

The species of *Ardeicola* (Phthiraptera) on *Threskiornis* (Aves)

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Abstract

The species of *Ardeicola* parasitic on the Ibis genus *Threskiornis* are reviewed—*clayae* Brelih, *freemani* sp.n., *ibis* Le Souef & Bullen, *indicus* Brelih, *intermedia* sp.n., *nippon* Hajela & Tandan—and a key for their identification is presented. Notes on the affinities of the species and a discussion on the distribution of *Ardeicola* on *Threskiornis* are included.

Introduction

The first species referable to *Ardeicola* Clay, 1935 from ibises of the genus *Threskiornis* was described as *Lipeurus ibis* by Le Souef & Bullen (1922), from the Australian White Ibis *Threskiornis strictipennis* = *T.molucca strictipennis*. Thereafter, Brelih (1965) described two species, *A.clayae* and *indicus* from *T.aethiopicus* and *T.melanocephala* respectively but they could not be compared with *A.ibis* owing to the loss of the types, lack of material and the inadequacy of the original description. However, Brelih did compare the new forms with *Ardeicola* from *T.m.molucca* and gave a short description of that form. Recently Dr M. D. Murray has kindly made available a male and females of *Ardeicola* from *T.m.strictipennis*, the type host of *ibis*.

The characters given under the definition of the genus in Kumar & Tandan (1971, 119) have been omitted from the descriptions and the same letters referring to the constant setae on the terminalia of the two sexes in earlier descriptions in Hajela & Tandan (1967, 1970) have also been used here. The chaetotaxy in the figures agrees with the specimens from which these were drawn; broken or missing setae have been completed either from the other side of the same specimen or from another con-

specific specimen. Figures in parentheses indicate the number of specimens examined; \bar{x} denotes the mean of setal counts as also of measurements in millimetres.

Species groups of *Ardeicola*

Elsewhere it has been shown that the species of *Ardeicola* living on the family Ciconiidae form a distinct species group (Kumar & Tandan, 1971, 120), designated as the *ciconiae* group, and those from the Ardeidae likewise form another species group (Tandan, 1972). Species of *Ardeicola* living on the Threskiornithidae, to which the third and last family of the avian order Ciconiiformes *Threskiornis* belongs, also form a distinct species group for which I propose the name *plataleae* group. The three most distinctive characters of the *plataleae* group are given below in a tabular form along with the corresponding ones of *Ardeicola* from the Ciconiidae and Ardeidae.

| | Pteronotal marginal setae | Anterocentral setae on tergum II | Pleural setae | |
|---|---------------------------------|--|---------------|-----|
| | | | II | III |
| Ciconiidae (Kumar & Tandan, 1971) | 5+5 | 2 | Absent | 1+1 |
| Ardeidae (Tandan, 1972) | 3+3 | Absent | Absent | 1+1 |
| Threshkiorni- thidae | 4+4 | 2 | 1+1 | 2+2 |

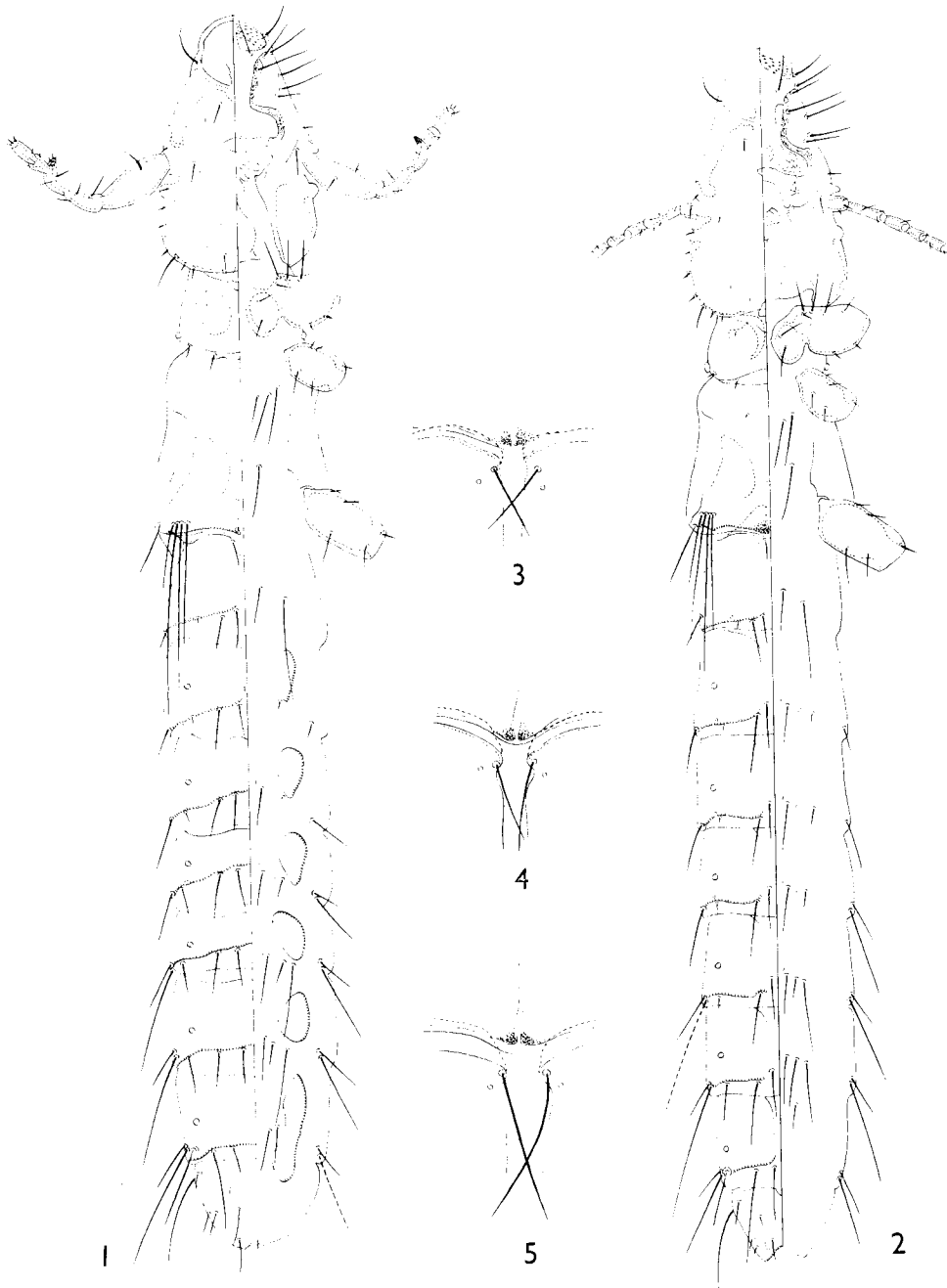
An examination of specimens from different taxa of *Threskiornis* shows that they resemble each other in their general habitus and in the setal count of the abdomen with the exception of the genital region of the two sexes; the chaetotaxy of the head and thorax being the same in all the species of *Ardeicola* from Threskiornithidae. The species parasitic on *Threskiornis* thus form a closely knit subgroup within the *plataleae* group which for convenience is here designated the *ibis* subgroup.

The *ibis* subgroup of *Ardeicola*

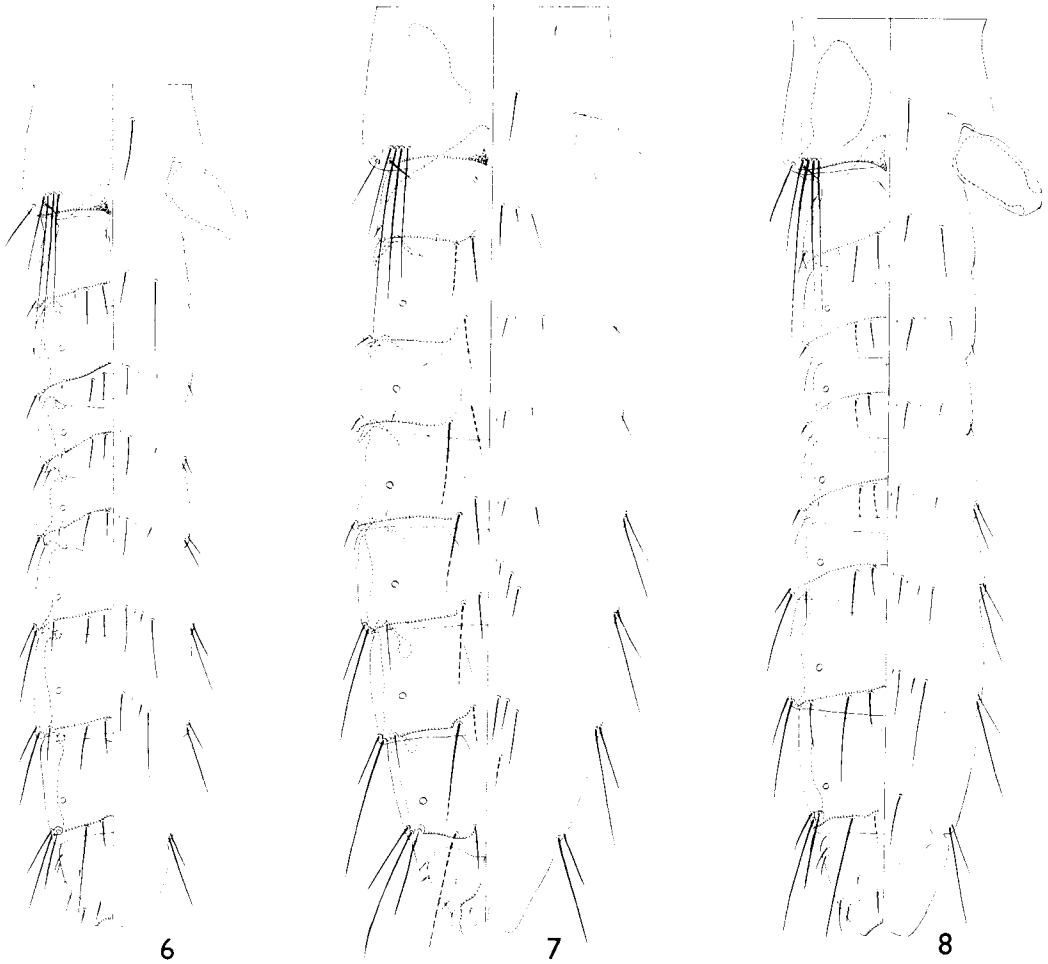
Not only is the setal count basically identical in the same sex of different species but also in the two sexes

of the same species; this basic count, together with the normal range of individual variation, for thorax and abdomen is as follows:

Thoracic setae: long to very long marginal



Figs. 1-5. *Ardeicola ibis*, from type host: (1, 2) left dorsal, right ventral; (1) male, neotype, sternum II damaged; (2) female. Marginal temporal setae shown on left side only. (3-5) The 2 antero-central setae on tergum II; (3) male; (4, 5) female.



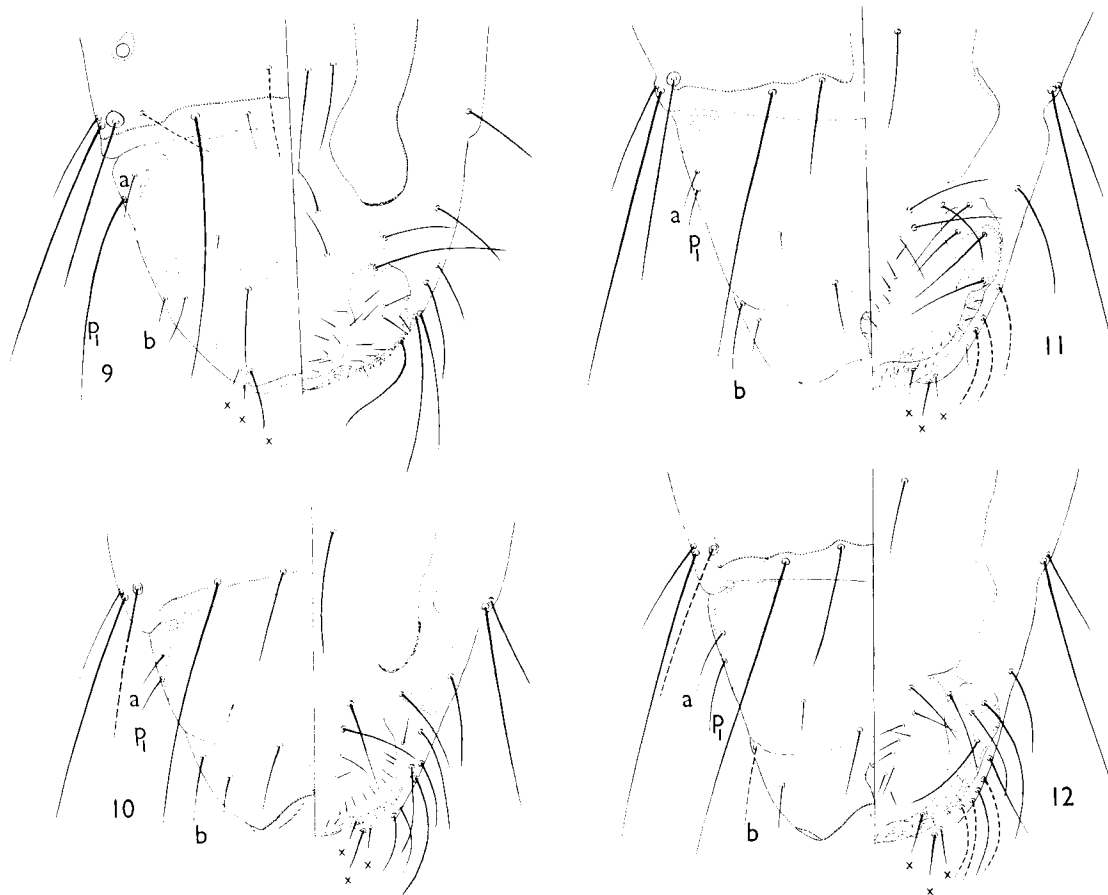
Figs. 6-8. *Ardeicola* spp., abdomen. (6) *A. clayae*, male, paratype; (7) *A. freemani*, female (the seta on tergite IV anteriorly seems to be the missing post-spiracular seta of III); (8) *A. freemani*, male, holotype. Details of genital region omitted.

pteronotal setae 4+4 (range 7-10). Mesosternal setae 2+2 (range 3-5); metasternal setae 1+1 (range 2-3).

Abdominal setae: tergal; II 2 anterocentral, each with a contiguous sensillum; II-VIII 2 central + 2 lateral marginal setae; setae a and b 1+1. Post-spiracular setae 1+1, on terga II-VII having contiguous sensillum on II-V; those on II and III being inner and closer to tergolateral setae than on IV-VII. Pleural setae: II 1+1; III, IV 2+2; V 3+3; VI-VIII 4+4. Terminal segment; seta p_1 1+1; seta p_2 1+1 spiniform and constant only in the female. Sternal setae; II-V 2 central + 2 lateral; VI 2 central + 4 lateral; VII 3+3. Usually minute, occasionally short, setae also present on these sterna: II 0-2 rarely only; III-VI 2-4 rarely more also on III and IV;

VII 0-4. Terminalia: group d 2+2 in the female, not identifiable in the male (but in the males of several species from Threskiornithidae as also from Ciconiidae and Ardeidae this group is recognizable).

An interesting feature of the *ibis* subgroup is the presence of a modified area in the female genital chamber, anterior to the opening of the supermathecal duct. In specimens treated with KOH and mounted this area comes into focus along with the dorsal wall of the genital chamber, an indication of its being associated with the inner surface thereof. It differs considerably among *Ardeicola* from *Threskiornis*, being seen most distinctly in *ibis* and *indicus*; its details are only clearly visible in either teneral (unsclerotized) specimens or specimens over-treated (de-sclerotized) with KOH. Brelih (1965) has



Figs. 9–12. *Ardeicola* spp., male terminalia, left dorsal right ventral: (9) *A. ibis*, from type host, the 2 setae shown by broken lines on tergite VIII are sternal setae; (10) *A. clayae*, paratype; (11) *A. freemani*; (12) *A. intermedia*. The 3 anal setae have been indicated by a cross near the tip of each seta.

shown this structure in *Ardeicola* from *T.m.molucca* (Fig. 10, g.c., in Brelih).

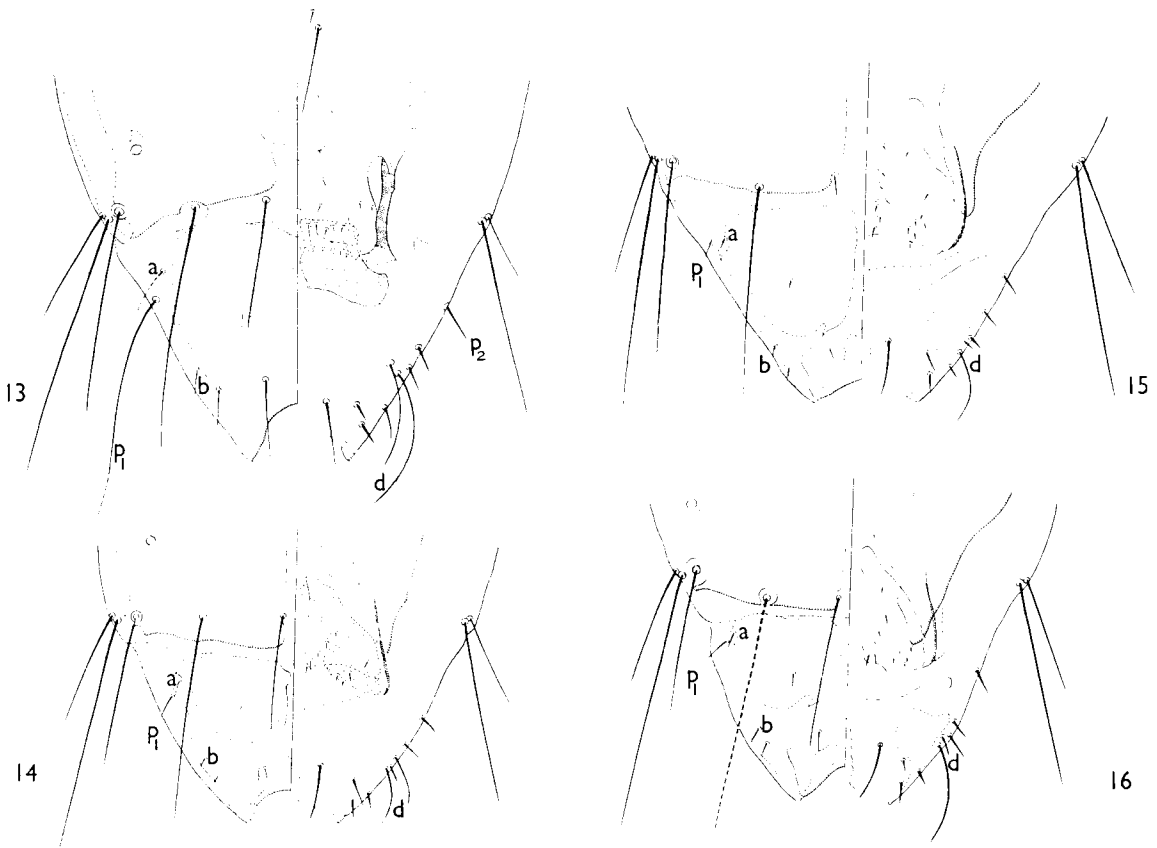
In *ibis* from the type host this modified area is posterior to the 2 setae on the sternum presumed to be VIII. It consists of what seem to be (i) a groove, horseshoe-shaped with the open end directed anteriorly and (ii) two membranous sacs or pouches, one each attached to the inner edge of the groove, and lying in the anterior half of the complex (Figs. 13, 21 and 36). Immediately underneath this area is a dense patch of microtrichia, present in all likelihood on the ventral wall of the genital chamber. This patch obscures the details of the area unless the specimen is teneral or overtreated with alkali (Fig. 37). Apparently, the two pouches press on the ventral wall of the genital chamber compressing the dense patch of microtrichia which as a result appears

more ventral than the combs of microtrichia on the general surface of the ventral wall.

In eleven specimens from *T.molucca* from Papua (Fig. 22) and Malaysia this area resembles that in *ibis* from the type host, although three of the seven females from Malaysia and the single female from Rennell Island show some individual variation.

The details of this area (Figs. 23, 24 and 38), visible in all the available specimens of *indicus*, as all are overtreated with alkali, differ slightly from those of *ibis*. Underneath the area the microtrichia of the ventral wall of the genital chamber form combs resembling those on the general surface of the ventral wall, no median patch of dense microtrichia as is present in *ibis* could be seen.

In *clayae* what appears to be the homologous structure is present at about the level of the 2 setae



Figs. 13–16. *Ardeicola* spp., female terminalia, left dorsal, right ventral: (13) *A. ibis*, from type host (in this female seta a is absent on both sides); (14) *A. clayae*; (15) *A. freemani*; (16) *A. intermedia*, holotype.

on sternum VIII, being relatively anterior to that in *ibis* and *indicus* and quite different in detail (Figs. 25, 26 and 39). It is in the form of two lateral areas consisting of what seem to be grooves that intertwine; no membranous sac or pouch associated with the grooves has been seen, but this might be due to the poor state of the specimens; being identifiable in *intermedia*, it is not unlikely that there is also one in *clayae*.

In the two new species, *freemani* and *intermedia*, this structure is also in the form of lateral areas. The details are not clear in *freemani*, as the specimens are suboptimal, but from whatever is delineable it seems to be formed of less extensive grooves than in *clayae*. In *intermedia* (Figs. 27, 28 and 41) there is a membranous portion each side associated with the system of lateral grooves, these again being less extensive than in *clayae*. In all the three species, *clayae*, *freemani* and *intermedia*, the median patch

of dense microtrichia is anterior to this structure, even anterior to the 2 setae on sternum VIII.

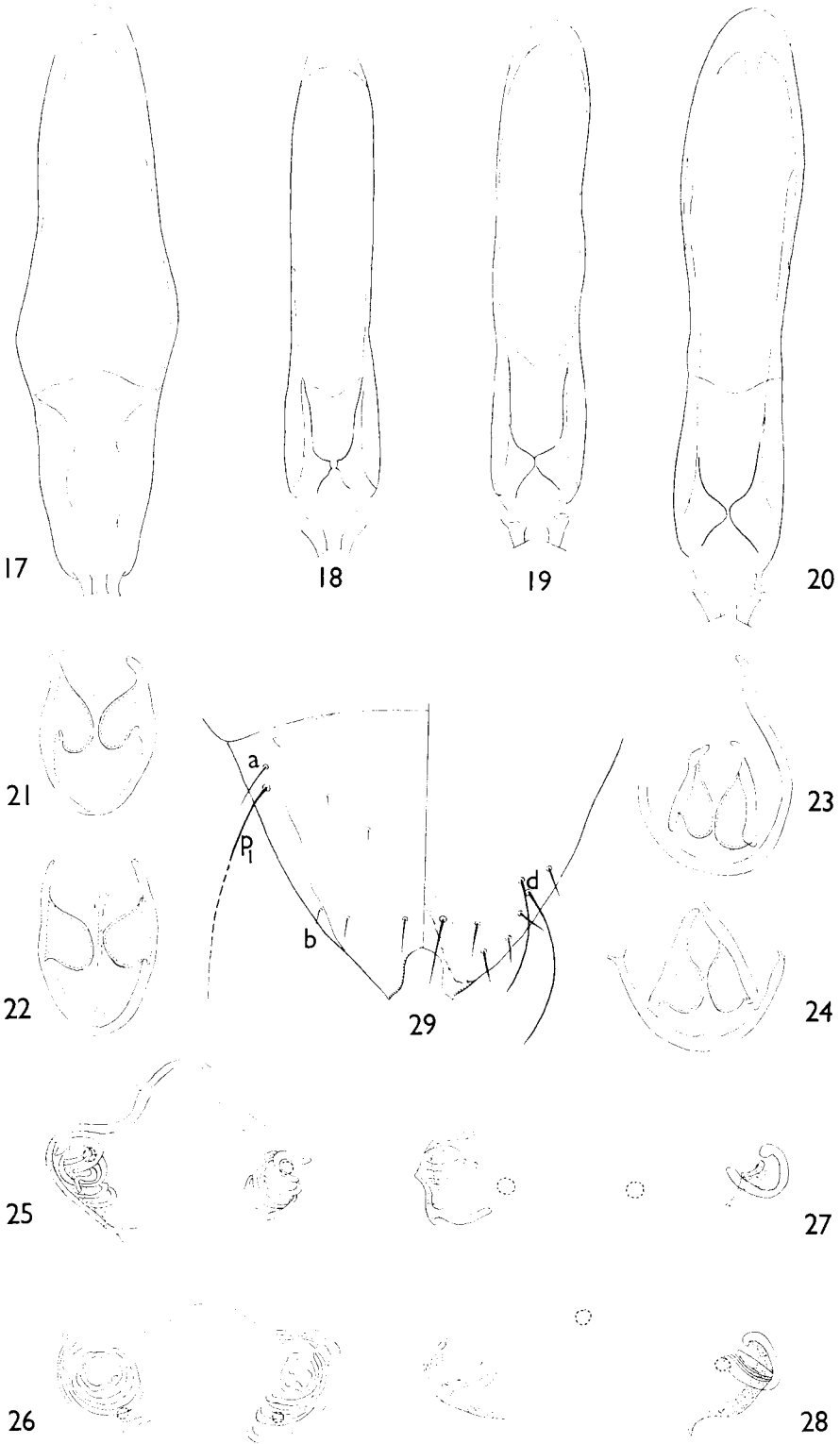
It would be interesting and desirable to know what structure is represented in the normal specimens by these remnants in those treated with KOH and also whether or not the structure of *ibis* and *indicus* is homologous with that of *clayae*, *freemani* and *intermedia*.

Ardeicola ibis (Le Souef & Bullen)

(Figs. 1–5, 9, 13, 21, 32 and 36)

Type host: *Threskiornis molucca strictipennis* (Gould)
Lipeurus ibis Le Souef & Bullen, 1922, 156. Host:
Threskiornis strictipennis.

The original description of this species does not give the number of specimens the authors collected or studied and enquiries have failed to trace the original material.



Harrison (1916, 136) transferred this species to his new genus *Esthiopterum*, besides giving it a *nomen novum*, *ibidis*, under the wrong impression that the original name was pre-occupied. Both these actions were unnecessary; the name, *ibis*, given in bold face in the check list of Mallophaga (Hopkins & Clay, 1952), is the valid name.

Male and female. General characters and chaetotaxy as shown in Figs. 1 and 2. In the male the anterior margin of tergite III with a slight to quite deep median incision. Composite tergite IX–XI without a suture but the appearance of the cuticle between the 2 anterior and the 4 posterior setae on this tergum is different from elsewhere, which suggests that this kind of modification might be the first stage in the differentiation of a suture (Fig. 9). Thickening along the margin of the genital opening characteristic. External genitalia as shown in Figs. 17 and 32; the knob-like structure anteriorly near the outer margin of the paramere is actually a hook, its proper shape being shown in Fig. 31; this represents the paramere of the left-hand side, drawn from the same specimen of *ibis* from *T.m.molucca* used by Brelüh (1965) for his Fig. 14.

In the female, the thickening of tergum IX–XI forms a large plate with a median depression in its anterior margin.

Important features of chaetotaxy: the 2 antero-central setae on tergum II medium in the male, medium to long in the female, varying considerably in thickness also (Figs. 3–5) their tips falling well short of the 4 marginal setae on this segment. In the female the tips of the 2 central setae on tergum VIII either fall slightly short of or extend slightly beyond the 2 anterior setae on tergum IX–XI, Fig. 13. (In the male the lateral and latero-ventral pleural setae on III–VII are ventral (Fig. 1), but this probably is not their normal position as in *ibis* from *T.m.molucca* and *m.pygmaeus* the corresponding setae are always lateral or latero-ventral.)

Terminalia: seta p_1 fine, short to medium in both sexes. Seta p_1 long, its tip extending beyond the end of the abdomen in the female, but in the only available male it is as long as in the female on one side, slightly shorter on the other. Genital region of the two sexes shown in Figs. 9 and 13. Female: short setae in genital region, each side 4–7, total 9–14, \bar{x} 11 (5); vulval marginal, each side 7–11, total

15–22, \bar{x} 17.4 (5); marginal and submarginal setae, each side 3–4, \bar{x} 3.7 (10 sides), total 7–8, spiniform but the last one tends to become somewhat longer. Anal setae: male; 1+1 dorsal on tergum XI (Fig. 9), 1+1 marginal and 1+1 ventral (internal).

Measurements of ♂ neotype and ♀ neoparatypes. *Length:* total, ♂ 3.62; ♀ 3.64–4.08, \bar{x} 3.91 (4). *Head,* ♂ 0.75; ♀ 0.77–0.82, \bar{x} 0.80 (4). *Prothorax,* ♂ 0.26; ♀ 0.22–0.26, \bar{x} 0.24 (4). *Pterothorax,* ♂ 0.52; ♀ 0.50–0.54, \bar{x} 0.53 (4). *Abdomen,* ♂ 2.10; ♀ 2.14–2.46, \bar{x} 2.33 (5). *Width:* head, level of pre-antennal setae, ♂ 0.44; ♀ 0.41–0.44, \bar{x} 0.42 (5). *Across temples,* ♂ 0.47; ♀ 0.44–0.49, \bar{x} 0.47 (5). *Prothorax,* ♂ 0.36; ♀ 0.35–0.40, \bar{x} 0.36 (5). *Pterothorax,* ♂ 0.56; ♀ 0.48–0.55, \bar{x} 0.52 (3). *Abdomen,* ♂ 0.50 (VI); ♀ 0.65–0.70, \bar{x} 0.67 (4) (V). *Cephalic index:* ♂ 0.63; ♀ 0.60–0.62 (4).

Neotype ♂, of *Lipeurus ibis* Le Souef & Bullen, by present designation, slide no. WV 470 in Australian National Insect Collection (ANIC), from *Threskiornis molucca strictipennis* (Gould), AUSTRALIA: Lake Cowal, New South Wales, 16.v.1972 (*W. Vestjens*).

Neoparatypes: 1 ♀, slide no. WV470; 4 ♀, slide nos. 393 and 449, other data as for neotype, 17.ii.1972 (*W. Vestjens*).

Specimens of *Ardeicola* have been seen from the two remaining subspecies of *T.molucca* (details below) and are considered to be conspecific with *ibis*.

Material examined. 1 ♀ from *T.molucca pygmaeus* Mayr, RENNEL IS., SOLOMON ISS.: 1.xi.1951 (collector unknown); 1 ♂ from same host, slide no. 1954–222, RENNEL IS.: Hutuna, 23.x.1953 (*Diana Bradley*). 1 ♂, 8 ♀ (3 teneral), from *T.m.molucca* (Cuvier), slides no. 4822, MALAYA (now MALAYSIA): no other data (*R. Meinertzhagen*). 5 ♂ (1 dissected), 4 ♀, from *T.molucca*, slides no. 691025/1a, NEW GUINEA: Wando District, Papua, x.1969 (*I. L. Owen*). All in BMNH.

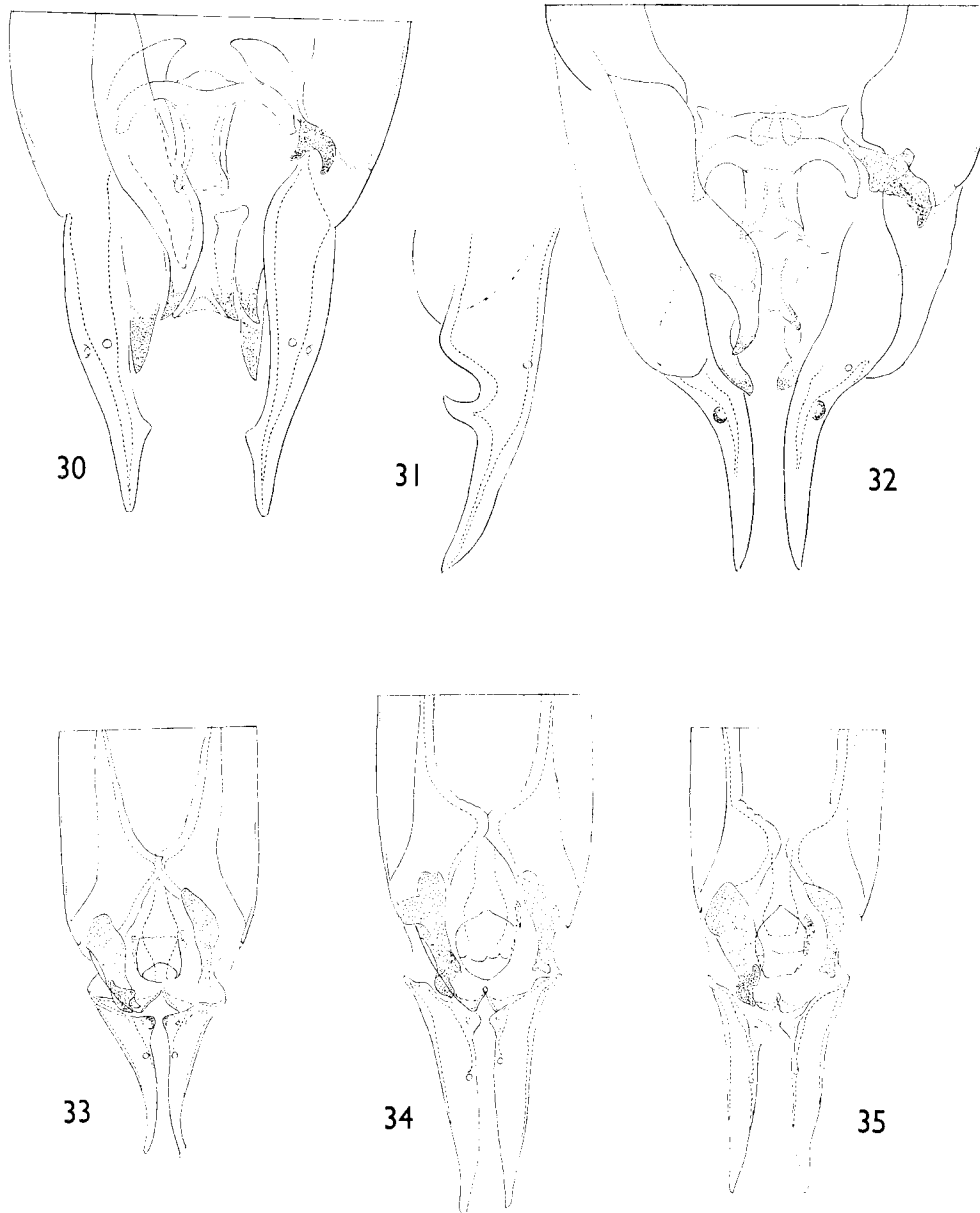
Ardeicola clayae Brelüh

(Figs. 6, 10, 14, 18, 25, 26, 33, 39 and 40)

Type host: *Threskiornis aethiopicus aethiopicus* (Latham)

Ardeicola clayae Brelüh, 1965, 51. Host: *Threskiornis aethiopicus aethiopicus*.

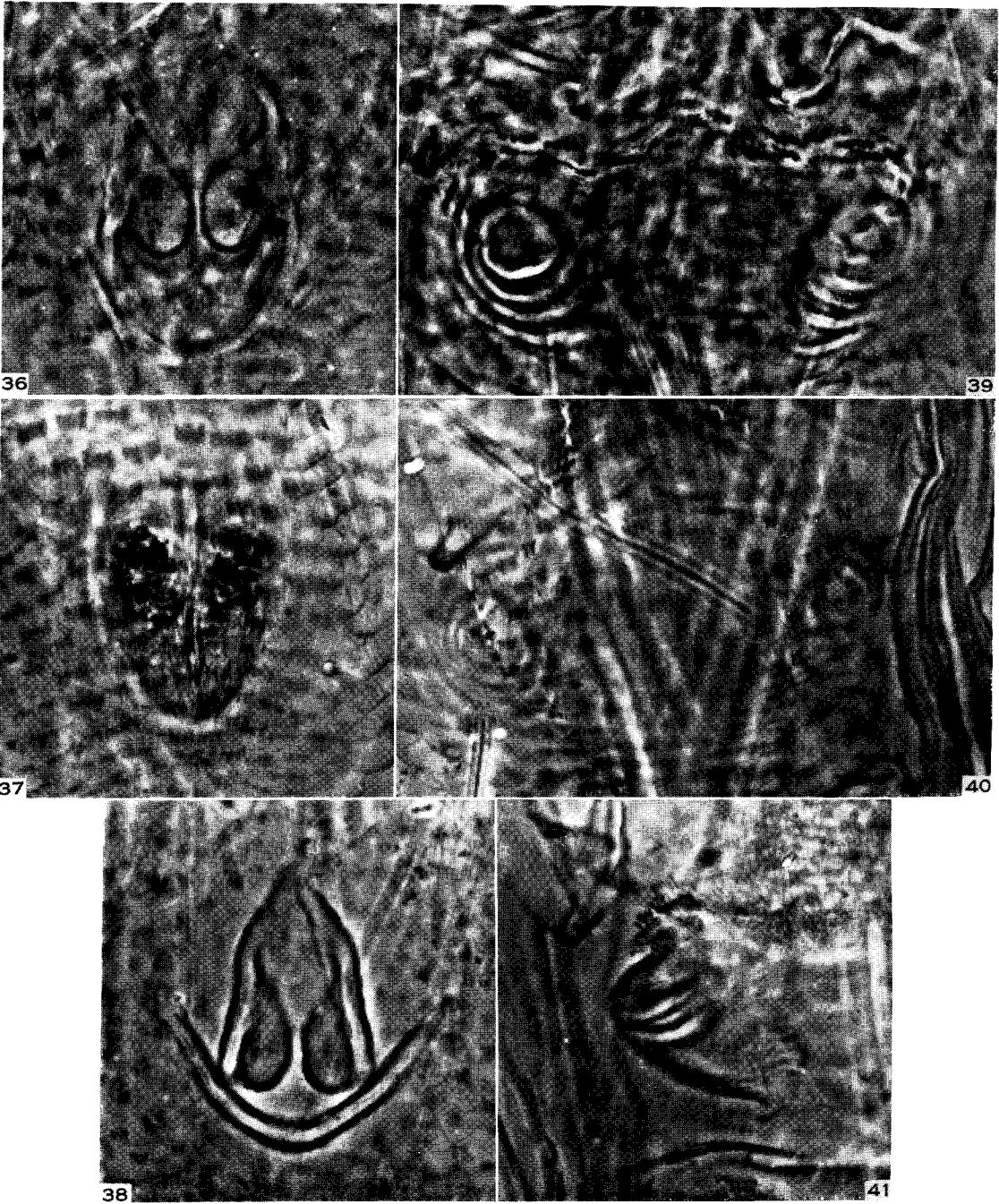
Figs. 17–29. *Ardeicola* spp., various parts: (17–20) basal apodeme; (17) *A.ibis*, from *Th.molucca*, Papua; (18) *A.clayae*; (19) *A.intermedia*; (20) *A.freemani*. (21–28). Modified area of female genital chamber; (21) *A.ibis*, from type host; (22) *A.ibis*, from *Th.molucca*, Papua; (23, 24) *A.indicus*; (25, 26) *A.clayae*; (27, 28) *A.intermedia*. The dotted circles in Figs. 25–28 represent the alveoli of the 2 setae on sternum VIII and the stippled part in Figs. 25, 27 and 28, the fold of membrane. (29) *A.indicus*, female, allotype, terminalia, genital region omitted.



Figs. 30–35. *Ardeicola* spp., posterior components of male genitalia in resting state, inside abdomen: (30) *A. indicus*, parameres being slightly apart, the dorsal and lateral sclerites of the mesosome have separated; (31) *A. ibis* from *Th.m. molucca*, Malaysia, paramere of left-hand side showing the hook (compare with Fig. 32); (32) *A. ibis*, from type host; (33) *A. clayae*, paratype; (34) *A. freemani*; (35) *A. intermedia*. Figs. 30–32 drawn to same scale; Figs. 33–35 to same but different scale.

Male and female. General characters and chaetotaxy as shown by Brelvi (1965) in Figs. 1–4 and in Figs. 6, 10 and 14. In the male, the anterior margin of tergite III usually straight, composite tergite IX–XI with an incipient suture between the 2 anterior and 4 posterior setae; thickening along the edge

of genital opening characteristic, especially medially (Fig. 10). External genitalia as shown in Figs. 18 and 33; the outer margin of each paramere curved; the basal apodeme, mesosomal sclerites and parameres differ distinctly from the corresponding sclerites of *ibis*. In the female, the terminal abdominal



Figs. 36–41. *Ardeicola* spp., modified area in the female genital chamber: (36) *A. ibis*, from type host; (37) *A. ibis*, from *Th. molucca*, Papua, the dense patch of microtrichia obscuring the area; (38) *A. indicus*; (39) *A. clayae*; (40) *A. clayae*, showing combs of microtrichia on ventral wall of genital chamber underlying the out of focus modified area; (41) *A. intermedia*, area of left-hand side only. Phase-contrast photomicrographs.

segment shortest among *Ardeicola* from *Threskiornis*; thickening of tergum IX–XI in the form of lateral plates (Fig. 14), unlike *ibis*.

Important features of chaetotaxy: the 2 antero-central setae on tergum II short to medium in the male, short in the female. In the female the tips of the 2 central setae on tergum VIII usually extend beyond the 2 anterior setae, occasionally even extending beyond the 4 posterior setae, on tergum IX–XI.

Terminalia: seta a fine, medium in the male, short in the female. Seta p_1 fine, long in the male, medium in the female. Genital region of the two sexes shown in Figs. 10 and 14. Female: short setae in genital region, each side 3–8, total 7–13, \bar{x} 10 (6); vulval marginal, each side 8–14, total 16–27, \bar{x} 21 (6); marginal and submarginal setae, each side 2–3, \bar{x} 2.93 (16 sides), total 5–6, spiniform, somewhat smaller in number than in *ibis*. The anterior and posterior setae of group d, ventrally on the terminalia, medium to long and long respectively, but both shorter than in *ibis*. Anal setae: male; 1 + 1 marginal, 2 + 2 ventral (Fig. 10).

Material examined. Paratypes 6 ♂, 9 ♀ designated by Brelih (1965). 7 ♂, 7 ♀, slides no. 20611, from the type host, KENYA: Naivasha, viii.1959 (*R. Meinertzhagen*) and 2 ♂, 2 ♀, TRANSVAAL: Benoui, 30.iii.1954 (*F. Zumpt*). All in BMNH.

Ardeicola freemani sp.n.

(Figs. 7, 8, 11, 15, 20 and 34)

Type host: *Threskiornis aethiopicus abboti* (Ridgway).

Owing to the resemblance of this species with *clayae*, only the more important differences have been given here.

General characters and chaetotaxy as shown in Figs. 7, 8, 11 and 15.

Male. Tergites III and VI relatively shorter. Thickening along the margin of genital opening characteristic, especially medially and setae thereon longer. External genitalia as shown in Figs. 20 and 34; parameres longer and stouter, of different shape, their outer margins without curvature. The 2 antero-central setae on tergum II shorter and the 2 lateral setae on VII longer. The 2 central setae on tergum VIII show variation: medium and fine (2), just long and stout (1); in one specimen broken on one side, just long and stout on other side. Setae a and p_1 fine and medium, either equally long or p_1 slightly longer (Fig. 11).

Female. Emargination in posterior margin of

terminal segment of the abdomen less pronounced and the two lateral points in which it ends of different shape. The 2 central setae on tergum VIII show variation, being fine and medium (3) stout and long (1), their tips falling short of the 2 anterior setae on tergum IX–XI. Short setae in genital region, each side 5–11, total 10–19, \bar{x} 13.5 (4); vulval marginal, each side 9–14, total 18–27, \bar{x} 22.5 (4); marginal and submarginal setae, each side 2–3, \bar{x} 2.87 (8 sides), total 5–6, spiniform. Anterior seta of group d spiniform, posterior seta long and somewhat stouter (Fig. 15) than in *clayae*.

Measurements of ♂ holotype and paratypes. *Length:* total, ♂, holotype 3.89, range 3.89–3.97, \bar{x} 3.92 (3); ♀ 3.95–4.04, \bar{x} 3.98 (3). Head, ♂, holotype 0.80, range 0.80–0.84, \bar{x} 0.82 (4); ♀ 0.85–0.87 (3). Prothorax, ♂, holotype, 0.27, range 0.25–0.27 (3); ♀ 0.25–0.26 (3). Pterothorax, ♂, holotype 0.55, range 0.55–0.59, \bar{x} 0.57 (4); ♀ 0.55–0.57 (3). Abdomen, ♂, holotype 2.27, range 2.22–2.29, \bar{x} 2.26 (4); ♀ 2.26–2.35, \bar{x} 2.30 (3). *Width:* head, level of pre-antennal setae, ♂, holotype 0.54, range 0.53–0.54 (4); ♀ 0.48–0.51, \bar{x} 0.49 (3). Across temples, ♂, holotype 0.53, range 0.52–0.55, \bar{x} 0.53 (4); ♀ 0.56–0.58 (3). Prothorax, ♂, holotype 0.41, range 0.41–0.42 (4); ♀ 0.42–0.43 (3). Pterothorax, ♂, holotype 0.66, range 0.62–0.66, \bar{x} 0.64 (4); ♀ 0.66–0.69 (3). Abdomen, ♂, holotype 0.58 (V), range 0.55–0.58, \bar{x} 0.56 (4) (V or VI); ♀ 0.77–0.81, \bar{x} 0.79 (3) (V). *Cephalic index:* ♂ 0.63–0.65 (4); ♀ 0.65–0.66 (3).

Holotype ♂, slide no. 764, in BMNH (1968–333), from the type host, ALDABRA Is.: Cinq Cases, South Island, 3–16.i.1968 (*B. Cogan* and *A. Hutson*, *Royal Society Expedition*).

Paratypes. All from the type host. 1 ♀ with data as for holotype; 3 ♂, 3 ♀, slides no. 1968–333, ALDABRA ATOLL: East Channel, 6.vi.1968 and ALDABRA Is.: Takamaka, S. Island, 13.vi.1968 (*R. Lowery* 335, 392); all in BMNH.

The species has been named in honour of Dr Paul Freeman, Keeper, Department of Entomology, BMNH.

Ardeicola intermedia sp.n.

(Figs. 12, 16, 19, 27, 28, 35 and 41)

Type host: *Threskiornis aethiopicus bernieri* (Bonaparte).

This species is slightly smaller than *freemani*. Its male is close to that of *freemani*, but the female is somewhat intermediate between *clayae* and

freemani, the important characters of the two sexes being as follows:

Male. Tergites III and VI intermediate in size between *clayae* and *freemani*. The following characters are much as in *freemani*: the size of the 2 (short) anterocentral setae on tergum II and of the 2 lateral setae on tergum VII; thickening along the margin of genital opening, but it differs in details of shape (Fig. 12); shape of parameres, but these are distinctly smaller, as is also the basal apodeme (Figs. 19 and 35).

Female. Posterior margin of the terminal abdominal segment, including the two lateral tips in which it ends, as in *freemani*. The tips of the 2 central setae on tergum VIII extend beyond the 2 anterior tergal setae on IX–XI, even occasionally beyond the 4 posterior setae on this tergum (Fig. 16), this character being similar to that of *clayae*. Short setae in genital region, each side 4–7, total 8–14, \bar{x} 11.16 (6); vulval marginal, each side 9–12, total 17–23, \bar{x} 21 (6); marginal and submarginal setae, each side 2–4, \bar{x} 3.16 (12 sides), total 5–8, spiniform. Anterior seta of group d although spiniform, as in *freemani*, tends to be slightly prolonged at the tip in one specimen.

Measurements of ♀ holotype and paratypes. *Length*: total, ♂ 3.46–3.75, \bar{x} 3.66 (4); ♀, holotype 3.91, range 3.68–3.91, \bar{x} 3.78 (6). Head, ♂ 0.74–0.82, \bar{x} 0.78 (4); ♀, holotype 0.81, range 0.78–0.81, \bar{x} 0.80 (6). Prothorax, ♂ 0.24–0.27 (4); ♀, holotype 0.26, range 0.22–0.26, \bar{x} 0.24 (6). Pterothorax, ♂ 0.50–0.54, \bar{x} 0.53 (4); ♀, holotype 0.54, range 0.50–0.54, \bar{x} 0.52 (6). Abdomen, ♂ 1.98–2.20, \bar{x} 2.10 (4); ♀, holotype 2.30, range 2.18–2.30, \bar{x} 2.22 (6). *Width*: head, level of pre-antennal setae, ♂ 0.48–0.49 (4); ♀, holotype 0.46, range 0.44–0.46 (6). Across temples, ♂ 0.45–0.51, \bar{x} 0.49 (4); ♀, holotype 0.54, range 0.51–0.54, \bar{x} 0.52 (6). Prothorax, ♂ 0.33–0.36 (4); ♀, holotype 0.40, range 0.36–0.40, \bar{x} 0.38 (6). Pterothorax, ♂ 0.46–0.50, \bar{x} 0.49 (3); ♀, holotype 0.60, range 0.54–0.60, \bar{x} 0.57 (6). Abdomen, ♂ 0.52 (3) (V or VI or VII); ♀, holotype 0.71 (V and VI), range 0.68–0.73, \bar{x} 0.70 (6) (V or VI). *Cephalic index*: ♂ 0.61–0.64 (4); ♀ 0.62–0.67, \bar{x} 0.64 (6).

Holotype ♀, slide no. 765, in BMNH, from skin of the type host, MADAGASCAR (NOW MALAGASY REPUBLIC): Soalala, 2.v.1930 (*Archbold-Verney Expedition*).

Paratypes. 4 ♂, 7 ♀, slides no. 1970–240, in BMNH, from three skins of the type host, MADAGASCAR: Bekopaka 29.vi.1929, Ampotaka 23.iii.1930 and Soalala 2.v.1930 (*Archbold-Verney Expedition*).

The name *intermedia* has been given to indicate the affinities of the two sexes.

Affinities and diagnoses

With the description of two new species, *A. freemani* and *intermedia*, five species of this genus are now known to parasitize *Threskiornis*. Of these five, *ibis* Le Souef & Bullen and *indicus* Brelieh, 1965 on the one hand and *clayae* Brelieh, *freemani* and *intermedia* on the other are phylogenetically closest to each other. A re-description of *A. ibis* and *clayae* has been given to enable their comparison with related taxa, an additional reason for giving that of *ibis* being that it is the earliest *Ardeicola* to have been described from *Threskiornis*.

A. ibis differs from *indicus* in the following important characters and can be distinguished in the male by the (i) shape of the thickening along the margin of the genital opening, (ii) details of the components of the mesosome, especially its dorsal (telomeres) and lateral (endomeres) sclerites (Figs. 32 and 30), (iii) in the shape and characters of the parameres, especially of the hook, which in *indicus* is on the inner posterior margin. In the female by the shape of the emargination in the posterior margin of the abdomen (Figs. 13 and 29), the details of the genital chamber and of its specialized structure (Figs. 37 and 38).

Both these species can readily be distinguished from *clayae*, *freemani* and *intermedia* in the male by the characters of the terminalia, the position of the 2+2 of the 3+3 anal setae, by the shape of the basal apodeme and of the posterior components of the external genitalia. In the female by the larger size of the terminal segment of the abdomen and the nature of its tergal thickening, shape and details of the genital chamber and its specialized structure and in both sexes by the size of seta p_1 . It may again be pointed out that the two setae, a and p_1 , occur on the terminalia of several Ischnoceran genera and that their proportions only are of specific importance.

The male of *clayae* can be distinguished from that of *freemani* and *intermedia* by the shape of the middle part of the thickening along the margin of the genital opening and the size and details of the external genitalia, especially of the parameres. Separation of the males of *freemani* and *intermedia* is possible only by the size of their genitalia. The females of these three species can be separated from each other by a

combination of three characters: (i) the size of the terminal abdominal segment, (ii) the length of the 2 central setae on tergum VIII relative to the position of the alveoli of the 2 anterior setae on tergum IX–XI and (iii) the size of the anterior seta of group d on the terminalia.

Another species deserving inclusion in this section on differential diagnosis is *A. nippon* Hajela & Tandan, 1968, parasitic on *Nipponia nippon* (Temminck), the Japanese Crested Ibis, found in China, Korea and Japan. Known from females only, the non-sexual characters indicate its closest affinities to be with the species parasitic on *Threskiornis*. In the female genital chamber no specialized structure is visible in six syntypes; in one the chamber does seem to have something like a modified area but details cannot be made out. Since the specimens are overtreated with alkali it is not possible to decide whether the area has been obliterated by prolonged alkali treatment or is actually absent. Until, therefore, a good series comprising both sexes is available, the precise relationships of *nippon* with the species living on *Threskiornis* cannot be established.

Discussion

This taxonomic study of *Ardeicola* from *Threskiornis* has added some information to the distribution of the chewing lice.

It may be safely generalized that all the subspecies of a host are parasitized by the same species of Ischnoceran lice. Exceptions to this are found amongst the Heptapsogasteridae of the tinamous and a small number of other cases amongst which is *Strigiphilus* of *Tyto alba*. Clay (1966) discovered the *Strigiphilus* on the owl found in the Americas, India (*T. alba hellmayri*) and in Australia to be specifically distinct, naming it as *S. aiteni*, from that found on the owl in Europe and Africa (*T. alba guttata*), which is *S. rostratus* (Burmeister, 1838). Interestingly enough, both these patterns of distribution are represented in *Ardeicola* from *Threskiornis*: thus the three subspecies of *molucca* are parasitized by a single species of *Ardeicola* (*ibis*), but the three subspecies of *aethiopicus* are each parasitized by a distinct species of *Ardeicola*. This speciation of populations living on different races of *aethiopicus* may well be due to their isolation from each other for a longer period than of those living on the three races of *molucca*.

Key

Males

- 1 Seta p_1 very long, its tip extending beyond the posterior margin of the abdomen (Fig. 9)..... 2
- Seta p_1 short to just long, its tip may extend to the middle of the terminal abdominal segment (Figs. 10–12)..... 3
- 2(1) Mesosome and parameres diagnostic (Fig. 32).
ibis Le Souef & Bullen
- Mesosome and parameres diagnostic (Fig. 30)
indicus Brelih
- 3(1) Thickening along margin of genital opening and the parameres characteristic (Figs. 10 and 33)
clayae Brelih
- Thickening along margin of genital opening and the parameres characteristic (Figs. 11, 12, 34 and 35)..... 4
- 4(3) Male external genitalia comparatively larger (Figs. 20 and 34)..... *freemani* sp.n.
- Male external genitalia comparatively smaller (Figs. 19, and 35)..... *intermedia* sp.n.

Females

- 1 Seta p_1 very long, its tip extending beyond the posterior margin of the abdomen (Figs. 13 and 29)..... 2
- Seta p_1 short to just long, its tip may extend to the middle of the terminal abdominal segment (Figs. 14–16)..... 4
- 2(1) The 2 central setae on tergum VIII slightly longer than the 2 lateral ones; tips of the 2 anterior setae on tergum II reach to or extend beyond the alveoli of marginal setae on this segment (Hajela & Tandan, 1968, Fig. 1)
nippon Hajela & Tandan
- The 2 lateral setae on tergum VIII much longer than the 2 central ones; tips of the 2 anterior setae on tergum II fall well short of the row of marginal setae on this segment (Figs. 2 and 13)..... 3
- 3(2) The two points in which the abdomen ends and the specialized area of the genital chamber diagnostic (Figs. 13 and 36)..... *ibis* Le Souef & Bullen
- The two points in which the abdomen ends and the specialized area of the genital chamber diagnostic (Figs. 29 and 38)..... *indicus* Brelih
- 4(1) Tips of the 2 central setae on tergum VIII fall well short of the 2 anterior setae on tergum IX–XI (Fig. 15)
freemani sp.n.
- Tips of the 2 central setae on tergum VIII extend beyond the 2 anterior setae on tergum IX–XI (Figs. 14 and 16)..... 5
- 5(4) Anterior seta of group d on the terminalia spiniform (Fig. 16)..... *intermedia* sp.n.
- Anterior seta of group d on the terminalia medium to long (Fig. 14)..... *clayae* Brelih

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