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# RELATIONSHIPS WITHIN *BOOPIA* (Phthiraptera: Insecta) WITH A DESCRIPTION OF A NEW SPECIES

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*Abstract:* *Boopia emersoni* is described from specimens from a New Guinea marsupial *Satanellus albopunctatus*. A decision on the generic position of this distinctive species necessitates a re-assessment of the characters of *Boopia*.

Through the kind co-operation of Dr K. C. Emerson I have been able to examine a series belonging to the Bishop Museum, Honolulu, of a new species of Boopid from *Satanellus albopunctatus*. The generic placing of this species in *Boopia* raises some interesting problems of relationships necessitating a re-assessment of the characters used in delineating the groups within *Boopia* sens. lat.

**Boopia emersoni** Clay, new species Fig. 1-9.

Type host: *Satanellus albopunctatus* (Schlegel)

This species is a typical *Boopia* with the exception of certain characters on the venter of the head which separate it from all known species of that genus. These are the presence of a toothed process arising at the base of each maxillary palpus, the absence of a slit in the ventrolateral margin and the prolongation of that margin as a thickened re-curved point.

♂ and ♀. With general characters as illustrated in fig. 7-8. Dorsolateral margin of head with broad preocular slit and shallow postocular notch; ventrolateral margin without slit, produced as thickened re-curved point; process at base of each maxillary palpus posteriorly bifid with or without a small lateral tooth. Hypopharynx strongly reduced; mandibles small; labial palpus with 5 terminal setae, seta at base medium length and stout; pointed seta of pair on last segment of maxillary palpus slightly shorter than blunt-ended one. Antenna typical for *Boopia* with a sensillum coeloconicum on each of segments IV and V and 2 further sensilla coeloconica of a different form on segment V (see Note 4, p. 404). Dorsal head setae 10 and 11 short, 11 less than 1/2 the length of 10; 8 and 19 (ocular seta) stoutly spiniform and set on papillae; 20 (postocular) anterior to postocular notch. Pronotum with 6 marginal setae each side, first 3 stoutly spiniform, the 2nd submarginal to the 1st; outer dorsal seta spiniform and set on a papilla, inner minute and posterior seta (Clay 1971) not apparent. The 2 mesonotal setae stout and spiniform, each with an adjacent short fine seta, thickening almost circular; the 2+2 anterior mesonotal setae close to postnotum and rather stout. Metanotum and tergum I fused. Prosternal plate without thickened rim and with many setae (in addition to the 2 small anterior prosternal setae): ♂, range 13-22, $\overline{X}$ (8) 18.4; ♀, 18-21, $\overline{X}$ (5) 20.4. Mesosternum with only the 2 minute mesosternal setae; thickened ridge of episternum with 2-4 setae each side (1 each with 5 and 7 on 1 side). Metasternum with 4 central setae (1 ♂ with 5) and probably fused with sternum I, but this area not readily visible in the available material. Legs short and tarsi, unlike those of most *Boopia*, similar in length to some of the similar-

1. British Museum (Natural History).


Fig. 1-2. *Boopia emersoni* n. sp. : 1, ♀ head and prothorax, dorsal ; 2, ♂ head, ventral and prosternal setae. Proximal setae of maxillary palpus and antenna and some anterior setae of head omitted.

sized avian Menoponidae such as *Myrsidea* and *Holomenopon* ; however, owing to the shorter tibia, the tibio-tarsal ratio is more similar to that of some *Boopia* species than to that of the former genera. Abdomen with characters as for *Boopia* ; spiracles large and together with post-spiracular complex lie on lateral plates (fig. 3). ♂ genitalia as in fig. 4, 9. ♀ gonapophyses with short fine terminal non-alveolar seta (similar to the non-alveolar seta of *Rallicola*, Clay in press) ; inner margin with "ampullae" (see Note 15, p. 407). Vulval margin strongly convex with 3-4 setae each side of a central gap, outer one each end being considerably longer than inner (fig. 6) ; genital papilla, especially distal end, not readily visible in available material. Tergite IX of ♀ with 5 sensillae each side.

Abdominal Chaetotaxy. Central tergal plates (♂ and ♀) : I, 2+2 outer seta, stoutly spiniform ; in the available material it is not possible to say whether a minute seta each end is on the central tergal or lateral plate. II, 4 stout central setae separated by a gap each side from a single stout seta and a minute seta (fig. 3). III-VIII with a single row of setae arranged 2+4+2, and usually with a minute seta at each end of row and one in gap between the groups of 2 and 4 ; the 2 lateral setae on segment VIII tend to be variable in size and number (0-2 on 1 or both sides) and in presence or absence of minute setae. ♂ IX : usually 4+4, (1 specimen each with 4+2 and 4+3) ; 4-6 minute supraanal setae (not always apparent) ; 4 (1 each with 3 and 5) subanal setae ; terminal margin with 2 stout setae. Posterior tergal setae of ♀ as in fig. 5. Sternal setae (♂ and ♀) : I, 2; II, 4 stout and 2+2 small setae each end of segment. III-VII with a row of long stout setae and a number of shorter setae forming an irregular row mainly anterior to the stout setae and in addition 1+1 minute to short setae each end of row : ♂ (4) (anterior setae first, followed by posterior row) : III, 3-9, 6-7 ; IV, 4-8, 7-8 ; V, 7-8, 8-9; VI, 6-9, 7-8 ; VII, 8-12, 7-9 ; VIII (6), 7-9, 6 ; terminal segment (6),

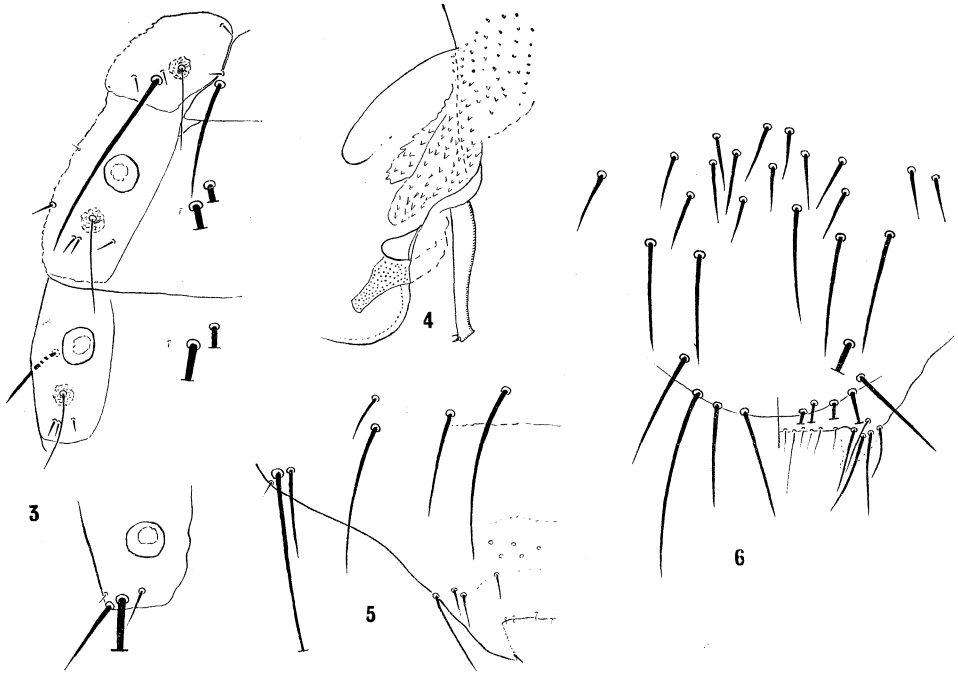



Fig. 3-6. *Boopia emersoni* n. sp. : 3, ♀ lateral plates II-VI and VIII and outer tergal setae. 4, Lateral sclerites and paramere of ♂ genitalia. 5-6. Terminal abdominal segments of ♀ : 5, Dorsal ; 6, ventral.

5-8 and 2 stout setae on posterior margin. ♀ (2), III, 3 & 5, 6 ; IV, 8, 8 ; V, 7, 8 ; VI, 10 & 13, 8 ; VII (3), 9-12, 7-9 ; terminal segments as in fig. 5. Lateral setae (♂ and ♀) : II-IV and VIII as in fig. 3 ; V-VII as in IV but with extra minute seta ventrally and post-spiracular setae not modified as trichbothria.

Dimensions (in mm) : Preocular width, ♂ (11) 0.28-0.30, $\overline{X}$ 0.29, ♀ (6) 0.28-0.31, $\overline{X}$ 0.30 ; temple width, ♂ (11) 0.38-0.43, $\overline{X}$ 0.41 ; ♀ (6) 0.40-0.45, $\overline{X}$ 0.42 ; head length, ♂ (11) 0.22-0.25, $\overline{X}$ 0.23, ♀ (5), 0.21-0.23, $\overline{X}$ 0.22 ; pronotum width, ♂ (1) 0.37, ♀ (1) 0.38 ; total length, ♂ (1) 1.53, ♀ (1) 1.63.

Holotype ♂ (BISHOP 9616), slide no. BBM-NG-98612 in the Bishop Museum, from *Satanellus albopunctatus* New Guinea, Papua, Star Mountains, Western District., 17.III. 1970. Paratypes : 10 ♂♂, 6 ♀♀ from the same host individual as the holotype.

*Discussion.* On first consideration it may seem strange to include this species in *Boopia*, having as it does such marked differences in the ventral aspect of the head. However, elsewhere (Clay 1969 : 4) it has been shown that postpalpus processes and various hook-like processes on the head have been developed independently in many unrelated forms and their occurrence, form and position are in general of little phylogenetic significance. It is possible that such characters have been given undue taxonomic weight in the recognition of genera. An example is the independant development of similar re-curved prolongations of the ventrolateral margin of the head in *emersoni* and *Chinchillophaga*, the latter being a typical member of the Trimenoponidae,

a family differing distinctly from Boopidae (see Clay 1970). Further, in other characters *emersoni* shows many similarities to a group of species now included partly in *Phacogalia* and partly in *Boopia*. The 2 species of *Phacogalia* (*brevispinosa* and *spinosa*), the new species *emersoni* and the 10 species included in *Boopia* by Kéler (1971) have the following characters in common : a 4-segmented maxillary palpus, a post-occipital notch or concavity (almost imperceptible in *brevispinosa*), 2 of the dorsal head setae (26 & 27) with contiguous alveoli, absence of dorsal head sensillum e., post-spiracular setae II–IV modified as trichobothria, spiracles and post-spiracular setal complex on the lateral plates and the general characters of the male genitalia (see Note 16, p. 407). In addition to these, *emersoni* has a combination of characters similar to that found in the 2 species of *Phacogalia* and *Boopia uncinata*. To demonstrate this, 16 character states have been chosen for *Boopia uncinata* and these compared with the remaining species, the results being shown in Table I.

It can be seen that the species are divisible into 2 groups, A and C, on characters 1, 2, 4, 5, 13, 14, and 15, with the 2 species in group B being somewhat intermediate. Within group C, 2 species (subgroup d.) resemble each other in the listed characters and differ from all other known species of *Boopia* in the form and chaetotaxy of the prosternal plate, in the presence of a plantar process (sens. Kéler 1971) on the 2nd tarsus of the hind leg, in the subapical position of the gonapophysal seta and the greatly reduced size of the trichobothrial pits.

In column H. of Table I the host families of the species have been given showing that Group A and C, with the exception of subgroup d, are found respectively on the Dasyuridae and the Macropodidae and that the 2 similar and distinctive species in subgroup d. are found on the Vombatidae. *B. bettongia* (Group B), the only species from the Peramelidae, is somewhat intermediate in its characters between A. and C. The only species not typical of its host group is *doriana*, recorded from the Macropodidae, but in some characters nearer group A. A possible explanation of this distribution is the secondary establishment on one of the Macropodidae of a species originally parasitic on one of the Dasyuridae or Peramelidae ; or if the suggestion of Murray & Calaby (in Kéler 1971 : 82) is correct that the ancestral boopids were first parasitic on the Macropodidae, *doriana* may be near the stock which became secondarily established on the Dasyuridae and already had some of the characters now typical of the species found on that family. Evidence from the species of *Boopia* does not conflict with the suggestion of the Macropodidae being the original hosts as some, at least, of the characters separating those species now parasitic on the Dasyuridae and Peramilidae appear to be derived characters ; further this evidence would also not conflict with a view that the Vombatidae are nearer the Macropodidae and the Peramilidae nearer the Dasyuridae.

As it is the general rule that groups of related hosts are parasitized by groups of similar species of Phthiraptera, it is justified to assume that at least some of the characters common to the species on such a group of hosts are of phylogenetic origin, a fact which in some ways compensates for the absence of a fossil record. Thus it can be presumed that the 4 species (*uncinata*, *emersoni*, *spinosa* and *brevispinosa*) parasitic on the Dasyuridae, having as they do a number of characters in common, are more closely related to each other than any of them are to any other of the species of *Boopia*.

Table I. Characters of *Boopia* species.

| | Species | Host | Character States | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| A | *brevispinosa* | D | + | + | + | + | + | 6a | + | + | + | + | + | + | + | + | + | + |
| A | *spinosa* | D | + | + | + | + | + | 6a | + | + | + | + | + | + | + | + | + | + |
| A | *emersoni* | D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| A | *uncinata* | D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| B | *bettongia* | P | + | + | + | + | O | O | + | 8a | + | + | + | O | O | O | + | + |
| B | *doriana* | M | O | + | + | + | O | O | O | + | + | + | O | + | O | O | + | O |
| C | *grandis* | M | O | V | + | O | O | 6a | O | + | O | + | + | + | O | O | O | O |
| C | *biseriata* | M | O | V | + | O | O | 6a | O | + | O | O | O | + | O | O | O | O |
| C | *notafusca* | M | O | O | O | O | O | O | O | + | + | + | O | + | O | O | O | O |
| C | *mjobergi* | M | O | O | O | O | O | O | O | + | ? | + | + | O | O | O | O | ? |
| C | *minuta* | M | O | O | O | O | O | O | O | + | O | O | + | + | O | O | O | ? |
| d | *tarsata* | V | O | O | + | O | O | O | + | 8b | O | + | + | O | O | O | O | O |
| d | *dubia* | V | O | O | + | O | O | O | + | 8b | O | + | + | O | O | O | O | O |

H=host families ; D=Dasyuridae, P. Peramelidae, M. Macropodidae, V. Vombatidae.

Table I. Character states: +. Character present in the state described ; o. Character absent or in a different state. v=character shows intraspecific variation.

1. Postocular seta (20) anterior to postocular notch or concavity=+ ; seta posterior to notch or concavity=o.
2. Ocular seta (19) short and stoutly spiniform (fig. 1)=+ ; ocular seta otherwise=o.
3. Dorsum of head without extra seta near 23 (23a)=+ ; with setae 23a=o.
4. Antenna with 4 sensilla coeloconica=+ ; antenna with 2 sensilla coeloconica=o.
5. Marginal pronotal seta 2 (anterior pronotal seta) short and spiniform (fig. 1)=+ ; this seta long and not spiniform=o.
6. 6 pronotal marginal setae arranged as in fig. 1 =+ ; extra seta between 3 & 4=6a ; marginal setae otherwise=o.
7. Long to medium posterior pronotal setal setae (Clay 1971) not present=+; this seta present=o.
8. 4 metasternal setae=+ ; 3 metasternal setae=8a ; 2 metasternal setae=8b.
9. 2nd ♂ femur with pair of stout spines=+ ; without=o.
10. Marginal tergal setae on III-VI arranged 2+4+2 or 3+4+3=+. ; otherwise:=o.
11. Tergites IV-VI without anterior setae=+ ; tergites with anterior setae=o.
12. Sternites IV-VI at least, with anterior setae=+ ; these sternites without anterior setae=o.
13. Abdominal lateral plate II without lateral setae (fig.3)=+ ; this plate with lateral setae=o.
14. Abdominal lateral plate III with seta d. short to minute (fig. 3)= + ; seta d. long and stout=o.
15. Inner margin of ♀ gonapophysis with sensilla (ampullae)=+ ; without=o.
16. Anterior median plate of ♂ genitalia without posterior spur=+ ; with spur=o.

The last 2 species were included in *Phacogalia* Mjöberg by Kéler (1971), who gave as distinguishing characters apart from the shape of the head, the presence of a well marked *sinus occipitalis*, a character found in some species of *Boopia* to a lesser degree, and by the plantar pulvillus of the tarsal claws having a freely projecting point ; a further character is the position of dorsal head setae 21–23 lying in the same horizontal plane. *B. emersoni* is distinguished by the characters of the venter of the head as described above, the shape and chaetotaxy of the prosternal plate and the smaller mandibles, and *B. uncinata* from the rest of *Boopia* by the combination of characters given in Table I.

There are 3 possible ways of classifying these species : (a) Recognize *Phacogalia*, erect a new genus for *emersoni* and leave *uncinata* in *Boopia*. This would make *Boopia* polyphyletic in terms of *Phacogalia* and the new genus. It could however be argued that differentiation has proceeded sufficiently far to recognize these genera and to ignore polyphyly at this level, accepting the monophyly at the level of the ancestral stock giving rise to the whole of *Boopia* sens. lat. (b) Include *emersoni* and *uncinata* in *Phacogalia*. (c) Include all 4 species in *Boopia*. Both (b) and (c) would be phylogenetically correct, the former perhaps being taxonomically somewhat confusing ; (c) would be the most satisfactory from the information retrieval aspect, courses (a) and (b) both obscuring the relationships of these species to the rest of *Boopia* especially to the intermediate *B. bettongia*. It has been decided to adopt course (c), at least provisionally, until more is known about the phylogeny of the Australasian marsupials and the finding of further species of Boopidae ; both perhaps would help to clarify the classification of *Boopia*.

The position of the genera *Paraboopia* and *Latumcephalum* is rather similar. These, except for the head in *Latumcephalum*, have a general *Boopia*-like habitus, resembling each other and differing from *Boopia* in the reduction of the number of segments of the maxillary palpus, absence of abdominal trichobothria, head setae 26 and 27 not contiguous and in the form of the prosternite and its setae. It is probable that these 2 genera either together or separately are near to one particular group of *Boopia*, so that here again *Boopia* is polyphyletic in terms of other genera ; it may be relevant as Murray & Calaby (in Kéler 1971 : 82) have pointed out that these 2 genera are parasitic on those kangaroos which are also parasitized by species of *Boopia*. The difference between this case and that of the *Boopia uncinata* group (A) is that the relationships of the former are much more a matter of conjecture and the divergence between the 2 genera and *Boopia* greater, making generic recognition reasonable and useful.

## Notes on Characters in Table I

*Position of seta* 20, *postocular* (1). There is no difficulty in recognizing this character state except in *B. bettongia*, in which there is no definite postocular notch but a smooth concavity ; as the seta arises towards the anterior end of the concavity, the character has been placed in the positive state.

*Antennal Sensilla* (4). Elsewhere (Clay 1970 : 76) it was said that the Boopidae had a sensillum coeloconicum on each of the last 2 segments of the antenna. However, further studies with the SEM show that in some species (see Table I) there are 2 additional sensilla on the terminal segment. Fig. 12 shows an end-on view of the antenna

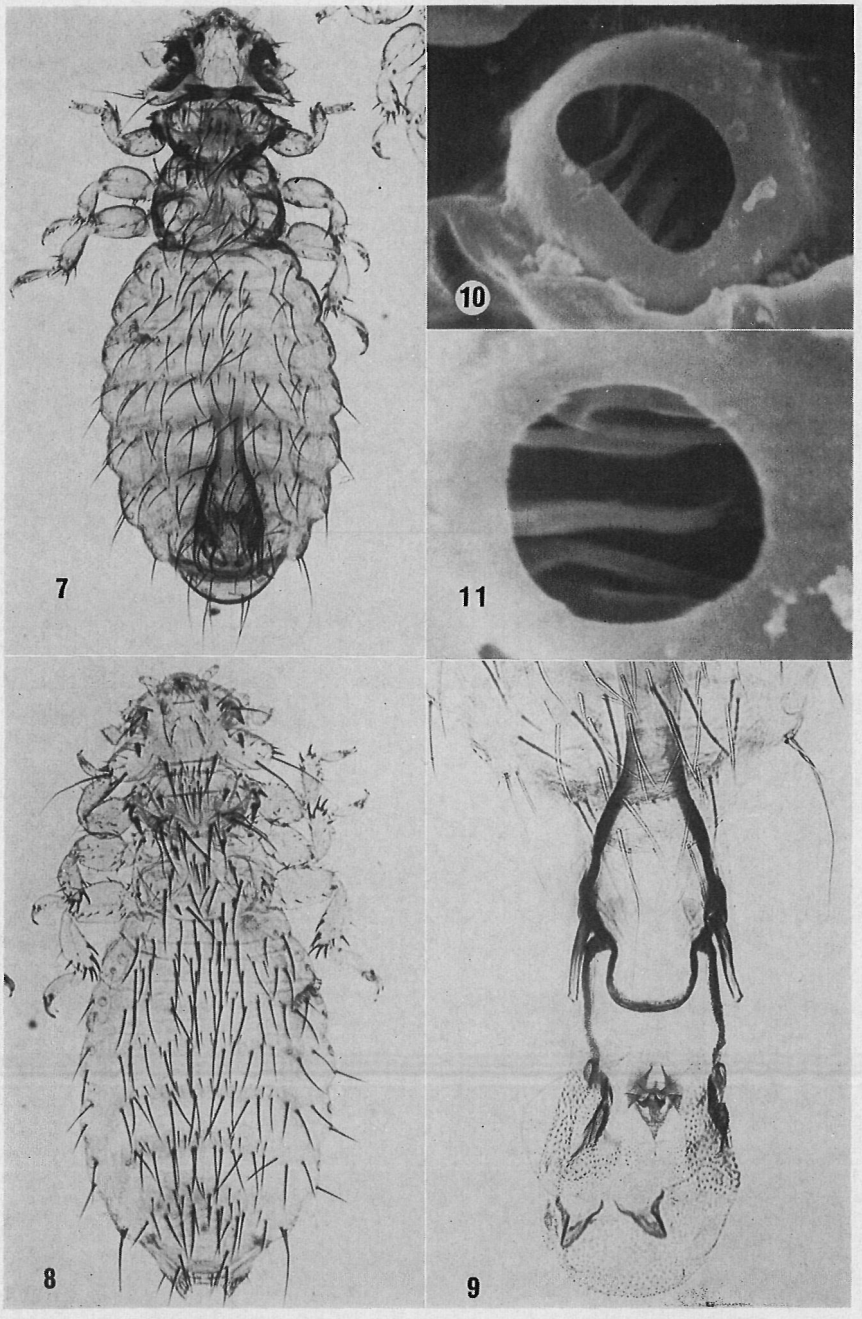
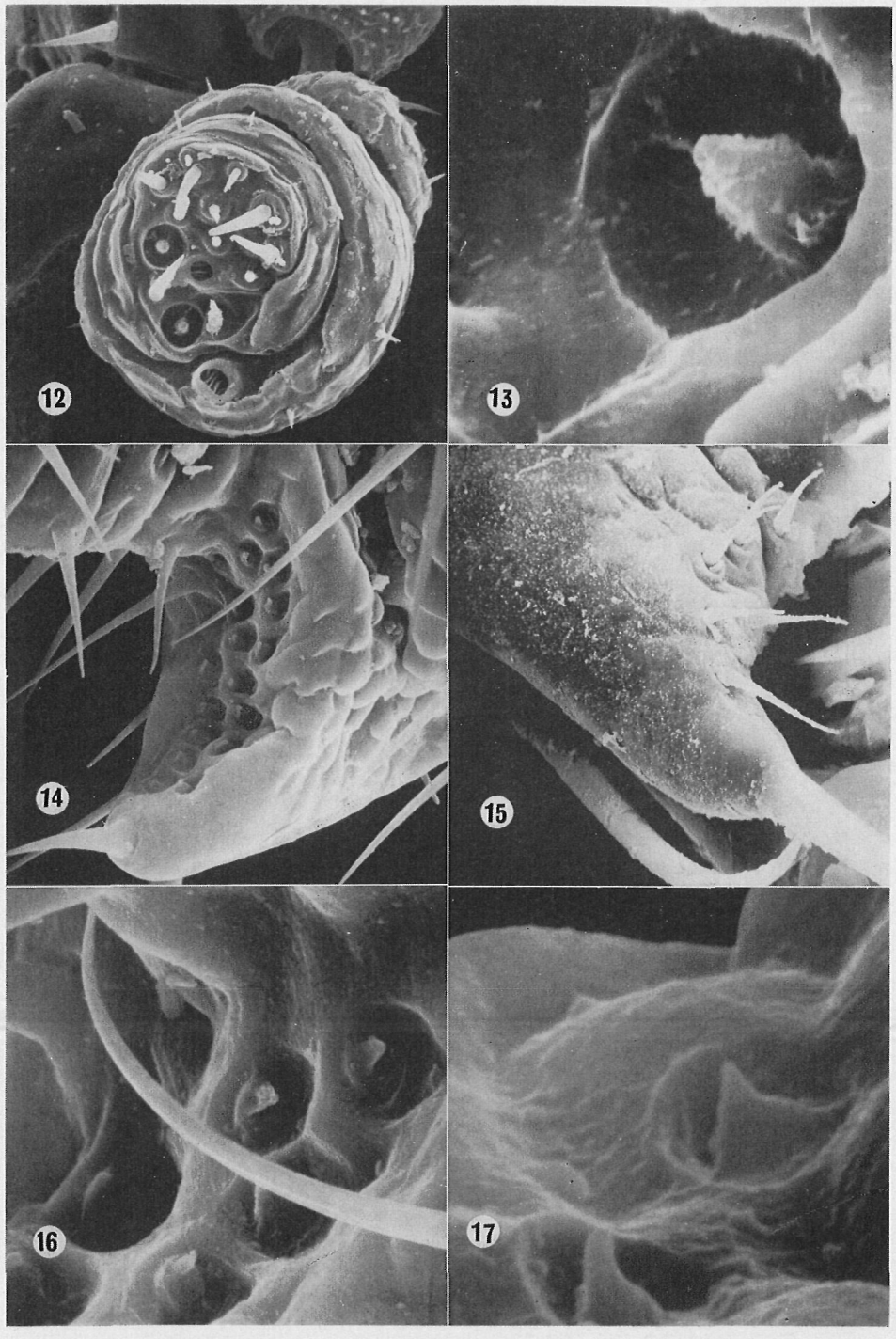



Fig. 7–11. 7–9, *Boopia emersoni* n. sp. : 7, ♂ ; 8, ♀; 9, ♂ genitalia everted. 10–11. *Boopia spinosa* Harrison & Johnson, antennal sense organs : 10, on segment IV ; 11, on segment V.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of *spinosa* with a sensillum on segment IV and 1 of a similar type on segment V. These appear to be globe-shaped with a narrow opening and to have a number of flattened outgrowths from the walls (fig. 10–11) ; examination with the light microscope shows a minute sense peg at the bottom of the cavity. Similar outgrowths, but fewer in number, can be seen in the sensilla of *brevispinosa*, *uncinata* and *bettongia*, but as these cannot be seen with the optical microscope and not at all angles with the SEM when only few are present, it is not possible to use their presence or absence as a taxonomic character. In addition to these sensilla there are 2 others each in the form of a wide open cavity with a sense peg arising from its base (fig. 13). These 2 sensilla have been seen on the terminal antennal segment with the SEM in *spinosa*, *brevispinosa*, *uncinata* and *bettongia* and also what appear to be the same in *emersoni* and *doriana* with the light microscope only, but in no other species.

*Gonapophysal Sensilla* (15). These are the "ampullae" of Kéler (1971), presumably given this name as in some species these sensilla examined with transmitted light may appear as elongated, rather ampulla-like structures. Viewed externally with the SEM, those of *brevispinosa* (fig. 14) appear as a number of cavities along the inner edge of the female gonapophysis, each with a sensory peg arising from the base (fig. 16). Similar sensilla have been seen with the SEM in *spinosa* and *bettongia* (fig. 17) and a comparison of their appearance when viewed with the SEM and light microscope makes it possible to identify similar sensilla in other species as shown in Table I with the light microscope only. In the remaining species of *Boopia* these sensilla are replaced by true alveolar setae (fig.15). Sensilla may be present along the supraanal margin as well as the gonapophysal margin (*Heterodoxus* spp.)

*Male Genitalia* (16). These are similar throughout the 13 species and have been described and figured by Kéler (1971). The armature of the vescia varies in different areas and the arrangement and form of the sculpture may provide specific characters. The surface may be granulated, have thorn-like projections, groups of rod-like thickening of various sizes and in one species (*dubia*) comb-like thickening. Specific characters are also shown in the form and arrangement of the sclerites of the vesica ; as shown in Table I the presence or absence of the posterior spur on the anterior median plate (see Kéler 1971) is a group character.

*SEM Photographs.* These were taken at the following magnifications : no. 10 at 9900 ; 11 at 17,600 ; 12 at 1650 ; 13 at 12,200 ; 14 at 2300 ; 15 at 2400 ; 19 at 7700 ; 17 at 14,000.

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Fig. 12–17. 12–13, *Boopia* (*Phacogalia*) *spinosa* H. & J. : 12, antenna, end on view ; 13, Single sense organ from antennal segment 5, 14–15. Inner margin of ♀ gonapophysis of *Boopia* spp. : 14, B. (P.) *brevispinosa* H. & J. ; 15, *B. grandis* Piaget. 16–17. Sensilla of the gonapophysis : 16, *B.* (*P.*) *brevispinosa* ; 17, *B. bettongia* Le Souef.

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