	3.257
	.529	.629	.543	.593	1.021	3.393
	.529	.629	.543	.686	1.071	3.093
	.529	.629	.536	.686	1.057	3.379
	.479	.650	.536	.664	1.079	3.007
	.479	.636	.536	.664	1.043	2.521
Sx_2 =	16.716	20.834	17.517	21.818	33.300	99.849
$\bar{x}_2$ =	0.492	0.613	0.515	0.642	0.979	2.937
Sx_2^2 =	8.230	12.775	9.036	14.024	32.745	29.602
$(Sx_2)^2$ =	279.425	434.056	306.845	476.025	1108.890	9969.823
$(Sx_2)^2/N$ =	8.218	12.766	9.025	14.001	32.614	29.323
$S(x-\bar{x}_2)^2$ =	0.0120	0.0090	0.0110	0.023	0.131	0.279
s_2^2 =	.000364	.000273	.000330	.000697	.00397	.00845

For Bucerophagus productus males on the 2 hosts computations are:

	Head Length	Head Width	Width Prothorax	Width Metathorax	Width Abdomen	Total Length
F =	.00186 / .00060 =3.10	.000286 / .000180 =1.589	.000571 / .000180 =3.172	.000444 / .000428 =1.037	.00118 / .000571 =2.067	.0311 / .00643 =4.837
df =	7/27					
P =	97.5-99%	70-90%	97.5-99%	50-70%	70-90%	97.5-99%
SE =	$\sqrt{\frac{.013+.017}{612}}$ =.0070	$\sqrt{\frac{.002+.005}{612}}$ =.00317	$\sqrt{\frac{.004+.005}{612}}$ =.00374	$\sqrt{\frac{.003+.012}{612}}$ =.00490	$\sqrt{\frac{.004+.032}{612}}$ =.00762	$\sqrt{\frac{.045+.841}{612}}$ =.0381
$t_{.05}^{df}$ =	34	2.034				
D =	.4095-.400 =.00950	.531-.525 =.0060	.450-449 =.0010	.5705-.538 =.0325	.746-.739 =.0070	2.041-1.907 =.134
CL =		.006±2.034 x.00317 =.006±.0064		.0325±2.034 x.0049 =.0325±.010	.007±2.034 x.00762 =.007±.015	

For Bucerophagus productus females on the 2 hosts computations are:

F =	.000714 / .000364 =1.962	.000428 / .000273 =1.568	.000332 / .0000714 =4.622	.000697 / .000286 =2.437	.00714 / .00397 =1.798	.0721 / .00845 =8.532
df =	7/33					
P =	90-95%	70-90%	97.5-99%	70-90%	70-90%	99.95%
SE =	$\sqrt{\frac{.005+.012}{840}}$ =.00447	$\sqrt{\frac{.003+.009}{840}}$ =.00374	$\sqrt{\frac{.005+.011}{840}}$ =.00436	$\sqrt{\frac{.002+.023}{840}}$ =.00538	$\sqrt{\frac{.002+.131}{840}}$ =.0135	$\sqrt{\frac{.505+.279}{840}}$ =.0306
$t_{.05}^{df}$ =	40	2.021				
D =	.492-.473 =.0190	.644-.613 =.0310	.540-515 =.0250	.691-.642 =.0490	1.0974-.979 =.0950	2.971-2.937 =.0340
CL =	.019±2.021 x.00447 =.019±.0090	.031±2.021 x.00374 =.031±.0076		.049±2.021 x.00538 =.049±.011	.095±2.021 x.0135 =.095±.027	

It is not possible by measurements alone to decide from which host Bucerophagus productus specimens came; therefore, populations from the two hosts are considered conspecific.

Material examined: 39 males and 44 females from fresh and dried material collected in the Ethiopian Region; from the type host: 4 males and 2 females from Gula, Uganda, Africa, 10 July 1936, collected by G. H. E. Hopkins, GHEH; 6 females from Ethiopia, Africa, March 1909, BM(NH) 3673; 1 female from CNHM skin from Africa, 30 January 1946 (REE); 3 males and 1 female from USNM skins from Sirre, Ethiopia, Africa, 13 February 1912, collected by Childs Frick (REE); 3 males from USNM skins from Uganda, Africa, January-February, 1910, collected by E. A. Mearns (REE); from Bucorvus leadbeateri (Vigors, 1825): 9 males and 18 females from CNHM skins from Chitau, Bihe, Angola, Africa, 1932-1934, collected by Jean Bodaly (REE); 15 males and 14 females from CNHM skin from Pondi, Benguela, Angola, Africa, 14 September 1936, collected by K. H. Prior (REE); 5 males and 2 females from CNHM skins from Kari Pan, Makari, Bechuanaland, Africa, August 1930, collected by Vernay, Lang, and Roberts (REE).

Drawings were made of a male and a female from the type host collected in Gula, Uganda, Africa. Specimens are in the collection of GHEH.

21. Bucerophagus africanus Bedford

(Figs. 55-56, 63, 68-69)

Bucerophagus africanus Bedford, 1929. Rep. vet. Res. S. Africa, 15: 509, figs. 11-12.

Type host: Bucorvus schlegeli Roberts = Bucorvus leadbeateri (Vigors, 1825).

Bucerophagus africanus Bedford. Hopkins and Clay, 1952. Checklist Mallophaga: 64.

Clay (1951 a) stated that according to Mr. G. H. E. Hopkins, Bucerophagus africanus also occurred on Bucorvus abyssinicus.

Male: As illustrated in Fig. 69. Larger than either Bucerophagus forcipatus or B. productus except for length of head (see Table 12). Metasternal plate trapezoidal, expanded anteriorly, with 30-34 setae (Fig. 68 c). Each lateral margin of abdominal tergites III-VIII with two short setae between the spiracle and post-spiracular seta except for tergites III and VIII each with one short seta. Abdominal sternite I with 40 total setae and abdominal sternite II with 62 total setae. Abdominal sternite VIII with central T-shaped plate (Fig. 69 d). Genitalia as shown in Fig. 63.

Female: As illustrated in Fig. 68. Approximately the same size as Bucerophagus productus; larger than B. forcipatus in all measurements except for width of metathorax (see Table 12). Resembles the male except that metasternal plate has 36-42 setae. Each lateral margin of abdominal tergites III-VIII with 3-5 short setae between the spiracle and post-spiracular seta except for tergite VIII with one seta. Abdominal sternite I with 50 total setae and abdominal sternite II with 86 total setae. Terminal abdominal tergite with 32-40 setae on posterior margin; abdominal sternite VIII with 28-38 setae on posterior margin (Fig. 55). Anal fringe with 60-66 setae (Fig. 56).

Discussion: Bucerophagus africanus resembles most closely B. productus which, however, is not as pigmented as B. africanus. Males of B. africanus are only slightly smaller than females, but males of B. productus are much smaller than females. The metasternal plate is trapezoidal in B. africanus, and triangular in B. productus; this plate has more setae in both sexes of

B. africanus than in corresponding sexes of B. productus. Each lateral margin of abdominal tergites III-VI between the spiracular and post-spiracular seta has fewer short setae in males and more in females of B. africanus than in corresponding sexes of B. productus. Abdominal sternite I has approximately twice the number of setae in both sexes of B. africanus as in corresponding sexes of B. productus; abdominal sternite II has slightly fewer setae in males and slightly more setae in females of B. africanus than of B. productus. The male abdominal sternite VIII has a central T-shaped plate in B. africanus which is absent in B. productus. The male genitalia has the internal branch connecting the parameres posterior to the endomeres rounded medianally in B. africanus, but pointed in B. productus. The female anal fringe has more than 58 setae in B. africanus, but fewer than 58 setae in B. productus.

Comparison on different hosts: No morphological differences were found between specimens of Bucerophagus africanus found on the two hosts, Bucorvus abyssinicus and B. leadbeateri, so standard measurements were tested against the null hypothesis that there were no differences in measurements (see Tables 8-11).

Terminology and formulae are as follows:

$\bar{x}_1$ = mean measurement of B. africanus specimens on host 1, Bucorvus abyssinicus.

$\bar{x}_2$ = mean measurement of B. africanus specimens on host 2, Bucorvus leadbeateri.

D = difference in mean measurements $(\bar{x}_1 - \bar{x}_2)$ or $(\bar{x}_2 - \bar{x}_1)$.

s^2 = variance $= \frac{S(x - \bar{x})^2}{N - 1} = \frac{Sx^2 - (Sx)^2/N}{N - 1}$

s_1^2 = variance of measurements of B. africanus specimens on host 1, Bucorvus abyssinicus.

s_2^2 = variance of measurements of B. africanus specimens on host 2, Bucorvus leadbeateri.

F = the ratio of the larger variance divided by the smaller = $\frac{s_1^2}{s_2^2}$ or $\frac{s_2^2}{s_1^2} = \frac{N_n}{N_d}$

SE = Standard Error of D = $\sqrt{\frac{S(x - \bar{x}_1)^2 + S(x - \bar{x}_2)^2}{N_n + N_{d-2}} \left(\frac{1}{N_n} + \frac{1}{N_d}\right)}$

CL = Confidence Limits for D = $D \pm t_{.05}(SE)$.

TABLE 8

Measurements in millimeters and computations for Bucerophagus africanus males on host 1, Bucorvus abyssinicus.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 3	0.457	0.628	0.528	0.693	0.957	2.528
	.471	.593	.507	.678	1.057	2.500
	.493	.586	.500	.728	1.050	2.557
Sx_1 =	1.421	1.807	1.535	2.099	3.064	7.585
$\bar{x}_1$ =	0.474	0.602	0.512	0.700	1.021	2.528
Sx_1^2 =	0.674	1.089	0.786	1.470	3.136	19.179
$(Sx_1)^2$ =	2.019	3.265	2.356	4.406	9.388	57.532
$(Sx_1)^2/N$ =	0.673	1.088	0.785	1.468	3.129	19.177
$S(x-\bar{x}_1)^2$ =	0.0010	0.0010	0.0010	0.0020	0.0070	0.0020
s_1^2 =	0.00050	0.00050	0.00050	0.0010	0.00350	0.0010

TABLE 9

Measurements in millimeters and computations for Bucerophagus africanus males on host 2, Bucorvus leadbeateri.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 6	0.393	0.557	0.500	0.650	0.943	2.371
	.400	.557	.500	.650	1.028	2.478
	.400	.586	.500	.650	0.971	2.428
	.443	.571	.485	.686	1.043	2.443
	.457	.586	.514	.686	1.050	2.486
	.371	.564	.521	.671	1.064	2.386
Sx_2 =	2.464	3.421	3.020	3.993	6.099	14.592
$\bar{x}_2$ =	0.411	0.570	0.503	0.666	1.016	2.432
Sx_2^2 =	1.017	1.951	1.521	2.659	6.211	35.499
$(Sx_2)^2$ =	6.071	11.703	9.120	15.944	37.198	212.926
$(Sx_2)^2/N$ =	1.0120	1.950	1.520	2.657	6.200	35.488
$S(x-\bar{x}_2)^2$ =	0.0050	0.0010	0.0010	0.0020	0.0110	0.0110
s_2^2 =	0.0010	0.00020	0.00020	0.00040	0.00220	0.00220

TABLE 10

Measurements in millimeters and computations for Bucerophagus africanus females on host 1, Bucorvus abyssinicus.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 4	0.493	0.664	0.564	0.728	1.214	3.300
	.514	.628	.543	.693	1.236	3.271
	.443	.628	.543	.786	1.300	3.428
	.486	.643	.586	.714	1.110	2.700
Sx_1 =	1.936	2.563	2.236	2.921	4.860	12.699
$\bar{x}_1$ =	0.484	0.641	0.559	0.730	1.215	3.175
Sx_1^2 =	0.940	1.643	1.251	2.138	5.924	40.631
$(Sx_1)^2$ =	3.748	6.569	5.000	8.532	23.620	161.265
$(Sx_1)^2/N$ =	0.937	1.642	1.250	2.133	5.905	40.316
$S(x-\bar{x}_1)^2$ =	0.0030	0.0010	0.0010	0.0050	0.0190	0.315
s_1^2 =	0.0010	0.000333	0.000333	0.00166	0.00633	0.104

TABLE 11

Measurements in millimeters and computations for Bucerophagus africanus females on host 2, Bucorvus leadbeateri.

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Abdomen	Length
N = 4	0.471	0.621	0.557	0.714	1.328	3.243
	.457	.593	.557	.678	1.143	3.000
	.457	.636	.514	.764	1.393	3.321
	.471	.628	.536	.743	1.321	3.386
Sx_2 =	1.856	2.478	2.164	2.899	5.185	12.950
$\bar{x}_2$ =	0.464	0.620	0.541	0.725	1.296	3.238
Sx_2^2 =	0.861	1.536	1.172	2.105	6.756	42.011
$(Sx_2)^2$ =	3.445	6.140	4.683	8.404	26.884	167.702
$(Sx_2)^2/N$ =	0.861	1.535	1.171	2.101	6.721	41.926
$S(x-\bar{x}_2)^2$ =	0.000	0.0010	0.0010	0.0040	0.0350	0.0850
s_2^2 =	0.000	0.000333	0.000333	0.00133	0.0117	0.0283

For Bucerophagus africanus males on the 2 hosts computations are:

	Head		Width			Total
	Length	Width	Prothorax	Metathorax	Adbdomen	Length
F =	$\frac{.0010}{.00050}$ = 2.0	$\frac{.00050}{.00020}$ =2.50	$\frac{.00050}{.00020}$ =2.50	$\frac{.0010}{.00040}$ =2.50	$\frac{.00350}{.00220}$ =1.591	$\frac{.00220}{.0010}$ =2.20
df =	2/5					
P =	Below 95%					
SE =	$\sqrt{\frac{.005+.001}{31.50}}$ = .0138	$\sqrt{\frac{.001+.001}{31.50}}$ = .00797	$\sqrt{\frac{.001+.001}{31,50}}$ =..00797	$\sqrt{\frac{.002+.002}{31.50}}$ = .0127	$\sqrt{\frac{.011+.007}{31.50}}$ = .0239	$\sqrt{\frac{.011+.002}{31.50}}$ = .0203
$t_{.05}^{df}$ =	7	2.365				
D =	.474-.411 = .0630	.602-.570 = .0320	.512-.503 =.0090	.700-.666 =.0340	1.0210 -1.0160 = .0050	2.528 -2.432 = .0960
CL =	$.063 \pm 2.365$ x .0138 $=.063 \pm .033$	$.032 \pm 2.365$ x .00797 $=.032 \pm 019$	$.009 \pm 2.365$ x.00797 $=.009 \pm .019$	$.034 \pm 2.365$ x.0127 $=.034 \pm .030$	$.005 \pm 2.365$ x.0239 $=.005 \pm .056$	$.096 \pm 2.365$ x.0203 $=.096 \pm .048$

For B. africanus females on the 2 hosts computations are:

F =	$\frac{.0010}{0}$ = 0	$\frac{.000333}{.000333}$ = 1.0	$\frac{.000333}{.000333}$ = 1.0	$\frac{.00166}{.00133}$ = 1.248	$\frac{.0117}{.00633}$ = 1.848	$\frac{.104}{.0283}$ = 3.675
df =	3/3					
P =	Below 95%					
SE =	$\sqrt{\frac{.003+0}{24}}$ =.0112	$\sqrt{\frac{.001+.001}{24}}$ =.00913	$\sqrt{\frac{.001+.001}{24}}$ =.00913	$\sqrt{\frac{.005+.004}{24}}$ =.0194	$\sqrt{\frac{.019+.035}{24}}$ =.0478	$\sqrt{\frac{.315+.085}{24}}$ =.129
$t_{.05}^{df}$ =	6	2.447				
D =	.484-.464 = .020	.641-.620 = .021	.559-.541 = .018	.730-.725 = .005	1.296 -1.215 = .081	3.238 -3.175 = .063
CL =	$.020 \pm 2.447$ x.0112 $=020 \pm .027$	$.021 \pm 2.447$ x.00913 $=.021 \pm .022$	$.018 \pm 2.447$ x.00913 $=.018 \pm .022$	$.005 \pm 2.447$ x.0194 $=.005 \pm .047$	$.081 \pm 2.447$ x.0478 $=.081 \pm .116$	$.063 \pm 2.447$ x.129 $=.063 \pm .316$

It is not possible by measurements alone to decide from which host Bucerophagus africanus specimens came; therefore, populations from the two hosts are considered conspecific.

Material examined: 13 males and 13 females from fresh and dried material collected in the Ethiopian Region; from the type host: 1 female from Mafa, Southwest Africa, February 1923, BM(NH); 9 males and 7 females from Cameroons Zoo, Africa, November 1936, BM(NH) 8127; 1 female from CNHM skins from Kari Pan, Makari, Bechuanaland, Africa, August 1930, collected by Vernay, Lang, and Roberts (REE); from Bucorvus abyssinicus (Boddaert, 1783): 1 male and 1 female from Koubadge, French Cameroons, Africa, July 1947, collected by V. Aellen, BM(NH) 1954-487; 2 males and 2 females from USNM skins from Sirre, Ethiopia, Africa, 13 February 1912, collected by Childs Frick (REE); 1 male and 1 female from Nyala, Sudan, Africa, 12 February 1949, KCE.

Drawings were made of a male and a female from the type host collected in the Cameroons Zoo. Specimens are in the BM(NH).

TABLE 12

Measurements in millimeters of Bucerophagus.

	Length		Width			
Bucerophagus:	Head	Total *	Head	Pro-thor.	Meta-thor.	Abdomen *
	Male.					
19. forcipatus.	0.318	1.725	0.492	0.413	0.565	0.625
a. B. r. sumatranus.	.322	-	.522	.438	.570	-
b. B. r. borneoensis.	.351	-	.515	.431	.652	-
20. productus.	.386	2.080	.528	.464	.578	.750
21. africanus.	.457	2.488	.586	.500	.686	1.050
	Female.					
19. forcipatus.	.370	1.125	.544	.435	.667	0.950
a. B. r. sumatranus.	.355	-	.584	.464	.677	-
b. B. r. borneoensis.	.344	-	.580	.467	.678	-
20. productus.	.464	3.172	.636	.536	.714	1.035
21. africanus.	.471	3.325	.636	.557	.764	1.390

* Measured only for specimens from which drawings were made.

a-b, from other hosts than those from which drawings were made.

Figs. 68-69. Dorsal-ventral view of male and of female, drawn to the same scale, as indicated; a-d, enlarged views, drawn to the same scale, as indicated.

Fig. 68. Bucerophagus africanus Bedford, female.

Fig. 69. Bucerophagus africanus Bedford, male.

a - antenna of female.

b - prosternal plate of female.

c - metasternal plate of female.

d - central T-shaped plate of male sternite VIII.

Fig. 70. Bucerophagus productus (Burmeister), metasternal plate of female, drawn to the same scale as c, as indicated.

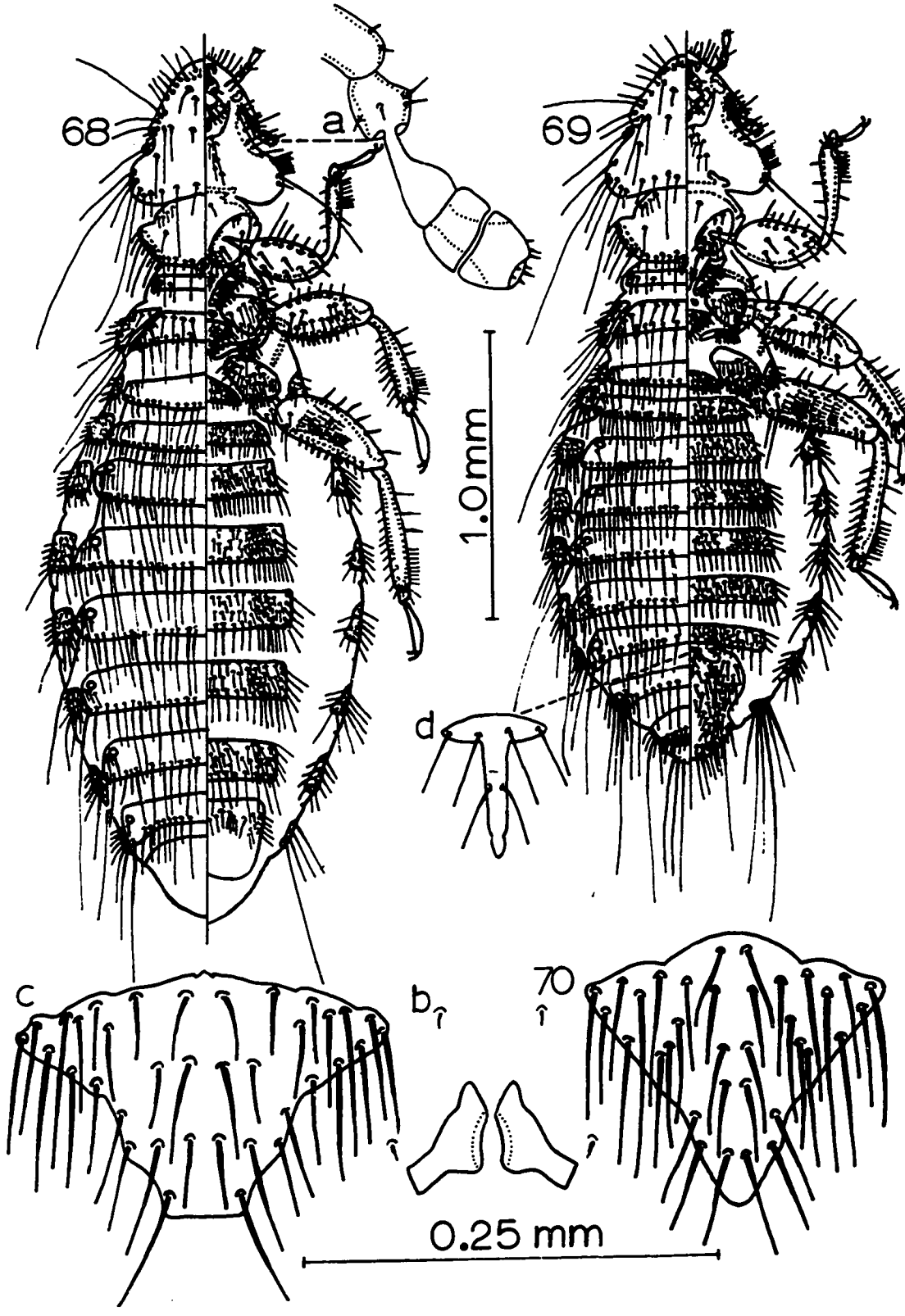

68
a
69
1.0mm
d
c
b
70
0.25 mm

TABLE 13

Bucerotidae arranged phylogenetically (Peters, 1945), geographical distribution, and amblyceran parasites.

Host	Geographical Region	Amblyceran	Species Group
Tockus birostris	Oriental	6.Chapinia clayae	acutovulvatum
Tockus f. semifasciatus	Ethiopian	-	
Tockus f. fasciatus	"	1.Chapinia fasciatus	lophocerus
Tockus alboterminatus geloensis	"	-	
Tockus a. stegmanni	"	-	
Tockus a. suahelicus	"	1.Chapinia fasciatus	lophocerus
Tockus a. angolensis	"	-	
Tockus a. alboterminatus	"	-	
Tockus a. australis	"	-	
Tockus b. bradfieldi	"	-	
Tockus b. williaminae	"	-	
Tockus p. pallidirostris	"	-	
Tockus p. neumanni	"	-	
Tockus n. nasutus	"	2.Chapinia lophocerus	lophocerus
Tockus n. forskâlii	"	-	
Tockus n. caffer	"	2.Chapinia lophocerus	lophocerus
Tockus h. hemprichii	"	-	
Tockus h. exsul	"	-	
Tockus monteiri marjoriae	"	-	
Tockus m. monteiri	"	-	
Tockus g. griseus	Oriental	6.Chapinia clayae	acutovulvatum
Tockus g. gingalensis	"	-	
Tockus h. hartlaubi	Ethiopian	-	
Tockus h. granti	"	-	
Tockus c. pulchrirostris	"	-	
Tockus c. camurus	"	3.Chapinia camurus	lophocerus
Tockus e. erythrorhynchus	"	2.Chapinia lophocerus	lophocerus
Tockus e. rufirostris	"	-	
Tockus e. damarensis	"	-	
Tockus e. ngamiensis	"	-	
Tockus f. flavirostris	"	2.Chapinia lophocerus	lophocerus
Tockus f. somaliensis	"	-	
Tockus f. leucomelas	"	2.Chapinia lophocerus	lophocerus
Tockus f. elegans	"	-	
Tockus deckeni	"	-	
Berenicornis comatus	Oriental	-	
Berenicornis a. albo-cristatus	Ethiopian	-	
Berenicornis a. macrourus	"	-	
Berenicornis a. cassini	"	-	
Ptilolaemus t. austeni	Oriental	17.Bucerocolpocephalum emersoni	
Ptilolaemus t. tickelli	"	-	

Host	Geographical Region	Amblyceran	Species Group
Ptilolaemus t. indochinensis	Oriental	17. Bucerocolpocephalum emersoni	
Anorrhinus g. carinatus	"	18. Bucerocolpocephalum deignani	
Anorrhinus g. galeritus	"	18. Bucerocolpocephalum deignani	
Anorrhinus g. minor	"	-	
Penelopides p. manilloe	"	11. Chapinia wenzeli	acutovulvatum
Penelopides p. subnigra	"	-	
Penelopides p. mindorensis	"	11. Chapinia wenzeli	acutovulvatum
Penelopides p. ticaensis	"	-	
Penelopides p. panini	"	-	
Penelopides p. samarensis	"	11. Chapinia wenzeli	acutovulvatum
Penelopides p. affinis	"	11. Chapinia wenzeli	acutovulvatum
Penelopides p. basilanica	"	-	
Penelopides e. exarhatus	Australasian	15. Chapinia muesebecki	hirtum
Penelopides e. sanfordi	"	-	
Rhyticeros nipalensis	Oriental	-	
Rhyticeros c. corrugatus	"	-	
Rhyticeros c. megistus	"	-	
Rhyticeros l. waldeni	"	12. Chapinia blakei	acutovulvatum
Rhyticeros l. leucocephalus	"	12. Chapinia blakei	acutovulvatum
Rhyticeros cassidix	Australasian	14. Chapinia lydae	acutovulvatum
Rhyticeros u. ticehursti	Oriental	10. Chapinia boonsongi	acutovulvatum
Rhyticeros u. undulatus	"	10. Chapinia boonsongi	acutovulvatum
Rhyticeros p. subruficollis	"	16. Chapinia hirta	hirtum
Rhyticeros p. plicatus	Australasian	-	
Rhyticeros p. ruficollis	"	16. Chapinia hirta	hirtum
Rhyticeros p. jungei	"	-	
Rhyticeros p. dampieri	"	-	
Rhyticeros p. harterti	"	-	
Rhyticeros p. mendanae	"	16. Chapinia hirta	hirtum
Rhyticeros everetti	"	-	
Rhyticeros narcondami	Oriental	-	
Anthracocerus malayanus	"	8. Chapinia malayensis	acutovulvatum
Anthracoceros a. albirostris	"	7. Chapinia acutovulvata	acutovulvatum
Anthracoceros a. leucogaster	"	7. Chapinia acutovulvata	acutovulvatum
Anthracoceros coronatus	"	7. Chapinia acutovulvata	acutovulvatum
Anthracoceros convexus	"	7. Chapinia acutovulvata	acutovulvatum
Anthracoceros montani	"	9. Chapinia hoplai	acutovulvatum
Anthracoceros marchei	"	7. Chapinia acutovulvata	acutovulvatum
Bycanistes b. fistulator	Ethiopian	-	
Bycanistes b. sharpii	"	4. Chapinia bucerotis	lophocerus
Bycanistes b. duboisi	"	4. Chapinia bucerotis	lophocerus
Bycanistes b. bucinator	"	4. Chapinia bucerotis	lophocerus
Bycanistes c. cylindricus	"	4. Chapinia bucerotis	lophocerus
Bycanistes c. albotibialis	"	4. Chapinia bucerotis	lophocerus
Bycanistes s. subcylindricus	"	-	
Bycanistes s. subquadratus	"	4. Chapinia bucerotis	lophocerus
Bycanistes b. omissus	"	4. Chapinia bucerotis	lophocerus

Host	Geographical Region	Amblyceran	Species Group
Bycanistes b. brevis	Ethiopian	4. Chapinia bucerotis	lophocerus
Ceratogymna atrata	"	5. Chapinia robusta	lophocerus
Ceratogymna elata	"	5. Chapinia robusta	lophocerus
Buceros r. rhinoceros	Oriental	-	
Buceros r. sumatranus	"	19. Bucerophagus forcipatus	forcipatum
Buceros r. silvestris	"	-	
Buceros r. borneoensis	"	19. Bucerophagus forcipatus	forcipatum
Buceros b. bicornis	"	-	
Buceros b. homrai	"	19. Bucerophagus forcipatus	forcipatum
Buceros h. hydrocorax	"	-	
Buceros h. semigaleatus	"	13. Chapinia traylori	acutovulvatum
Buceros h. mindanensis	"	13. Chapinia traylori	acutovulvatum
Buceros h. basilanicus	"	-	
Rhinoplax vigil	"	19. Bucerophagus forcipatus	forcipatum
Bucorvus abyssinicus	Ethiopian	20. Bucerophagus productus	productum
		21. and B. africanus	productum
Bucorvus leadbeateri	"	21. Bucerophagus africanus	productum
		20. and B. productus	productum

- Denotes that amblyceran lice were not found on these hosts.

AVIPARASITOLOGICAL RELATIONSHIPS

Since Mallophaga are obligatory, usually highly host-specific, external parasites, their distribution is dependent on the distribution of their hosts (Emerson and Ward, 1958). The arrangement of the Mallophaga based on morphological similarities does not follow exactly Peter's (1945) phylogenetic arrangement of the Hornbill hosts (see Table 13). In the genus Chapinia species of the lophocerus species-group infest hosts in the genera Tockus, Bycanistes, and Ceratogymna of the Ethiopian Region; and species of the acutovulvatum and hirtum species-groups infest hosts in the genera Tockus, Penelopides, Rhyticeros, Anthracoceros, and Buceros of the Oriental and Australasian Regions. Species of Bucerocolpocephalum infest hosts in the genera Ptilolaemus and Anorrhinus of the Oriental Region. In the genus Bucerophagus species of the forcipatum species-group infest hosts in the genera Buceros and Rhinoplax of the Oriental Region, and species of the productum species-group infest hosts in the genus Bucorvus of the Ethiopian Region.

Tockus is the only Hornbill genus that has members in both the Ethiopian and Oriental Regions (see Table 13). Yet the amblyceran, Chapinia clayae, from the Oriental species, Tockus birostris and Tockus g. griseus, does not resemble members of the lophocerus species-group which infest other species of Tockus. Instead, C. clayae resembles most closely

C. acutovulvata from the Oriental species of Anthracoceros. It would appear that there has been more recent contact between the Indian Tockus and Anthracoceros whose ranges overlap than between the more nearly related Indian Tockus and African Tockus. Kellogg (1896) was the first to mention that Mallophaga live their entire lives on the host bird; and that infestation of new hosts is accomplished by the actual migration of individuals from one bird to another, during copulation, nesting, or roosting. As an example of the latter, he mentioned that the crowding together of gulls of more than one species on small masses of floating sea weed or on rocks of the shore must bring about actual contact of their bodies facilitating the transfer of their lice. Clay (1949 b) stated that normally birds of different species did not come into close enough contact for lice to be transferred from host to host; but that inter-change of lice could take place between predator and prey, nestling and foster parent in brood parasites, by the use of common dust baths (according to Hoyle, 1938), and by phoresy which is the transfer of lice by Hippoboscid flies. In the case of brood parasites she stated that there was ample opportunity for transference during brooding of the young; but that for the European Cuckoo, Cuculus canorus, lice of the foster parents had never been established on the cuckoo. This is also true for other brood parasites. She further stated that establishment on the new host might be prevented by competition of the already adapted resident louse population, by the host specificity of the immigrant louse making feeding and development on the new host impossible, or by the fact that only males or unfertilized females had been introduced. Clay (1962) described natural straggling as occurring between hosts that

happened to be nesting in close proximity, and that establishment on the new host might be facilitated by the absence of a resident louse.

It would appear that both lophocerus and acutovulvatum species-groups shared a common ancestor of Chapinia on Tockus before the Indian and African Tockus became separated. Once separated, the Chapinia evolved as did the birds to the recognized species within each species group. Natural straggling may have accounted for establishment on some of the hosts.

Clay (1949 b) mentioned that the chief factor influencing the production of allopatric species and genera of Mallophaga has been the successive splitting of the host populations during the evolution of the birds thus leaving isolated louse populations. The louse population is considered as comprising all individuals that can interbreed because their hosts can interbreed (Clay, 1958). Kellogg (1896) stated that with the spreading of the ancestral bird species geographical races arose within the limits of the species which with time and isolation caused by newly appearing geographical barriers, came to be distinct species which were often distinguished only by superficial differences in color, etc. The Mallophaga remained practically unaffected since their enviornment was essentially unchanged. The enviornment of the Mallophaga, the physical and chemical composition of the feathers and blood, changes more slowly than do other factors leading toward speciation of the bird; and until this enviornment changes, the Mallophaga would remain unchanged (Elbel and Emerson, 1959). For example, in the acutovulvatum species-group the hosts Anthracoceros coronatus and A. convexus are now considered to be full species distinct from A. a. albirostris, A. a. leucogaster, and A. marchei; yet all three

hosts bear the same species of Mallophaga, Chapinia actuvulvata. Similarly, in the lophocerus species-group, Chapinia bucerotis infests eight subspecies in four species of Bycanistes; and C. lophocerus infests five subspecies in three species of Tockus. In the forcipatum species-group, Bucerophagus forcipatus infests three subspecies in three species and two genera.

Although Anthracoceros marchei is restricted to the Philippines, it is host to Chapinia acutovulvata which infests other Anthracoceros species with wider distribution in the Oriental Region. However, C. hoplai from A. montani also is restricted to the Philippines; but resembles most closely C. boonsongi from Rhyticeros undulatus, which is distributed elsewhere in the Oriental Region. Chapinia wenzeli from Penelopides panini and C. traylori from Buceros hydrocorax both resemble most closely C. blakei from Rhyticeros leucocephalus. Although the host genus Buceros is not considered to be as related to Rhyticeros as is Penelopides, the host species from which C. wenzeli, C. blakei, and C. traylori were obtained are all restricted to the Philippines. Thus, C. traylori may have evolved as a result of natural straggling from the stock that gave rise to C. wenzeli and C. blakei; and subsequently become established on the host Buceros.

Chapinia lydae from Rhyticeros cassidix (Temminck) has the characters of the acutovulvatum species-group; but superficially resembles members of the hirtum species-group of which C. muesebecki from Penelopides e. exarhatus (Temminck), like C. lydae, is restricted to the Australasian Region. Chapinia hirta, the other member of the hirtum species-group, infests subspecies of Rhyticeros plicatus in both the Oriental and Australasian Regions.

Buceros is the only hornbill genus that is host to both Chapinia and Bucerophagus (see Table 13). However, these Mallophaga do not infest the same hosts. Buceros hydrocorax, the host of Chapinia traylori, is restricted to the Philippines; but B. rhinoceros and B. bicornis, the hosts of Bucerophagus forcipatus, are distributed elsewhere in the Oriental Region.

In the productum species-group both Bucerophagus productus and B. africanus infest the two hosts, Bucorvus abyssinicus and B. leadbeateri. The population of each mallophagan species on each host could not be separated morphologically or statistically. Thus, only one species of Bucerophagus productus and one species of B. africanus could be recognized. Similarily, Clay (1955) recognized only one species of Bucorvellus docophorus although specimens from Bucorvus leadbeateri showed a tendency to be smaller in size than specimens from B. abyssinicus. She further stated that it would be expected from Harrison's rule (1915) that specimens from B. leadbeateri, the smaller host, would be smaller than specimens from the large B. abyssinicus. However, Mackworth-Praed and Grant (1952) stated that B. leadbeateri was the largest of the Hornbills; they gave wing measurements for B. leadbeateri as 509-595 mm. and for B. abyssinicus as 495-595 mm.

Harrison (1915) stated the rule that bears his name, that in general, when a mallophagan genus is well distributed over a considerable number of nearly related hosts, the size of the parasite is roughly proportional to the size of the host. Chapinia camurus, the smallest species of Chapinia, infests the smallest Hornbill, Tockus camurus; but Chapinia acutovulvata, the largest species of Chapinia, does not infest Rhyticeros undulatus, the largest host for species of Chapinia.

SUMMARY

Amblyceran Mallophaga of the family Menoponidae were examined from 50 species or subspecies of Hornbills. Descriptions and illustrations are presented for 21 species in three genera of Hornbill Menoponidae of which 13 species are new. The genus Chapinia now contains three species-groups and 16 species of which 11 are new. The genus Bucerophagus now contains two species-groups and three species. The new genus Bucerocolpocephalum is erected here for two new comb-bearing species. The new species are as follows: Chapinia fasciatus, C. camurus, C. clayae, C. malayensis, C. hoplai, C. boonsongi, C. wenzeli, C. blakei, C. traylori, C. lydae, C. muesebecki, Bucerocolpocephalum emersoni, and B. deignani. New synonymy is C. acutovulvata (Piaget, 1881) (= C. mjöbergi (Eichler, 1947)). New type designations are: a neotype for Chapinia hirta (Rudow, 1866), a neotype for Bucerophagus forcipatus (Nitzsch, 1874), and a lectotype for C. bucerotis (Kellogg, 1908). Differential characters are listed for genera, species-groups, and species; and a key is provided for separating the species.

Bucerophagus productus and B. africanus infest both Bucorvus abyssinicus and B. leadbeateri, but it was not possible by morphological or statistical means to separate the populations of each mallophagan species on each host.

In the genus Chapinia species of the lophocerus species-group infest hosts in the Ethiopian Region, but species of the acutovulvatum and hirtum

species-groups infest hosts in the Oriental and Australasian Regions. Species of the genus Eucerocolpocephalum infest hosts in the Oriental Region. In the genus Bucerophagus the species of the forcipatum species-group infests hosts in the Oriental Region, and species of the productum species-group infest hosts in the Ethiopian Region.

Tockus is the only Hornbill genus that is present in both the Ethiopian and Oriental Regions. However, Chapinia clayae of the acutovulvatum species-group from the Oriental species of Tockus resembles C. acutovulvata from Oriental species of Anthracoceros more closely than species of the lophoceras species-group from Ethiopian species of Tockus. Thus, it would appear that there has been more recent contact between the Oriental species of Tockus and Anthracoceros whose ranges overlap than between the more closely related Oriental and Ethiopian species of Tockus. If both lophoceras and acutovulvatum species-groups shared a common ancestor of Chapinia on Tockus before the Indian and African species of Tockus became separated, then the species of Chapinia may have evolved with the Hornbills to the recognized species and hosts within each species-group in each region.

BIBLIOGRAPHY

Bedford, G. A. H. 1920. Anoplura from South African hosts. Part II. Rep. vet. Res. S. Africa, 7-8: 709-41, 7 pls.

----------1929. Anoplura (Siphunculata and Mallophaga) from South African hosts. Rep. vet. Res. S. Africa, 15: 501-49, 34 figs.

----------1930. New genera and species of Mallophaga from South African hosts. Rep. vet. Res. S. Africa, 16: 153-73, 16 figs.

Burmeister, C. H. C. 1838. Mallophaga. In Handbuch der Entomologie, 2: 418-43.

Clay, Theresa 1947. A preliminary key to the genera of the Menoponidae (Mallophaga). Proc. Zool. Soc. London, 117: 457-77, 40 figs.

----------1949 a. Systematic notes on the Piaget collections of Mallophaga. Part I. Ann. Mag. Nat. Hist., (12) II: 811-38; 895-921, 6 figs.

----------1949 b. Some problems in the evolution of a group of ectoparasites. Evol., 3: 279-99, 4 figs.

----------1951 a. Systematic notes on the Piaget collections. Part II. Ann. Mag. Nat. Hist., (12) IV: 173-82.

----------1951 b. Systematic notes on the Piaget collections of Mallophaga. Part III. Ann. Mag. Nat. Hist., (12) IV: 1159-68, 15 figs., 1 pl.

Clay, Theresa 1954. The post-spiracular seta and sensillus in the Mallophaga (Insecta). Ann. Mag. Nat. Hist., (12) VII: 716-18, 2 figs.

----------1955. A new genus of Ishnocera (Mallophaga). Proc. R. Ent. Soc. London, (B) 24: 1-6, 7 figs., 1 pl.

----------1956. Phthiraptera. In Tuxen, Taxonomists Glossary of Genitalia in Insects: 145-48, 4 figs.

----------1958. Revisions of Mallophaga genera. Degeeriella from the Falconiformes. Bull. Brit. Mus. (Nat. Hist.) Ent., 7: 5-217, 164 figs., 9 pls.

----------1961. A new genus and species of Menoponidae (Mallophaga, Insecta) from Apteryx. Ann. Mag. Nat. Hist., (13) III: 571-77, 12 figs., 1 pl.

----------1962. A key to the Species of Actornithophilus Ferris with notes and descriptions of new species. Bull. Brit. Mus. (Nat. Hist.) Ent., 11: 191-252, 72 figs., 8 pls.

Conci, Cesare 1950. Mallophaga. Riv. Biol. Colon., 10: 77-82, 7 figs.

Cope, Oliver B. 1941. The Morphology of a species of the genus Tetrophthalmus (Mallophaga: Menoponidae) Microent., 6: 71-92, 10 figs.

Deignan, H. G. 1963. Checklist of the Birds of Thailand. USNM Bull., 226: 1-263, 1 fig.

Edwards, Robert L. 1961. Studies of the Philopteridae (Mallophaga) from birds of the order Procellariformes. 1. The genus Halipeurus Thompson. J. Parasitol., 47: 125-57, 7 figs.

Eichler, von Wolfdietrich 1947. Dr. E. Mjöberg's Zoological Collections from Sumatra. 15. Mallophaga. Ark. Zool., 39 A: 1-21, 40 figs.

Elbel, Robert E. and Emerson, K. C. 1959. The taxonomic position of an Asiatic species of Otus (Aves: Strigiformes) as indicated by the Mallophaga. Proc. Okla. Acad. Sci., 39: 76-78.

Emerson, K. C. 1954. Review of the genus Menopon Nitzsch 1818 (Mallophaga). Ann. Mag. Nat. Hist., (12) VII: 225-232, 12 figs.

----------and Ward, Ronald A. 1958. Notes on the Philippine Mallophaga, 1. Species from Ciconiiformes, Anseriformes, Falconiformes, Galliformes, Gruiformes, and Charadriiformes. Philippine Zool. Exped. 1946-47. Fieldiana, 42: 49-61, 4 figs.

Ewing, H. E. 1927. Descriptions of new genera and species of Mallophaga together with keys to some related genera of Menoponidae and Philopteridae. J. Wash. Acad. Sci., 17: 86-96.

Ferris, G. F. 1923. The mallophagan family Menoponidae. Parasitol., 16: 55-65.

Giebel, C. 1866. Die im Zoologischen Museum der Universität Halle aufgestellten Epizoen nebst Beobachtungen über diselben. Z. ges. NatWiss., 28: 353-97.

----------1874. Insecta Epizoa. 329 pp., 20 pls.

Harrison, L. 1915. Mallophaga from Apteryx and their significance with a note on the genus Rallicola. Parasitol., 8: 88-100, 6 figs.

Hopkins, G. H. E. 1941. Stray notes on Mallophaga 15. Notes on the types of the Mallophaga described by Bedford. Ann. Mag. Nat. Hist., (11) VII: 274-94.

----------and Clay, Theresa 1952. A Checklist of the Genera and Species of Mallophaga. 362 pp.

Hoyle, W. L. 1938. Transmission of poultry parasites. Trans. Kans. Acad. Sci., 41: 379-84.

Johnson, Phyllis T. 1960. The Anoplura of African Rodents and Insectivores. USDA Tech. Bull., 1211: 1-116, 180 figs.

Kellogg, V. L. 1896. New Mallophaga I. With special reference to a collection made from maritime birds of the bay of Monterey, California. Proc. Calif. Acad. Sci., 6: 31-182, 4 figs. 14 pls.

Kellogg, V. L. 1908. Wissenschaftliche ergebnisse der Schwedischen zoologischen expedition nach dem Kilimandjaro, dem Meru und den umgebenden massaisteppen. Deutsch-Ostafrikas 1905-06., 15. Corrodentia. 4. Mallophaga: 43-58, 1 pl.

Mackworth - Praed and Grant, G. H. B. 1952. Birds of East and Northeast Africa. Ser. 1, vol. I, 836 pp.

Nitzsch, L. 1874, (see Giebel).

Peters, J. L. 1945. Bucerotidae. In Checklist of Birds of World, 5: 254-72.

Piaget, E. 1880. Les Pédiculines. Essai Monographique. 810 pp., 56 pls.

----------1881. Quatre Nouvelles Pédiculines. Tijdschr. Ent., 24: 1-6, 1 pl.

----------1885. Les Pédiculines. Supplément. 213 pp., 17 pls.

----------1888. Quelques nouvelles Pédiculines. Tijdschr. Ent., 31: 147-166, 2 pls.

Rudow, F. 1866. Charakteristik neuer Federlinge. Z. ges. NatWiss., 27: 465-77.

----------1869. Neue Mallophagen. Z. ges. NatWiss., 34: 387-407.

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