

TAXONOMY AND HOST PREFERENCES OF INDO-AUSTRALIAN FIG WASPS OF THE GENUS CERATOSOLEN (AGAONIDAE)

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INTRODUCTION

The systematic position of the fig wasps has for a long time been a challenging problem to biologists. Up to about 1880, the literature on fig wasps consisted of only a few occasional papers on the curious creatures found in the receptacles of Ficus species, and on the function they were supposed to fulfil, or were denied to have, in the process of caprification. For a survey of the literature prior to 1880, I refer to the critical review by MAYER (1882).

SAUNDERS (from 1878 onwards) and WESTWOOD (1882, 1883) described a number of genera and species of fig wasps from India and Australia.

PAUL MAYER (1882) reported upon a collection of fig insects from several parts of the world, mainly collected by H. ZU SOLMS-LAUBACH in the Botanical Gardens at Bogor (Java), and by F. MÜLLER in Brazil.

GUSTAV MAYR (1885) described and named the species listed by MAYER and some additional material sent by SOLMS from Bogor, thus providing a firm basis for the study of the fig wasps. In 1906, MAYR contributed an additional paper, consisting of corrections to his 1885 paper and descriptions of new species and genera.

In the meantime ASHMEAD (1904) reviewed the classification of the Chalcidoidea, and assigned the fig wasps to their proper place in this large group of Hymenoptera.

From 1916 onwards, the knowledge of the fig wasps was greatly enlarged by GRANDI, who published some fifty-five papers on their taxonomy, morphology,

and bionomics. A survey of GRANDI's work may be found in GRANDI (1955c, 1961). Among his outstanding contributions to the knowledge of the Agaonidae, the critical review (1928c) of the species described by MAYR, the monograph of *Blastophaga psenes* (second edition, 1929), and the world catalogue (last edition, 1955b) especially may be mentioned.

Up to a few years ago, only little attention could be given to the host relations of the Agaonidae, due to the fact that it was very difficult to have the host *Ficus* properly identified. Although MAYR (1885) cooperated with the botanist SOLMS, and WILLIAMS (1921, 1928) with MERRILL, the host preferences could in many instances not be ascertained.

It was a fortunate coincidence that at the time when Dr. J. VAN DER VECHT took up the study of fig wasps in the Botanical Gardens at Bogor, Java, Mr. E. J. H. CORNER was working on a revision of the genus *Ficus*. They cooperated in the study of the symbiosis between figs and fig wasps, and pointed out the fact that the relation between figs and fig wasps is highly specific. VAN DER VECHT (1956, p. 103; 1960) emphasized the particular importance of the study of the symbiosis, "for probably nowhere will botanists and entomologists find such an interesting opportunity to compare and check their ideas about certain problems of natural relationships and evolution".

VAN DER VECHT started his studies on fig wasps in 1954, and collected many samples in Java. In 1955, however, he returned to Holland, and soon found himself engaged in other work. In 1959 he suggested that I should proceed with the subject, and kindly gave the collection and his field notes in my care.

In the meantime CORNER enlarged the collection with many samples of wasps taken from figs preserved in botanical collections. A few years later he sent to me two collections of fig insects made on his expeditions to New Guinea, Melanesia, and Borneo. This material, together with the collections made by VAN DER VECHT, is preserved in the Rijksmuseum van Natuurlijke Historie, Leiden.

It soon became evident that the outcome of my study of the fig wasps could only gain by the incorporation of the data of collections available from other museums. Upon my request, material was sent on loan by various institutions. The material on which the present paper is based belongs to the institutions mentioned below; the names are preceded by the abbreviations used in the text of this paper.

BM — British Museum (Natural History), London;

BMH — Bernice P. Bishop Museum, Honolulu;

HSPA — Hawaiian Sugar Planters' Association, Honolulu (the collection of Dr. F. X. WILLIAMS);

ML — Rijksmuseum van Natuurlijke Historie, Leiden (in most instances, however, indicated by a collection number only);

NMB — Naturhistorisches Museum, Basel;

NMW — Naturhistorisches Museum, Wien;

OUM — Hope Department of Entomology, University Museum, Oxford;

USNM — United States National Museum, Washington.

Moreover, some typical specimens were received in exchange for specimens from the collection ML from Dr. G. GRANDI (Bologna) and Dr. K. J. JOSEPH (Dharmwar, India) or in loan from Dr. E. F. RIEK (Canberra).

Because of practical reasons I restrict the work to the Indo-Malayan and Papuan areas. The bulk of the material is from Malaya, Indonesia, and New Guinea, and these are the areas in which CORNER made an extensive research on the genus *Ficus*. As Dr. E. F. RIEK informed me that he has prepared a manuscript on the Australian Chalcidoidea, I do not include the Australian species. Only some Australian records of Indo-Malayan species are mentioned.

All information on *Ficus* mentioned in the present paper was either given by CORNER (personal communication, and in litt. to VAN DER VECHT and WIEBES), or taken from his publications (CORNER, 1958, 1960—1962).

#### A c k n o w l e d g e m e n t s.

For loan of material, and for generous help in numerous ways, I am indebted to the institutions mentioned above and to the following persons: J. H. ARDLEY (Lae), F. A. BIANCHI (Honolulu), B. D. BURKS (Washington), J. H. CALABY (Canberra), M. FISCHER (Vienna), M. DE V. GRAHAM (Oxford), G. GRANDI (Bologna), K. J. JOSEPH (Dharwar), F. KEISER (Basel), J. F. PERKINS (London), E. F. RIEK (Canberra), Miss. M. T. WIEBES (Leiden), and C. M. YOSHIMOTO (Honolulu).

The work on this paper could not have begun without the collection of VAN DER VECHT as a firm working basis, and it could not have been completed without the continuous cooperation of Mr. E. J. H. CORNER. I am grateful to Dr. J. VAN DER VECHT for entrusting me with this research, and for valuable comment and advice. To be permitted to cooperate with Mr. CORNER is a highly esteemed privilege.

A grant from the "Zoölogisch Insulinde Fonds" enabled me to travel to Cambridge, Oxford, and London, in order to discuss some problems with Mr. CORNER, and to go through the collections of the Oxford University Museum (Hope Department of Entomology) and the British Museum (Natural History).

The Nederlandsche Entomologische Vereeniging kindly accepted this paper for publication.

## THE INDO-MALAYAN AND PAPUAN SPECIES OF THE GENUS CERATOSOLEN

### TAXONOMIC REVISION

#### *Ceratosolen* Mayr

*Sycocrypta* Coquerel, 1855, pp. 367, 422 (monobasic, type: *S. coeca* Coquerel); Walker, 1871, p. 60 (in family Agaonidae s.l.); Newman, 1871, p. 400 (do.); Saunders, 1878, pp. 316—317 (in synonymy of *Blastophaga* Gravenhorst); Westwood, 1882, p. 48 (do.); Mayer, 1882, p. 586 (do.); Westwood, 1883, p. 379 (do.); Mayr, 1885, pp. 187—188 (incertae sedis); Dalla Torre, 1898, p. 321 (catalogue); Ashmead, 1904, p. 389 (in synonymy of *Blastophaga* Gravenhorst); Gahan & Fagan, 1923, p. 138 (types of Chalcid genera); Wiebes, 1961a, p. 236 (synonymous with *Ceratosolen* Mayr); 1961c, pp. 283—384 (proposed suppression).

*Ceratosolen* Mayr, 1885, pp. 150, 159, 160, 162, 164 (seven species; subgenus of *Blastophaga* Gravenhorst, key, description, key to species); Dalla Torre, 1898, pp. 323—325 (catalogue); Mayr, 1906, p. 153 (treated as separate genus); Schmiedeknecht, 1909, pp. 7, 9—10 (key, catalogue); Grandi, 1916a, pp. 133—153 (description, key to species); Gahan & Fagan, 1923, p. 29 (types of Chalcid genera); Aiyar, 1925, pp. 236—237 (catalogue of

Indo-Ceylonese species); Grandi, 1928c, pp. 221—225 (catalogue); 1935, pp. 225—229 (do.); Mani, 1938, pp. 29—30 (catalogue of Indian species); Grandi, 1941, pp. 13—18 (catalogue); 1952c, pp. 81—85 (do.); 1955b, pp. 120—125 (do.); Wiebes, 1961a, pp. 236, 238 (synonymous with *Sycocrypta* Coquerel, key); 1961c, pp. 383—384 (proposed validation).

*Ceratosolens* [!] Ashmead, 1904, pp. 233, 234 (key, type designated: *Blastophaga* (*Ceratosolen*) *appendiculata* Mayr).

*Ceratosolensia* Girault<sup>1)</sup>, 1915, p. 311 (monobasic, type, originally designated: *C. ficophaga* Girault); Gahan & Fagan, 1923, p. 29 (types of Chalcid genera); Grandi, 1928c, p. 229 (catalogue, incertae sedis); 1935, p. 239 (do.); 1941, p. 27 (do.); 1952c, p. 94 (do.); 1955b, p. 135 (do.).

### Restriction.

As may be seen from the synonymy, the genus *Ceratosolen* was originally established as a subgenus of *Blastophaga* Gravenhorst. The most important differential characters are the situation of the male antennae in separate grooves, and the elongate shape of the spiracular peritremata of the eighth urotergite in the female. In 1906 MAYR, without explicitly stating the change, treated the group as a separate genus, an opinion adhered to by all subsequent authors.

It appears, however, that there are some species that constitute a grade between *Blastophaga* and *Ceratosolen*. Especially in the figs of the section *Sycidium* Miq., I find species of wasps that show *Blastophaga* characters in the male, whereas the female has large, elongate, instead of circular peritremata on the eighth abdominal segment; other species have females with circular peritremata, and males with a *Ceratosolen* facies. Suffice it here to mention the gradation in these few characters only.

The genus evidently needs redefinition against *Blastophaga* and against some genera named by GIRAULT. This redefinition, however, cannot be given before the other genera have been revised. In this paper, the genus *Ceratosolen* is treated in its restricted sense, excluding the species that do not show the above-mentioned differential characters in both sexes.

### Description.

For an extensive diagnosis of the genus, I refer to GRANDI (1916a, pp. 133—153). The following description may serve to facilitate recognition, and to elucidate some terms and notations used in this paper.

The quotients given in parentheses with the descriptions of some body-parts — e.g., pronotum (10 : 7) — refer to the relative length and width, respectively; if given in square brackets behind a comparative remark — e.g., femur longer than tibia [10 : 7] — they refer to the comparison.

The morphological terms used in the descriptions are the English equivalents of those used by GRANDI (1929) in his monograph on *Blastophaga psenes* (L.). In

<sup>1)</sup> Dr. E. F. RIEK, who studied the type specimens of GIRAULT's Australian Chalcidoidea, drew my attention to this new synonym, and kindly sent to me some female specimens of *C. ficophaga* for comparison with the other species of *Ceratosolen*. *C. ficophaga* seems to belong to the group of *C. appendiculatus* (Mayr), but the males should be studied for a definitive classification of the species.

a few cases, e.g., the venation of the wings, I use different names, which are self-evident.

Male. Head longer than wide. The head may be pubescent, or provided with small spines. In most cases, these adornments are omitted from the figures. Epistomal margin usually trilobate, bilobate in one species; always prominent and distinctly visible. Antenna — not counting the radicola — consisting of four to six segments: scape, pedicel, flagellar segments; not clubbed. Unless otherwise stated, the lengths of the segments are measured along the dorsal edges. In preparing the figures, care was taken not to press the antenna between slide and cover-glass. Contrarily, the mouthparts were flattened into one plane, so that they may look different when studied *in situ*. Labium and maxillae sometimes atrophied, mostly present; maxillae with or without distinct lateral expansions. Mandible bidentate, each tooth with a subapical expansion.

Thorax simple; dorsally, the following terga are visible: pronotum, mesonotum, metanotum. The metanotum is, in most species, incompletely separated from the propodeum. Propodeum, and its spiracular peritremata, variable in shape. Ventrally, the following sterna are visible: prosternum (with the propleurae indicated in the figures by a dotted line), mesosternum, and metasternum. The metasternum is hirsute in some species.

Tibia of the fore leg with a varying number of apical teeth. Tarsus consisting of two or three segments, which are sometimes incompletely separated. Tibiae of mid and hind legs with or without spines on the disks. The normal number of tarsal segments is five, although in one species there are only three tarsal segments in the mid and hind legs, and in other species oligomery or heteromery occurs. Unless otherwise stated, the length of the distal tarsal segment is measured without the claws. In many species the hind legs are hirsute, and the tarsi are greatly dilated. The figures of these parts are semi-diagrammatical, merely indicating the size of the segments and the length of the pubescence.

Gaster. The tenth urite may or may not bear cerci or parameres, or both; the aedeagus is in most instances dilated subapically.

Length. The measurements given refer to the total length of head, thorax, and propodeum. The colour is that of specimens preserved in alcohol.

Female. Head approximately as long as wide across the compound eyes. The length of the cheek, given in comparison with the longitudinal diameter of the eye, refers to the distance from the lower margin of the eye to the point of insertion of the mandible. Three ocelli. Lateral expansions of the epistomal margin more or less angular, or rounded. Antenna relatively simple, the club in most species only indicated by the shape of the loosely connected apical two or three segments, or absent; in other species the apical two or three segments completely united. Maxilla with or without a bacilliform process. Mandible, and its appendage, with a varying number of ventral ridges.

Thorax. Wings pubescent, or with glabrous parts. Venation of the fore wing complete, i.e., consisting of submarginal, marginal, stigmal, and postmarginal veins. Stigma sometimes with dark radiating striae.

Fore leg with a distinct comb on the dorso-apical edge of the tibia, which may

consist of a varying number of teeth. In some cases, the ventral tooth of this comb is blunt. Ventro-apical edge with smaller teeth, and, mostly, with a long, simple spur. Tarsus usually pentamerous, in a few species consisting of only four segments. Mid leg slender; tarsus pentamerous, tetramerous in two species. Hind tibia with apical teeth, which may vary in shape and number. Hind tarsus pentamerous.

Gaster. The spiracular peritremata of the eighth urotergite elongate, gouge-like. The ovipositor projecting beyond the gaster to a varying extent.

Length. The measurements given refer to the total length of head, thorax, and gaster (without the ovipositor). Colour as seen in the alcohol samples.

### B i o n o m i c s.

Two authors gave notes on the bionomics of species of *Ceratosolen*, viz., BAKER (1913) on *C. notus* (Baker), and WILLIAMS (1928) on the same species, on *C. appendiculatus* (Mayr) (not indicated by name), and on *C. bakeri* Grandi.

The following short description of the life of a species of *Ceratosolen* — nearly all species of which live in dioecious figs — is almost verbally borrowed from WILLIAMS (1928, p. 7).

The wasps issue from the gall flowers of a mature fig. The males, which are quite flightless, hatch first and immediately seek the females by biting open the occupied galls. After mating the males perish, with some exceptions within the receptacles. On the other hand the females are fully winged, and in seeking egress from the receptacle through the ostiole or by a hole drilled through the rind, inadvertently dust themselves with pollen from the ripe stamens. They take wing, and under proper conditions find and enter a young fig in the right stage of development, i.e., one whose stamens are as yet undeveloped but whose gall flowers and seed flowers are in the one instance ready and adapted to receive the egg, and in the other instance, the pollen to fertilize the seed-producing ovary. Evidently, the females are unable to distinguish between the male and the female fruits, and enter whatever sort is available. Of course, the wasp cannot reproduce in the seed or female fig because this is not modified to that end, neither does it find fig flowers to fertilize in the male or gall fig.

The young fig grows to maturity, the stamens and seeds ripen, and wasps issue from the galls.

### R e m a r k s.

Under each species I give a list of synonyms — not necessarily exhaustive, as the references to the catalogues are not included — the data on the material studied, a description or descriptive notes, if necessary, and, in most cases, general remarks.

In general, the geographical names mentioned are those now in common use (e.g., Bogor, not Buitenzorg).

Hosts identified by CORNER are indicated as such, other host names are given as I found them on the labels. Discussion of the host records may be found in the chapter on host preferences.

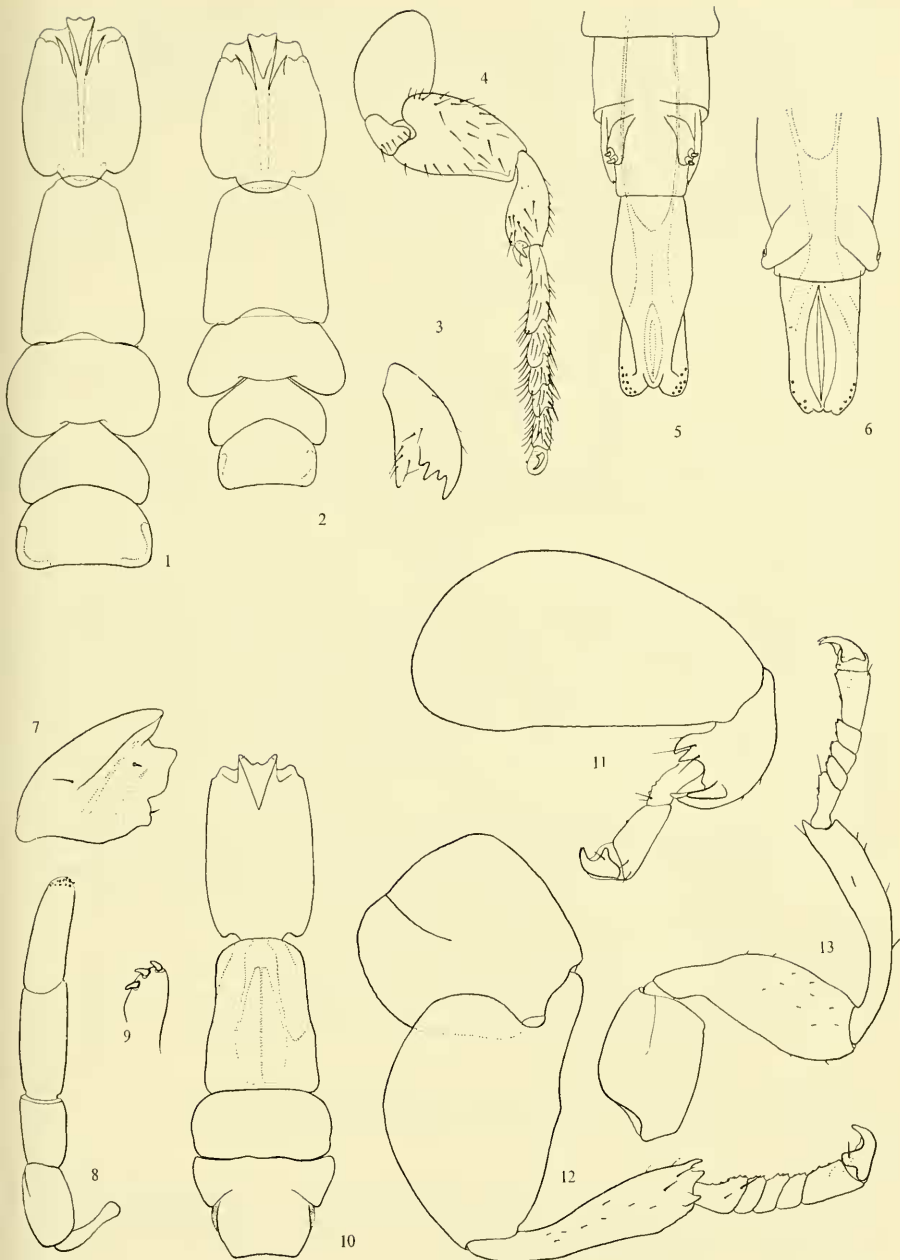


Fig. 1, *Ceratosolen bewitti*, Singapore, male, 2—5, *C. constrictus*, Java, 2, male, 3, female fore tibia, 4, female hind leg, 5, apex of male abdomen, 6, *C. pygmaeus*, Mindanao, apex of male abdomen, 7—13, *C. marshalli*, Fiji, male, 7, mandible, 8, antenna, 9, cercus of tenth urite, 10, male, 11, fore leg, 12, hind leg, 13, mid leg. Figs. 1, 2, 10,  $\times 50$ ; 4,  $\times 80$ ; 11—13,  $\times 115$ ; 3, 7, 8,  $\times 155$ ; 5,  $\times 215$ ; 6, 9,  $\times 365$

### Figures.

If not otherwise stated, the following body-parts are figured as seen in dorsal aspect: male head and thorax, antenna; figured as seen in ventral aspect: male and female mouthparts, male genitalia; as seen in antaxial aspect: male and female legs (i.e., retrolateral aspect of fore leg, prolateral aspects of mid and hind legs), female antenna.

As there are some differences between the various samples in the state of preservation, all specimens from coll. HSPA and BMH were sent to me dry, and they had to be relaxed in alcohol, not all figures of comparable body-parts could be magnified to the same, large scale.

But for the plate, the figures are original camera lucida drawings by the author.

### *Ceratosolen pygmaeus* Grandi (fig. 6)

*Ceratosolen pygmaeus* Grandi, 1927a, pp. 317—320, Pl. 4 figs. 50—65, Pl. 5 fig. 66 [descr. ♀, ♂, ex *Ficus minabassae* Miq., Mt. Maquiling (Luzon, Philippine Is.), leg. C. F. Baker].

#### Material.

One ♀, 1 ♂, ex *Ficus minabassae* Miq., Luzon (Philippine Is.), ex coll. GRANDI; coll. ML, no. 508.

Series ♀, 1 ♂, ex *Ficus minabassae* Miq., Los Baños (Luzon, Philippine Is.), Coll. Agric., leg. F. X. WILLIAMS, 1.VII.1921; coll. HSPA.

Series ♀, ♂, ex *Ficus minabassae* Miq., Lake Lanao (Mindanao, Philippine Is.), leg. F. X. WILLIAMS, XI.1921; coll. HSPA; coll. ML, no. 588: 5 ♀, 5 ♂.

#### Description — Additional note.

Male. Labium and maxillae completely atrophied. The tenth urite bears cerci, which are, due to the smallness of the specimens, and to the fact that these appendages are almost hyaline, very difficult to be observed. In the specimens from the HSPA collection, the cercus bears one claw (fig. 6).

Female. Tarsi of the fore and mid legs heteromerous.

### *Ceratosolen marshalli* Grandi (figs. 7—13)

*Ceratosolen Marshalli* Grandi, 1931, pp. 8—11, figs. I—II [descr. ♀, ex *Ficus* spec., Mt. Labasa (Fiji Is.), leg. W. Greenwood, 1.VII.1923, no. W. G. 532<sup>1</sup>)].

#### Material.

Series ♀, ♂, ex *Ficus* spec. near *storcki*, Fiji, leg. C. E. PEMBERTON, 1920; coll. HSPA, 1 ♂ (allotype) slide mounted; coll. ML, no. 595: 10 ♀, 2 ♂; ♂, slide 595a, ♀, 595b, c.

#### Description — Additional note.

Female. The specimens from the collection WILLIAMS are very similar to the

<sup>1</sup>) CORNER studied W. G. 532, and identified it with *Ficus pritchardii* Seem.



species described by GRANDI as *C. Marshalli*. There are some minor differences, viz., in the specimens seen by me, the mandibular appendages bear five ventral ridges instead of four, and the sensilla of the funicular segments seem to be more numerous. As the material has been desiccated, as have GRANDI's specimens, the last mentioned character is not easily to be observed. The colour-differences between head, thorax, and gaster, mentioned by GRANDI (l.c., p. 8): "colore fondamentale isabellino-ferrugineo sfumato di umbrino, con la parte posteriore del cranio e gli uotergiti tendenti al fuligineo", are very conspicuous. I consider the sample conspecific with GRANDI's species, and describe the hitherto unknown male.

Male. Head (fig. 10) not quite twice as long as wide. Lateral lobes of the epistomal margin prominent, median lobe small. Eyes absent. Antennal grooves half closed. Antenna (fig. 8) four-segmented: scape (8 : 5) slightly longer than the pedicel (3 : 2), which is two-thirds the length of the next segment (9 : 4), Third segment nearly as long as the apical segment (3 : 1). Mandible, fig. 7; labium and maxillae atrophied.

Thorax, fig. 10. Length of the pronotum four-thirds of the posterior width, and nearly twice the anterior width. Mesonotum twice as wide as long. Metanotum incompletely separated from the propodeum, approximately as wide as the mesonotum. Propodeum wider than long [4 : 3], narrower than the mesonotum. Fore leg (fig. 11): femur more than twice as long as the tibia, which bears three dorsal and two ventro-apical teeth. Tarsus bimerous, segments in ratio 5 : 6. Mid leg (fig. 13): the coxa two-thirds the length of the clavate femur, the trochanter small. Tibia arcuate, as long as femur and trochanter combined, with acute apical edges. Tarsus pentamerous, the segments in ratio 8 : 3 : 3 : 4 : 9. Femur of the hind leg (fig. 12) slightly larger than the coxa; the tibia about as long as the femur, with three apical teeth. Tarsus pentamerous, the segments in ratio 8 : 3 : 3 : 4 : 8.

Gaster. Cerci (fig. 9) of the tenth urite with three rather robust claws.

Length, 1.1—1.3 mm. Colour light yellow-brown.

#### Remark.

There are several characters by which *C. marshalli* can be distinguished from *C. pygmaeus*, but it is evident from other features (e.g., the dentation of the fore legs, the constitution of the antennae) that the two are closely related.

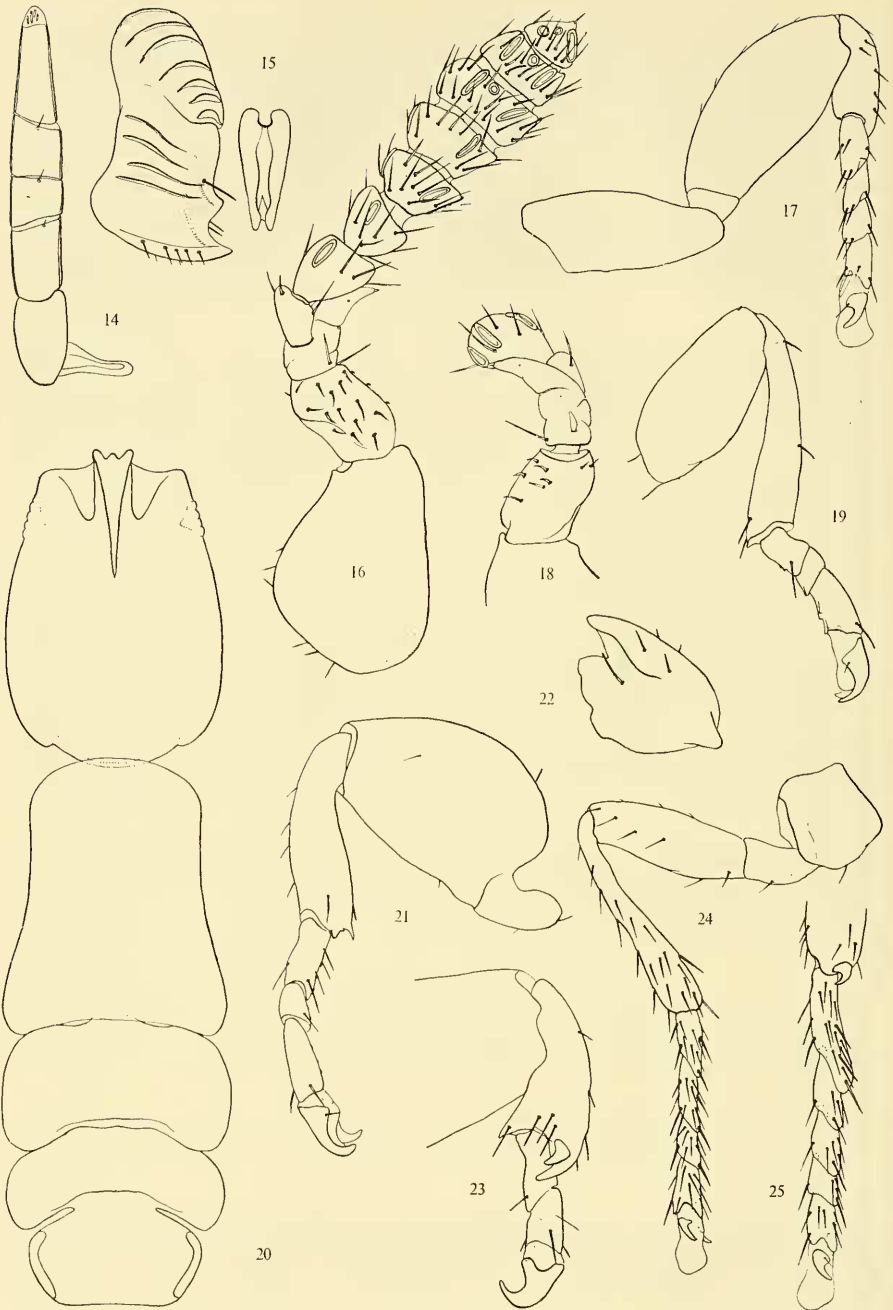
#### *Ceratosolen nanus* sp. n. (figs. 14—25)

#### Material.

Series ♀, ♂, ex *Ficus pungens* Reinw. (det. E. J. H. CORNER), Lae (Terr. New Guinea), leg. E. J. H. CORNER, 5.IX.1960; coll. no. 548; ♂ (holotype), slide 548a, ♀ (allotype), 548c, ♂, ♀ (paratypes), 548b, d.

#### Description.

Male. Head (fig. 20) slightly more than twice as long as wide anteriorly, and approximately one and a half times as long as its maximum width [13 : 9]. Dorsal surface with very small bristles. Epistomal margin obtusely trilobate, the lateral



Figs. 14—25, *Ceratosolen nanus*, New Guinea, 14, male antenna, 15—18, female, 15, mouthparts, 16, antenna, axial aspect, 17, fore leg, axial aspect, 18, antenna, detail, 19—23, male, 19, mid leg, 20, male, 21, hind leg, 22, mandible, 23, detail of fore leg, 24, female mid leg, 25, detail of female hind leg. Figs. 20,  $\times 115$ ; 17, 19, 21, 23—25,  $\times 155$ ; 14—16, 18, 22,  $\times 215$

lobes about twice as long as the median one, and without hairs. Eyes large. Antennal grooves half closed, obtuse behind. Antenna (fig. 14) five-segmented; the scape (7 : 4) slightly longer than the pedicel (3 : 2), first flagellar segment (7 : 6) half as long as the pedicel, second segment (1 : 1) somewhat longer than the first, apical segment (3 : 1) distinctly longer than the pedicel. Pedicel, first, and second flagellar segments with one apical hair. Mandible, fig. 22; labium and maxillae completely atrophied.

Thorax, fig. 20. Posterior width of the pronotum distinctly less than its length [9 : 11]. The pronotum is narrower in front than behind [7 : 9]. Length of the mesonotum one half, that of the metanotum one third of the width. Propodeum about one and a half times as wide as long [14 : 9], with rounded edges. Tibia of the fore leg (fig. 23) half as long as the femur, the tarsus (including the claws) as long as the tibia. Tibia with two large teeth at the dorso-apical edge and one small ventral tooth. Tarsal segments subequal, claws large. Mid leg (fig. 19): coxa and femur subequal, tibia a little longer, without apical teeth. Tarsus trimerous, the segments in ratio 4 : 2 : 5. Coxa of the hind leg (fig. 21) slightly longer than the femur; the tibia distinctly shorter, with ventral teeth. Tarsus trimerous, the segments in ratio 5 : 3 : 7.

Gaster. Genitalia without cerci.

Length, 0.95—1.0 mm. Colour yellowish.

Female. Head as long as wide across the eyes. Longitudinal diameter of the compound eye longer than the cheek [7 : 5]. Pubescence short. Antenna (figs. 16, 18): scape as long as fourth to seventh segments combined; pedicel not half as long as the scape, with approximately twenty spines on the axial surface. Fourth segment small. Fifth to eleventh segments gradually diminishing in length, the ninth segment the widest. Segments with few sensilla: the fifth with three, the sixth and seventh with five, the eighth with six, the ninth with seven, the tenth with five, and the eleventh with two oblong sensilla; the ninth to eleventh segments with some circular sensilla. Mouthparts, fig. 15. Mandible with four ventral ridges, longer than the appendage, which bears six ventral ridges. Labium and maxillae much like those of *C. pygmaeus*.

Thorax. Pronotum broad and bristly. Scutum nearly as long as wide; scutellum approximately as long as wide posteriorly, with a few scattered hairs. Metanotum with many hairs. Propodeum as wide as scutum and scapulae combined, with tufts of five hairs above and beneath the spiracular peritremata. Fore wing (16 : 7), 1.1 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 8 : 5 : 4 : 2. Submarginal vein with three pustules, stigmal vein with four. Hind wing (6 : 1), 0.6 mm long. Wings pubescent over nearly the whole surface, marginal fringes long. Coxa and femur of the fore leg (fig. 17) subequal, the tibia half as long as the femur. Dorsal apex of the tibia with two teeth. Tarsus tetramerous, the segments in ratio 25 : 14 : 12 : 15. Coxa of the mid leg (fig. 24) semi-globular, the tibia about as long as femur and trochanter combined. Tarsus tetramerous, the segments in ratio 22 : 23 : 16 : 17. Hind leg (fig. 25): the femur a little longer than the coxa, the tibia nearly as long as the coxa. Apical tibial tooth bidentate. Tarsus pentamerous, the segments in ratio 10 : 6 : 5 : 3 : 4.

Gaster. Ovipositor barely projecting beyond the apex of the gaster. Length, 1.2 mm. Colour light brown.

#### R e m a r k.

This species is well characterized by the shape of the female antenna. The oligomery of the legs and the general facies connect it with *C. pygmaeus*.

*Ceratosolen constrictus* (Mayr) and *C. hewitti* Waterston (figs. 1—5; map, fig. 261)

It is possible that *C. constrictus* (Mayr) and *C. hewitti* Waterston merely represent two races of one species. *C. constrictus* is known from Java and Sumatra, *C. hewitti* from Borneo and Malaya<sup>1</sup>). Moreover, the specimens from Mt. Kinabalu (N. Borneo) are provisionally referred to *C. constrictus*. For distribution, see the map (fig. 261).

The males of *C. hewitti* differ from those of *C. constrictus* in the relative proportions of head, thorax, and propodeum (figs. 1 and 2), and are slightly longer. The females of *C. hewitti* have longer antennal segments than those of *C. constrictus*, longer sensilla, and more hairs near the propodeal spiracle (cf. the figures given by WATERSTON, 1921, and GRANDI, 1928c).

Although there are some characters connecting *C. constrictus* and *C. hewitti* with *C. crassitarsus* and its relatives, the general facies, the heteromery of the male mid and hind tarsi, and the absence of the tibial spur from the female fore leg, are arguments for placing them in the relationship of *C. pygmaeus*.

#### *Ceratosolen constrictus* (Mayr) (figs. 2—5)

*Blastophaga* spec., Mayer, 1882, p. 571 [♀, ♂, ex *Covellia subopposita* Miq.<sup>2</sup>], Bogor (Java), Bot. Gdn., no. 9a].

*Blastophaga* (*Ceratosolen*) *constricta* Mayr, 1885, pp. 154, 161, 163, 169—170, Pl. XI fig. 6 [key ♀, ♂, descr. ♀, ♂, ex *Ficus* (*Cystogyne*) *subopposita* Miq. (*fistulosa* Reinw. sec. Miq.) (det. Solms), P. Mayer, no. 9a; type: ♂].

*Ceratosolen constrictus*: Grandi, 1928c, pp. 184—188, figs. XXXI—XXXII [redescr. ♀, ♂, type specimens of *B. constricta* Mayr].

#### M a t e r i a l.

Series ♀, ♂, ex *Ficus fistulosa* Reinw. (det. E. J. H. CORNER), Bogor (Java), Bot. Gdn., fern garden, 1.XI.1954; coll. no. 60; ♂, slide 60a.

Series ♀, ♂, ex *Ficus fistulosa* Reinw. (det. E. J. H. CORNER), Bogor (Java), Semplak, 28.XI.1954; coll. nos. 209, 211; ♂, slide 211a, ♀, ♂, 211b, ♂, 211c, ♀, 211d.

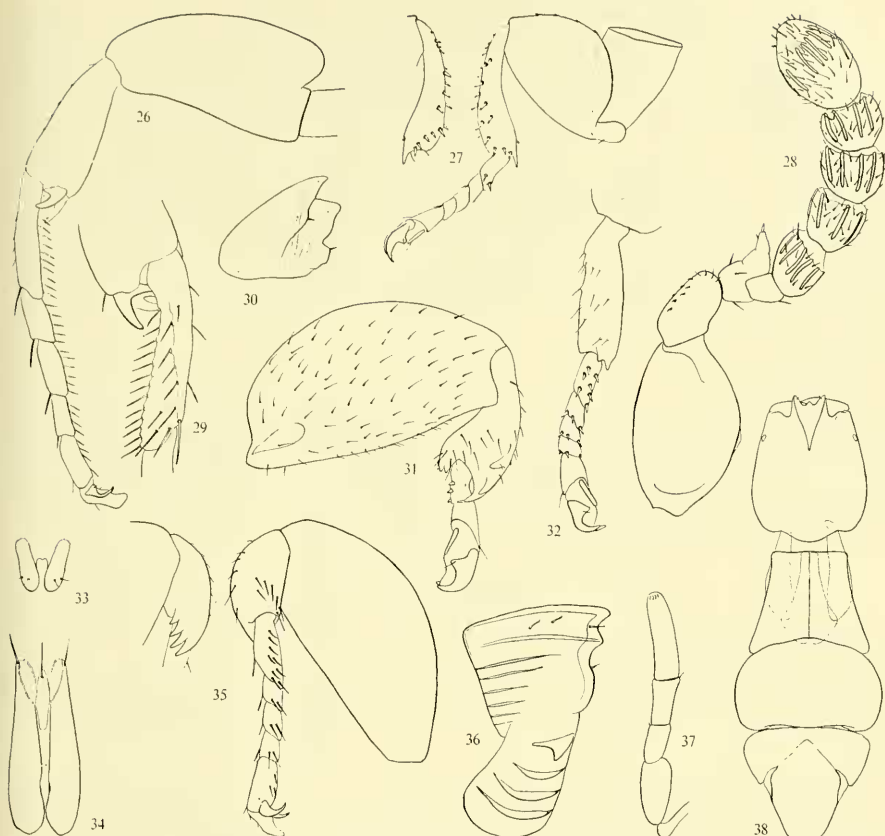
Series ♀, ♂, ex *Ficus fistulosa* Reinw., Tjibodas (Java), 8.II.1955; coll. no. 302.

Series ♀, ♂, ex *Ficus dimorpha* King<sup>3</sup>) (det. E. J. H. CORNER), Pajakumbuh

<sup>1</sup>) The wasps introduced to Hawaii, with Malayan *Ficus fistulosa* (cf. CORNER, 1958, p. 18), probably belong to *C. hewitti* Waterston.

<sup>2</sup>) = *Ficus fistulosa* Reinw.

<sup>3</sup>) see p. 96.



Figs. 26—38, *Ceratosolen grandii*, New Guinea, 26, female hind leg, 27, male mid leg, and detail in axial aspect, 28, female antenna, axial aspect, 29, detail of female hind leg, axial aspect, 30—33, male, 30, mandible, 31, fore leg, 32, detail of hind leg, 33, labium and maxillae, 34—36, female, 34, labium and maxillae, 35, fore leg, axial aspect, and detail in antaxial aspect, 36, mandible, 37, male antenna, 38, male. Figs. 38,  $\times 40$ ; 27, 31, 32, 37,  $\times 90$ ; 26, 28, 30, 33, 35,  $\times 115$ ; 29, 34, 36,  $\times 160$

(Sumatra), leg. W. MEIJER, III—V.1956, no. 3473; coll. nos. 465, 467, 469;  $\delta$ , slide 465a,  $\eta$ ,  $\delta$ , 465b.

? Series  $\eta$ ,  $\delta$ , ex *Ficus fistulosa* Reinw. var. *tengerensis* O.K. (det. E. J. H. CORNER), Mt. Kinabalu East (N. Borneo), 3000 ft. alt., leg. E. J. H. CORNER, 25.VII.1961, RSNB no. 967; coll. no. 626;  $\eta$ , slide 626a,  $\delta$ , 626b.

#### Description — Additional note.

The males have small eyes, near the insertion of the mandibles. Maxilla with two lateral hairs. Head, thorax, and propodeum, fig. 2. Fore tibia with seven apical teeth: two stout teeth at the dorsal edge, with a smaller one in between, one dorsally on the disk, and three more slender teeth at the ventral edge. Mid tibia with five apical teeth. Hind tibia with three dorso-apical teeth. The aedeagus (fig. 5) is slightly dilated, and the cerci of the tenth urite bear two large claws.

Female. Mandibular appendage with five or six ventral ridges. Maxilla with one lateral hair, and a subapical one. Fore wing (2 : 1), 1.2 mm long. Submarginal, marginal, stigmal, and postmarginal veins approximately in ratio 20 : 7 : 6 : 8. Submarginal vein with three postulus, stigmal vein with four. Hind wing (10 : 3), 0.7 mm long. Fore tibia, fig. 3; there are four apical teeth at the dorsal edge. Ventral edge without a long spur. Mid leg long and slender. Femur two-thirds the length of the tibia, which is as long as the tarsal segments combined. First tarsal segment one fourth longer than the fifth, the intermediates subequal and approximately half as long as the first. Tibia without prominent apical teeth, but with some very stout hairs at the ventro-apical edge. Hind leg, fig. 4. Ovipositor scarcely projecting beyond the apex of the gaster.

#### Remark.

The specimens from Sumatra, ex *F. dimorpha* King, resemble the Javanese specimens in all details. The sample from Mt. Kinabalu is provisionally referred to *C. constrictus*, although the females differ slightly from the Javanese specimens: antenna with short segments as in *C. constrictus*, but the sensilla rather long, as in *C. hewitti*, fore tibia with two dorso-apical teeth.

#### *Ceratosolen hewitti* Waterston (fig. 1)

*Ceratosolen hewitti* Waterston, 1921, pp. 35—38, fig. 1 [descr. ♀, ♂, ex *Ficus* spec., Sarawak (Borneo), leg. J. Hewitt, VII.1907; type: ♀].

*Ceratosolen imbecillus* Grandi, 1927a, pp. 315—317, Pl. 3 figs. 33—42, Pl. 4 figs. 43—49 [descr. ♀, ♂, ex *Ficus chartacea* Wall.<sup>1</sup>], Singapore, leg. C. F. Baker]; 1928c, p. 223 [= *C. hewitti* Waterston].

#### Material.

One ♀, 1 ♂, "from a fruiting trunk. *Ficus*. July 1907. J. HEWITT", Sarawak (Borneo), from type lot of *C. hewitti* Waterston; coll. BM, 1 slide.

Series ♀, ♂, ex *Ficus* aff. *fistulosa* Reinw. (det. E. J. H. CORNER), Bau (Kuching, Borneo), leg. E. J. H. CORNER, 25.IX.1961; coll. no. 640; ♀, slide 640a, ♂, 640b.

Series ♀, ♂, ex *Ficus chartacea* Wall.<sup>1</sup>), Singapore, from type lot of *C. imbecillus* Grandi; coll. USNM.

Series ♂, ex *Ficus fistulosa* Reinw. (det. E. J. H. CORNER), Singapore, Bot. Gdn., 1932; coll. no. 422; ♂, slides 422a, b.

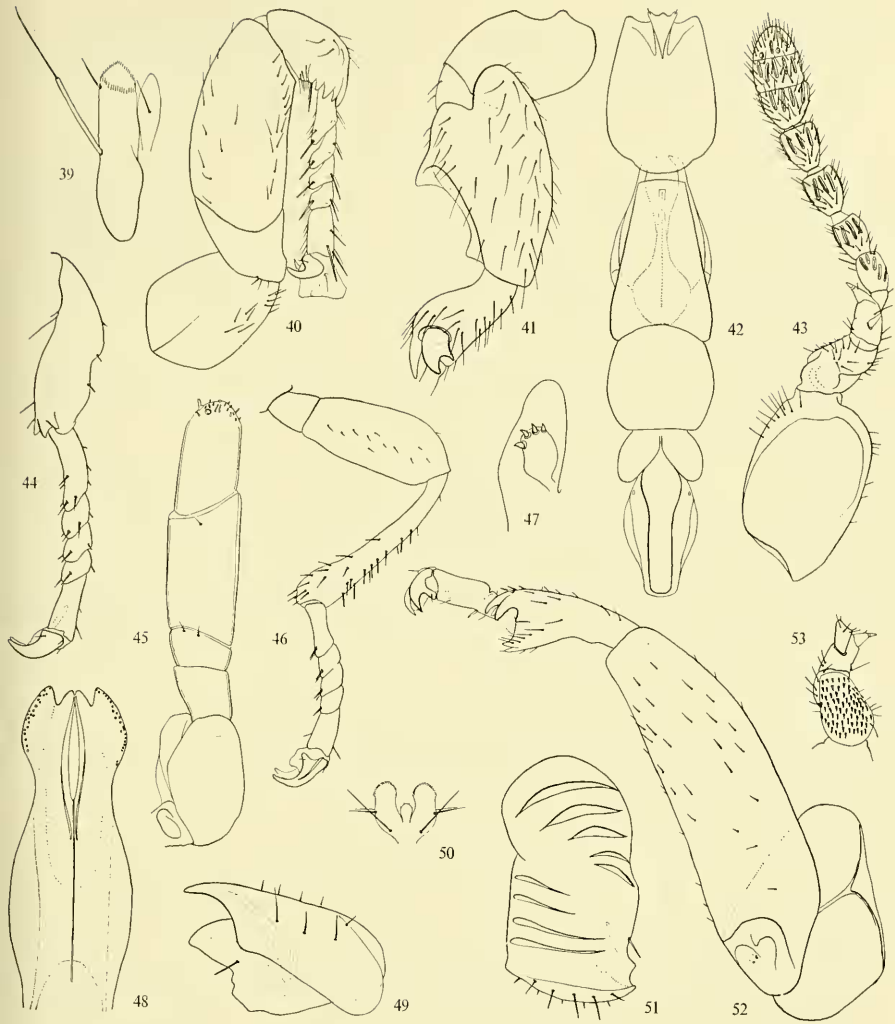
Series ♀, ♂, ex *Ficus fistulosa* Reinw. (det. E. J. H. CORNER), Sungei Gombah (Selangor, Malaya), leg. E. J. H. CORNER, 4.X.1961; coll. no. 638; ♀, slide 638a, ♂, 638b.

#### *Ceratosolen graveleyi* Grandi

*Ceratosolen graveleyi* Grandi, 1916a, pp. 150, 152 [descr. ♀, ♂, in key]; 1916b, pp. 201—207, figs. IX—XI [descr. ♀, ♂, ex *Ficus cumia* Hann.<sup>2</sup>], Paresnath Hill (Chota Nagpur, India), 4300 ft. alt., leg. N. Annandale, 9 & 14.IV.1909]; Joseph, 1954, p. 409, figs. IV, 36—41 [descr. note ♂, ex *Ficus cumia* Hann.<sup>2</sup>], Dehra Dun (India), Forest Research Inst. Estate, New Forest, leg. K. J. Joseph, 25.VI.1953].

<sup>1</sup>) Probably incorrect, see p. 97.

<sup>2</sup>) = *Ficus semicordata* Ham. ex Smith.



Figs. 39—53, *Ceratosolen boschmai*, Bougainville I., 39—41, female, 39, labium and maxilla, 40, fore leg, 41, hind leg (tarsus omitted), 42, male, 43, female antenna, 44—50, male, 44, detail of hind leg, 45, antenna, 46, mid leg, 47, cercus of tenth urite, and paramere, 48, aedeagus, 49, mandible, 50, labium and maxillae, 51, female mandible, 52, male fore leg, 53, detail of female antenna in axial aspect. Figs. 42,  $\times 40$ ; 40, 41, 43, 44, 46, 52, 53,  $\times 90$ ; 39, 51,  $\times 115$ ; 45, 47—50,  $\times 160$

#### Material.

One ♀, 2 ♂, ex *Ficus cunia* Hann.<sup>1)</sup>, Paresnath Hill (Chota Nagpur, India), ex coll. GRANDI; coll. ML, no. 509.

Nine ♂, India, ex coll. JOSEPH; coll. ML, no. 566.

<sup>1)</sup> = *Ficus semicordata* Ham. ex Smith.

## R e m a r k.

This species shows some resemblance to both *C. pygmaeus* and *C. emarginatus*, but it appears to be more closely related to the latter.

*Ceratosolen emarginatus* Mayr

*Ceratosolen emarginatus* Mayr, 1906, pp. 153—154 [descr. ♀, ♂, ex *Ficus* spec., Tonkin (N. Vietnam), leg. P. Marchal, no. 20b]; Grandi, 1928c, pp. 189—190, figs. XXXIII—XXXIV [redescr. ♀, ♂, type specimens of *C. emarginatus* Mayr = *C. effractarius* Grandi]; Joseph, 1954, p. 409 [♀, ♂, ex *Ficus roxburghii* Wall.<sup>1)</sup>], Dehra Dun (India), leg. K. M. Vaid & K. J. Joseph, 30.VI.1953].

*Ceratosolen effractarius* Grandi, 1927b, pp. 169—174, figs. I—II [descr. ♀, ♂, ex *Ficus Roxburgii*<sup>1)</sup>], Hanoi (Indo-China), leg. F. Silvestri, 4.III.1925].

## M a t e r i a l.

Five ♀, 1 ♂, Calcutta (India); coll. USNM, incorrectly identified with *Blastophaga appendiculata* Mayr.

Series ♀, ♂, India, ex coll. JOSEPH; coll. ML, no. 565; ♂, slide 565a, ♀, 565b.

Series ♀, ♂, ex *Ficus* spec., Chiangmai (N.W. Thailand), Fang, 500 m alt., leg. T. C. MAA, 12/19.IV.1958, no. 380; coll. BMH.

Series ♀, ♂, ex *Ficus oligodon* Miq.<sup>2)</sup> (det. E. J. H. CORNER), Fraser's Hill (Selangor, Malaya), 4000 ft. alt., leg. E. J. H. CORNER, 3.X.1961; coll. no. 609; ♂, slides 609a, b, ♀, 609c.

## R e m a r k.

This species is very close to *C. fusciceps* (Mayr). It differs, however, in having an extra ring segment in the male antenna, and in the absence of spines from the disk of the male hind tibia.

*Ceratosolen fusciceps* (Mayr)

*Blastophaga* spec., Mayer, 1882, p. 570 [♀, ex *Covellia glomerata* Willd.<sup>3)</sup>], Bogor (Java), Bot. Gdn., no. 4a].

*Blastophaga (Ceratosolen) fusciceps* Mayr, 1885, pp. 154, 161, 164, 167—168, Pl. XI fig. 3 [key ♀, ♂, descr. ♀, ♂, ex *Ficus (Sycomorus) glomerata* horti Bogor., nec Roxb. (det. Solms), P. Mayer, no. 4a; type: ♂].

*Blastophaga (Ceratosolen) fuscipes* Mayr, 1885, p. 249 [incorrect spelling].

*Ceratosolen fusciceps*: Mayr, 1906, p. 153 [descr. note ♂, ex *Ficus Covellii*<sup>4)</sup>], Bogor (Java), Bot. Gdn., leg. C. Aurivillius, no. 1; also ? ♀, ex *Covellia glomerata* Miq., and *Urostigma luscenscens* Miq.<sup>4)</sup>, same locality, leg. C. Aurivillius, nos. 5 and 6, respectively]; Grandi, 1928a, pp. 79—80 [♀, ♂, ex *Ficus glomerata* Roxb., Chambaganour (Pulneys, India)<sup>5)</sup>, 4000 ft. alt., leg. E. Gombert, 7.VI.1914]; 1928c, p. 171 [type specimens studied]; Joseph, 1953a, p. 61 [♀, ♂, ex *Ficus glomerata* Roxb., Agra (India), leg. K. J. Joseph, 12.IV.1952]; 1953b, p. 137 [♀, ♂, ex *Ficus glomerata* Roxb., Agra, 28.VIII.1950, and Trivandrum, 5.VII.1950 (India), leg. K. J. Joseph].

*Ceratosolen fuscipes*: Grandi, 1916a, pp. 151—152 [♀, ♂, in key]; 1916b, pp. 194—201,

<sup>1)</sup> = *Ficus auriculata* Lour.

<sup>2)</sup> The question of the host *Ficus* is discussed on p. 97.

<sup>3)</sup> = *Ficus racemosa* Linn.

<sup>4)</sup> see p. 98.

<sup>5)</sup> ? = Shembaganur, Palni Hills, South India?



figs. V—VIII [descr. ♀, ♂, ex *Ficus glomerata* Roxb., Bogor (Java), Bot. Gdn., leg. E. Jacobson, 1.1915; and Colombo (Ceylon), leg. O. Beccari, 1870]; 1923a, p. 299 [♀, India, leg. H. M. Lefroy].

*Ceratosolen mysorensis* Joseph, 1953c, pp. 277—282, figs. IV—V [descr. ♀, ♂, ex *Ficus mysorensis* Hayne<sup>1)</sup>, Trivandrum (India), Bot. Gdn., leg. K. J. Joseph, 12.VII.1950].

?*Blastophaga niveipes* Girault<sup>2)</sup>, 1927, p. 338 [descr. (♀), ex *Ficus glomeratus*, Roper River (N. Terr., Australia), leg. N. B. Tindale].

### Material.

Series ♀, ♂, ex *Ficus racemosa* Linn., Bogor (Java), Bot. Gdn., VI—VIII.1954; coll. no. 83; ♂, slide 83a, ♀, ♂, 83b.

Series ♀, ♂, ex *Ficus racemosa* Linn., Bogor (Java), Bot. Gdn., near warung, 24.IX.1954; coll. no. 479.

Series ♀, ♂, ex *Ficus racemosa* Linn. var. *elongata* (King) Barrett (det. E. J. H. CORNER), Bogor (Java), Bot. Gdn., 18.X.1954; coll. no. 236; ♂, slide 236a, ♀, 236b.

Series ♀, ♂, ex *Ficus racemosa* Linn. (det. E. J. H. CORNER), Timor, leg. M. E. WALSH, no. 95; coll. no. 386; ♂, slide 386a, ♀, 386b.

Series ♀, ♂, ex *Ficus racemosa* Linn., Sudadji (Bali, distr. Sawahan, 16 km SE of Singaradja), leg. NJOMAN TOJA; coll. no. 59; ♂, slide 59a, ♀, slide 59b.

Series ♀, ♂, ex *Ficus racemosa* Linn.<sup>3)</sup>, Ujung Kulon (Java), leg. A. HOOGERWERF, XI.1954, no. 1; coll. no. 276; ♀, ♂, slide 276a.

Series ♀, ♂, ex *Ficus racemosa* Linn.<sup>3)</sup>, Ujung Kulon (Java), leg. A. HOOGERWERF, XI.1954, no. 2; coll. no. 292; ♂, slide 292a, ♀, 292b.

Series ♀, ♂, ex *Ficus racemosa* Linn.<sup>3)</sup>, Ujung Kulon (Java), leg. A. HOOGERWERF, XI.1954<sup>4)</sup>; coll. no. 279; ♀, ♂, slide 279a.

Fifteen ♀, series ♂, ex *Ficus racemosa* Linn. var. *elongata* (King) Barrett<sup>5)</sup> (det. E. J. H. CORNER), Koung, Mt. Kinabalu (N. Borneo), ± 400 m alt., 17.V.1933, Sing. F. no. 27322; coll. no. 420; ♂, slide 420a, ♀, ♂, 420b.

Series ♀, ♂, ex *Ficus racemosa* Linn. var. *elongata* (King) Barrett (det. E. J. H. CORNER), Kota Belud (N. Borneo), leg. E. J. H. CORNER, 23.IX.1961; coll. no. 622.

Three ♀, 10 ♂, ex *Ficus racemosa* Linn. (det. E. J. H. CORNER), Sungei Nenggiri (Kelantan, Malaya), leg. E. McCLURE, 13.XI.1961; coll. no. 667.

Fourteen ♀, 2 ♂, ex *Ficus racemosa* Linn. (det. E. J. H. CORNER), Negri Sembilan (Malaya), 1932, Sing. F. no. 26135; coll. no. 416; ♀, ♂, slide 416a; do., 12 ♀ from a young fig; coll. no. 418.

Series ♀, 7 ♂, ex *Ficus glomerata* Roxb.<sup>6)</sup>, Pusa, Bihar (India), leg. D. T. FULLAWAY, 13.II.1921; coll. HSPA.

<sup>1)</sup> see p. 98.

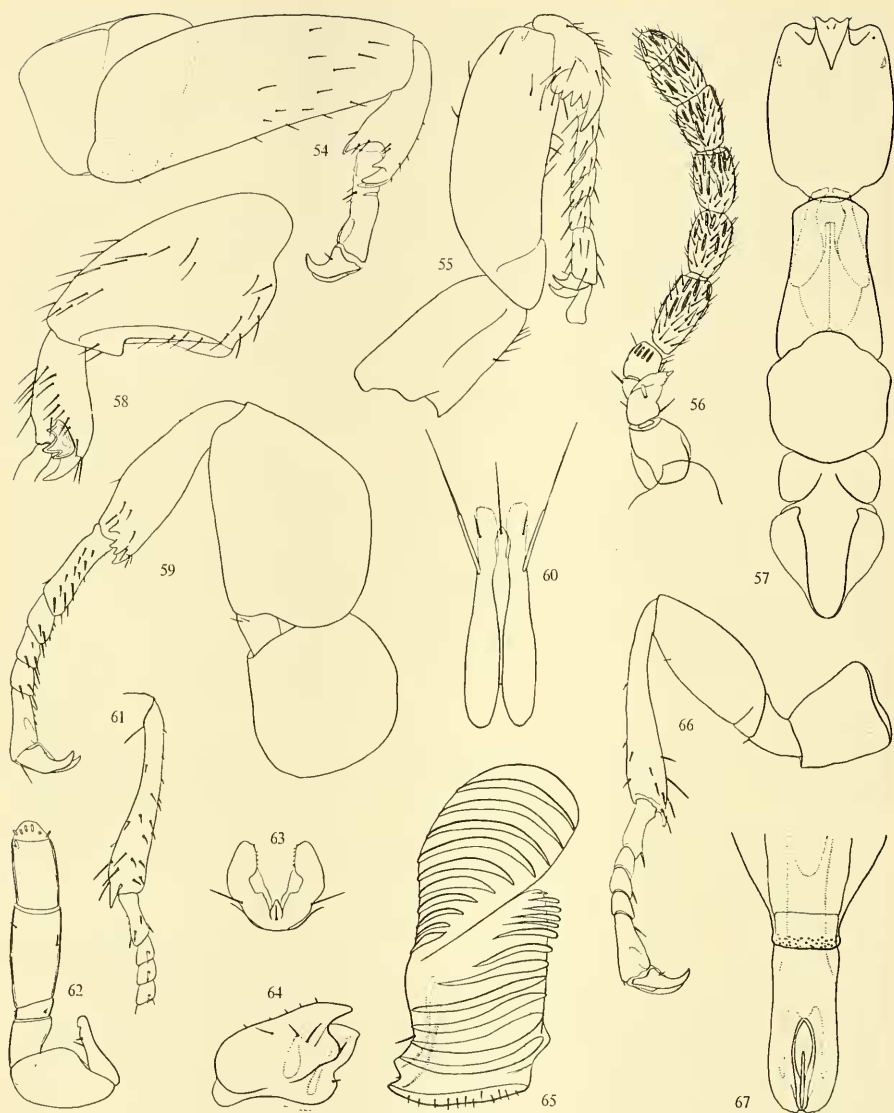
<sup>2)</sup> I saw one ♀ from the type series (S. Australian Museum, Adelaide), but the (as yet unknown) male should be studied for a definitive identification. Another Australian sample of *C. fusciceps* seen by me is: series ♀, ♂, ex *Ficus glomerata* Roxb. (= *F. racemosa* Linn.), Greenhills, Meringa (Queensland, Australia), leg. C. E. PEMBERTON, 28.XI.1921; coll. HSPA; coll. ML, no. 589; series ♀, ♂; ♀, ♂, slide 589a.

<sup>3)</sup> identification uncertain.

<sup>4)</sup> locality uncertain.

<sup>5)</sup> *Ficus acidula* King.

<sup>6)</sup> = *Ficus racemosa* Linn.



Figs. 54—67, *Ceratosolen bianchii*, Fiji, 54, male fore leg, 55, female fore leg, 56, female antenna, 57, male, 58, detail of female hind leg, 59, male hind leg, 60, female labium and maxillae, 61—64, male, 61, detail of mid leg, 62 antennae, 63, labium and maxillae, 64, mandible, 65, female mandible, 66, male mid leg, axial aspect, 67, apex of male abdomen.

Figs. 57,  $\times 40$ ; 54—56, 58, 59, 61, 66,  $\times 90$ ; 60, 62—65, 67,  $\times 115$

Five ♀, 5 ♂, ex *Ficus glomerata* Roxb. 1), Pusa, Bihar (India), leg. I. R. Durr, 2.III.1923; coll. HSPA; ♂, ♀, slide mounted.

1) = *Ficus racemosa* Linn.

One ♀, 4 ♂, India, ex coll. JOSEPH; coll. ML, no. 563; ♀, slide 563a, ♂, 563b.

Two ♀, 4 ♂, ex *Ficus glomerata* Roxb.<sup>1)</sup>, Poona (India), leg. P. VARMA; coll. USNM.

Ten ♀, 5 ♂, ex *Ficus* spec., Bangalore (India), leg. G. COMPÈRE, VIII.1907; coll. USNM.

Nine ♀, ex *Ficus glomerata* Roxb.<sup>1)</sup>, Bangalore (India), leg. D. T. FULLAWAY, 25.II.1921; coll. HSPA.

Five ♀, 8 ♂, ex *Ficus glomerata* Roxb.<sup>1)2)</sup>, Bangalore (India), II.1921; coll. HSPA.

Ten ♀, Peradeniya (Ceylon), leg. A. RUTHERFORD; coll. USNM.

One ♂, ex *Ficus glomerata* Roxb.<sup>1)</sup>, Colombo (Ceylon), leg. STAINFORTH GREEN; coll. OUM, 1 slide.

### *Ceratosolen appendiculatus* (Mayr) and *C. striatus* Mayr

In 1885, MAYR described *Blastophaga* (*Ceratosolen*) *appendiculata* from the Botanical Gardens at Bogor, Java. It was not recognized by subsequent authors, although GRANDI, in his revision of the Agaonidae (1928c), redescribed typical specimens from MAYR's collection<sup>3)</sup>.

*C. striatus* Mayr was described, in 1906, as being different from *C. appendiculatus* in the shape of the head, and in the striate head and pronotum of the male. Later, GRANDI (1917) described *C. striatus notandus*, the male of which is essentially the same as in the nominate form, but for the non-striate head and pronotum, the shape of the head, and the relative length of the antennal segments. According to GRANDI, this new form could not be identical with *C. appendiculatus*, because the female had the ovipositor three quarters the length of the gaster, whereas in *C. appendiculatus* this relative length was given by Mayr as approximately one third. In 1928, GRANDI referred *C. striatus notandus* again, with some doubts, to the nominate form.

In my opinion, *C. striatus notandus* Grandi belongs indeed in the synonymy of *C. striatus* Mayr, as I find characters of both (viz., the striate head and pronotum, and the relative proportions of the antenna) in the same specimen. Moreover, after having studied the type series of *C. appendiculatus* (Mayr), I am convinced of the identity of *C. striatus* and *C. appendiculatus*. The length of the ovipositor in the only female of *C. appendiculatus* before me is four-sevenths the length of the gaster, which falls entirely within the variability of *C. striatus*.

### *Ceratosolen appendiculatus* (Mayr)

*Blastophaga* spec., Mayer, 1882, pp. 570—571 [♀, ♂, ex *Ficus umbellata* Vahl (or *umbonata* Reinw.?)<sup>4)</sup>, Bogor (Java), Bot. Gdn., no. 8a].

<sup>1)</sup> *Ficus racemosa* Linn.

<sup>2)</sup> This sample bears another label: "*F. mysorensis*? COLEMAN's comp. Bangalore". See the remark on *Ficus mysorensis*, p. 98.

<sup>3)</sup> A sample from Calcutta, in the USNM collection identified with *Blastophaga appendiculata* Mayr, belongs to *Ceratosolen emarginatus* Mayr.

<sup>4)</sup> For a discussion of this host record, see p. 97.

*Blastophaga (Ceratosolen) appendiculata* Mayr, 1885, pp. 154, 161, 162, 164—166, Pl. XI figs. 1—2 [key ♀, ♂, descr. ♀, ♂, ex *Ficus (Sycomorus) umbellata* horti Bogor., nec Vahl (det. Solms)<sup>1</sup>], P. Mayer, no. 8a; type: ♂].

*Ceratosolen* spec., Williams, 1928, p. 12 [biological note on the wasps from *Ficus integrifolia* Elmer<sup>2</sup>], Philippine Is.].

*Ceratosolen appendiculatus*: Grandi, 1928c, pp. 176—179, figs. XXVII—XXVIII [redescr. ♀, ♂, type specimens of *B. appendiculata* Mayr].

*Ceratosolen striatus* Mayr, 1906, p. 153 [descr. (♀), ♂, ex *Ficus variegata* Bl. var., Bogor (Java), Bot. Gdn., leg. C. Aurivillius, no. 3]; Grandi, 1916a, p. 153 [♂, in key]; 1917, pp. 32—34, fig. XI [descr. ♂, ex *Ficus variegata* Bl., Bogor (Java), Bot. Gdn., leg. E. Jacobson, I.1915]; 1928c, pp. 179—180 [type specimens of *C. striatus* Mayr studied; ? = *C. striatus notandus* Grandi].

*Ceratosolen striatus notandus* Grandi, 1916a, pp. 151, 153 [♀, ♂, in key]; 1917, pp. 34—40, figs. XII—XIII [descr. ♀, ♂, ex *Ficus variegata* Bl., Bogor (Java), Bot. Gdn., leg. E. Jacobson, I.1915].

?*Ceratosolensia ficophaga* Girault<sup>3</sup>, 1915, pp. 311, 312 [descr. ♀, ♂, ex *Ficus* spec., Gordonvale (Cairns, Queensland), I, and 18.IX.1912].

### Material.

One ♀, 17 ♂, from type series of *Blastophaga appendiculata* Mayr; coll. NMW.

Series ♀, ♂, ex *Ficus variegata* Bl., Bogor (Java), Bot. Gdn., fern garden, 28.XI.1954; coll. no. 222; ♀, ♂, slide 222a.

Series ♀, ♂, ex *Ficus variegata* Bl., Bogor (Java), Bot. Gdn., 24.IX.1954; coll. no. 237; ♀, ♂, slide 237a.

Series ♀, ♂, ex *Ficus variegata* Bl., Tjiwaringin, Bogor (Java), 22.IX.1954; coll. nos. 40, 125; ♀, ♂, slide 40a.

Series ♀, ♂, ex *Ficus variegata* Bl. (det. E. J. H. CORNER), Tjibodas (Java), 30.XI.1954; coll. no. 230; ♀, ♂, slide 230a.

Fragments ♀, ♂, ex *Ficus variegata* Bl. var. *garciae* (Elmer) Corner (det. E. J. H. CORNER), Mt. Iraya (Batan I., Philippine Is.), Bur. Sci. no. 80191; coll. no. 430; ♀, ♂, slide 430a.

Series ♀, ♂, ex *Ficus integrifolia* Elmer<sup>2</sup>), Los Baños (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 17.V.1921; coll. HSPA; coll. ML, no. 593: 5 ♂; ♂, slide 593a.

Six ♂, several immature ♀, ex *Ficus variegata* Bl. var. *sycomoroides* (Miq.) Corner (det. E. J. H. CORNER), Mt. Maquiling (Luzon, Philippine Is.), Coll. Agric., Laguna, no. 592; coll. no. 409; ♂, slides 409a, b, immature ♀, 409c.

Four ♀, 4 ♂, ex *Ficus variegata* Bl., Mt. Maquiling (Luzon, Philippine Is.), "on the Calamba-trail", leg. F. X. WILLIAMS, 30.I.1922; coll. HSPA.

Series ♀, ♂, ex *Ficus variegata* Bl., Mt. Maquiling (Luzon, Philippine Is.),

<sup>1</sup>) For a discussion of this host record see p. 97.

<sup>2</sup>) = *Ficus variegata* Bl. var. *sycomoroides* (Miq.) Corner.

<sup>3</sup>) I saw 1 ♀ from the type series (Queensland Museum, Brisbane), but the male should be studied for a definitive identification. Other Australian samples of *C. appendiculatus* seen by me are:

Series ♀, ♂, ex *Ficus ebretioides* F. v. Muell. (= *Ficus variegata* Bl.), Hambleton (Queensland), leg. C. E. PEMBERTON, 6.XII.1921; coll. HSPA.

Series ♀, ♂, ex *Ficus ebretioides* F. v. Muell. (= *Ficus variegata* Bl.), Merawa (Queensland), leg. C. E. PEMBERTON, 18.XI.1921; coll. HSPA.

leg. F. X. WILLIAMS, 11 & 14.XII.1921; coll. HSPA; coll. ML, no. 592: 5 ♀, 5 ♂.

Immature ♀, ♂, ex *Ficus viridicarpa* Corner<sup>1</sup>) (det. E. J. H. CORNER), Ke-manan (Trengganu, Malaya), 23.XI.1935, Sing. F. no. 30553; coll. no. 478; immature ♀, ♂, slide 478a.

Immature ♀, ♂, fragments, ex *Ficus viridicarpa* Corner<sup>1</sup>) (det. E. J. H. CORNER, type no.), Jelebu (Negri Sembilan, Malaya), 29.X.1932, Sing. F. no. 26032; coll. no. 432; immature ♀, ♂, slide 432a, ♂, fragments, 432b.

### *Ceratosolen grandii* sp. n. (figs. 26—38)

#### Material.

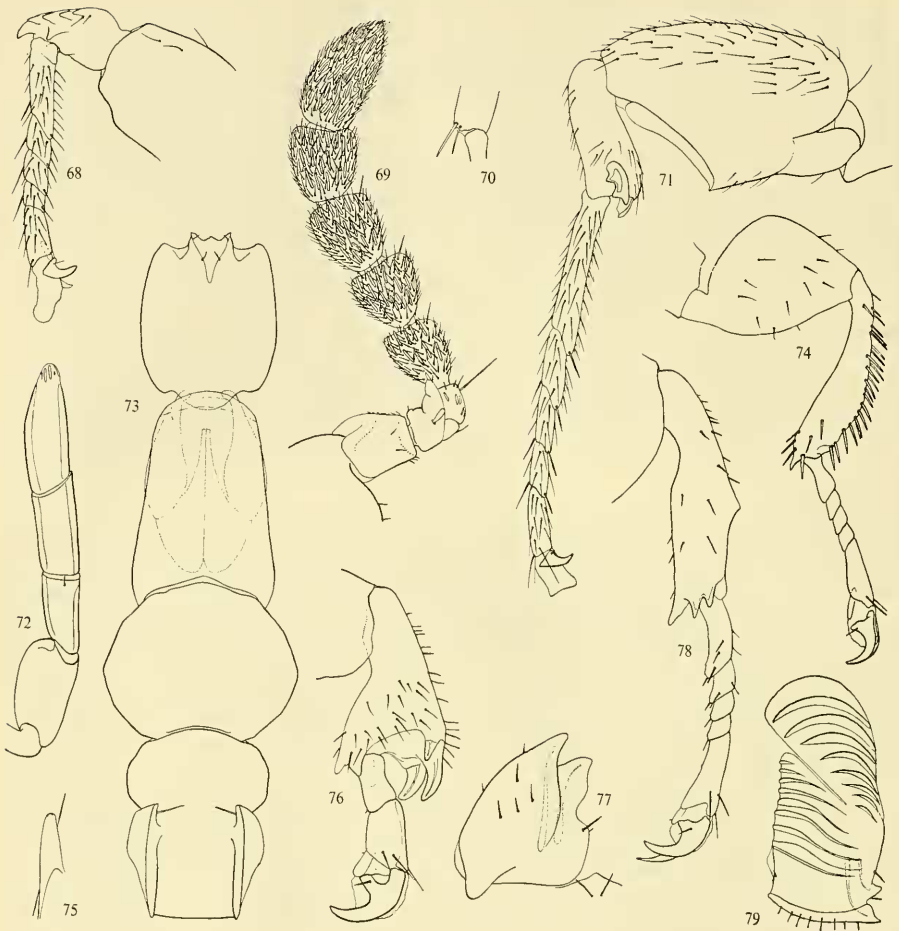
Series ♂, a few immature ♀, ex *Ficus semivestita* Corner (det. E. J. H. CORNER, type no.), Morobe district (Terr. New Guinea), 3000 ft. alt., leg. E. J. H. CORNER, 10.X.1955, NGF no. 7358; coll. no. 452; ♂ (holotype), slide 452a, ♀ (allotype), 452b.

#### Description.

Male. Head (fig. 38) nearly twice as long as wide anteriorly, and longer than its maximum width [6 : 5], with many small triangular bristles. The lateral lobes of the epistomal margin are much longer than the median one, and bear small hairs. Eyes present. Antennal grooves half closed. Antenna (fig. 37) four-segmented. Pedicel (2 : 1) two-thirds the length of the scape (2 : 1), third segment (2 : 1) somewhat longer than the pedicel, and approximately half as long as the apical segment (4 : 1). Mandible, fig. 30. Labium and maxillae, fig. 33; the maxilla bears two subbasal hairs.

Thorax, fig. 38. Pronotum only little longer than wide anteriorly, its maximum width one and a half times the length. Mesonotum wide, the length three-fifths of the width. Metanotum anteriorly nearly as wide as the mesonotum, narrower behind. Propodeum narrow and rather long, indistinctly separated from the metanotum. Tibia of the fore leg (fig. 31) half as long as the femur, tarsus nearly as long as the tibia. Tibia with two dorsal and three ventro-apical teeth; a third dorsal tooth is situated on the disk. Tarsal segments incompletely separated, the first with three conical ventral spines; the second, subequal in length to the first (measured dorsally), without spines. Mid leg, fig. 27. Tibia with one ventro-apical tooth, about as long as the femur, and but little shorter than the tarsus. Dorsal surface of the tibia provided with diverging rows of conical spines; one spine at the ventral margin. First tarsal segment nearly as long as the three following combined, with a pair of ventral spines. Fifth segment shorter than the first [2 : 3], but about twice as long as the intermediate segments. Tibia of the hind leg (fig. 32) with a bidentate ventro-apical tooth; the disk with hairs that are situated on small protuberances. First tarsal segment as long as the three following combined, with seven ventral conical spines. Second to fourth segments with three apical spines each. Fifth segment shorter than the first [3 : 5], without spines.

<sup>1</sup>) see p. 97.



Figs. 68—79, *Ceratosolen armipes*, New Guinea, 68—71, female, 68, detail of fore leg, 69, antenna, 70, detail of mid tibia, 71, hind leg, 72—78, male, 72, antenna, 73, male, 74, mid leg, 75, cercus of tenth urite, 76, detail of fore leg, 77, mandible and hypostomal margin, 78, detail of hind leg, 79, female mandible. Figs. 73,  $\times 40$ ; 68—71, 74, 76, 78, 79,  $\times 90$ ; 72, 77,  $\times 115$ ; 75,  $\times 275$

Gaster. Genitalia without cerci.

Length, 1.6 mm. Colour yellowish brown.

Female. The description is made from immature specimens taken from the gall-flowers. Head slightly longer than wide across the compound eyes. Longitudinal diameter of the eye one and a half times as long as the cheek. Antenna (fig. 28) with nine free segments. Scape large, twice as long as the pedicel. Flagellum short, with rather wide segments. Funicular segments with one row of sensilla each; the club, consisting of the apical three segments, with one complete and one in-

complete row. Mandible, fig. 36: its appendage with four transverse ridges. Labium and maxillae (fig. 34) with one apical hair each.

Thorax very much like that of *C. appendiculatus*, but scutum and scutellum with more hairs: eight and twenty, respectively. Close to the propodeal spiracle there are only a few hairs. Wings still folded; not studied. Femur of the fore leg (fig. 35) nearly as long as tibia and tarsus together. Tibia with four apical teeth visible in antaxial aspect. First tarsal segment not quite as long as the three following combined, second to fourth segments subequal, the fifth as long as third and fourth segments combined. Tarsal segments with stout ventral hairs: ten on the first, others with two apicals only, except for the fifth, which has three ventrals. Tibia of the mid leg nearly as long as femur and trochanter combined, without apical spines, but with many spines on the disk. Tarsal segments in ratio 8 : 5 : 4 : 3 : 8 (with the claws). Hind leg, figs. 26, 29. Coxa and femur subequal, length of the tibia two-thirds of that of the femur. Tibia with two apical bidentate teeth. Tarsal segments in ratio 14 : 5 : 6 : 4 : 6; all segments with rows of ventral spines (fig. 29).

Gaster. Protruding part of the ovipositor approximately half as long as the gaster.

Length, 1.6 mm.

#### Remark.

This species appears to be close to *C. appendiculatus*, judging from the structure of the female antenna, and of the male genitalia. On the other hand there are several structures in the male suggesting a close affinity to *C. fusciceps*: antenna consisting of four segments, mouthparts not atrophied.

I dedicate this species to Professor GUIDO GRANDI (Bologna), the well-known authority on fig wasps.

#### *Ceratosolen boschmai* sp. n. (figs. 39—53)

#### Material.

Series ♀, ♂, ex *Ficus salomonensis* Rech. (det. E. J. H. CORNER), Arawa, Kieta (Bougainville I.), leg. E. J. H. CORNER, X.1960; coll. no. 532; ♂ (holotype), slide 532a, ♀ (allotype), 532b, ♂, ♀ (paratypes), 532c, d.

#### Description.

Male. Head (fig. 42) approximately twice as long as wide anteriorly, maximum width two-thirds of the length. Dorsal surface with many small hairs. Lateral lobes of the epistomal margin with one apical hair. Eyes wanting. Antennal grooves half closed. Antenna (fig. 45) five-segmented; the scape (3 : 2) about twice as long as the pedicel (5 : 4), which is not quite twice as long as the next segment (5 : 3). This segment is, in some specimens, half split into two parts, in others it is entire, or shows only a small notch at the antaxial margin. Fourth segment (7 : 4) three to four times as long as the third, the apical segment (2 : 1) thrice as long as the third. Mandible, fig. 49. Labium and maxillae (fig. 50): there are three (one basal and two lateral) hairs on each maxilla.

Thorax, fig. 42. The pronotum is rather narrow, and does not quite conceal the propleurae. Posteriorly it is about twice as wide as it is anteriorly; its length is equal to the sum of the anterior and posterior widths. Mesosternum about as long as wide, with rounded lateral edges. Metanotum consisting of two ear-like plates, not quite separated in the mid line, and almost free from the long propodeum. The lateral edges of the propodeum are folded ventrally, leaving a very narrow dorsal surface; the lateral surfaces are almost wholly occupied by the large peritremata. The fore leg (fig. 52) shows a very long femur, much longer than tibia and tarsus combined [3 : 2]. Tibia (without the apical teeth) more than twice as long as the second tarsal segment, which is slightly longer than the first [6 : 5]. Tibial armature consisting of four dorsal and two ventro-apical teeth. Tarsus bimerous, the segments incompletely separated. Mid leg, fig. 46. Tibia as long as femur and trochanter combined, and but little longer than the pentamerous tarsus. Tarsal segments in ratio 7 : 3 : 3 : 3 : 5. Femur of the hind leg (fig. 44) large, tibia not much more than half as long, with three dorso-apical teeth. Tarsus pentamerous, segments in ratio 9 : 3 : 3 : 3 : 2 : 6.

Tergites of the gaster distinctly sclerotized. Genitalia (fig. 48) with cerci (four claws) and parameres (fig. 47).

Length, 1.5—1.9 mm. Colour yellowish brown, head and fore legs darker, the propodeal peritremata strikingly black-brown.

Female. Head approximately as long as wide across the eyes. Longitudinal diameter of the eye short, about four-fifths the length of the cheek. Lateral lobes of the epistomal margin rather angular. Antenna (fig. 43): the scape two and a half times as long as the pedicel, which has many minute spines on the axial surface (fig. 53). Fifth to eleventh segments with one row of oblong sensilla; the fifth with five sensilla, the sixth with six, the seventh and eighth with eight, the ninth with nine, the tenth with ten, and the eleventh with four oblong and two circular sensilla. Ninth to eleventh segments combined into a loose club. Mandible (fig. 51) with four ventral ridges, its appendage with five. Labium and maxilla, fig. 39. The bacilliform process is about half as long as the maxilla.

Thorax very finely striate, with long hairs. Scutum not quite as long as its maximum width [3 : 4], with fifteen hairs. Scutellum about as long as wide, with seven hairs on each side. Metanotum not much wider than scutellum and axillae combined, propodeum distinctly wider. Propodeal peritremata large; tufts of about ten hairs occur beneath the spiracles. Fore wing (9 : 4), 1.6 mm long; nearly the whole surface setose. Submarginal, marginal, stigmal, and postmarginal veins in ratio 22 : 6 : 7 : 11; stigmal vein with three or four pustules, submarginal vein with three. Hind wing (5 : 2), 1.0 mm long. Femur of the fore leg (fig. 40) about as long as coxa and trochanter combined, the tibia half as long, with five apical teeth — the first of which is blunt — arranged in a dorsal comb. Tarsal segments with expanded plantar edges, the first segment is distinctly longer than the fifth [7 : 5], and more than twice as long as the subequal intermediates. Tibia of the mid leg about as long as trochanter and femur combined. Tarsus pentamerous, the segments in ratio 17 : 7 : 8 : 7 : 14. Femur of the hind leg (fig. 41) with a very distinct ventral groove. Tibia with one apical axial tooth,





Figs. 80—83, *Ceratosolen abnormis*, West New Guinea, male, 80, detail of hind leg, 81, apex of abdomen, 82, mandible, 83, mid leg, axial aspect, 84—91, *C. sordidus*, Solomon I., 84, detail of female hind leg, 85—88, male, 85, mandible, 86, detail of hind leg, 87, male, 88, mid leg, 89, detail of female fore leg, 90, male antenna, 91, male fore leg. Figs. 87,  $\times 40$ ; 81, 91,  $\times 90$ ; 80, 82—86, 88—90,  $\times 115$

and a bidentate antaxial tooth. Tarsal segments in ratio 20 : 8 : 5 : 6 : 11.

Gaster. Ovipositor distinctly projecting.

Length, 1.7—2.1 mm. Colour black-brown, distal parts of the extremities lighter.

#### Remark.

*C. boschmai* is easily distinguished from its congeners by the peculiar propodeum of the male. It is a pleasure to dedicate this species to Dr. H. BOSCHMA, Professor of Systematic Zoology at Leiden University.

#### *Ceratosolen bianchii* sp. n. (figs. 54—67)

#### Material.

Series ♀, ♂, ex *Ficus* spec. ("no. 2"), Fiji I., leg. C. E. PEMBERTON, 1920; coll. HSPA, slide mounted: ♂ (holotype), ♀ (allotype), ♀, ♂ (paratypes); coll. ML, no. 598: 5 ♀, 2 ♂.

#### Description.

Male. Head (fig. 57): the width two-thirds of the length. Median lobe of epistomal margin broad. Eyes present. Antennal grooves half closed. Antenna (fig. 62) five-segmented; the scape not quite twice as long as its maximum width, the pedicel as long as the width of the scape, and half as wide. Third segment (1 : 2) annuliform, fourth and fifth segments subequal in length, the latter (2 : 1) is narrower than the former. Labium and maxillae, fig. 63; labium with one ventral hair, maxilla with one lateral hair. The maxillae are rather long; and they fold easily in the slides. Mandible, fig. 64.

Thorax, fig. 57. Pronotum approximately twice as long as wide anteriorly, wider behind. Mesonotum large; metanotum narrower, incompletely separated from the long propodeum. Propodeal peritremata large. Femur of the fore leg (fig. 54) more than twice as long as the tibia. Apical dentation of the tibia consisting of four dorsal and two ventro-apical teeth. Tarsus bimerous, though the two segments are not completely separated. Segments in ratio 5 : 7. Mid leg, figs. 61, 66. Femur longer than coxa and trochanter combined, but shorter than the tibia [8 : 11]. Tibia with a few stout hairs and spines, especially on the antaxial surface, and one ventro-apical tooth. Tarsus pentamerous, segments in ratio 9 : 3 : 4 : 3 : 12. Coxa of the hind leg (fig. 59) semiglobular, trochanter small; the femur expanded dorsally. Tibia not quite as long as the femur, with four antaxial ventro-apical teeth. Tarsus pentamerous, the segments in ratio 24 : 9 : 8 : 8 : 15.

Gaster. Genitalia (fig. 67) without cerci or parameres; apex of the aedeagus scarcely dilated.

Length, 2.0—2.1 mm. Colour uniformly dark yellow-brown.

Female. Head approximately as long as wide across the eyes. Eyes small, the longitudinal diameter distinctly shorter than the cheek [7 : 9]. Face with rather

1) As the material has been desiccated, some characters are not easily to be observed, and some must remain undescribed.

long pubescence. Antenna, fig. 561). Scape two and a half times as long as the pedicel. Fifth segment with five oblong subapical and two circular sensilla. Sixth segment twice as long as the fifth, seventh and eighth segments subequal, shorter than the sixth. Apical three (or two?) segments shaped so as to form a club, ninth and tenth segments subequal, the eleventh shorter. Sixth to eleventh segments with irregular rows of oblong sensilla. Mandible (fig. 65) with twelve ventral ridges, its appendage with ten. Labium and maxillae, fig. 60. Labium with one apical hair, maxilla with a subapical hair and a bacilliform process. The latter has not quite one third the length of the maxilla, and bears a long apical hair.

Thorax pubescent, relative proportions much as in *C. boschmai*. Propodeum with five hairs below the large peritremata. Fore wing, 2.0 mm long, more than twice as long as wide. Submarginal, marginal, stigmal, and postmarginal veins in ratio 15 : 6 : 4 : 6. Stigmal vein with four pustules, submarginal vein with three. Postmarginal vein rather robust and dark. Hind wing (6 : 1), 1.3 mm long. Fore leg (fig. 55): femur and trochanter together as long as tibia and tarsus combined, and not quite twice as long as the coxa. Apical dentation of the tibia consisting of five teeth, the ventral one of which is blunt; the dorsal one is the longest. Tarsus five-segmented; first and fifth segments subequal in length, fourth segment approximately half as long, second and third segments shorter, subequal. Coxa of the mid leg semiglobular; the trochanter small, the femur thrice as long; the tibia a little longer than the femur, with one ventro-apical spur. Tarsal segments in ratio 42 : 20 : 21 : 16 : 25. Hind leg, fig. 58. Femur with a distinct ventral groove. Antaxial apical tooth of the tibia tridentate (the median tooth the longest); the axial apical tooth long and curved. Tarsal segments in ratio 15 : 7 : 5 : 4 : 7, rather pubescent.

Gaster. Ovipositor slightly projecting beyond the apex of the gaster.

Length, 2.3 mm. Colour olive-brown, thorax and apical part of the gaster darker.

#### Remark.

This species appears to be close to *C. boschmai*, but it differs in the relative proportions of the male thorax, the absence of cerci and parameres from the male genitalia, the female antenna, the dentation of the fore and hind tibiae, etc.

I have great pleasure in naming the new species after F. A. BIANCHI, Principal Entomologist, Experiment Station, HSPA, Honolulu, who gave much help by making F. X. WILLIAMS' collection of fig wasps available for examination.

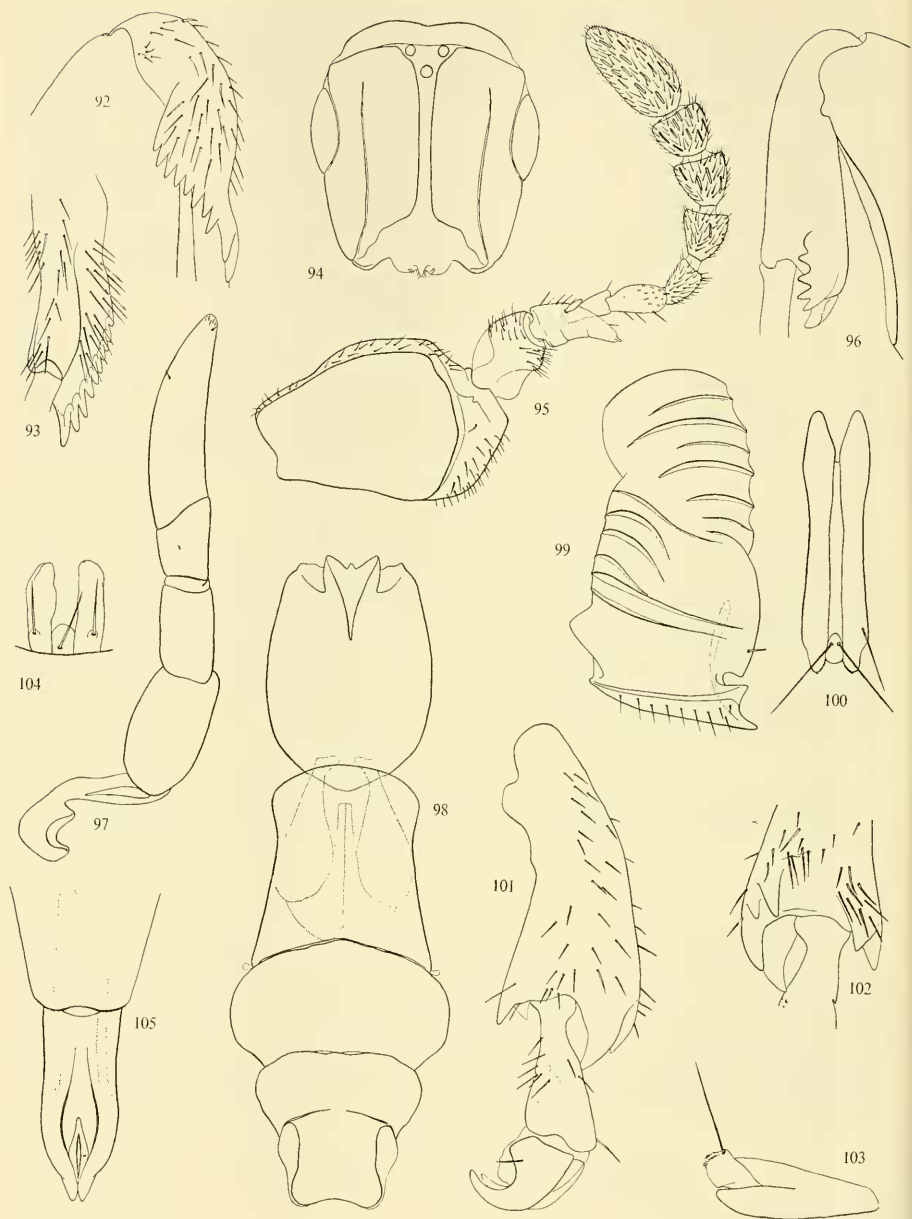
#### *Ceratosolen armipes* sp. n. (figs. 68—79)

#### Material.

Series ♀, ♂, ex *Ficus itoana* Diels (det. E. J. H. CORNER), Wau (Terr. New Guinea), 3000 ft. alt., leg. E. J. H. CORNER, 13.IX.1960; coll. no. 546; ♂ (holotype), slide 546a, ♀ (allotype), 546d, ♀, ♂ (paratypes), 546b, c, e.

#### Description.

Male. Head (fig. 73) nearly rectangular, longer than wide [5 : 4]. Dorsal



Figs. 92—103, *Ceratosolen abnormis*, West New Guinea (94, 103: specimens from East New Guinea), 92—96, female, 92, detail of fore leg, 93, fore tibia, axial aspect, 94, head, 95, antenna, 96, detail of hind leg, 97, male antenna, 98, male, 99, female mandible, 100, female labium and maxillae, 101—103, male, 101, detail of fore leg, axial aspect, 102, apex of fore tibia, 103, labium and maxillae, lateral aspect, 104—105, *C. bakeri*, Luzon, male, 104, labium and maxillae, 105, apex of abdomen. Figs. 94, 98,  $\times 40$ ; 95,  $\times 90$ ; 92, 93, 96, 97, 99—103, 105,  $\times 115$ ; 104,  $\times 160$

surface anteriorly with small hairs. Epistomal margin broadly tridentate, the lateral lobes with one subapical hair, and one hair at mid length. Antennal grooves half closed. Antenna (fig. 72) four-segmented. Pedicel (2 : 1) two-thirds the length of the scape (2 : 1), and little shorter than the third segment (2 : 1). Apical segment (14 : 5) nearly one and a half times as long as the third segment. Mandible, fig. 77. Labium and maxillae atrophied, the hypostomal margin with two long hairs.

Thorax, fig. 73. Pronotum approximately twice as long as wide anteriorly, the posterior width two-thirds of the length. Mesonotum sub-oval, wider than long [5 : 4]. Metanotum narrower than the mesonotum, about twice as wide as long. Propodeum incompletely separated from the metanotum, longer than wide [13 : 9], with the large spiracular peritremata protruding laterally. Fore leg, fig. 76. Femur twice as long as the tibia. Tibia with three dorsal and three ventro-apical teeth. Tarsus bimerous, segments in ratio 7 : 8. Tibia of the mid leg (fig. 74) longer than the femur [5 : 4], the ventro-apical edges produced; the dorsal edge with many stout spines, which also occur on the axial and antaxial disks, and at the ventral apex. Tarsus pentamerous, segments in ratio 14 : 5 : 5 : 5 : 16. Tibia of the hind leg (fig. 78) shorter than the large femur [8 : 11], with three ventro-apical teeth. Dorsal edge produced at mid length. Tarsus pentamerous, segments in ratio 21 : 7 : 5 : 5 : 19, with ventral protuberances and few hairs.

Gaster. Tergites weakly sclerotized. Genitalia with very small, hyaline cerci (fig. 75), which seem to bear two claws.

Length, 2.2—2.3 mm. Colour dark brown.

Female. Head approximately as long as wide across the eyes. Longitudinal diameter of the eye not quite as long as the cheek. Pubescence scattered, denser towards the inner rims of the eyes. Antenna (fig. 69) rather short, the scape large, nearly thrice as long as the pedicel. Axial surface of the pedicel with about one hundred and fifty small spines. Fifth segment with six short sensilla. The other segments bear two to three irregular rows of small sensilla, and they are heavily pubescent. Sixth to ninth segments subequal, tenth and eleventh segments united into a club. Mandible (fig. 79), and its appendage, with eight ventral ridges. The labium bears two long apical hairs.

Thorax. Pronotum wide. Scutum as long as wide at mid length, wider anteriorly, and tapering behind. Width of the scutellum four-fifths of the length; scutellum with about twenty hairs. Metanotum with a few lateral hairs. Propodeum with ten hairs next to the spiracular peritremata, and four larger hairs beneath. Fore wing (2 : 1), 2.1 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 9 : 3 : 2 : 6. Submarginal vein with two pustules, stigmal vein with three. Hind wing (7 : 2), 1.2 mm long. Wings pubescent. Fore leg, fig. 68. Femur more than one and a half times as long as the coxa, and nearly twice as long as the tibia. Tibia apically with a dorsal comb of five teeth, the first of which is blunt. Tarsus pentamerous, rather pubescent, segments in ratio 5 : 2 : 2 : 1 : 3. Tibia of the mid leg nearly as long as trochanter and femur combined, with two apical spurs (fig. 70). Tarsal segments in ratio 16 : 7 : 6 : 4 : 8. Hind leg, fig. 71: the femur about one and a half times as long as the coxa, and nearly twice as long

as the tibia. Ventral edge of the femur with a distinct groove. Apex of tibia with a shovel-shaped axial tooth and a three-dentate antiaxial tooth. Tarsus pubescent, segments in ratio 16 : 7 : 6 : 5 : 7.

Gaster. Projecting part of the ovipositor approximately one third the length of the gaster.

Length, 2.0—2.3 mm. Colour dark brown, with lighter extremities.

#### Remark.

*C. armipes* is remarkable in having, among other differential characters, the armature of the male mid leg rather heavy, the propodeum of a peculiar shape, and the apical two segments of the female antenna united into a club. Apparently, it is related to *C. boschmai*, *C. bianchii*, and *C. sordidus*, and to some extent also to *C. abnormis*.

### *Ceratosolen sordidus* sp. n. (figs. 84—91)

#### Material.

Series ♂, 1 immature ♀, ex *Ficus cynaroides* Corner (det. E. J. H. CORNER), Bougainville I. (Solomon Is.), leg. J. K. L. WATERHOUSE, 1933, no. 845; coll. no. 552; ♂ (holotype), slide 552b, ♂ (paratype), 552a, ♀, ♂ (allotype and paratype, in copula), 552c.

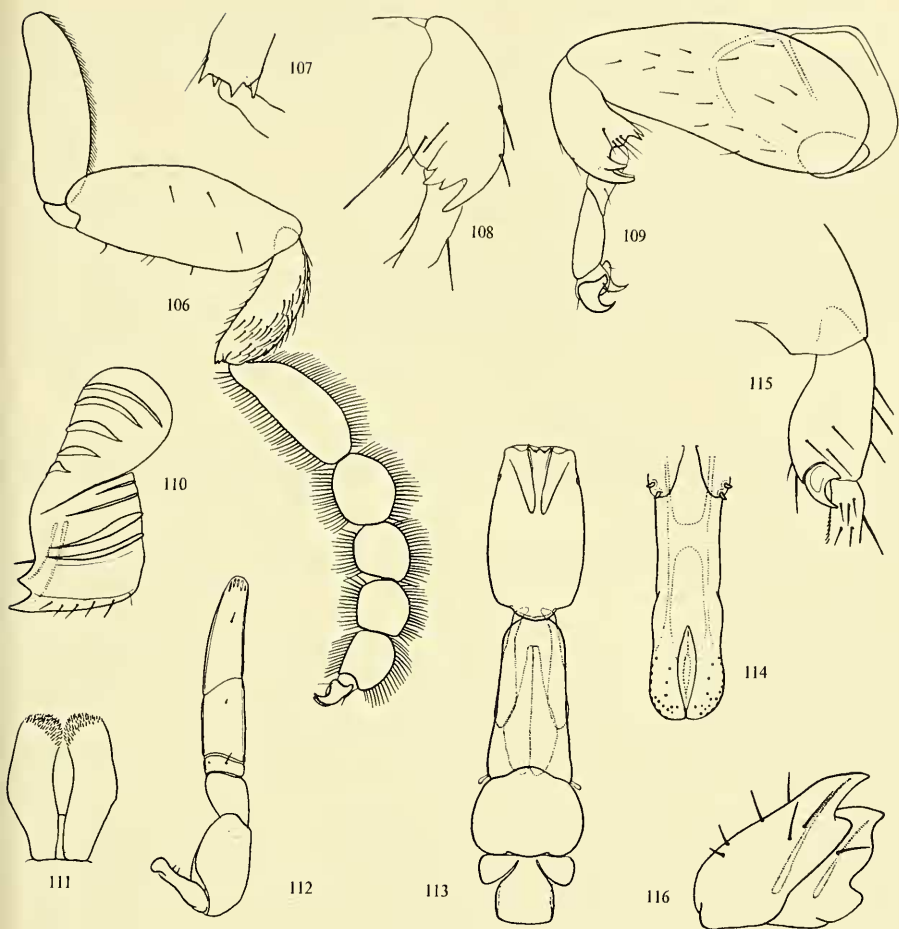
#### Description.

Male. Head (fig. 87): width at mid length three quarters of the length, slightly narrower in front and behind. Lateral lobes of the epistomal margin wide. Eyes absent. Antennal grooves half closed. Antenna (fig. 90) five-segmented; the scape (9 : 5) one and a half times as long as the pedicel (2 : 1), third segment annuliform. Fourth segment (15 : 8) shorter than the apical segment (19 : 8), which is approximately as long as the scape. Mandible, fig. 85. Labium and maxillae present, but not clearly visible in the badly preserved material.

Thorax, fig. 87. Pronotum nearly twice as long as wide anteriorly, and not much longer than wide posteriorly. Mesonotum transverse, incompletely separated from the metanotum, and about as wide. Metanotum and propodeum narrowly fused; propodeum more than twice as long as wide, with large spiracular peritremata. Fore leg, fig. 91. Femur more than twice as long as the tibia, which bears two apical teeth at the ventral edge, and four at the dorsal edge. Tarsus bimerous, segments subequal. First segment with small ventral spines. Femur and tibia of the mid leg (fig. 88) subequal in length; the tibia with a few dorsal spines, the ventral edge produced. Tarsus pentamerous, with stout ventral spines on the first four segments; the segments in ratio 10 : 3 : 4 : 3 : 8. Tibia of the hind leg (fig. 86) with four apical teeth, and with small spines along the dorsal edge. First four tarsal segments with ventral spines and small protuberances; the segments in ratio 15 : 5 : 4 : 4 : 12.

Gaster. The genitalia seem to bear no cerci, but the state of preservation does not permit of a close examination.

Length, 1.0—1.1 mm.



Figs. 106—116, *Ceratosolen gracilis*, Luzon, 106, male hind leg, 107, apex of male mid tibia, 108, detail of female fore leg, 109, male fore leg, 110, female mandible, 111—114, male, 111, labium and maxillae, 112, antenna, 113, male, 114, apex of abdomen, 115, detail of female hind leg, 116, male mandible. Figs. 113,  $\times 50$ ; 106,  $\times 80$ ; 109,  $\times 115$ ; 107, 110, 112, 115,  $\times 155$ ; 108, 114, 116,  $\times 215$ ; 111,  $\times 365$

Female. The immature female specimen is badly preserved. Some characteristics are: the antennal club consists of the apical three segments, which, however, are not completely fused; the fore tibia (fig. 89) and the fore and hind tarsi are heavily armed with spines; the hind tibia (fig. 84) bears an apical armature, which is shaped as in the other species related to *C. armipes*.

#### Remark.

Although the specimens are badly preserved, and the new species could not be described in full, *C. sordidus* is easily recognized by the shape of the male head and thorax, and by the armature of male and female legs.

**Ceratosolen bakeri** Grandi (figs. 104 and 105)

*Ceratosolen bakeri* Grandi, 1927a, pp. 312—314, Pl. 2 figs. 18—25, Pl. 3 figs. 26—32 [descr. ♀, ♂, ex *Ficus pseudopalma* Blanco, Los Baños (Luzon, Philippine Is.), leg. C. F. Baker]; Williams, 1928, pp. 12—13 [biological note].

**Material.**

Series ♀, ♂, ex *Ficus pseudopalma* Blanco, Los Baños (Luzon, Philippine Is.), leg. C. F. BAKER; coll. USNM.

Series ♀, ♂, ex *Ficus pseudopalma* Blanco, Manila (Luzon, Philippine Is.), leg. WESTER, 30.IV.1919; coll. HSPA; coll. ML, no. 591: 2 ♀, 2 ♂.

Fragments of 2 ♀, ex *Ficus pseudopalma* Blanco (det. E. J. H. CORNER), Phil. Nat. Herb. no. 16894; coll. ML, slide no. 385a.

**Description** — Additional note.

Male. Labium and maxillae (fig. 104) with one long hair each. Genitalia (fig. 105) without cerci.

**Ceratosolen abnormis** sp. n. (figs. 80—83; 92—103)**Material.**

Two immature ♀, 6 ♂, ex *Ficus dammaropsis* Diels (det. E. J. H. CORNER), Begowri River (N.W. New Guinea), leg. GJELLERUP, no. 207; coll. no. 408; ♂ (holotype), slide 408a, ♀ (allotype), 408d, ♂ (paratypes), 408b, c.

One immature ♀, ex *Ficus dammaropsis* Diels (det. E. J. H. CORNER), Albatros Bivak (West New Guinea), leg. W. M. DOCTERS VAN LEEUWEN, no. 9162; coll. no. 394.

Three ♀, series ♂, ex *Ficus dammaropsis* Diels var. *obtusa* Corner, Aiyura (Terr. New Guinea), Highland Experiment Station, leg. J. H. ARDLEY, 5.IX. 1961; coll. no. 575; ♀, ♂ (paratypes), slides 575a, b, c.

**Description.**

Male. Head (fig. 98) one third longer than its maximum width and a little over twice as long as wide anteriorly. Eyes absent. Epistomal margin with two large, wide lateral lobes; the median lobe is smaller. Lateral lobes with many small hairs. Antennal grooves half closed. Antenna (fig. 97) five-segmented; scape (15 : 8) one and a half times as long as the pedicel (5 : 3); third segment annuliform. Fourth segment (4 : 3) shorter than the pedicel, and about one third the length of the apical segment (11 : 3). Mandible, fig. 82. Labium and maxillae (fig. 103); labium with one (coll. no. 575) or three (coll. no. 408) hairs.

Thorax, fig. 98. Pronotum little longer than wide posteriorly. Anterior width nearly three quarters of the length. Mesonotum very wide, distinctly more than twice as wide as long. Metanotum narrower, about as wide as the pronotum posteriorly, incompletely separated from the propodeum. Propodeum approximately as long as wide, with large peritremata. Fore leg, figs. 101, 102. Femur nearly twice as long as the tibia. Tibia with four dorso-apical teeth, and two ventral



teeth. Tarsal segments fused, with a small ventral notch reminding one of the usual bimerous condition. Trochanter of the mid leg (fig. 83) half as long as the coxa, the femur not quite as long as the tibia. Tarsus pentamerous, segments in ratio 32 : 12 : 11 : 18 : 50. Coxa and tibia of the hind leg (fig. 80) subequal in length, the femur is considerably longer. Tibia with three apical teeth at the ventral edge, the relative proportions of which vary in the various samples. Tarsus with stout ventral hairs; first segment approximately thrice as long as the second, second to fourth segments subequal, the fifth segment, including the claws, two and a half times as long as the first.

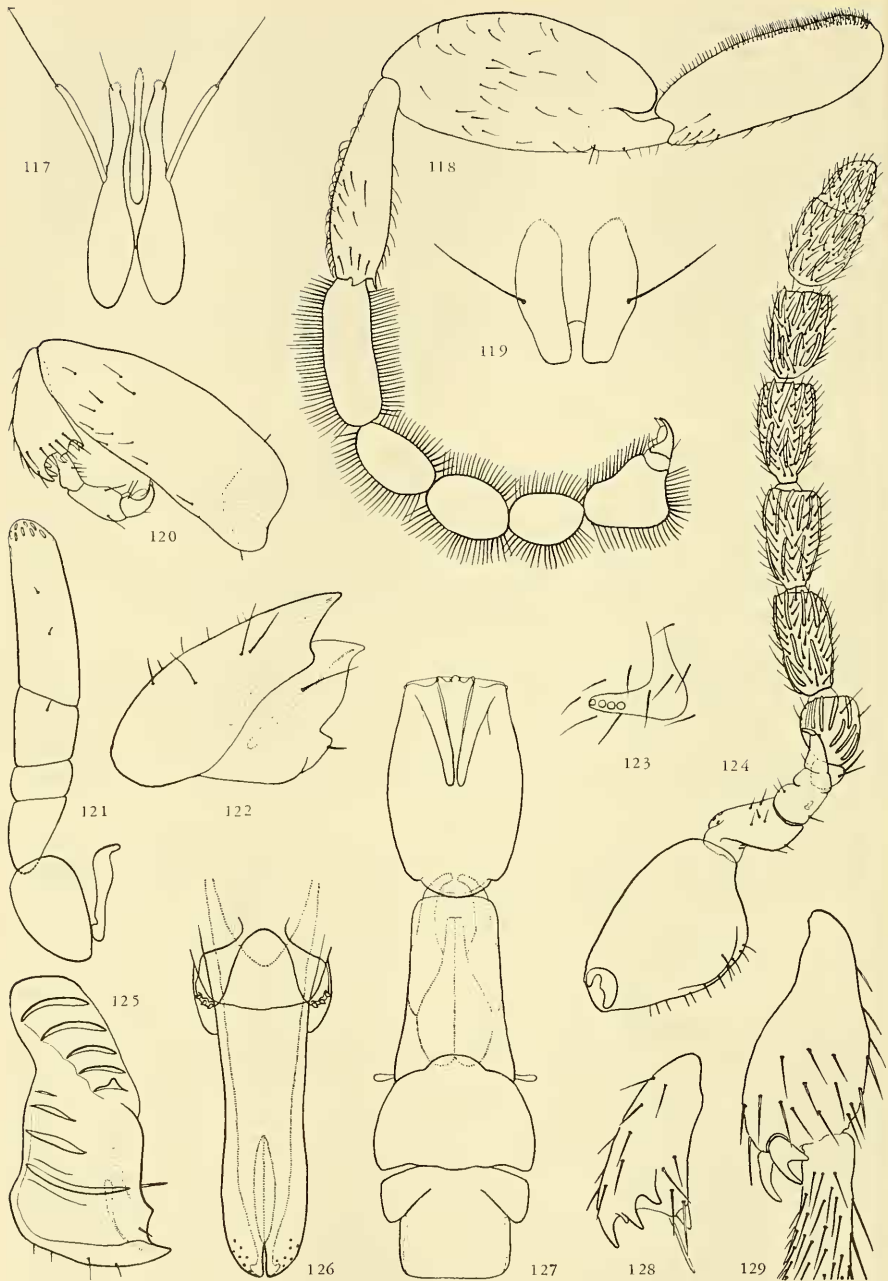
Gaster. Tenth urite, and aedeagus: fig. 81. The genitalia are different from the normal type in having very large parameres. The apodemae aedeagales are rather short and robust.

Length, 2.2 mm. Colour dark brown.

Female. The description was originally made from immature specimens (coll. no. 408), but it was later completed from the mature specimens of sample no. 575.

Head (fig. 94) approximately as long as wide across the eyes. Longitudinal diameter of the eye slightly shorter than the cheek. Antenna (fig. 95) rather short. Scape large, thrice as long as the pedicel. Third segment rather robust, fourth and fifth segments long and slender, the fifth with circular sensillar pits in the apical half. Sixth segment without sensilla, seventh segment with one oblong sensillum. Eighth and ninth segments wide, with two incomplete, irregular rows of sensilla; apical two segments united into a club, with irregular rows of sensilla. Mandible (fig. 99), and its appendage, with six ventral ridges. Labium with two hairs: maxillae in most specimens without hairs, in one specimen (575a) there is one lateral hair on one side only (fig. 100).

Thorax. Pronotum large, approximately twice as wide as long. Scutum not much shorter than wide anteriorly, glabrous. Scutellum as long as wide posteriorly, narrower in front; with about fifteen to twenty hairs. Metanotum short, lateral parts longer, with fifteen hairs. Propodeum large, nearly half as long as wide; spiracles concealed from dorsal view by antero-lateral expansions. Many long hairs occur next to and beneath the peritremata. Fore wing (5 : 2), 2.9 mm long. Surface pubescent, except for some glabrous parts near the base of the wing; with indistinct darker striae radiating from base and stigma. Submarginal, marginal, stigmal, and postmarginal veins in ratio 24 : 6 : 6 : 13. Postmarginal vein distinctly enlarged apically. Submarginal and stigmal veins with three pustules each. Hind wing (4 : 1), 1.65 mm long. Fore leg (fig. 92): femur not quite as long as tibia and tarsus combined. The tibia bears an apical row of eight to ten teeth, the dorsal one of which is particularly long. As seen on the axial side (fig. 93), the tibia appears to be a very slender segment, dorso-antaxially broadened into the wing-shaped shield bearing the apical teeth. Tarsal segments in ratio 14 : 5 : 6 : 9 : 11. Tibia of the mid leg not much longer than the femur, and as long as the tarsus. Tarsal segments in ratio 10 : 6 : 5 : 5 : 8 (including the claws). Hind leg, fig. 96. The femur has a distinct ventral groove. Apically, the tibia bears a quadridentate appendage at the antaxial edge, and a spade-shaped tooth at the axial edge. Tarsal segments in ratio 14 : 5 : 4 : 3 : 6 (including the claws).



Figs. 117—129, *Ceratosolen hooglandi*, New Guinea, 117, female labium and maxillae, 118—122, male, 118, hind leg, 119, labium and maxillae, 120, fore leg, axial aspect, 121, antenna, 122, mandible, 123—125, female, 123, stigmal vein of fore wing, detail, 124, antenna, 125, mandible, 126, apex of male abdomen, 127, male, 128, female fore tibia, 129, detail of female hind leg. Figs. 127,  $\times 60$ ; 118, 120,  $\times 95$ ; 124,  $\times 135$ ; 117, 123, 125, 128, 129,  $\times 185$ ; 121, 122, 126,  $\times 255$ ; 119,  $\times 315$

Gaster. The projecting part of the ovipositor three quarters the length of the gaster; the sheaths robust.

Length, 2.35 mm. Colour black-brown; wings infuscated.

#### Remark.

The female of *C. abnormis* is abnormal in various aspects (e.g., the antenna, dentation of fore and hind tibiae), but the species shows some resemblance to *C. armipes* and relatives.

There is some variation between the specimens from West and East New Guinea, to which more attention should be given when more and better material becomes available.

#### *Ceratosolen crassitarsus* (Mayr)

*Blastophaga (Ceratosolen) crassitarsus* Mayr, 1885, pp. 154, 161, 163, 171—172, Pl. XI fig. 7 [key ♀, ♂, descr. ♀, ♂, ex *Ficus (Cystogyne) Ribes* Reinw. (det. Colms), Sukawana (Tangkuban Prahau, near Bandung, Java), leg. H. Solms-Laubach; type: ♂].

*Ceratosolen crassitarsus*: Grandi, 1916a, pp. 150, 152 [♀, ♂, in key, Java]; 1917, pp. 40—46, figs. XIV—XV [descr. ♀, ♂, ex *Ficus ribes* Reinw., Tjibodas (Java), Bot. Gdn., leg. J. Boldingh, II.1915]; 1928c, p. 172 [type specimens studied].

#### Material.

Six ♀, ex *Ficus ribes* Reinw., Tjibodas (Java), leg. J. H. DE GUNST, 5.XI.1954; coll. no. 94.

Series ♀, ♂, ex *Ficus ribes* Reinw., Tjibodas (Java), 20 & 23.XII.1954; coll. no. 145; ♂, slide 145a.

#### Remark.

For the records of *C. ? crassitarsus*: Grandi (1923a, p. 299; 1927b, p. 174), see p. 83.

#### *Ceratosolen gracilis* sp. n. (figs. 106—116)

#### Material.

Series ♂, ex *Ficus ribes* Reinw. var. *cuneata* (Miq.) Corner (det. E. J. H. CORNER), Mt. Pinatubo (Prov. Pampanga, Luzon, Philippine Is.), ELMER no. 21980; coll. no. 401; ♂ (holotype), slide 401a, ♂ (paratypes), 401b.

Series ♀, ♂, ex *Ficus ? merrilli*<sup>1</sup>), Mt. Maquiling (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 11.V.1921, no. 202; coll. HSPA, ♀ (allotype and paratypes), and ♂ (paratypes) slide mounted; coll. ML, no. 681: 10 ♀, 10 ♂.

Series ♀, ♂, ex *Ficus merrilli*<sup>1</sup>), Mt. Maquiling (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 11.V.1921, no. 303; coll. HSPA, ♀ (paratype) slide mounted.

Series ♀, ♂, ex *Ficus ribes*<sup>2</sup>), Mt. Maquiling (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 10.V.1921, no. 404; coll. HSPA.

Seven ♀, 6 ♂, ex *Ficus ribes*<sup>2</sup>), Mt. Maquiling (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 26.XI.1921; coll. HSPA.

<sup>1</sup>) *Ficus merrilli* Elmer = *F. ribes* Reinw. var. *cuneata* (Miq.) Corner.

<sup>2</sup>) True *Ficus ribes* Reinw. does not occur in the Philippines.

### Description.

Male. Head (fig. 113) more than twice as long as wide anteriorly, its maximum width nearly two-thirds of the length. Lateral lobes of the epistomal margin rather sharp. Pubescence sparse and short. Eyes distinct. Antennal grooves open, wide behind. Antenna (fig. 112) five-segmented; scape (2 : 1) slightly more than one and a half times as long as the pedicel (2 : 1), the first flagellar segment short, about one fifth the length of the second (10 : 7), which is three quarters the length of the apical segment (8 : 3). Mouthparts, figs. 111, 116.

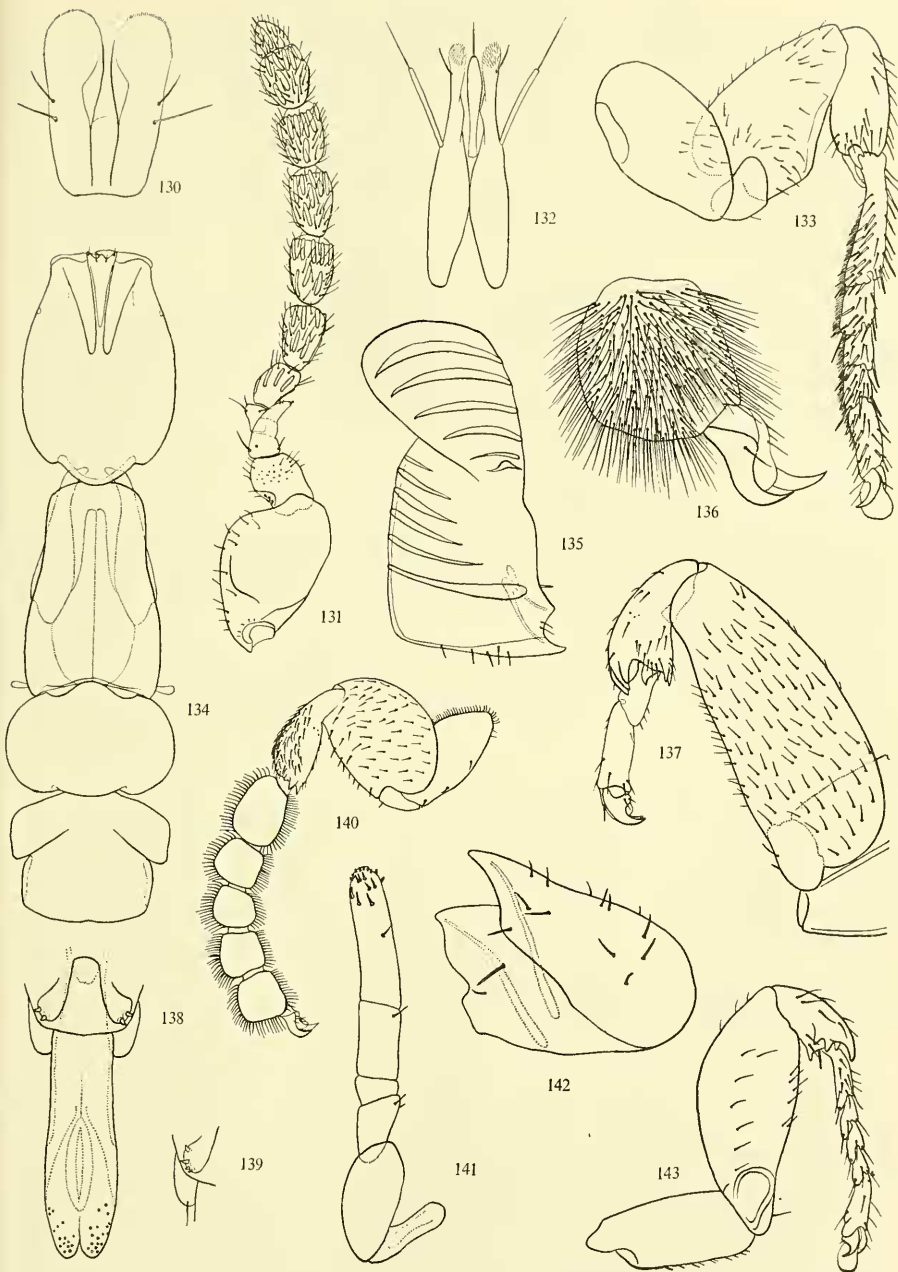
Thorax, fig. 113. Pronotum more than two and a half times as long as wide anteriorly, and twice as long as its maximum width. Mesonotum wider than long [5 : 4]. Metanotum not quite as wide as the mesonotum, and incompletely separated from the propodeum, which is nearly as long as wide. Fore leg (fig. 109): femur more than twice as long as the tibia. Tibial armature consisting of four dorso-apical teeth, one of which is very small, and two ventral teeth. Tarsal segments in ratio 5 : 6. Mid leg slender, the coxa nearly as long as trochanter and femur combined, and as long as the clavate tibia. The tibia apically armed with a series of sharp teeth (fig. 107). Tarsus pentamerous, the first segment slightly longer than the fifth [14 : 13], the intermediates subequal, not quite half as long as the fifth [5 : 12]. Hind leg (fig. 106) rather long, the femur as long as coxa and trochanter combined; all these segments slender. Tibia nearly two-thirds the length of the femur, with a dorsal hyaline ridge. Ventro-apical armature and pubescence as in the figure. Tarsus dilated, the first segment as long as the tibia, the second half as long; third to fifth segments subequal, two-thirds the length of the second. Pubescence half as long as the width of the segments.

Gaster. Cerci of the tenth urite with two claws, aedeagus slightly dilated subapically and apically (fig. 114).

Length, 1.1 mm. Colour uniformly yellow-brown.

Female. Antenna consisting of eleven segments, of which the apical two form a loose club. Scape approximately twice as long as the pedicel, appendage of the third segment rather short and robust. Fifth segment three quarters the length of the seventh, the eighth segment slightly longer than the seventh, ninth to eleventh segments gradually diminishing in size. The funicular segments bear two irregular rows of long sensilla. Maxilla without a bacilliform process, but with a long, subapical hair. Mandible (fig. 110) with four ventral ridges, its appendage with five ridges.

Thorax. A few hairs occur above and beneath the propodeal spiracle. Fore wing (2 : 1), 1.4 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 20 : 7 : 7 : 11, the submarginal vein with three pustules, the stigmal vein with four pustules. Hind wing (4 : 1), 0.8 mm long. Coxa of the fore leg (fig. 108) two-thirds the length of the femur, the tibia not quite half as long as the femur. Tibial armature consisting of four dorsal teeth. Tarsal segments approximately in ratio 11 : 7 : 5 : 4 : 5. Mid leg slender, the subclavate tibia not quite as long as femur and trochanter combined. First tarsal segment twice as long as the second, second to fifth segments subequal. Hind leg (fig. 115): length of the coxa two-thirds of that of the femur, which is not nearly twice as long as the



Figs. 130—143, *Ceratosolen vehtii*, Java (139, specimen from Sumatra), 130, male labium and maxillae, 131—133, female, 131, antenna, 132, labium and maxillae, 133, hind leg, 134, male, 135, female mandible, 136—142, male, 136, fifth tarsal segment of hind leg, 137, fore leg, 138, apex of abdomen, 139, cercus of tenth urite and paramere, specimen from Sumatra, 140, hind leg, 141, antenna, 142, mandible, 143, female fore leg. Figs. 134, 140,  $\times 50$ ; 131, 133, 137, 143,  $\times 80$ ; 132, 135, 141,  $\times 155$ ; 138, 139, 142,  $\times 215$ ; 130, 136  $\times 265$

tibia [12 : 7]. The antaxial tibial tooth is bidentate; the axial tooth, usually found in the species of *Ceratosolen*, is lacking in all specimens studied. Tarsus pubescent, especially along the plantar edge, the segments with heavy ventro-apical spines. Tarsal segments approximately in ratio 25 : 5 : 5 : 4 : 5.

Gaster. The ovipositor distinctly projecting beyond the apex of the gaster. Length, 1.3—1.4 mm.

#### Remark.

Due to the fact that the samples have been desiccated, this species could not be described and figured in the usual detail. Notably the chaetotaxy must for the greater part remain undescribed. Yet, *C. gracilis* is easily recognizable by its size, by the relatively long hind legs of the male, and by the absence of a bacilliform process from the female maxilla.

#### *Ceratosolen hooglandi* sp. n. (figs. 117—129)

#### Material.

Series ♀, ♂, ex *Ficus bernaysii* King (det. E. J. H. CORNER), Mawan Village (Gogol Valley, Madang distr., Terr. New Guinea), leg. R. D. HOOGLAND, 16.VI.1955, no. 4890; coll. no. 362; ♂ (holotype), slide 362a, ♀ (allotype), 362c, ♂, ♀ (paratypes), 362b, d.

Series ♀, ♂, ex *Ficus bernaysii* King (det. E. J. H. CORNER), Lae (Terr. New Guinea), Busu River, leg. E. J. H. CORNER, 8.IX.1960, NGF 12471; coll. no. 517.

#### Description.

Male. Head (fig. 127) more than twice as long as wide anteriorly, and one and a half times as long as its maximum width. Pubescence short and sparse. Epistomal margin with four short hairs. Eyes absent. Antennal grooves open, not very wide behind. Antenna (fig. 121) consisting of five segments. Pedicel (5 : 3) more than half as long as the scape (8 : 5); the first funicular segment (5 : 8) half as long as the pedicel, the second flagellar segment (5 : 4) half as long as the first; the apical segment (3 : 1) more than twice as long as the second. Mandible, fig. 122. Maxilla and labium, fig. 119; maxilla with one lateral hair.

Thorax, fig. 127. Pronotum nearly twice as long as wide anteriorly; the maximum width four-fifths of the length. Length of the mesonotum three quarters of the width. Metanotum incompletely separated from the propodeum, slightly narrower than the mesonotum. Tibia of the fore leg (fig. 120) not nearly half as long as the femur, with three large dorsal and three ventro-apical teeth. Second tarsal segment slightly longer than the first. Coxa of the mid leg as long as the femur, tibia nearly as long as femur and trochanter combined. Tibia with only one inconspicuous apical tooth. Tarsal segments in ratio 3 : 1 : 1 : 1 : 3. Hind leg, fig. 118. Coxa and tibia shorter than the femur [7 : 8]. Tibia one third longer than the first tarsal segment, which is as long as third and fourth segments combined. Second, third, and fifth segments subequal, fourth smaller. Tarsal pubescence distinctly shorter than half the width of the segments; dilatation not very wide.

Gaster. Cerci of the tenth urite with three short claws, aedeagus not dilated at apex (fig. 126).

Length, 1.4 mm. Colour uniformly yellowish brown.

Female. Head longer than wide between the external margins of the eyes [10 : 9]. Longitudinal diameter of the eye little shorter than the cheek. Pubescence rather long. Antenna (fig. 124): the scape relatively small, about as long as third to fifth segments combined. Pedicel slender, and little more than one third the length of the scape. Fourth segment very small, the fifth more than twice as long. Sixth segment more than one and a half times as long as the fifth, seventh to tenth segments gradually diminishing in size; the eleventh as long as the fifth. Funicular segments with two rows of long narrow sensilla. Mandible (fig. 125) with four ventral ridges; the appendage shorter than the mandible, with five ridges. Maxilla (fig. 117) with a long bacilliform process, which is nearly half as long as the maxilla. Maxilla as well as its process with a long hair; labium without hairs.

Thorax slender, its parts with many long hairs. Scutum as long as wide anteriorly, with approximately ten hairs on each side. Scutellum little longer than wide anteriorly, with lateral rows of fifteen to twenty hairs. Metanotum with five hairs on each side of the mid-line. Propodeum wide; little groups of hairs are situated above and beneath the spiracle. Forewing (7 : 3), 1.4 mm long. Submarginal, marginal, stigmal, and postmarginal veins approximately in ratio 30 : 9 : 11 : 17. Submarginal vein with three pustules, stigmal vein (fig. 123) with four. Hind wing (5 : 1), 0.8 mm long. Fore leg, fig. 128. Coxa nearly as long as the femur, tibia half as long. Tibia with four teeth along the dorsal edge, ventral edge with one tooth. Tarsal segments in ratio 3 : 2 : 2 : 2 : 3. Mid leg slender, tibia shorter than trochanter and femur combined [7 : 8]; tarsal segments in ratio 12 : 5 : 4 : 4 : 7. Coxa and femur of the hind leg (fig. 129) subequal in length, the tibia shorter [8 : 11]. Tibia with the usual two apical teeth, the one bidentate, and the other unidentate. First tarsal segment as long as the tibia, and nearly thrice as long as the fifth tarsal segment. Intermediate segments shorter than the fifth [2 : 3]. Ventral edge of the tarsus fimbriated.

Gaster. Ovipositor scarcely projecting beyond the apex of the gaster.

Length, 1.4 mm. Colour dark brown, with lighter ventral surface and legs. Nervures of wings yellowish brown.

#### Remark.

*C. booglandi* is recognizable by the long and slender tibia and metatarsus of the male hind leg, and by the relatively long bacilliform process of the female maxilla.

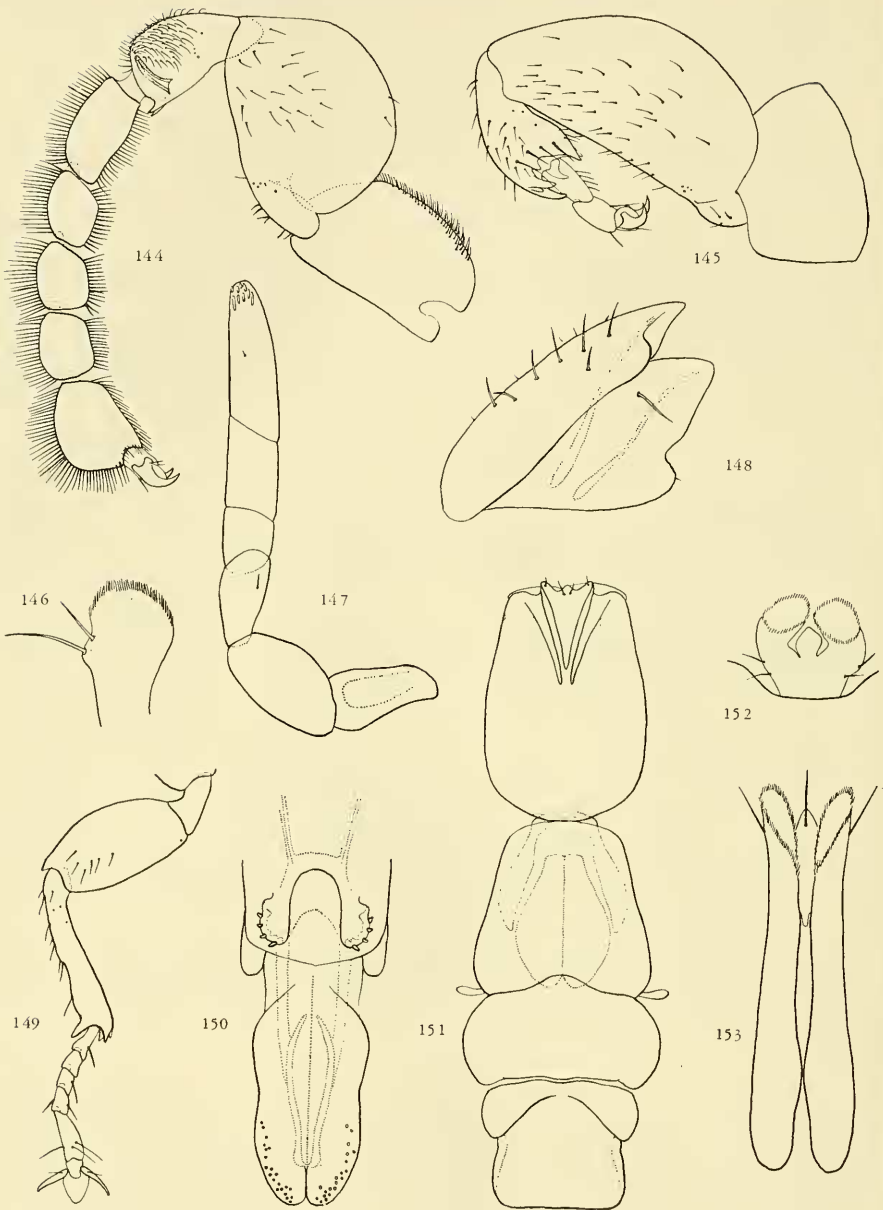
It is a pleasure to name the species after its collector, Dr. R. D. HOOGLAND.

#### *Ceratosolen vechti* sp. n. (figs. 130—143; Pl. 1)

#### Material.

Series ♀, ♂, ex *Ficus lepicarpa* Bl.<sup>1)</sup> (det. E. J. H. CORNER), Tjibodas (Java),

<sup>1)</sup> Discussion of host record, see p. 98.



Figs. 144—151, *Ceratosolen nugatorius*, Kelantan, male, 144, hind leg, 145, fore leg, 146, maxilla, 147, antenna, 148, mandible, 149, mid leg (coxa omitted), 150, apex of abdomen, 151, male, 152—153, *C. bisulcatus*, Java, 152, male labium and maxillae, 153, female labium and maxillae. Figs. 151,  $\times 60$ ; 144, 145, 149,  $\times 95$ ; 147,  $\times 185$ ; 148, 150, 152, 153,  $\times 255$ ; 146,  $\times 315$



along stream, 1500 m alt., leg. J. H. DE GUNST, 16.XI.1954; coll. no. 98; ♂ (holotype), slide 98a, ♀ (allotype), 98d, ♂, ♀ (paratypes), 98b, c, e, f.

Six ♀, 5 ♂, ex *Ficus lepigarpa* Bl., Tjibodas (Java), Mt. Gedeh, 1400 m alt., leg. J. H. DE GUNST, 16.XI.1954; coll. no. 6.

Fragments ♀, ex *Ficus lepigarpa* Bl., Tjibodas (Java), leg. J. H. DE GUNST, 5.XI.1954; coll. no. 70.

Eleven ♀, ex *Ficus lepigarpa* Bl., Tjibodas (Java), leg. J. H. DE GUNST, 11.II.1955; coll. no. 300.

Four ♀, series ♂, ex *Ficus lepigarpa* Bl. (det. E. J. H. CORNER), Pajakumbuh (Sumatra), Mt. Sago, leg. W. MEIJER, 14.V.1955, no. 3334; coll. no. 371; ♂, slide 371a.

? Six ♀, ex *Ficus lepigarpa* Bl. (det. E. J. H. CORNER), Kundasan (N. Borneo), 4000 ft. alt., leg. E. J. H. CORNER, 6.IX.1961; coll. no. 624.

### Description.

Male. Head (fig. 134) more than twice as long as wide anteriorly, its maximum width three quarters of the length. Epistomal margin with four short hairs. Pubescence short. Eyes small. Antennal grooves open, not very wide behind. Antenna (fig. 141) five-segmented; pedicel (5 : 3) half as long as the scape (2 : 1). First flagellar segment (2 : 3) small, the apical (11 : 3) somewhat longer than the scape, and more than one and a half times as long as the subapical segment (7 : 4). Mandible, fig. 142. Labium and maxillae, fig. 130; maxilla with two hairs at mid length.

Thorax, fig. 134. Pronotum twice as long as wide anteriorly, the maximum width nearly three quarters of the length. Mesonotum with rounded edges, one and a half times as wide as long. Metanotum incompletely separated from the propodeum, approximately as wide as the mesonotum; propodeum narrower, and more than twice as long as the metanotum. Femur of the fore leg (fig. 137) more than twice as long as the tibia, which bears four dorsal and three ventro-apical teeth. Tarsus bimerous, the second segment is the longer. Coxa of the mid leg nearly as long as the femur [5 : 6], the trochanter small. Tibia longer than the femur [7 : 6], apically with three teeth, the dorsal one of which is particularly long. Tarsal segments in ratio 3 : 2 : 2 : 2 : 5. Hind leg, fig. 140; coxa, femur, and tibia about equal in length [10 : 11 : 9], the tibia as long as the first and second tarsal segments combined. First tarsal segment one and a half times as long as the fifth (fig. 136), the fourth as long as the fifth, second and third segments smaller. Tarsus dilated, with pubescence approximately as long as one third the width of the segments.

Gaster. Cerci of tenth urite with two claws, aedeagus not dilated at apex (fig. 138). Some specimens from Sumatra differ in having the cerci with three or four claws, and the parameres with a subapical hair (fig. 139).

Length, 1.7 mm. Colour yellowish, with darker hind tarsi in some specimens, or only the distal segments brown.

Female. Head as long as wide across the compound eyes. Longitudinal diameter of the eye about as long as the cheek. Pubescence short. Antenna (fig. 131) with

the scape as long as third to sixth segments together; the pedicel half as long as the scape, the fourth segment small, the fifth approximately twice as long. Segments six to ten subequal, the eleventh smaller. Two apical segments shaped so as to form together a club. Sensilla of the funicle numerous, rather wide, mainly situated in the distal parts of the segments. Mandible (fig. 135) with six ventral ridges, the appendage but little shorter than the mandible, with six ridges. Maxilla (fig. 132) with a bacilliform process, which is one third the length of the maxilla, and a subapical hair; labium and the process with an apical hair.

Thorax. Pronotum wide and bristly. Scutum shorter than wide anteriorly [2 : 3], scutellum nearly one and a half times as long as wide anteriorly. Scutum with three hairs, scutellum with seven to ten hairs along each lateral margin. Metanotum with eight hairs on each side of the mid line. Propodeum with little groups of hairs above and beneath the spiracle. Fore wing (2 : 1), 2.0 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 42 : 15 : 13 : 23. Submarginal vein with two or three pustules, stigmal vein with four (or sometimes five). Hind wing (5 : 1), 1.2 mm long. Coxa of the fore leg (fig. 143) two-thirds the length of the femur; the tibia not half as long as the femur, with four dorsal and one ventro-apical teeth. First tarsal segment a little longer than the fifth [5 : 4], intermediates subequal, half as long as the fifth. Coxa and trochanter of the mid leg short, the tibia longer than the femur [4 : 3], tarsal segments in ratio 7 : 3 : 3 : 2 : 4. Tibia and tarsus rather bristly. Coxa of the hind leg (fig. 133) nearly as long as the femur, trochanter small. Tibia with the usual two apical teeth, more than half as long as the femur. Tarsal segments in ratio 11 : 4 : 3 : 3 : 6, with fimbriated ventral edges.

Gaster. Ovipositor barely projecting beyond the apex of the gaster.

Length, 2.2 mm. Colour dark brown, legs and ventral surface lighter. Nervures of the wings light brown.

#### Remark.

This species is remarkable by the robust hind legs of the males, and by the wide sensilla of the female antenna.

It is a pleasure to name this species after Dr. J. VAN DER VECHT, Professor of Systematic Zoology at Groningen University, Curator of Hymenoptera, Rijksmuseum van Natuurlijke Historie, Leiden, who recognized it as new when studying the samples from Java.

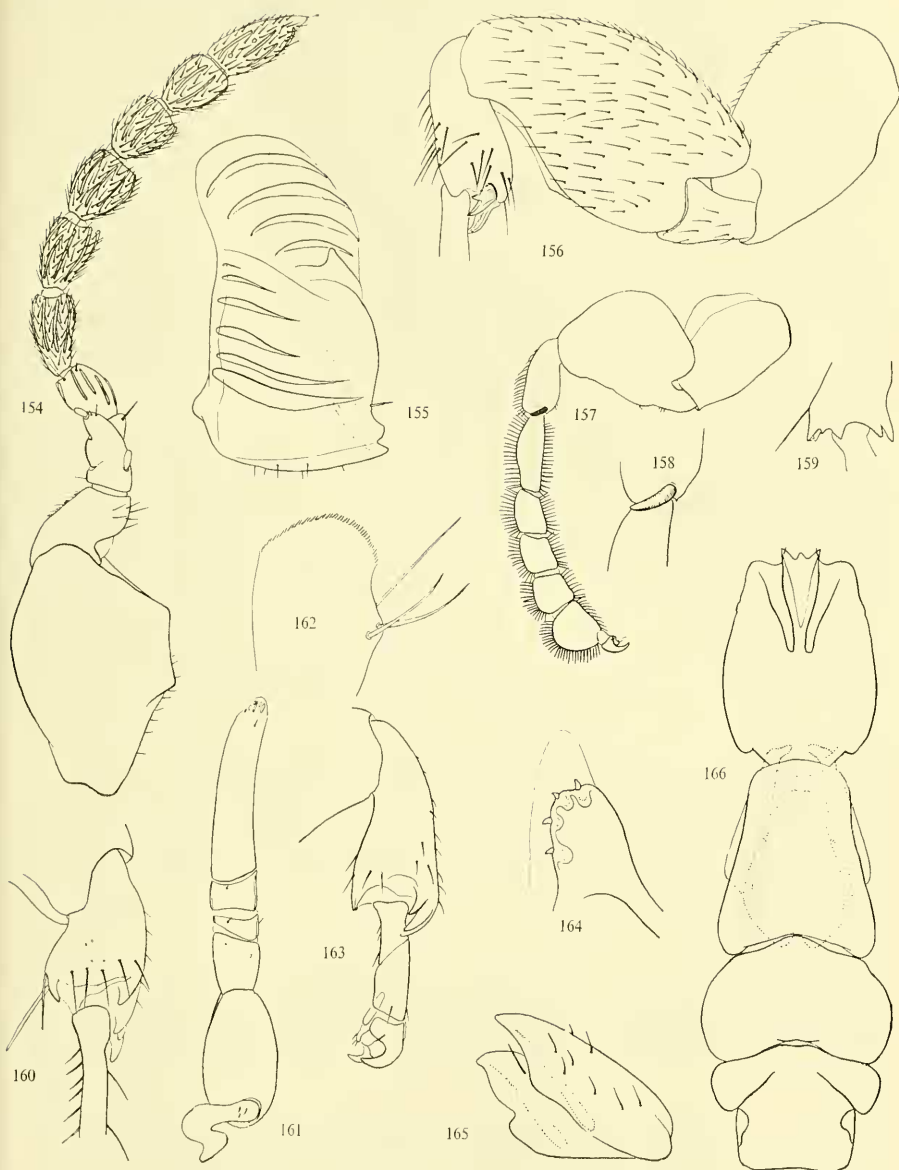
### *Ceratosolen nugatorius* Grandi (figs. 144—151)

*Ceratosolen nugatorius* Grandi, 1952b, pp. 55—57, figs. V—VI [descr. ♀, ex *Ficus* spec., Kuala Lumpur (Malaya), IX.1948].

#### Material.

Three ♀, Kuala Lumpur (Malaya), ex coll. GRANDI; coll. ML, no. 510.

Series ♀, ♂, ex *Ficus obpyramidata* King (det. E. J. H. CORNER), Batu Papan (Kelantan, Malaya), leg. E. J. H. CORNER, Sing. F. no. 29526; coll. no. 368; ♂ (allotype), slide 368a, ♀, ♂, 368b-e.



Figs. 154—166, *Ceratosolen dentifer*, New Guinea, 154—156, female, 154, antenna, 155, mandible, 156, detail of hind leg, 157—159, male, 157, hind leg, 158, detail of hind leg, 159, apex of mid tibia, 160, detail of female fore leg, 161—166, male, 161, antenna, 162, maxilla, 163, detail of fore leg, 164, cercus of tenth urite and paramere, 165, mandible, 166, male. Figs. 157, 166,  $\times 50$ ; 154, 156, 158, 163,  $\times 115$ ; 155, 159—161, 165,  $\times 155$ ; 162, 164,  $\times 365$

Two ♀, 7 ♂, ex *Ficus obpyramidata* King (det. E. J. H. CORNER), Kemanan (Trengganu, Malaya), leg. E. J. H. CORNER, Sing. F. no. 25843; coll. no. 365; ♂, slide 365a.

#### Description — Additional note.

I consider the specimens from *Ficus obpyramidata* conspecific with *C. nugatorius* Grandi, and describe the hitherto unknown male.

Male. Head (fig. 151) twice as long as wide anteriorly, its maximum width more than two-thirds the length. Pubescence short. Epistomal margin with four short hairs. Eyes very small. Antennal grooves open, narrow behind. Antenna (fig. 147) five-segmented; the pedicel (2 : 1) two-thirds the length of the scape (9 : 5), the first flagellar segment (7 : 6) three quarters the length of the second (2 : 1), the apical segment (7 : 2) nearly twice as long as the subapical one. Mandible, fig. 148. Maxilla (fig. 146) with two lateral hairs.

Thorax, fig. 151. Pronotum one and a half times as long as wide anteriorly, and but little longer than its maximum width. Maximum width of the mesonotum approximately five-thirds of the length. Metanotum almost completely separated from the propodeum, propodeum subquadrate. Fore leg (fig. 145): the tibia approximately half as long as the femur, with four dorsal and two ventro-apical teeth. Tarsal segments in ratio 4 : 3. Coxa and femur of the mid leg subequal in length, the tibia much longer [4 : 3], with four sharp, apical teeth (fig. 149). Tarsal segments in ratio 11 : 7 : 7 : 8 : 17. Hind leg, fig. 144. Coxa little shorter than the femur, and nearly one and a half times as long as the tibia. Tibia with a large motile spur on the disk. First tarsal segment little shorter than the tibia, but longer than the fifth, intermediate segments shorter, subequal. Tarsus dilated, the pubescence nearly as long as half the width of the segments.

Gaster. Cerci of the tenth urite with four short claws (two of which are small and sometimes difficult to be observed), the aedeagus dilated (fig. 150).

Length, 1.3 mm. Colour reddish brown. Head darker than the other parts of the body, hind tarsi light brown.

#### Remark.

The peculiar spur of the male hind leg, the short and robust male thorax, and the very few sensilla of the female antenna, distinguish this species from its congeners.

### *Ceratosolen dentifer* sp. n. (figs. 154—166)

#### Material.

Series ♀, ♂, ex *Ficus hispidooides* S. Moore var. *succosa* Corner (det. E. J. H. CORNER), Lae (Terr. New Guinea), leg. E. J. H. CORNER, X.1960; coll. no. 524; ♂ (holotype), slide 524a, ♀ (allotype), 524c, ♀, ♂ (paratypes), 524b, d.

Series ♀, ♂, ex *Ficus hispidooides* S. Moore var. *succosa* Corner (det. E. J. H. CORNER), Lae (Terr. New Guinea), leg. E. J. H. CORNER, 5.IX.1960; coll. no. 522; ♂, slide 522a, ♀, 522b.

### Description.

Male. Head (fig. 166) twice as long as wide anteriorly, the maximum width two-thirds of the length. Pubescence short. Eyes small. Antennal grooves open, not very wide behind. Antenna (fig. 161) five-segmented; the scape (2:1) more than twice as long as the pedicel (5:4), the first flagellar segment short, the second approximately twice as long as the first, and half as long as the pedicel; the apical segment (5:1) thrice as long as the pedicel. Mandible, fig. 165. Maxilla (fig. 162) with three lateral hairs, labium without long hairs.

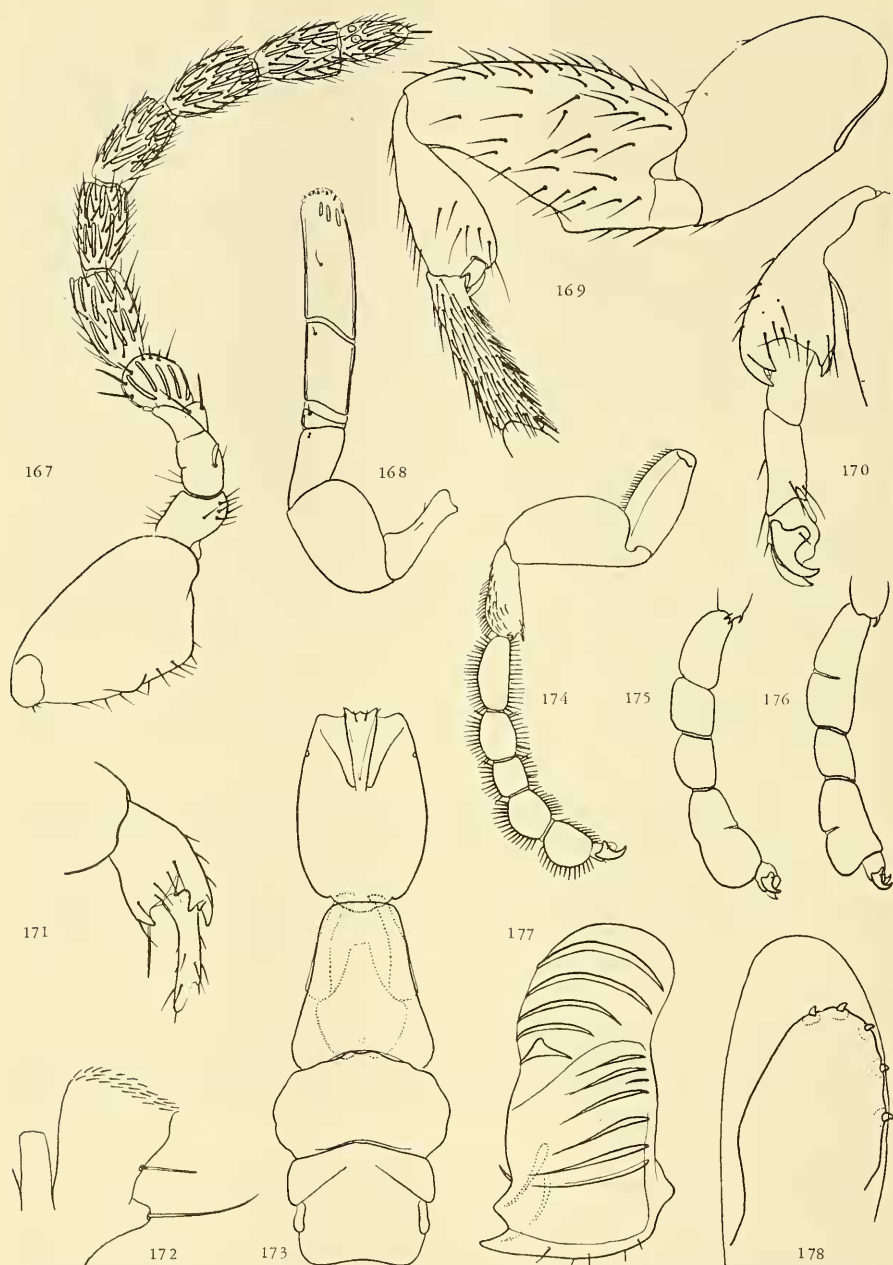
Thorax, fig. 166. Pronotum not quite twice as long as wide anteriorly, the posterior width slightly smaller than the length. Mesonotum nearly twice as wide as long. Metanotum short, incompletely separated from the large propodeum, which is nearly as long as wide [8:9]. Fore leg, fig. 163. Femur twice as long as the tibia, which bears four dorso-apical teeth and three ventral teeth. Tarsal segments in ratio 4:5. Coxa, femur, and tibia of the mid leg subequal in length, the tibia (fig. 159) with seven apical teeth. Tarsal segments in ratio 5:2:3:3:8. Hind leg (figs. 157—158): coxa smaller than the femur, the tibia about half as long. Apex of the tibia with a motile spur (fig. 158). Tarsus dilated, the first segment as long as the tibia, the second segment half as long, third and fourth segments slightly smaller than the second. Fifth segment two-thirds the length of the first. The segments gradually widening distally; pubescence approximately half as long as the width of the segments.

Gaster. Cercus of the tenth urite (fig. 164) with three or four claws.

Length, 1.6 mm; very small specimens measure 1.2—1.3 mm. Colour uniformly yellow-brown, head a trifle darker.

Female. Head as long as wide across the compound eyes, the cheeks as long as the eyes. Pubescence sparse, not very long. Antenna, fig. 154. Scape two and a half times as long as the pedicel; the pedicel with approximately fifty-five small spines on the axial surface. Fifth segment, with six long sensilla, shorter than the sixth, and about as long as the tenth. Seventh to tenth segments gradually diminishing in size, the eleventh, which forms a loose club with the tenth, one and a half times as long as the tenth. Funicular segments with regular rows — one per segment — of seven to nine long sensilla, the apical segment moreover with two circular pits. Mandible (fig. 155) with six ventral ridges, its appendage with five ridges. Maxilla with a subapical hair, and a bacilliform process, which is less than half as long as the maxilla [9:22], and bears a long apical hair. Labium without long hairs.

Thorax. Pronotum with sparse, long pubescence. Scutum one and a half times as long as wide maximally, and thrice as long as wide posteriorly, with seven to nine hairs along the lateral margins. Scutellum as long as wide posteriorly, narrower anteriorly, with eight to nine hairs along the lateral edges. Metanotum with ten hairs anteriorly, and two posteriorly, on each side of the mid line. Propodeum wide, with two hairs above, and a group of approximately ten hairs below the spiracle. Fore wing (2:1), 1.4 mm long. Submarginal, marginal, stigmal, and postmarginal veins approximately in ratio 14:5:5:12. Submarginal vein with three pustules, stigmal vein with four. Hind wing (9:2), 1.1 mm long. Femur



Figs. 167—178, *Ceratosolen moderatus*, Borneo, 167, female antenna, 168, male antenna, 169, detail of female hind leg, 170, detail of male fore leg, 171, detail of female fore leg, 172—176, male, 172, labium and maxilla, 173, male, 174, hind leg, 175, detail of hind leg, 176, detail of hind leg, same specimen as 175, axial aspect of other leg, 177, female mandible, 178, male cercus of tenth urite and paramere. Figs. 173—176,  $\times 60$ ; 169—171,  $\times 140$ ; 167, 168, 177,  $\times 185$ ; 172, 178,  $\times 440$

of the fore leg (fig. 160), with long pubescence along the dorsal and ventral margins, nearly twice as long as the coxa, and more than thrice as long as the tibia. Tibia with four dorsal and one ventro-apical teeth. Tarsus pentamerous, with rows of spines; segments in ratio 19 : 6 : 6 : 4 : 9. Mid leg slender; the tibia nearly as long as trochanter and femur combined, tarsal segments in ratio 16 : 9 : 8 : 6 : 9. Tibia and tarsus with long pubescence, tarsal segments with apical spines. Hind leg, fig. 156. Coxa smaller than the femur, the tibia more than half as long [13 : 25]. Femur heavily pubescent. Antiaxial tibial spur bidentate, the axial one curved. Tarsus with long pubescence and apical spines; segments in ratio 16 : 8 : 6 : 4 : 7.

Gaster. Ovipositor slightly protruding behind the gaster.

Length, 2.2—2.4 mm (very small specimens measure 1.8 mm). Colour: head and dorsal surface of thorax dark brown, gaster lighter.

Extremities yellow-brown. Nervures of the wings brown.

#### Remark.

The tibial spur of the male hind leg is a common character of *C. dentifer* and *C. nugatorius*; they are, however, distinguishable by the male and female mouthparts, the relative proportions of the male thorax, etc.

#### *Ceratosolen moderatus* sp. n. (figs. 167—178)

#### Material.

Series ♀, ♂, ex *Ficus moderata* Corner (det. E. J. H. CORNER), Kundasan (N. Borneo), 3500 ft. alt., leg. E. J. H. CORNER, 31.VIII.1961, RSNB no. 2594; coll. nos. 628, 647, 649, 651; ♂ (holotype), slide 628a, ♀ (allotype), 628d, ♂, ♀ (paratypes), 628b, c, e.

#### Description.

Male. Length of the head (fig. 173) one and a half times the maximum width, and more than twice the anterior width. Eyes small. Antennal grooves open, not very wide behind. Antenna (fig. 168) five-segmented, the scape (3 : 2) one and a half times as long as the pedicel (2 : 1); the first flagellar segment annuliform, the second nearly as long as the pedicel, and more than half as long as the apical segment (5 : 2). Maxilla (fig. 172) with two hairs, the sub-apical one of which is absent in some specimens; labium without long hairs. Mandible as in the preceding species.

Thorax, fig. 173. Pronotum slightly shorter than wide posteriorly, and twice as long as wide anteriorly. Mesonotum approximately twice as wide as long. Metanotum short, incompletely separated from the propodeum, which is distinctly wider than long (3 : 2). Femur of the fore leg (fig. 170) twice as long as the tibia, with few hairs. Tibia with three dorsal and three ventro-apical teeth. Tarsus bimerous, the segments approximately equal in length; axially with a few stout hairs. Mid leg slender, the femur shorter than the tibia [6 : 7], the coxa shorter than the femur [5 : 6], but wider. Tibia with three apical teeth. Tarsal segments approximately in ratio 10 : 5 : 4 : 5 : 10. Oligomery, in casu, incomplete separation

of second, third, and fourth segments, occurs sporadically. Hind leg, figs. 174—176. Coxa and femur subequal in length, the tibia shorter. Tibia with a bidentate apical tooth at the antaxial edge and a ventral spur. Tarsus dilated, segments (in the holotype) in ratio 25 : 16 : 11 : 15 : 16; the pubescence as long as one third the width of the segments. There is a considerable variation in the relative proportions of the tarsal segments, which may be wider than shown in fig. 174, but nearly always the second and fifth segments are subequal, and the first distinctly larger. The third and fourth segments are nearly as long as the second, or longer, or as drawn in fig. 174. Moreover, some of the specimens with large hind feet show oligomery: the first and second, second and third, or fourth and fifth tarsal segments being incompletely separated (figs. 175, 176).

Gaster. Cerci of the tenth urite large, with five small claws (fig. 178).

Length, 1.2—1.3 mm. Colour uniformly light yellow-brown.

Female. Head as long as wide across the compound eyes. Longitudinal diameter of the eye as long as the cheek. Pubescence not very long. Antenna (fig. 167): scape large, four times as long as the pedicel, which bears approximately forty axial spines. Third segment not very long, the fourth small. Fifth segment with ten long sensilla. Sixth to tenth segments subequal, distinctly longer than the fifth, the eleventh shorter, about as long as the fifth. Eleventh segment with six oblong and two circular sensilla, other segments with two rows of six to nine sensilla. Maxilla with one subapical hair, and with a bacilliform process, which is half as long as the maxilla, and bears one apical hair. Mandible (fig. 177) with six large ventral ridges, and five ridges on the appendage.

Thorax. Pronotum with sparse, but long pubescence. Scutum as long as wide maximally, the posterior width slightly more than two-thirds the length. Seven to eight hairs occur on each lateral side. Anterior width of the scutellum four-fifths, posterior width six-sevenths of the length, lateral margins with about ten hairs. Metanotum with eight hairs on each side of the mid line; propodeum with three hairs above, and six hairs below the spiracles. Fore wing (7 : 3), 1.65 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 14 : 4 : 5 : 11; submarginal vein with two pustules, stigmal vein with four. Hind wing (5 : 1), 0.95 mm long. Fore leg (fig. 171): length of the coxa three-fifths, length of the tibia two-fifths of that of femur and trochanter combined. Tibia with four dorsal and one ventral teeth. Tarsal segments in ratio 40 : 13 : 13 : 14 : 20. Mid leg slender, the tibia nearly as long as femur and trochanter combined, with long hairs. Tarsus with long pubescence, segments in ratio 15 : 5 : 5 : 5 : 6. Coxa of the hind leg (fig. 169) slightly shorter than the femur; the tibia two-thirds of the femur, with an antaxial bidentate, and an axial unidentate tooth at the ventro-apical edge. Tarsal segments wide, ratio: 30 : 9 : 6 : 5 : 9.

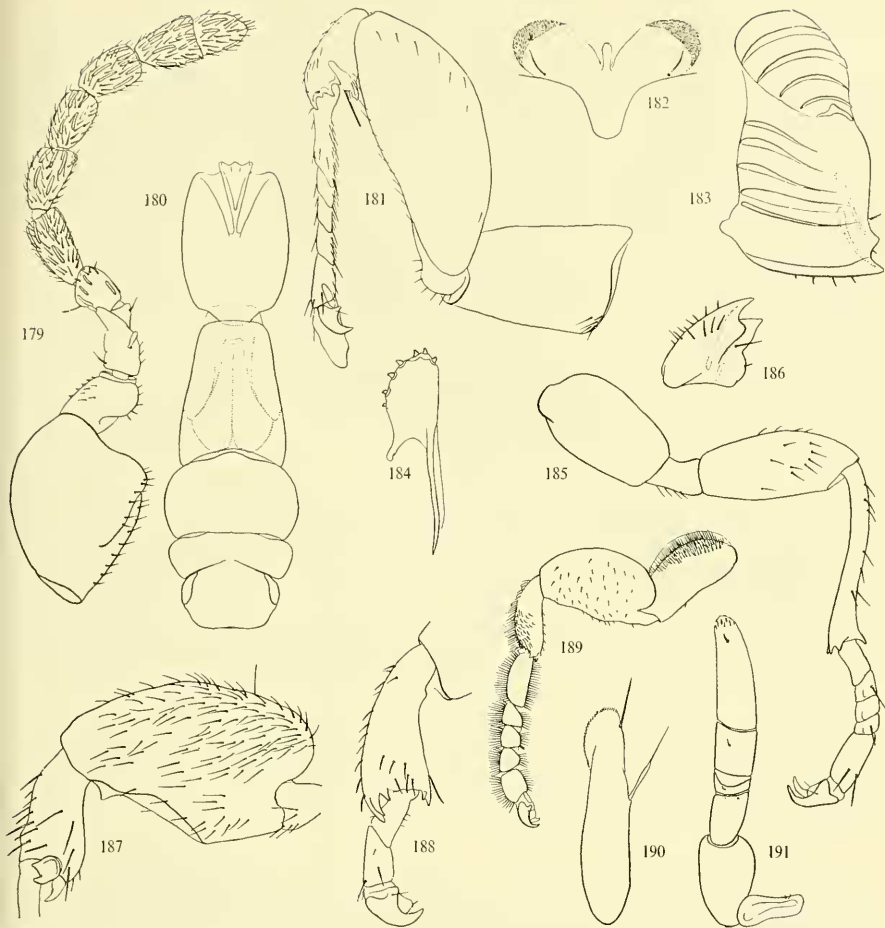
Gaster. Ovipositor slightly projecting beyond the apex of the gaster.

Length, 1.7—1.8 mm. Colour: head and dorsal surface of body grey-brown, ventral surface and extremities lighter. Nervures of the wings brown.

#### Remark.

*C. moderatus* is not much larger than *C. crassitarsus*, but it is easily recognized by the relative proportions of the male antenna and hind leg, the heteromery of





Figs. 179—191, *Ceratosolen praestans*, New Britain, 179, female antenna, 180, male, 181, female fore leg, 182, male labium and maxillae, 183, female mandible, 184—186, male, 184, cercus of tenth urite, 185, mid leg, 186, mandible, 187, detail of female hind leg, 188, detail of male fore leg, 189, male hind leg, 190, female maxilla, 191, male antenna. Figs. 180, 189,  $\times 40$ ; 179, 181, 185, 187, 188,  $\times 90$ ; 183, 186, 190, 191,  $\times 115$ ; 182,  $\times 160$ ; 184,  $\times 200$

the male hind tarsus, and the presence of five claws on the cerci of the tenth urite. The females have hyaline wings without striae.

#### *Ceratosolen praestans* sp. n. (figs. 179—191)

##### Material.

Series ♀, ♂, ex *Ficus praestans* Corner (det. E. J. H. CORNER), Keravat (New Britain), leg. E. J. H. CORNER, X.1960; coll. no. 533; ♂ (holotype), slide 533a, ♀ (allotype), 533c, ♂, ♀ (paratypes), 533b, d.

### Description.

Male. Head (fig. 180) nearly twice as long as wide anteriorly, and one and a half times as long as its maximum width. Epistomal margin prominent, with six hairs. Dorsal and ventral surfaces with sparse, thin hairs. Eyes wanting. Antennal grooves open, not very wide behind. Antenna (fig. 191) five-segmented. Scape (5 : 3) nearly twice as long as the pedicel (3 : 2); the first flagellar segment short the second (5 : 4) slightly shorter than the pedicel, the apical segment (3 : 1) more than twice as long. Mandible, fig. 186. Labium and maxillae, fig. 182; labium small, maxilla large, with one apical hair.

Thorax, fig. 180. Pronotum not quite twice as long as wide anteriorly, and distinctly longer than wide posteriorly [7 : 6]. Mesonotum with rounded edges, its length two-thirds of the maximum width. Metanotum short, incompletely separated from the propodeum. Propodeum slightly tapering behind, its length three quarters of the maximum width. Femur of the fore leg (fig. 188) twice as long as the tibia. Tibia with four dorsal and three ventro-apical teeth. Tarsus consisting of two segments, the first of which is the longer [6 : 5]. Mid leg (fig. 185): the coxa a little shorter than the femur; the tibia as long as coxa and trochanter combined. Tibia with five apical teeth: three ventrals and two dorsals. Tarsus pentamerous, the segments in ratio 11 : 5 : 5 : 4 : 15. Hind leg (fig. 189): the coxa slightly shorter than the femur, but longer than the tibia. Dorsal edge of the coxa, axial surfaces of femur and tibia, and dorsal edge of the tibia pubescent. Tibia with three ventral apical teeth. Tarsus dilated, with pubescence approximately as long as half the width of the segments. Segments in ratio 29 : 12 : 12 : 13 : 16.

Gaster. Aedeagus dilated apically. Cerci of the tenth urite (fig. 184) with seven claws, parameres tapering distally.

Length, 1.6 mm. Colour uniformly yellow-brown.

Female. Head slightly longer than wide between the external margins of the eyes. Longitudinal diameter of the eye a little longer than the cheek [6 : 5]. Antenna, fig. 179. Scape as long as second to fifth segments combined. Pedicel not quite half as long as the scape, with approximately forty-five slender spines. Fifth segment with two rows of four sensilla, and two apical sensilla which are oriented perpendicularly to the others; the sixth segment with four sensilla in the basal row, and seven apical sensilla, seventh to tenth segments with two rows of six to eight sensilla; the apical segment with five sensilla. Mandible (fig. 183), and its appendage, with five ventral ridges. Labium without hairs. Maxilla (fig. 190) with one subapical hair, and a bacilliform process. The bacilliform process, which is about one fifth the length of the maxilla, seems to be very delicate, and it is, more often than not, broken off close to its base, or even entirely absent.

Thorax. Pronotum wide, with many hairs. Scutum nearly as long as wide anteriorly, scutellum one and a half times as long as wide anteriorly. Metanotum nearly as wide as scutum and scapulae together, with ten hairs on each side of the mid line. Propodeum wider, with six hairs above, and twelve hairs beneath the spiracular peritremata. Fore wing (2 : 1), 2.2 mm long. Submarginal, marginal stigmal, and postmarginal veins in ratio 17 : 7 : 5 : 13. Submarginal vein with

three pustules, stigmal vein with four. Hind wing (4 : 1), 1.3 mm long. Coxa of fore leg (fig. 181) not quite two-thirds the length of the femur, tibia much shorter than the femur [2 : 5], with four teeth at the antaxial, dorso-apical edge, and one ventral tooth. Tarsal segments in ratio 16 : 4 : 5 : 6 : 9; first segment with ventral spines, other segments with hairs and apical spines. Coxa and trochanter of the mid leg short; the femur four times as long as the trochanter, the tibia nearly as long as femur and trochanter combined. Tarsal segments in ratio 10 : 4 : 4 : 4 : 5. Hind leg, fig. 187. Coxa slightly smaller than the femur, the tibia half as long as the femur. Tibia with one ventral axial tooth, and a bidentate antaxial tooth. Tarsus pubescent, especially along the plantar edge; segments in ratio 42 : 14 : 14 : 10 : 9 : 11.

Gaster. Ovipositor scarcely projecting beyond the apex of the gaster.

Length, 2.4—2.6 mm. Colour dark brown, legs and antennae lighter. Wings with dark striae radiating from the stigma.

#### Remark.

This species is similar to some other species in which the hind feet of the males are dilated. It is distinguished by the male genitalia (cerci with seven claws) and by the short bacilliform process of the female maxilla.

#### *Ceratosolen iodotrichae* sp. n. (figs. 192—203)

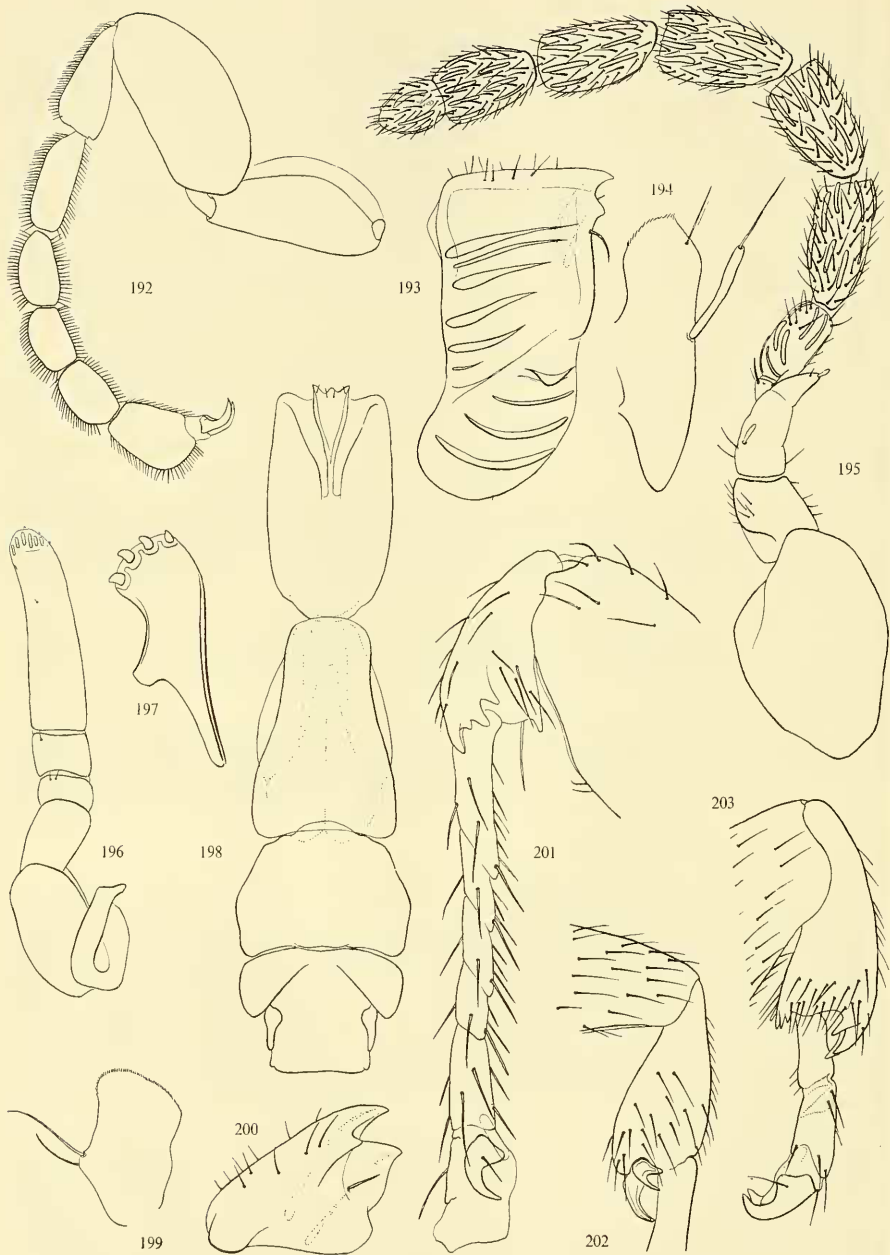
#### Material.

Series ♀, ♂, ex *Ficus iodotricha* Diels (det. E. J. H. CORNER), Wau (Terr. New Guinea), Edie Creek, leg. E. J. H. CORNER, 19.IX.1960, NGF no. 12498; coll. no. 535; ♂ (holotype), slide 535a, ♀ (allotype), 535c, ♀, ♂ (paratypes), 535b, d, e.

#### Description.

Male. Head (fig. 198) twice as long as wide anteriorly, with almost parallel sides. Pubescence short and sparse. Eyes wanting. Antennal grooves open, not very wide behind. Antenna (fig. 196) five-segmented; the scape (2 : 1) not quite twice as long as the pedicel (3 : 2); the first flagellar segment (1 : 2) slightly shorter than the second (2 : 3), the apical segment (4 : 1) six times as long as the second. Mandible, fig. 200. Maxilla (fig. 199) with two lateral hairs; labium without long hairs.

Thorax, fig. 198. Pronotum nearly one and a half times as long as wide posteriorly, much narrower anteriorly. Maximum width of the mesonotum distinctly longer than the length [7 : 5]. Metanotum incompletely separated from the propodeum, as wide as the mesonotum. Propodeum approximately as long as wide, its posterior margin nearly straight. Fore leg (fig. 203): the tibia, without the apical teeth, half as long as the femur. Tibia with four dorsal and four ventro-apical teeth. Tarsus bimerous, distal segment slightly longer than the proximal one. Femur and tibia of the mid leg subequal in length, slightly shorter than coxa and trochanter combined. Tibia with seven apical teeth: six at the ventral margin, and one bidentate, dorsal tooth. Tarsus pentamerous, segments in ratio 4 : 2 : 2 : 2 : 5.



Figs. 192—203, *Ceratosolen iodotrichae*, New Guinea, 192, male hind leg, 193—195, female, 193, mandible, 194, maxilla, 195, antenna, 196—200, male, 196, antenna, 197, cercus of tenth urite, 198, male, 199, maxilla, 200, mandible, 201, detail of female fore leg, 202, detail of female hind leg, 203, detail of male fore leg. Figs. 192, 198,  $\times 50$ ; 195, 202, 203,  $\times 115$ ; 193, 194, 196, 200, 201,  $\times 155$ ; 197, 199,  $\times 365$

Hind leg (fig. 192) much like that of *C. booglandi*, but more robust; the tibia with one small apical tooth. Tarsal segments in ratio 14 : 10 : 9 : 9 : 11; dilated, pubescence approximately as long as one third the width of the segments.

Gaster. Cerci of the tenth urite (fig. 197) with four or five claws.

Length, 1.7—1.8 mm. Colour uniformly yellowish brown.

Femåle. Head as long as wide across the compound eyes. Eyes protruding, about as long as the cheek. Pubescence sparse, but long. Antenna (fig. 195); pedicel not half as long as the scape, with approximately forty short spines axially. Fifth segment twice as long as the short fourth, sixth to ninth subequal, longer than the fifth, tenth and eleventh smaller, together forming a loose club. Funicular segments with rather long sensilla: the fifth with twelve, sixth to tenth with two irregular rows of six to eight sensilla. Apical segment with six oblong and two circular sensilla. Mandible (fig. 193) with six ventral ridges, its appendage with four. Maxilla (fig. 194) with one, or sometimes two, subapical hairs, and a bacilliform process, which is, without the apical hair, between one third and one half the length of the maxilla. Labium bare.

Thorax. Scutum approximately one and a half times as long as wide posteriorly, much wider anteriorly; seven hairs occur along each lateral margin. Scutellum little wider behind than in front, its length four-thirds of the posterior width. Metanotum short, with eight hairs on each side of the mid line. Propodeum with six hairs above, and approximately twice as many behind the spiracle. Fore wing (8 : 3), 2.6 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 24 : 5 : 7 : 13; submarginal vein with three pustules, stigmal vein with four. Hind wing (4 : 1), 1.4 mm long. Femur of the fore leg (fig. 201) nearly twice as long as the coxa, the tibia not half as long as the femur. Tibia with four dorso-apical teeth, and one ventral tooth. Tarsal segments in ratio 12 : 5 : 5 : 5 : 7. Mid leg slender, the subclavate tibia nearly as long as femur and trochanter combined; tarsal segments in ratio 20 : 10 : 9 : 8 : 10, long pubescent. Hind leg robust, the coxa as long as the tibia, but much wider, the femur not quite twice as long. Tibia (fig. 202) with two ventro-apical teeth, the antaxial one of which is bidentate. Tarsus pubescent, especially along the plantar edge; the segments in ratio 19 : 9 : 7 : 6 : 8.

Gaster. Ovipositor distinctly projecting beyond the apex of the gaster.

Length, 2.6 mm. Colour of head and thorax dark brown; abdomen and extremities lighter. Some females have the last three antennal segments, and the distal segments of the legs, of an ivory-white colour, and are evidently not fully mature. Nervures of the wings light brown, three dark striae radiate from the stigma.

#### R e m a r k.

*C. iodotrichae* is remarkable in having the apical segment in the male antenna very long. The specimens are rather large, as in *C. vechti*, but they differ distinctly in the relative proportions.

**Ceratosolen notus** (Baker), *C. orientalis* sp. n. and *C. calopilinae* sp. n.

*Ceratosolen notus* (Baker), and the new species *C. orientalis* and *C. calopilinae* (described below) are very similar.

There are no distinct structural differences between *C. orientalis* and *C. calopilinae*, yet the two are recognizable by the male trophi, and by the relative proportions of some body-parts, notably the female maxilla and antenna, and the male hind leg.

*C. orientalis* is much like *C. notus*, but it differs in the relative proportions of the hind leg in the male, of the female antenna, etc.

Examination of more material may prove the three forms to be only sub-specifically distinct.

**Ceratosolen notus** (Baker) (figs. 204—217)

*Blastophaga nota* Baker, 1913, pp. 65—67, 69, 70—72, 81, 82, figs. 2, 3D, E, 4D [descr. ♀, ♂, ex *Ficus nota* (Blanco) Merrill, Los Baños (Luzon, Philippine Is.), biological notes].

*Ceratosolen notus*: Williams, 1928, pp. 9—11, 14, Pl. I figs. 2, 5, Pl. II fig. 16 [biological notes].

**Material.**

Series ♀, ♂, ex *Ficus nota* (Blanco) Merr., Los Baños (Luzon, Philippine Is.), Coll. Agric., leg. F. X. WILLIAMS, 24.VI.1921; coll. HSPA, ♀, ♂ slide mounted; coll. ML, no. 683: 10 ♀, 10 ♂.

Six ♀, 8 ♂, ex *Ficus nota* (Blanco) Merr., Los Baños (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 26.II.1921; coll. HSPA; 2 ♀, 6 ♂, coll. USNM, 1 ♂ slide mounted.

Series<sup>1)</sup> ♀, ♂, ex *Ficus nota* (Blanco) Merr., Los Baños (Luzon, Philippine Is.), Coll. Agric., 9.VI.1921; leg. F. X. WILLIAMS, coll. HSPA.

Series ♀, ♂, ex *Ficus nota* (Blanco) Merr. (several trees), Los Baños (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 15/17.VI.1921; coll. HSPA.

Series ♀, ♂, ex *Ficus spec.*, Luzon (Philippine Is.), 20 min. SW of Baguio, leg. H. E. MILLIRON, 24.IX.1945; coll. BMH.

Series ♀, 7 ♂, ex *Ficus nota* (Blanco) Merr., Manila (Luzon, Philippine Is.), leg. D. T. FULLAWAY, 1.I.1921; coll. HSPA; 6 ♀, 2 ♂, coll. USNM, 1 ♀ slide mounted.

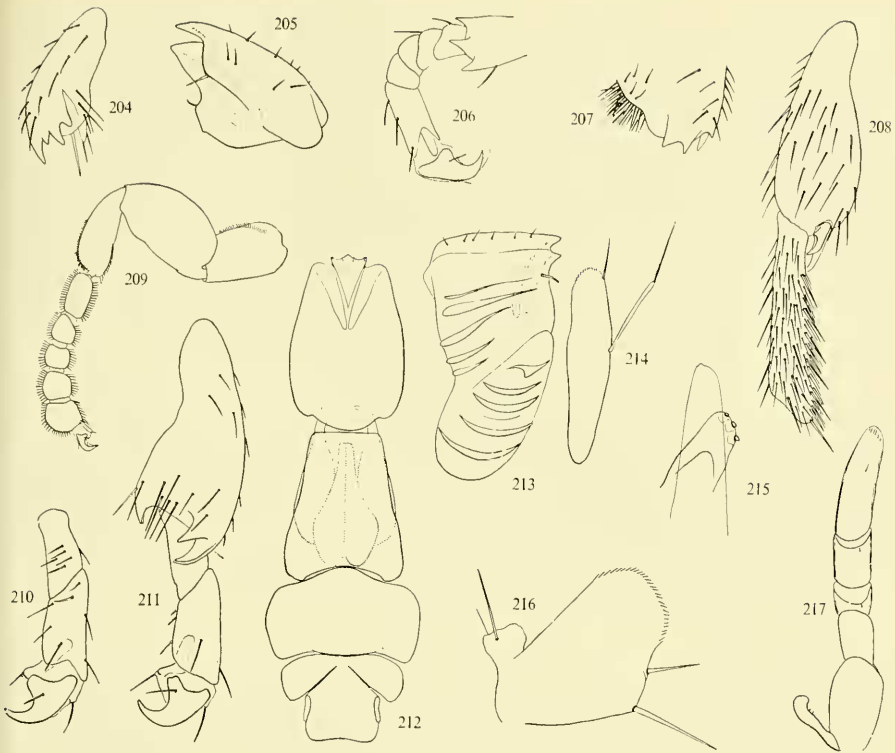
Series ♀, ♂, ex *Ficus nota* (Blanco) Merr. ("purple fruited"), Mt. Maquiling (Luzon, Philippine Is.), 3000 ft. alt., leg. F. X. WILLIAMS, 25.I.1922; coll. HSPA.

One ♂, ex *Ficus nota* (Blanco) Merr. ("purple ♂"), Mt. Maquiling (Luzon, Philippine Is.), at mud spring, leg. F. X. WILLIAMS, 8.II.1922; coll. HSPA.

Series ♀, ♂, ex *Ficus satterthwaitei*<sup>2)</sup>, Mt. Maquiling (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 21.IX.1921; coll. HSPA.

<sup>1)</sup> Except for three or four escapes, this is the total content of one fig: 759 ♀, 255 ♂, no parasites or inquilines.

<sup>2)</sup> *Ficus satterthwaitei* Elmer = *F. congesta* Roxb.



Figs. 204—217, *Ceratosolen notus*, Luzon, 204, female fore tibia, 205—207, male, 205, mandible, 206, detail of mid tibia, and tarsus, 207, apex of hind tibia, 208, female hind tibia and metatarsus, 209—212, male, 209, hind leg, 210, fore tarsus, axial aspect, 211, fore tibia and tarsus, 212, male, 213, female mandible, 214, female maxilla, 215—217, male, 215, cercus of tenth urite, and paramere, 216, maxilla (ventral aspect), and labium (lateral aspect), 217, antenna. Figs. 209, 212,  $\times 40$ ; 204—208, 210, 211, 213, 214, 217,  $\times 115$ ; 215, 216,  $\times 275$

## Description.

As the original description by BAKER is very short, I give a redescription of *C. notus*. The described specimens, taken at the type locality of *C. notus* (College of Agriculture, Los Baños, WILLIAMS, 24.VI.1921), were sent to me dry, and I relaxed them in diluted alcohol.

**Male.** Head (fig. 212) more than twice (9 : 4) as long as wide anteriorly, the maximum width two-thirds of the length. Eyes absent. Epistomal margin wide, with four hairs. Pubescence long. Antennal grooves open, rather wide behind. Antenna (fig. 217) five-segmented: the scape, nearly twice as long as wide, one and a half times as long as the pedicel (2 : 1): the first flagellar segment short, the second (5 : 4) three quarters the length of the pedicel, the apical segment (4 : 1) two and a half times as long as the second. Maxilla (fig. 216) expanded laterally, with two lateral hairs; labium with one subapical hair. Mandible, fig. 205.

Thorax, fig. 212. Pronotum slightly longer than wide posteriorly, and not quite twice as long as wide anteriorly. Mesonotum (8 : 5) much wider than long; metanotum narrower, incompletely separated from the subquadrate propodeum. Fore leg (figs. 210—211): the tibia not quite half as long as the femur [7 : 16], apically with three dorsal and three ventral teeth. Tarsus bimerous, the distal segment slightly longer than the proximal one. Mid leg rather robust; coxa and femur subequal in length; the tibia distinctly longer [4 : 3], with four apical teeth (fig. 206). Tarsus coiled in nearly all specimens, the segments approximately in ratio 5 : 3 : 3 : 4 : 10. Hind leg (fig. 209) pubescent, the coxa three quarters the length of the femur, the tibia slightly longer than the coxa. Tibial armature (fig. 207) consisting of a bidentate antaxial process, a small tooth at the ventral edge, and a motile axial spur. Tarsus dilated, the pubescence slightly longer than one third of the width of the segments. Relative proportions of the segments rather variable, even in specimens from the same sample. First segment always approximately half as long as the tibia, second and third segments subequal, approximately half as long as the first; the fourth distinctly longer than the third; the fifth segment is slightly longer (as in fig. 209) or much longer and wider (as in BAKER's fig. 3D) than the fourth.

Gaster. Cerci of the tenth urite with three claws, parameres narrow (fig. 215). Length, 1.6 mm. Colour yellowish brown.

Female. Scape of the antenna large, nearly four times as long as the pedicel, which bears some thirty slender spines at the axial surface. Appendage of the third segment robust, the fourth segment small. Fifth to eighth segments gradually increasing in length, the eighth distinctly longer than the fifth [5 : 4]; the ninth segment as long as the fifth, the tenth slightly longer, the eleventh, forming a loose club with the tenth, distinctly shorter [3 : 4]. Funicular segments with two irregular rows of short, wide sensilla. Mandible, and its appendage, with five ventral ridges (fig. 213). Maxilla (fig. 214) with a subapical hair, and a bacilliform process, which is two-fifths the length of the maxilla.

Thorax pubescent; two hairs occur above, and a group of about ten hairs below the propodeal spiracle. Fore wing (5 : 2), 1.8 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 28 : 10 : 9 : 24; submarginal and stigmal veins with four pustules each. Hind wing (5 : 1), 1.1 mm long. Tibia of the fore leg (fig. 204) less than half as long as the femur [5 : 13], and more than half as long as the coxa [5 : 8]. Apical armature consisting of a dorsal comb of four teeth, and one ventral tooth. Tarsal segments in ratio 20 : 10 : 9 : 8 : 15. Mid leg long pubescent, the tibia shorter than femur and trochanter combined [10 : 11]; tarsal segments in ratio 18 : 8 : 9 : 8 : 14. Coxa of hind leg (fig. 208) shorter than the femur [14 : 17], the tibia two-thirds the length of the femur. Antaxial apical tooth bidentate, the axial tooth simple, strongly curved at apex. Tarsus heavily pubescent and spinose, the segments in ratio 20 : 7 : 7 : 6 : 9.

Gaster. Projecting part of the ovipositor one sixth the length of the gaster.

Length, 1.8 mm. Colour brown, head darker, legs yellow-brown. Nervures of the wings light brown.



**Remark.**

There are some minor differences between the specimens described above and the description by BAKER, notably in the male genitalia (described by BAKER as being "without armed claspers", but the cerci are not distinctly visible) and in the relative proportions of the female hind leg (tibia half as long as the femur, according to BAKER, two-thirds in length of the femur in the specimens measured by me, but probably BAKER measured the part of the tibia visible in situ, and not the whole segment).

I fail to find any differences between the specimens from *Ficus nota* and those from *F. congesta*. For a discussion of the host records, see p. 97.

***Ceratosolen orientalis* sp. n. (figs. 218—230)****Material.**

Series ♀, ♂, ex *Ficus subcongesta* Corner (det. E. J. H. CORNER), Keravat (New Britain), leg. E. J. H. CORNER, 14.X.1960, NGF no. 13783; coll. no. 540; ♂ (holotype), slide 540a, ♀ (allotype), 540c, ♂, ♀ (paratypes), 540b, d.

? Sixteen ♀, 8 ♂, ex *Ficus subcongesta* Corner var. *symmetrica* Corner (det. E. J. H. CORNER), Crown Prince Mts. (Bougainville I.), leg. E. J. H. CORNER, NGF no. 13735; coll. no. 550; ♂, slide 550a, ♀, 550b.

**Description.**

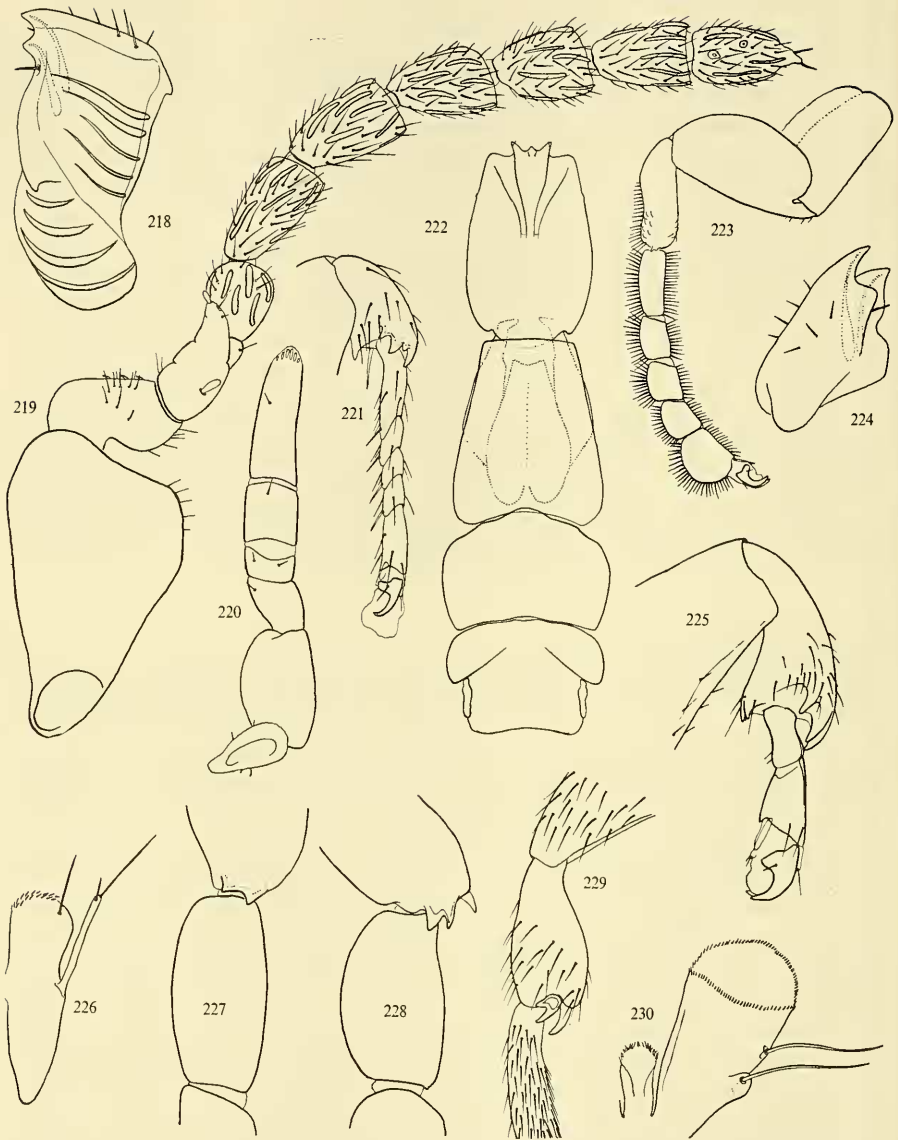
Male. Head (fig. 222) slightly longer than twice the anterior width, maximum width two-thirds of the length. Pubescence short and sparse. Eyes small. Antennal grooves open, not very wide behind. Antenna (fig. 220): the scape (5:3) is two and a half times as long as the pedicel (1:1), which is twice as long as the first flagellar segment (1:2). The following segment (8:7) as long as the pedicel, and not quite half as long as the apical one (3:1). Maxilla (fig. 230) with two lateral hairs; labium without long hairs. Mandible, fig. 224.

Thorax, fig. 222. Pronotum nearly twice as long as wide anteriorly; the posterior width slightly shorter than the length. Mesonotum transverse (14:9); metanotum incompletely separated from the propodeum, which is nearly twice as wide as long. Femur of fore leg (fig. 225) twice as long as the tibia (apical teeth included); the tibia with four dorsal and three ventro-apical teeth. Tarsus bimerous, segments in ratio 5:6. Coxa of the mid leg as long as the femur, the tibia as long as femur and trochanter combined, subclavate, with four apical teeth. Hind leg (figs. 223, 227): coxa and femur subequal in length, the tibia little shorter. Tibia with a bidentate process at the antaxial apical edge. Tarsus dilated, segments approximately in ratio 6:4:4:3:5. Pubescence longer than half the width of the segments.

Gaster. Cerci of the tenth urite with three or four claws.

Length, 1.5 mm. Colour uniformly yellowish brown.

Female. Head shorter than wide across the compound eyes [15:16]. Eye longer than the cheek [11:9]. Pubescence short and sparse. Antenna (fig. 219): scape not very wide, and nearly thrice as long as the pedicel, which bears forty-five axial spines. Third segment not very long, the fourth small; the fifth twice, the



Figs. 218—230, *Ceratosolen orientalis*, New Britain (228, specimen from Bougainville I.), 218, female mandible, 219, female antenna, 220, male antenna, 221, female fore leg, 222—225, male, 222, male, 223, hind leg, 224, mandible, 225, detail of fore leg, 226, female maxilla, 227, detail of male hind leg, 228, do., specimen from Bougainville I., 229, detail of female hind leg, 230, male labium and maxilla. Figs. 222, 223,  $\times 50$ ; 221, 225, 229,  $\times 115$ ; 218—220, 224, 226—228,  $\times 155$ ; 230,  $\times 365$

sixth and seventh approximately thrice as long as the fourth. Eighth to eleventh segments slightly shorter than the seventh, and gradually diminishing in length. The subapical and apical segments shaped so as to form a loose club. Fifth segment with eight oblong sensilla, sixth to tenth segments with two irregular rows of sensilla (eleven to fourteen per segment), the apical segment with six oblong, and some circular sensilla. Maxilla (fig. 226) with one subapical hair, and a long bacilliform process. Mandible (fig. 218), and its appendage, with five ventral ridges.

Thorax. Pronotum with long hairs. Scutum longer than wide posteriorly [4 : 3], the posterior width slightly longer than half the maximum width. Lateral margins with six hairs. Scutellum one and a half times as long as wide anteriorly, and slightly longer than wide posteriorly; with rows of six or seven hairs along the lateral margins, and approximately ten hairs on the disk. Metanotum rather long, with six hairs on each side of the mid line. Propodeum with two hairs above, and four beneath the large spiracle. Fore wing (7 : 3), 1.7 mm long. Submarginal, marginal, stigmal, and postmarginal veins approximately in ratio 3 : 1 : 1 : 2; submarginal vein with three pustules, stigmal vein with four. Hind wing (5 : 1), 0.9 mm long. Femur of the fore leg (fig. 221) longer than the coxa [3 : 2], and thrice as long as the tibia. Tibia with a dorso-apical row of four teeth, and one ventral tooth. Tarsal segments in ratio 20 : 4 : 4 : 5 : 10. Tibia of the mid leg as long as femur and trochanter combined, with long hairs. First tarsal segment as long as the following two combined, second to fifth segments gradually, but slightly, increasing in length. Femur of the hind leg (fig. 229) slightly longer than the coxa, the tibia two-thirds the length of the femur, with two apical teeth, the antaxial one of which is bidentate. Tarsus rather pubescent, especially along the plantar edge; segments in ratio 12 : 6 : 5 : 5 : 6.

Gaster. Ovipositor slightly projecting beyond the apex of the gaster.

Length, 1.9 mm. Colour brown, ventral surface and extremities lighter. Nervures of the wings brown, stigma with dark radiating striae.

#### Remark.

The specimens from Bougainville I. (coll. no. 550) differ from those of the typical sample. The females have the third antennal segment more slender, with longer and more slender, hyaline processes, and the pedicel bears less (approximately twenty-five) teeth at the axial surface. In the male, the first flagellar segment of the antenna is only one third the length of the second. The hind leg is shorter than in the New Britain specimens, and the metatarsus is less slender. The tibia bears a prominent tooth at the axial edge (fig. 228). As the specimens are few, and not in a very good condition, I do not name the form from Bougainville I., which should perhaps be regarded as a distinct species or subspecies.

#### *Ceratosolen calopilinae* sp. n. (figs. 231—242)

#### Material.

Series ♀, ♂, ex *Ficus calopilina* Diels (det. E. J. H. CORNER), Wau (Terr. New Guinea), leg. E. J. H. CORNER, 13.IX.1960; coll. no. 538; ♂ (holotype), slide 538a, ♀ (allotype), 538c, ♂, ♀ (paratypes), 538b, d, e.

### Description.

Male. Head (fig. 237) little more than twice as long as wide anteriorly, and nearly twice as long (8 : 5) as the maximum width. Eyes absent. Antennal grooves open, not very wide behind. Antenna (fig. 238) slender; the scape (2 : 1) nearly twice as long as the pedicel (3 : 2), the first flagellar segment short, the second (7 : 6) distinctly shorter than half the length of the apical segment (4 : 1). Mandible, fig. 236. Labium and maxillae, fig. 241; maxilla with one lateral hair.

Thorax, fig. 237. Pronotum twice as long as wide anteriorly, and one and a half times as long as wide posteriorly. Mesonotum with a straight posterior margin, tapering anteriorly; the length more than half the maximum width. Metanotum nearly as wide as the mesonotum, incompletely separated from the propodeum, which is approximately one and a half times as long as wide. Fore leg (fig. 240): the tibia nearly half as long as the femur, with three dorsal and three ventro-apical teeth. Tarsus bimerous, distal segment distinctly longer than the proximal one, with long hairs. Coxa and femur of mid leg subequal, approximately as long as the tibia. Tibia subclavate, with long hairs along the dorsal margin and on the axial surface. The apical edge dorsally produced into a stout tooth, ventrally with four smaller teeth. Tarsal segments in ratio 8 : 4 : 4 : 3 : 11. Coxa of the hind leg (fig. 232) little shorter than the femur. Tibia with one apical antiaxial tooth, pubescent along the dorsal edge. Tarsus dilated, with pubescence approximately half as long as the width of the segments. There is some variation in the dimensions of the segments, but the relative lengths are rather constant: 11 : 8 : 7 : 6 : 10.

Gaster. Aedeagus slightly dilated at mid length. Cercus of the tenth urite with three claws, paramere with parallel edges (fig. 239).

Length, 1.3 mm. Colour uniformly yellow-brown.

Female. Head slightly shorter than wide across the compound eyes. Longitudinal diameter of the eye longer than the cheek [8 : 7]. Pubescence short. Antenna (fig. 231): scape more than twice as long as the pedicel, which bears approximately twenty axial spines. Third segment not very long, the fourth small, the fifth shorter than the sixth [5 : 6], the seventh longer than the sixth [7 : 6]. Eighth to tenth segments gradually diminishing in length, the tenth as long as the sixth. Eleventh and tenth segments shaped so as to form a club, but not fused. Fifth segment with ten sensilla, sixth to tenth segments with thirteen or fourteen sensilla in two irregular rows; the apical segment with six oblong and two circular sensilla. Mandible (fig. 235), and its appendage, with six ventral ridges. Maxilla (fig. 234): bacilliform process not quite half as long as the maxilla [4 : 9]. Labium without long hairs.

Thorax. Pronotum wide, with long hairs. Scutum one and a half times as long as wide posteriorly, and nearly twice as wide anteriorly; with rows of four hairs along the lateral margins. Scutellum one and a half times as long as wide, with rows of five hairs along the lateral margins, and approximately ten hairs on the disk. Metanotum short, with nine hairs on each side of the mid line. Propodeum with three hairs above, and six beneath the propodeal spiracle. Fore wing (7 : 3), 1.6 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 75 : 17 : 24 : 44. Submarginal vein with three pustules, stigmal vein with five.



Figs. 231—242, *Ceratosolen calopilinae*, New Guinea, 231, female antenna, 232, male hind leg, 233—235, female, 233, detail of fore leg, 234, maxilla, 235, mandible, 236—241, male, 236, mandible, 237, male, 238, antenna, ventral aspect, 239, cercus of tenth urite, and paramere, 240, detail of fore leg, 241, labium and maxillae, 242, detail of female hind leg. Figs. 232, 237,  $\times 50$ ; 231, 233, 240, 242,  $\times 115$ ; 234—236, 238,  $\times 155$ ; 239, 241,  $\times 365$

Hind wing (4 : 1), 0.9 mm long. Coxa of the fore leg (fig. 233) more than half as long as the femur, tibia distinctly smaller than the coxa. Tibia with four dorso-apical teeth, and one ventral tooth. Tarsal segments in ratio 13 : 4 : 4 : 5 : 6. Mid leg of the usual slender build, the clavate tibia slightly longer than the femur; tarsal segments in ratio 15 : 7 : 7 : 5 : 9. Coxa of the hind leg (fig. 242) shorter than the femur [4 : 5]. Tibia nearly three quarters the length of the femur, with two ventro-apical teeth, the antiaxial one of which is bidentate. Tarsus pubescent, segments in ratio 25 : 10 : 8 : 8 : 11.

Gaster. Ovipositor short, but distinctly projecting beyond the apex of the gaster.

Length, 1.8 mm. Colour dark brown, ventral surface and extremities lighter. Nervures of wings light brown.

#### Remark.

*C. calopilinae* is very similar to *C. orientalis*, but it differs in the length of the bacilliform process of the female maxilla, the chaetotaxy of the male maxilla, and in the proportions of the male hind leg.

#### *Ceratosolen corneri* sp. n. (figs. 243—254)

#### Material.

Series ♀, ♂, ex *Ficus endobrix*<sup>1</sup>), Mt. Maquiling (Luzon, Philippine Is.), at first creek crossing, leg. F. X. WILLIAMS, 27.VI.1928, no. 3131; coll. HSPA, ♂ (holotype), ♀ (allotype), slide mounted; coll. ML, no. 682: 10 ♀, 10 ♂.

Fragments of several ♂, and 1 ♀, ex *Ficus botryocarpa* Miq. var. *subalbido-ramea* (Elmer) Corner (det. E. J. H. CORNER), Mindoro (Philippine Is.), leg. E. D. MERRILL, no. 1813; coll. no. 405; ♂ (paratypes), slide 405a, ♀ (paratype), 405b.

Series ♀, ♂, ex *Ficus barnesii*<sup>2</sup>), Mt. Maquiling (Luzon, Philippine Is.), leg. F. X. WILLIAMS, 28.VI.1928, no. 3131<sup>3</sup>), coll. HSPA.

#### Description.

Male. Head (fig. 246) more than twice as long as wide anteriorly. Epistomal margin (fig. 247) with four hairs. Eyes very small. Antennal grooves open, narrow behind. Antenna (fig. 248) five-segmented, the scape (5 : 2) four-thirds the length of the pedicel (15 : 7). Pedicel six times as long as the first flagellar segment (5 : 13), the second segment (25 : 14) half as long as the apical segment (4 : 1), and five times as long as the first. Maxillae (fig. 252) for a great part concealed under the hypostomal margin; labium atrophied. Mandible, fig. 251.

Thorax, fig. 246. Pronotum more than twice as long as wide anteriorly, its length one and a half times the maximum width. Mesonotum wider than long (7 : 5). Metanotum incompletely separated from the propodeum, not nearly as wide as the mesonotum [11 : 14]. Propodeum shorter than wide [3 : 4]. Fore leg (fig. 243): the tibia not quite half as long as the femur, with four dorsal and two ventro-apical teeth. Tarsal segments subequal in length. Coxa of the mid leg longer than the femur; the tibia longer than the femur, but not as long as the coxa. Tibia with four sharp apical teeth. Tarsal segments in ratio 22 : 6 : 5 : 4 : 14. Hind leg (fig. 253) very long, all segments with thick pubescence of small hairs. Coxa and femur very long (each about as long as the pronotum), and dilated. Tibia more than half as long as the femur, without any distinct apical armature. Tarsal segments in ratio 15 : 8 : 7 : 6 : 7. Metatarsus distinctly produced dorsally.

Gaster. Cerci of the tenth urite (fig. 249) with three claws.

Length, 1.5 mm. Colour uniformly yellow-brown.

<sup>1</sup>) *Ficus endobrix* Warb. = *F. botryocarpa* Miq.

<sup>2</sup>) *Ficus barnesii* Merr. = *F. botryocarpa* Miq.

<sup>3</sup>) ?, same tree as the first sample (no. 682)?



Figs. 243—254, *Ceratosolen corneri*, Luzon (except 246, 247, 251, 254, specimen from Mindoro), 243, detail of male fore leg, 244, detail of female hind leg, 245, female mandible, 246—249, male, 246, male, 247, epistomal margin, 248, antenna, 249, cercus of tenth urite, and paramere, 250, female fore leg, 251—254, male, 251, mandible, 252, maxillae and hypostomal margin, 253, detail of hind leg, 254, hind leg (specimen from Mindoro). Figs. 246,  $\times 50$ ; 253, 254,  $\times 80$ ; 243, 244, 247, 248, 250,  $\times 155$ ; 245, 251,  $\times 215$ ; 249, 252,  $\times 365$

Female. Antenna consisting of eleven segments, the last two of which are joined into a loose club. Scape twice as long as the pedicel, appendage of the third segment robust, the fourth segment small. Length of the fifth segment four-fifths of that of the sixth, two-thirds of that of the seventh, eighth and tenth segments; the ninth as long as the sixth segment. Eleventh segment half as long as the tenth. Funicular segments with one or two rows of long sensilla. Maxilla with one subapical hair, without a bacilliform process. Mandible (fig. 245) with five ventral ridges, its appendage with five large ridges, and smaller ridges in between the larger ones.

Thorax. A few hairs occur along the lateral edges of the scutum, five hairs along the edges of the scutellum. Metanotum with about ten hairs on each side of the mid line. Propodeum with two hairs above, and five beneath the spiracle. Fore wing (5 : 2), 1.4 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 12 : 4 : 3 : 6; the submarginal and stigmal veins with three pustules each. Hind wing (5 : 1), 0.8 mm long. Fore leg (fig. 250): the coxa smaller than the femur [11 : 14], and approximately twice as long as the tibia. Tibial armature consisting of four dorsal teeth. Tarsal segments in ratio 8 : 3 : 3 : 4 : 5. Mid leg slender, the tibia as long as femur and trochanter combined, tarsal segments in ratio 25 : 9 : 9 : 7 : 10. Coxa of hind leg (fig. 244) six-sevenths the length of the femur, tibia slightly longer than half the length of the femur. Tibial armature consisting of a bidentate antaxial, and a long, curved axial tooth. Tarsus fimbriated at the plantar edge, segments in ratio 8 : 3 : 2 : 2 : 3.

Gaster. Projecting part of the ovipositor not quite one quarter the length of the gaster.

Length, 1.4—1.6 mm. Colour brown, ventral surface and extremities lighter. Nervures of the wings light brown.

#### R e m a r k.

Although the female of this species is in no way aberrant from the normal type, the male is very remarkable. Its very long hind legs distinguish it at once from its congeners; in fact, in none of the other fig wasps have I seen the like.

There are some differences between the samples from Luzon and Mindoro. The specimens from the last mentioned locality are badly damaged, and better series should be studied to be certain of the differences. The males have the tarsus of the hind leg slightly more robust, and the metatarsus without the dorsal protuberance (fig. 254).

I name this species in honour of Mr. E. J. H. CORNER F.R.S., Lecturer in Botany, University of Cambridge.

*Ceratosolen solmsi* (Mayr) and *C. marchali* Mayr (figs. 255—260, 262—265; map, fig. 261; Table I)

Two forms of *Ceratosolen* were described that are known to live in *Ficus hispida* Linn. f., viz., *C. solmsi* (Mayr) and *C. marchali* Mayr. According to GRANDI (1928c, pp. 174—175), the species differ in the following characters:

♀. Eleventh antennal segment longer than the tenth in *C. solmsi*; shorter in *C. marchali*.



Bacilliform process of the maxilla one quarter the length of the maxilla in *C. solmsi*; one half as long as the maxilla in *C. marchali*.

? Mandibular process with six or seven ridges in *C. solmsi*; with nine ridges in *C. marchali*.

Fore wing hyaline in *C. solmsi*; darker, with striae radiating from the stigmal vein, in *C. marchali*.

♂. Antennal groove narrow behind in *C. solmsi*; wide in *C. marchali*.

Fourth antennal segment slightly longer than the third in *C. solmsi*; distinctly longer in *C. marchali*.

According to GRANDI (1926, p. 358), the male hind tibia is thrice as long as the first tarsal segment in *C. solmsi* from Java; and twice as long in *C. marchali* from Vietnam.

The forms were known from Java and S. Vietnam (*C. solmsi*) and from N. Vietnam and India (*C. marchali*). Moreover, GRANDI (1928c, p. 176) found one slide in MAYR'S collection, labelled "Tonkin", and containing *C. solmsi*.

I have seen material from Ceylon, India, Malaya (Selangor and Langkawi Is.), Hongkong, Java, and Queensland (distribution, see map, fig. 261). The data on some of the above mentioned differential characters are arranged in Table 1 (cf. figs. 255—269).

The male mouthparts are identical in the two forms (fig. 264). The genitalia bear cerci (fig. 265), which are clearly visible in the specimens from the Asian continent. In the specimens from Java and Langkawi, however, they are hyaline, and very difficult to be observed: I cannot even find them in all of these specimens, and in none of the sample from Queensland (but this is badly preserved). In general, the specimens from India, Ceylon, and Hongkong are slightly smaller and less slender than those from Malaya, Java, and Queensland.

It seems best to treat *C. solmsi* and *C. marchali* as subspecies. The specimens from Java are distinctly different from those collected in Ceylon, India, and China, but the characters seem to intergrade on the Malayan peninsula. The Australian specimens<sup>1</sup>) are intermediate in some aspects, but they resemble *C. marchali* more closely than they do *C. solmsi*.

### *Ceratosolen solmsi solmsi* (Mayr)

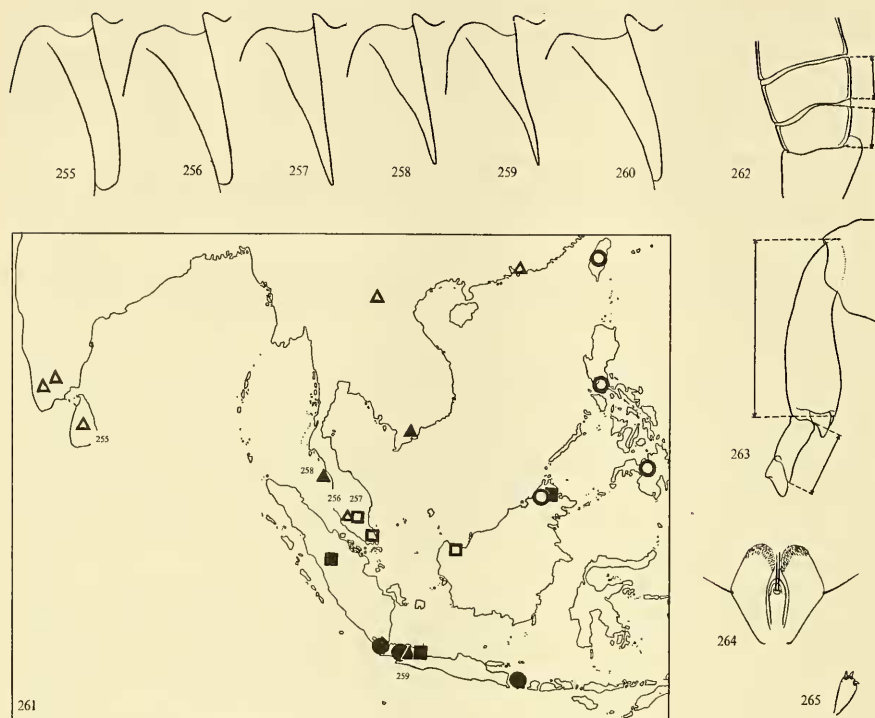
*Blastophaga (Ceratosolen) Solmsi* Mayr, 1885, pp. 154, 161, 163, 168—169, Pl. IX figs. 4—5 [key ♀, ♂, descr. ♀, ♂, ex *Ficus (Cystogyne) canescens* Kurz<sup>2</sup>) (det. Solms), Bogor (Java), Bot. Gdn., leg. H. Solms-Laubach; type: ♂].

*Ceratosolen Solmsi*: Mayr, 1906, p. 155 [rectification of original descr., ex *Covellia didyma* Miq.<sup>2</sup>), Bogor (Java), Bot. Gdn., leg. C. Aurivillius, no. 2]; Grandi, 1928c, pp. 173—176 [type specimens of *Blastophaga Solmsi* Mayr studied, = *C. ? Marchali*; Grandi; differences from *C. marchali* Mayr].

*Ceratosolen ? Marchali*: Grandi, 1926, pp. 357—358 [♀, ♂, ex *Ficus hispida* L. (det. J. Beumée; Herb. Bog. no. E. J. 2173), Djakarta (Java), leg. E. Jacobson, IV.1924]; Grandi, 1927b, pp. 174—178, figs. III—IV [descr. ♀, ♂, ex *Ficus* spec., Saigon (S. Vietnam), leg. F. Silvestri, 1924].

<sup>1</sup>) Series ♀, ♂, ex *Ficus hispida* Linn.f., Hambleton (Queensland), leg. C. E. PEMBERTON, 9.XI.1921; coll. HSPA; coll. ML, no. 590: 20 ♀, 10 ♂.

<sup>2</sup>) For a discussion of the host records, see p. 97.



Figs. 255—260, *Ceratosolen s. solmsi* (255, 256) and *C. s. marchali* (257—260), antennal groove of male, specimens from: 255, Ceylon, 256, 257, Selangor, 258, Langkawi I., 259, Java, 260, Queensland, 261, distribution on the Asian continent, and in the Philippines and Indonesia, of: *C. s. solmsi* (black triangles), *C. s. marchali* (open triangles) — the numbers refer to the figures above —, *C. bisulcatus* (black dots), *C. jucundus* (open circles), *C. constrictus* (black squares), and *C. heuitti* (open squares), 262—264, *C. s. solmsi*, Java, male, 262, detail of right antenna, with the measurements of third and fourth segments, used in Table I, 263, detail of hind leg, with the measurements of tibia and metatarsus, used in Table I, 264, labium and maxillae, 265, *C. s. marchali*, Selangor, male, cercus of tenth urite. Figs. 255—260, 263,  $\times 105$ ; 265,  $\times 140$ ; 264,  $\times 190$ ; 262,  $\times 235$

### Material.

Series ♀, ♂, ex *Ficus hispida* Linn. f., Bogor (Java), Bot. Gdn, VIII.1954; coll. nos. 9, 10, 11 (205 ♀, 47 ♂, all from one fig), 12; ♂, slide 12a.

One ♀, 1 ♂, Java, no. 186; coll. USNM.

Fragments of 5 ♀, series ♂, ex *Ficus hispida* Linn. f. 1) (det. E. J. H. CORNER), Langkawi Is. (Malaya), 1941, Sing. F. no. 37889; coll. no. 412; ♀, slide 412a.

1) "This was a rather unusual form of *F. hispida* with completely geocarpic figs (borne on slender twigs rooting in the ground)" (CORNER, 1956, in litt.).

TABLE I. SOME MEASUREMENTS OF *C. s. solmsi* AND *C. s. marchali* FROM DIFFERENT LOCALITIES

Collection number	Locality	♀. Length of: 1) maxilla bacilliform process	♀. Number of ridges on mandibular appendage. 2)	♀. length of: 1) tenth antennal segments.	♂. Length of: 3) fourth third antennal segments.	♂. Width of antennal groove. 4)	♂. Length of: 5) tibia metatarsus of hind leg.	Number of specimens measured.	Subspecies.
9	Java	3.75 (3.3—4.3)	7 (6—8)	1.7 (1.55—1.76)	1.5 (1.2—2.0)	1	2.9 (2.7—3.0)	10 ♀, 10 ♂	<i>C. s. solmsi</i>
412	Langkawi	2.75	7	broken	1.5 (1.25—1.75)	1	3.0 (2.8—3.2)	1 ♀, 10 ♂	<i>C. s. solmsi</i>
618	Selangor	2.2 (2.1—2.4)	6—7	0.8 (0.76—0.85)	2.0 (1.5—2.5)	1—2	2.6 (2.4—3.3)	10 ♀, 10 ♂	<i>C. s. marchali</i>
594	Hongkong	2.1	6	0.67	3.5	3	2.4	1 ♀, 1 ♂	<i>C. s. marchali</i>
564	India	2.3 (2.1—2.5)	8 (8—9)	0.75 (0.7—0.8)	4.0 (3.3—4.7)	3	2.2 (2.0—2.4)	5 ♀, 5 ♂	<i>C. s. marchali</i>
378 382	Ceylon	2.4	9	broken	3.5	3	3.0	1 ♀, 2 ♂	<i>C. s. marchali</i>
590	Queensland	2.9 (2.5—3.3)	6	0.66 (0.62—0.76)	1.25 (1.0—1.6)	2	3.75 (3.5—4.0)	10 ♀, 5 ♂	<i>C. s. cf. marchali</i>

1) Unit of measure, 4.5  $\mu$ .

2) Ridges only, distal edge not counted

3) Measured along the antaxial margin, in dorsal view (fig. 262). Unit of measure, 4.5  $\mu$ .

4) A grade from narrow to wide is indicated by the numbers 1—3 (see figs. 255—260).

5) Metatarsus measured along the plantar edge, tibia without the apical teeth (fig. 263).

Unit of measure, 15  $\mu$ .

### Ceratosolen solmsi marchali Mayr

*Ceratosolen Marchali* Mayr, 1906, pp. 155—156 [descr. ♀, ♂, ex *Ficus spec.*, Tonkin (N. Vietnam) leg. P. Marchal, no. 20a]; Grandi, 1928c, pp. 173—175 [type specimens of *C. Marchali* Mayr studied, = *C. Berlandi* Grandi; differences from *C. solmsi* (Mayr)]; Joseph, 1953c, p. 282 [♀, ♂, ex *Ficus hispida* L., Kottayam (Travancore, India), leg. K. J. Joseph, 26.VI.1951].

*Ceratosolen Berlandi* Grandi, 1928a, pp. 74—79, fig. II [descr. ♀, ♂, ex *Ficus hispida* L., Chambaganour (Pulneys, India)<sup>1</sup>], 5000 ft. alt., leg. E. Gombert, 14.IV.1914].

#### Material.

Series ♀, ♂, India, ex coll. JOSEPH; coll. ML, no. 564.

Ten ♂, 5 ♀, Calcutta (India), leg. ROTHNEY, VIII.1885; coll. OUM.

Series ♀, ♂, ex *Ficus hispida* Linn. f., Hongkong (China), leg. GREEN, issued at Honolulu, 29.VIII—1.IX.1921; coll. HSPA; coll. ML, no. 594: 1 ♀, 1 ♂.

Series ♀, ♂, ex *Ficus hispida* Linn. f., Hongkong (China), leg. D. T. FULLAWAY, 16.I.1921; coll. HSPA.

Series ♀, ♂, ex *Ficus hispida* Linn. f. (det. E. J. H. CORNER), Sungei Gombah (Selangor, Malaya), leg. E. J. H. CORNER, 4.X.1961; coll. no. 618; ♀, slide 618a, ♂, 618b, c.

Ten ♀, 2 ♂, ex *Ficus hispida* Linn. f., Peradeniya (Ceylon), Bot. Gdn., leg. F. KEISER, 25.II.1954; coll. NMB; coll. ML, no. 378: 1 ♀.

Three ♀, series ♂, ex *Ficus hispida* Linn. f., Peradeniya (Ceylon), Bot. Gdn., leg. F. KEISER; coll. NMB; coll. ML, no. 382: 3 ♂.

### *Ceratosolen brongersmai* sp. n. (figs. 266—277)

#### Material.

Series ♀, ♂, ex *Ficus treubii* King (det. E. J. H. CORNER), Sungei Mesilau (N. Borneo), 5500 ft. alt., leg. E. J. H. CORNER, VIII.1961; coll. no. 604; ♂ (holotype), slide 604a, ♀ (allotype), 604c, ♂, ♀ (paratypes), 604b, d.

Series ♀, ♂, ex *Ficus treubii* King (det. E. J. H. CORNER), Sungei Bembangan (N. Borneo), 5500 ft. alt., leg. E. J. H. CORNER, VIII.1961, RSNB no. 1891; coll. no. 612; ♂, slide 612a, ♀, ♂, 612b.

#### Description.

Male. Maximum width of the head (fig. 269) three quarters of the length, the head slightly narrower anteriorly and posteriorly. Pubescence short and sparse. Eyes absent. Antennal grooves open, wide behind. Antenna (fig. 270) five-segmented: the scape (7 : 4) one and a half times as long as the pedicel (2 : 1); the first flagellar segment annuliform, the second (1 : 2) less than one fifth the length of the third (3 : 1). Labium and maxillae (fig. 277) large, the labium bilobate, the lobes not equal; maxilla with a lateral expansion bearing one long hair. Mandible, fig. 266.

Thorax, fig. 269. Pronotum nearly twice as long as wide anteriorly, the posterior width one and a half times the anterior width. Maximum width of the

<sup>1</sup>) ? = Shembaganur, Palni Hills, S. India?

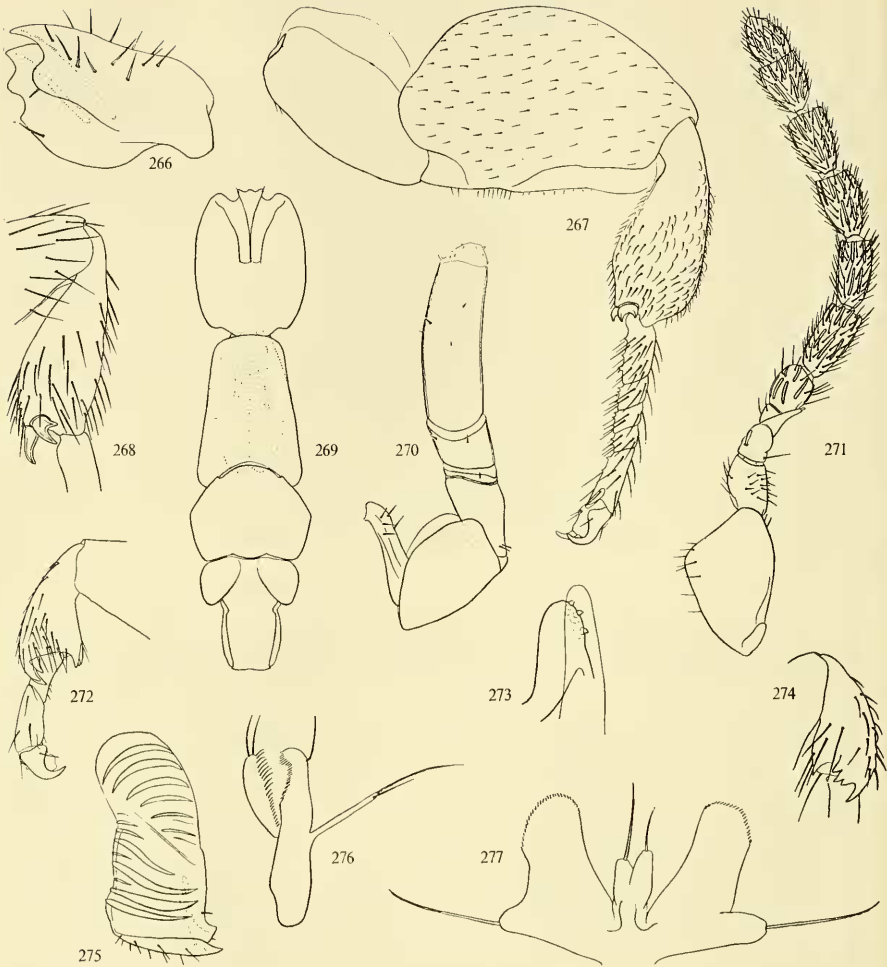
mesonotum, across the lateral angles, distinctly longer than the length [13 : 10]. Metanotum narrower than the mesonotum, incompletely separated from the propodeum. Propodeum long and rather narrow, with large peritremata. Metasternum glabrous. Femur of the fore leg (fig. 272) twice as long as the tibia. Tibia apically with four dorsal teeth (three large and one smaller), and three ventral teeth. Tarsus bimerous, segments in ratio 5 : 6. Mid leg slender, the coxa nearly as long as the femur, the tibia distinctly longer [3 : 2]. Tibia with the ventro-apical edge produced into two teeth. Tarsus pentamerous, the segments in ratio 7 : 2 : 2 : 2 : 7. Hind leg, fig. 267. Coxa large, with a hyaline border along the dorsal margin as in the species with dilated hind feet, pubescent axially, glabrous antaxially. Femur with a hyaline part along the distal ventral border; antaxial surface with small hairs, axially with many long stout hairs. Tibia two-thirds the length of the femur; ventral apex with two articulating teeth: the axial one curved, the antaxial one deeply bidentate. Tarsus with small protuberances along the ventral margin; the five segments in ratio 16 : 6 : 5 : 5 : 14.

Gaster. Cerci of the tenth urite with three claws, parameres straight and narrow (fig. 273).

Length, 1.7 mm. Colour uniformly olive-brown, the pubescent parts of the hind legs darker.

Female. Head as long as wide across the eyes. Longitudinal diameter of the eye longer than the cheek [7 : 5]. Pubescence long. Antenna (fig. 271): scape not very long, but wide; the pedicel not quite half as long as the scape, with approximately thirty-five spines at the axial surface. Appendix of the third segment long and slender; the fourth segment small. Fifth segment wide, with twelve long sensilla. Sixth segment longer than the following [8 : 7], seventh to ninth segments subequal, and longer than the tenth [7 : 6], which is a little longer than the apical segment. Sixth to tenth segments with two irregular rows of ten long sensilla each; the eleventh segment with ten long and two circular sensilla. Labium and maxillae (fig. 276): labium with two hairs, maxilla with one apical hair; maxilla moreover with a bacilliform process, which is nearly half as long as the maxilla. The process bears two hairs. Mandible (fig. 275) with four large and four smaller ventral ridges, the appendage with six or seven ventral ridges.

Thorax. Pronotum not very large, pubescent. Scutum nearly as long as its maximum width, a little narrower behind; with approximately twenty long hairs. Scutellum one and a half times as long as wide, with eight hairs along each lateral edge. Metanotum with a row of nine or ten hairs on each side of the mid line. Propodeum large, with two hairs above, and fifteen beneath the peritremata. Fore wing (2 : 1), 2.0 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 7 : 3 : 3 : 4; the stigma with four pustules, the submarginal vein with three. Hind wing (4 : 1), 1.2 mm long. Fore leg (fig. 274): the coxa two-thirds the length of the femur, which is more than twice as long as the tibia. Apical tibial comb consisting of four sharp teeth. Tarsus pentamerous, the segments in ratio 18 : 8 : 7 : 7 : 8. Mid leg slender, with long hairs. Tibia nearly as long as femur and trochanter combined, with a long, slightly curved ventral spur. Tarsal segments in ratio 17 : 8 : 8 : 8 : 11. Coxa of the hind leg (fig. 268) large;



Figs. 266—277, *Ceratosolen brongersmai*, Borneo, 266, male mandible, 267, male hind leg, 268, detail of female hind leg, 269, male, 270, male antenna, 271, female antenna, 272, detail of male fore leg, 273, male, cercus of tenth urite, and paramere, 274—276, female, 274, fore tibia, 275, mandible, 276, labium (lateral aspect), and maxilla, 277, male labium and maxillae. Figs. 269,  $\times 40$ ; 272,  $\times 90$ ; 267, 268, 271, 274—276,  $\times 115$ ; 266, 270,  $\times 160$ ; 273, 277,  $\times 275$

the femur long but not very wide, with long hairs; the tibia as long as the coxa, and nearly two-thirds the length of the femur. Tibia with two ventral teeth: the axial one rather long and curved, the antaxial one bidentate. Tarsus pubescent, especially along the plantar edge; segments in ratio 15 : 6 : 6 : 4 : 8.

Gaster. Projecting part of the ovipositor about one tenth the length of the gaster.

Length, 2.0 mm. Colour brown, the extremities and ventral surface lighter. Nervures of the wings brown, light brown striae radiate from the stigma.

## R e m a r k.

In some aspects, this species is close to *C. humatus* and *C. albulus* (see below), notably in the shape of the male trophi. The female, however, has a different tibial armature in the fore leg, and the male hind tarsi are not dilated. The other connection is that with *C. solmsi*, which, however, has different male mouthparts. For further remarks on the classification of *C. brongersmai* and *C. solmsi*, see p. 87.

I name this remarkable species in honour of Dr. L. D. BRONGERSMA, Director of the Rijksmuseum van Natuurlijke Historie, Leiden.

**Ceratosolen pilipes** sp. n. (figs. 278—285; 287—292)

## M a t e r i a l.

Series ♀, ♂, ex *Ficus cereicarpa* Corner (det. E. J. H. CORNER), Mt. Kinabalu East (N. Borneo), 2000 ft. alt., leg. E. J. H. CORNER, VI.1961; coll. no. 636; ♂ (holotype), slide 636a, ♀ (allotype), 636e, ♂, ♀ (paratypes), 636b, c, d, f.

## D e s c r i p t i o n.

Male. Head (fig. 279) nearly twice as long as wide anteriorly; the maximum width two-thirds of the length. Dorsal surface, especially along each side of the antennal grooves, with rather long hairs. Eyes present. Antennal grooves open, wide behind. Antenna (fig. 281) five-segmented; the scape (17 : 10) nearly twice as long as the pedicel (9 : 5); the first flagellar segment annuliform, the second (1 : 1, longer antaxially than axially) one third the length of the apical segment (9 : 4). Labium and maxillae, fig. 288. Labium with two subapical hairs, and sometimes with a pair of basal hairs, which, however, more often than not are absent. Maxilla expanded laterally, with two lateral hairs. Mandible, fig. 278.

Thorax, fig. 279. Pronotum not quite twice as long as wide anteriorly, and nearly as long as wide posteriorly. Mesonotum large, little wider than long. Metanotum incompletely separated from the propodeum; propodeum long and rather narrow, with large peritremata. The metasternum, and to a lesser extent also the mesosternum, with a rather long and heavy pubescence (fig. 289). Fore leg (fig. 292): the coxa large, the femur twice as long as the tibia including the large dorsal teeth. Tibia with a comb of four closely joined large teeth at the dorsal edge, and three ventral teeth. Tarsus bimerous, but with an indication of a trimerous condition; the two free segments subequal in length. Coxa of the mid leg little shorter than the femur; the tibia as long as femur and trochanter combined, with heavy pubescence apically, the ventral edge produced into two teeth. Tarsus pentamerous; the segments in ratio 23 : 7 : 9 : 8 : 23. Hind leg (fig. 287) with heavy pubescence on all segments. Coxa wide, but shorter than the femur. Tibia two-thirds the length of the femur; the dorso-apical edge produced; ventrally with a bidentate tooth. Tarsal segments in ratio 12 : 6 : 6 : 5 : 9, the length of the pubescence approximately two-thirds the width of the segments.

Gaster partly sclerotized. Cerci of the tenth urite (fig. 284) with five or six short claws, the parameres curved axially.

Length, 2.3—2.4 mm. Colour yellow-brown, the head a trifle darker. Hind legs, especially the femora, dark brown.

Female. Head longer than wide across the eyes [10 : 9]; pubescent. Longitudinal diameter of the eye three quarters the length of the cheek. Antenna (fig. 283): the scape large; the pedicel with several hundreds of small spines (fig. 285) at the axial surface; the third segment rather robust, its appendage strongly curved. Fourth segment small. Fifth segment almost glabrous, with ten oblong sensilla. Sixth to ninth segments long, about twice the length of the fifth segment. Tenth segment shorter; the apical segment but little longer than the fifth. Sixth to eleventh segments with several irregular rows of sensilla. Labium with two sub-apical hairs. Maxilla (fig. 291) with one subapical lateral hair, and a bacilliform process, which is nearly half as long as the maxilla itself. The process bears one apical hair, and a lateral hair at four-fifths of the length. The mandible (fig. 290) bears nine ventral ridges, its appendage seven.

Thorax. Pronotum rather long, with long hairs. Scutum about as long as its maximal width; its lateral and ventral edges with about ten long hairs. Anterior width of the scutellum five-sevenths of its length; the scutellum bears approximately forty long hairs. Metanotum with rows of fifteen hairs on each side of the mid line. Propodeum long, with tufts of seven hairs above, and nearly fifty hairs beneath and next to the spiracular peritremata. Fore wing (11 : 5), 3.0 mm long. Submarginal, marginal, stigmal, and postmarginal veins approximately in ratio 16 : 5 : 4 : 11; the stigma distally produced, with two pairs of pustules; the submarginal vein with three pustules. Hind wing (4 : 1), 1.85 mm long. Fore leg (fig. 280): the coxa two-thirds, the tibia (including the dorsal armature) one half the length of the femur. Tibia with a dorso-apical comb of four sharp and one blunt teeth; ventrally with a blunt protuberance, which bears several long hairs. Axially, the tibia and the tarsus bear several long, stout spine-like hairs. Tarsal segments in ratio 18 : 5 : 5 : 4 : 8. Mid leg slender; the coxa semiglobular, the trochanter short, but rather wide, the subclavate tibia nearly as long as trochanter and femur combined, with one long ventral spur; tarsal segments in ratio 10 : 4 : 4 : 3 : 6. Hind leg (fig. 282): the coxa as wide as the femur, but shorter [4 : 5]; the femur pubescent, with a distinct ventral groove for the reception of the tibia. Tibia with two ventro-apical teeth, the antaxial one of which is bidentate. Tarsus with spines and many hairs, especially along the plantar edge, the segments in ratio 16 : 7 : 7 : 4 : 8.

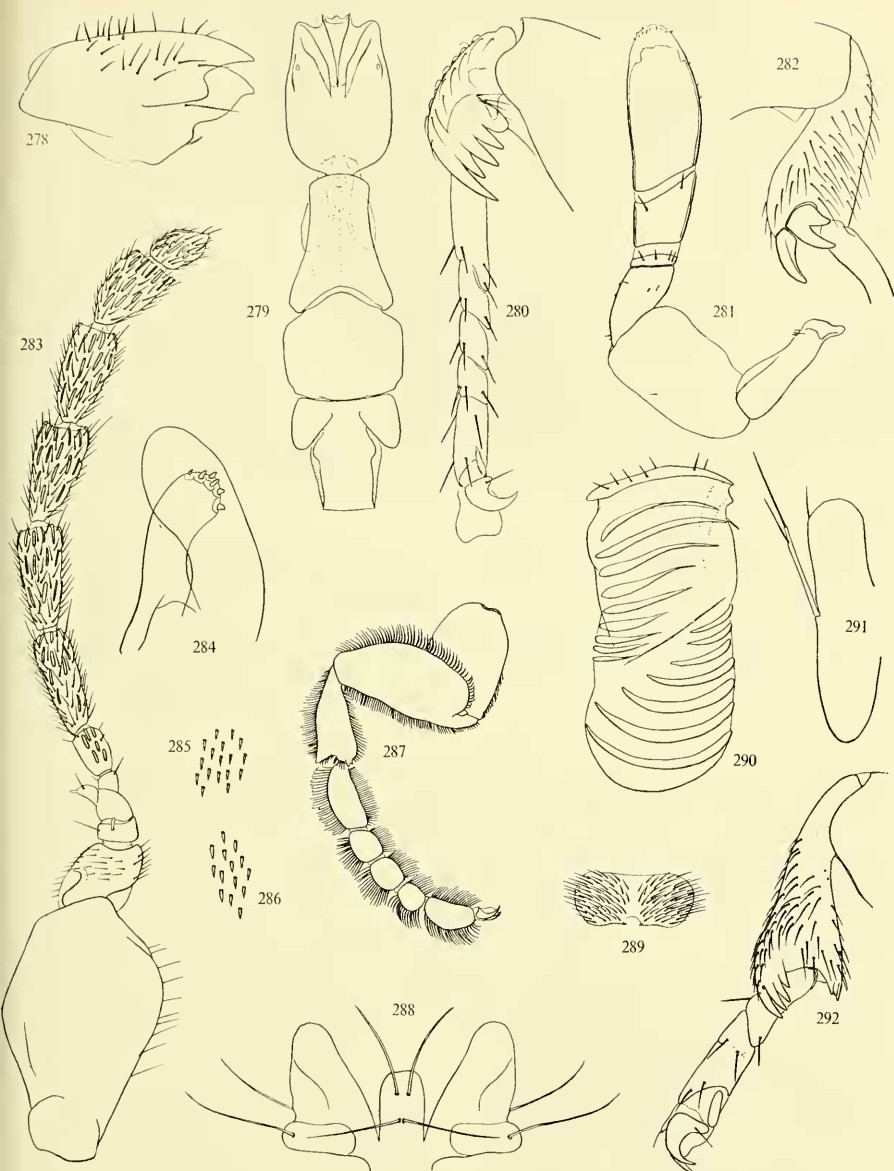
Gaster. Ovipositor short, approximately one tenth the length of the gaster.

Length, 3.2—3.4 mm. Colour of head and dorsal surfaces of thorax and gaster black-brown, lighter ventrally. Nervures of wings brown, with dark striae radiating from the stigma.

#### R e m a r k.

*C. pilipes* is remarkable in having the dorso-apical edge of the male hind tibia produced, and the parameres strongly curved. The dorsal armature of the female fore tibia — and this holds for several other species in the relationship of *C. pilipes* — reminds one of the tibial comb in *C. armipes* and relatives.





Figs. 278—292, *Ceratosolen pilipes* (286, *C. josephi*), Borneo, 278, male mandible, 279, male, 280, detail of female fore leg, 281, male antenna, 282, detail of female hind leg, 283, female antenna, 284, male, cercus of tenth urite, and paramere, 285, female, axial spines of pedicel, 286, do., of *C. josephi*, 287—289, male, 287, hind leg, 288, labium and maxillae, 289, metasternum, 290, female mandible, 291, female maxilla, 292, male fore leg. Figs. 279, 287, 289,  $\times 40$ ; 280, 282, 283, 290—292,  $\times 90$ ; 278, 281,  $\times 115$ ; 285, 286, 288,  $\times 200$ ; 284,  $\times 275$

*Ceratosolen josephi* sp. n. (figs. 286, 293—303)

## Material.

Series ♀, ♂, ex *Ficus francisci* Winkler (det. E. J. H. CORNER), Sungei Mamut (N. Borneo), 3000 ft. alt., leg. E. J. H. CORNER, VIII.1961; coll. no. 621; ♂ (holotype), slide 621a, ♀ (allotype), 621c, ♂, ♀ (paratypes), 621b, d-g.

## Description.

Male. Head (fig. 296) twice as long as wide anteriorly. The maximum width is but little longer than the anterior width [5 : 4]. Pubescence short, especially occurring along the antaxial edges of the antennal grooves. Eyes present. Antennal grooves open, wide behind. Antenna (fig. 294) five-segmented; the scape, not nearly twice as long as wide apically, twice as long as the pedicel (3 : 2); the first flagellar segment annuliform, the apical segment (7 : 3) thrice as long as the second flagellar segment (9 : 7). Mouthparts, fig. 301. Labium with a pair of subapical hairs; maxilla expanded laterally, with two lateral hairs. Mandible, fig. 298.

Thorax, fig. 296. Pronotum twice as long as wide anteriorly, and distinctly longer than wide posteriorly [6 : 5]. Maximum width of the mesonotum four-fifths of its length. Metanotum incompletely separated from the propodeum, which is but little longer than its maximum width. Metasternum with heavy pubescence, mesosternum with less hairs. Fore leg (fig. 303): the femur more than twice as long as the tibia [11 : 5]; the four dorsal teeth of the tibia not so close together as in *C. pilipes*. Tibia with three ventral apical teeth. Tarsus bimerous, with notches indicating the presence of a third intermediate segment; the two free segments subequal. Mid leg: the coxa smaller than the femur; the tibia smaller than femur and trochanter combined. Tibia with long dorsal and ventral hairs, the ventral edge produced into two apical teeth. Tarsus with long hairs, the segments in ratio 9 : 4 : 4 : 4 : 8. Hind leg (fig. 299) with heavy pubescence on all segments. Coxa rather narrow, shorter than the femur, the tibia two-thirds the length of the femur. Dorso-apical edge of the tibia produced; ventrally, the apical edge bears a bidentate tooth, and a sharp tooth at the outermost corner. Tarsal segments in ratio 9 : 7 : 6 : 4 : 7; pubescence nearly as long as the width of the segments.

Gaster partly sclerotized. Cerci of the tenth urite with three short claws, parameres almost straight (fig. 297).

Length, 2.0—2.2 mm. Colour light brown, with darker hind legs.

Female. Head as long as wide across the compound eyes; with rather long hairs. Longitudinal diameter of the eye four-fifths of the length of the cheek. Antenna (fig. 293): scape not very large relative to the large pedicel, which bears approximately one hundred and fifty spines. Compared with those of *C. pilipes*, these spines are rather large (fig. 286). Fifth segment with ten oblong sensilla. Sixth to eighth segments longer than the ninth [11 : 10], which is twice as long as the fifth. Tenth segment smaller than the ninth, the apical segment slightly longer than the fifth. Sixth to eleventh segments bear several irregular rows of sensilla. Labium and maxillae (fig. 302): the labium bears two subapical hairs; the max-

illa bears one subapical hair and a bacilliform process, which is half as long as the maxilla. The apical hair of the bacilliform process is visible in all specimens. The presence of a lateral hair is indicated by a small pit, at four-fifths of the length; I cannot find any specimens in which the hair is actually present. Mandible (fig. 300) with eight ventral ridges, the appendage with seven.

Thorax. Relative proportions much as in *C. pilipes*, but some parts are distinctly less pubescent: scutellum with four hairs along each lateral edge; metanotum with rows of four to five hairs on each side of the mid line; propodeum with about twenty-five hairs below the peritremata. Fore wing (21:10), 2.55 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 20:7:8:15. Stigma rather blunt distally, with three pustules; submarginal vein with three pustules. Hind wing (4:1), 1.6 mm long. Fore leg (fig. 295): the coxa nearly two-thirds the length of the femur, which is more than twice as long as the tibia including the dorsal armature. Dorsal comb of the tibia consisting of four sharp and one blunt teeth; ventrally, the tibia bears a protuberance with long hairs. Axial surfaces of tibia and tarsus with several stout hairs. Tarsal segments in ratio 22:7:8:7:14. Mid leg as in *C. pilipes*. Femur of the hind leg rather pubescent, twice as long as the tibia, which bears the usual axial, and bidentate antiaxial teeth. Tarsus rather wide, pubescent along the plantar edge; segments in ratio 30:13:11:10:16.

Gaster. Ovipositor distinctly projecting, one seventh the length of the gaster.

Length, 2.5—2.7 mm. Colour dark brown dorsally, lighter ventrally. Fore wings with brown nervures and dark striae.

#### Remark.

This species is close to *C. pilipes*, yet it is easily recognized by its smaller size, and by several characters in the female antenna and thorax, and in the male mouthparts and legs.

I name the species after Dr. K. J. JOSEPH, Head, Department of Zoology, Karnatak University, Dharwar (India), in recognition of his contributions to the knowledge of Indian fig insects.

#### *Ceratosolen albulus* sp. n. (figs. 304—316)

#### Material.

Series ♀, ♂, ex *Ficus uncinata* Becc. var. *strigosa* Corner (det. E. J. H. CORNER), Mt. Kinabalu East (N. Borneo), 3500 ft. alt., leg. E. J. H. CORNER, VI.1961, RSNB no. 666; coll. no. 603; ♂ (holotype), slide 603a, ♀ (allotype), 603b, ♀, ♂ (paratypes), 603c, d.

#### Description.

Male. Head (fig. 305) longer than its maximal width [5:4], the anterior width three-fifths of the length. Pubescence short and sparse. Eyes absent. Antennal grooves open, wide behind. Antenna (fig. 306) five-segmented; the scape (3:2) but little longer than the pedicel (4:1). First flagellar segment (1:2) one sixth the length of the pedicel; the second segment nearly thrice as long as the first, and one third the length of the apical segment (3:1). Labium and maxilla (fig. 316)



Figs. 293—303, *Ceratosolen josephi*, Borneo, 293, female antenna, 294, male antenna, 295, detail of female fore leg, 296—299, male, 296, male, 297, cercus of tenth urite, and paramere, 298, mandible, 299, hind leg, 300, female mandible, 301, male labium and maxillae, 302, female labium and maxilla, lateral aspect, 303, detail of male fore leg. Figs. 296, 299,  $\times 40$ ; 293, 295, 300—303,  $\times 90$ ; 294, 298,  $\times 115$ ; 297,  $\times 275$

wide, with one lateral hair on the maxilla; labium bilobate. Mandible, fig. 315.

Thorax, fig. 305. Pronotum as long as wide posteriorly, the anterior width two-thirds of the length. Mesonotum distinctly wider than long [17 : 14], the lateral edges with a stricture at mid length. Metanotum rather large, incompletely separated from the propodeum; the latter longer than wide [5 : 4], with straight lateral margins. Fore leg (fig. 304): the coxa two-thirds the length of the femur, which is twice as long as the tibia. Dorso-apical comb of the tibia consisting of three large and two smaller teeth; there are several ventral teeth. Tarsus bimerous, segments approximately in ratio 2 : 3. Femur of the mid leg as long as coxa and trochanter combined; the tibia slightly longer than femur and trochanter combined. Ventral tibial edge produced into two apical teeth. Tarsal segments in ratio 17 : 5 : 6 : 6 : 20. Femur of the hind leg (fig. 307) not much longer than coxa and trochanter combined; the tibia distinctly shorter [4 : 5]. The coxa with a small hyaline dorsal ridge, and many hairs on the axial surface; the femur and tibia, as well as the tarsus, pubescent. Tibial armature consisting of two ventro-apical

teeth (fig. 308), the antaxial one of which is bidentate. Tarsus dilated, the segments in ratio 45 : 22 : 23 : 20 : 40. Length of the pubescence one half to three quarters the width of the segments.

Gaster. Cerci of the tenth urite with six claws; in many specimens, the parameres are folded longitudinally (fig. 309).

Length, 2.2—2.3 mm. Colour yellowish; the thoracic terga ivory-whitish.

Female. Head slightly shorter than wide across the eyes [17 : 18]. Pubescence long. Longitudinal diameter of the eye longer than the cheek [5 : 3]. Antenna, fig. 310. Scape two and a half times as long as the pedicel, which bears approximately fifty spines at the axial surface. Third segment small, not half as long as the fifth; the latter two-thirds the length of the sixth; seventh to eleventh segments gradually diminishing in size, the eleventh about as long as the fifth, but narrower. Sensilla rather long and narrow; fifth to tenth segments with about twenty to twenty-five, the apical segment with fifteen sensilla. Labium and maxilla (fig. 311): the labium with two hairs; the maxilla with a bacilliform process (half as long as the maxilla) and a subapical, lateral hair. Mandible (fig. 312) with seven ridges, the appendage with eleven ridges, the proximal two of which are very small and not always distinctly visible.

Thorax. Pronotum with rather short hairs. Scutum anteriorly one and a half times as wide as long, the posterior width half the anterior width; with five long hairs along each lateral margin. Posterior width of the scutellum nearly equal to its length, anterior width four-fifths of the length. Lateral margins with five hairs. Metanotum rather long, with fourteen hairs on each side of the mid line. Propodeum with two hairs above, and nine hairs beneath the peritremata. Fore wing (2 : 1), 2.5 mm long. Submarginal, marginal, stigmal, and postmarginal veins in ratio 39 : 21 : 20 : 25; submarginal vein with three pustules, stigma with four. Hind wing (5 : 1), 1.6 mm long. Fore leg (fig. 314): the coxa more than half as long as the femur [5 : 8], which bears long hairs. Tibia, not nearly half as long as the femur [3 : 8], with a dorso-apical comb of six teeth, the first of which is blunt. Ventrally, the tibia bears a blunt tooth and a long spur. Antaxial surface with long hairs, especially in the ventral part; axial surface with ten stout spine-like hairs. Tarsal segments in ratio 13 : 5 : 5 : 6 : 7; axial surfaces of the segments with stout spines, except for the fifth, which has hairs instead. Mid leg slender, the tibia nearly as long as trochanter and femur combined; tarsal segments in ratio 23 : 11 : 13 : 12 : 15. Hind leg (fig. 313); the femur slender, one and a half times as long as the tibia. Tibia with long hairs and two ventral teeth, the antaxial one of which is bidentate. Tarsus pubescent, segments in ratio 23 : 9 : 7 : 8 : 11.

Gaster. Ovipositor short, but distinctly protruding behind the gaster.

Length, 2.3—3.0 mm. Colour brown, pronotum and head darker, ventral surface and extremities lighter. Fore wing with two dark striae radiating from the stigma

#### Remarks.

*C. albulus* is close to *C. humatus*, but it differs in its dimensions, the dentation of the male fore tibia, the length of the pedicel of the male antenna, etc.

*Ceratosolen humatus* sp. n. (figs. 317—329)

## Material.

Series ♀, ♂, ex *Ficus beccarii* King var. *latifolia* Corner (det. E. J. H. CORNER), Kundasan (N. Borneo), 4000 ft. alt., leg. E. J. H. CORNER, 24.VIII.1961; coll. no. 608; ♂ (holotype), slide 608a, ♀ (allotype), 608c, ♂ (paratype), 608b.

Series ♀, ♂, ex *Ficus beccarii* King var. *latifolia* Corner (det. E. J. H. CORNER), Mt. Kinabalu East (N. Borneo), 6500 ft. alt., leg. E. J. H. CORNER, 7.VIII.1961, RSNB no. 709; coll. no. 611; ♀, ♂ (paratypes), slides 611a, b.

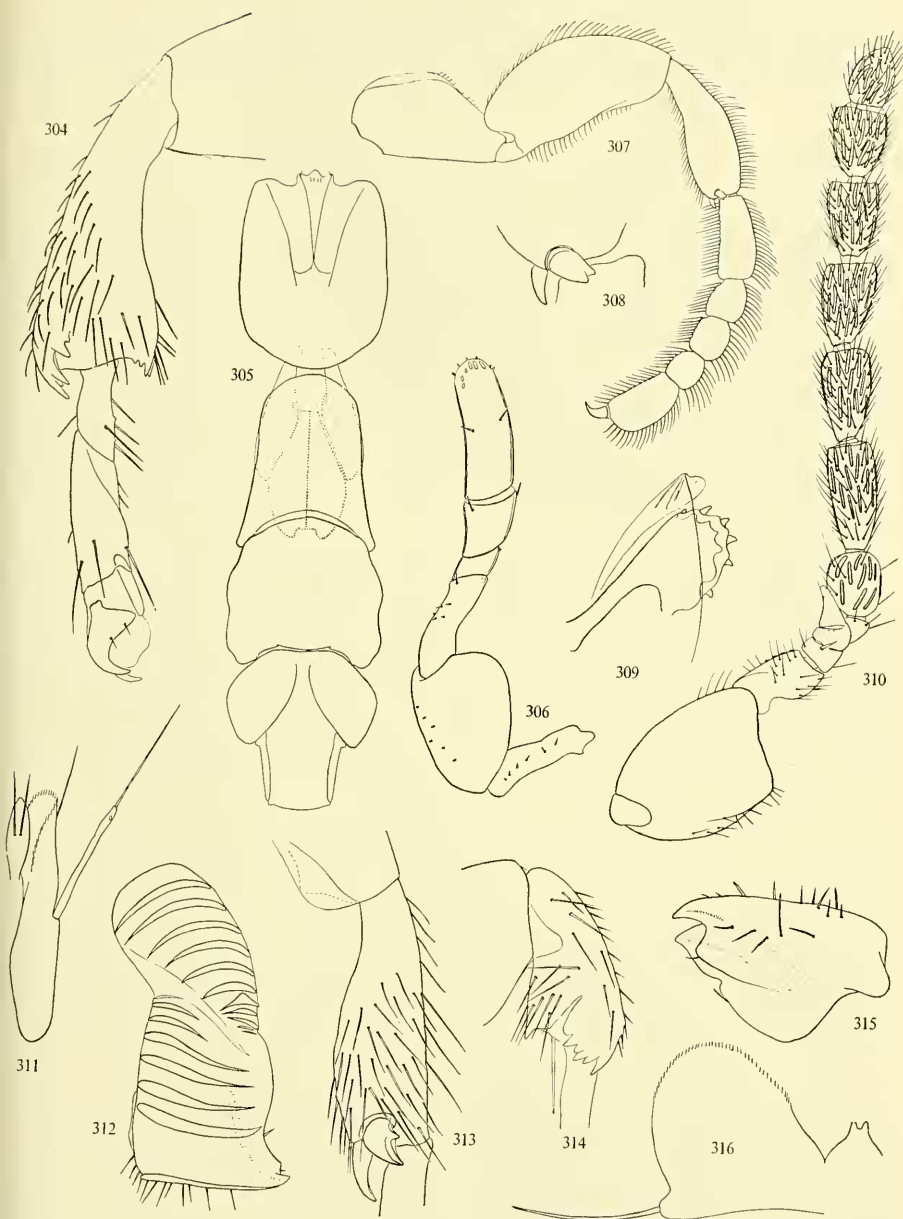
Series ♀, ♂, ex *Ficus beccarii* King var. *latifolia* Corner (det. E. J. H. CORNER), Mt. Kinabalu East (N. Borneo), 3500 ft. alt., leg. E. J. H. CORNER, VI.1961, RSNB no. 665; coll. no. 614; ♀, ♂ (paratypes), slides 614a, b.

Series ♀, ♂, ex *Ficus subterranea* Corner (det. E. J. H. CORNER), Tenompok (N. Borneo), 4500 ft. alt., leg. E. J. H. CORNER, VIII.1961, RSNB no. 1987; coll. no. 607; ♂, slides 607a, b, ♀, 607c, d.

## Description.

Male. Head (fig. 326) one and a half times as long as wide anteriorly, and distinctly longer than its maximum width [9 : 7]. Pubescence short and sparse. Eyes absent. Antennal grooves open, wide behind. Antenna (fig. 323) five-segmented: the scape (12 : 7) twice as long as the pedicel (2 : 1); the first flagellar segment (3 : 7) one third the length of the pedicel, the second segment (2 : 3) twice, the apical segment (3 : 1) seven times as long as the first. Labium and maxillae, fig. 319. Labium bilobate at apex, each lobe with an apical hair, and sometimes with an extra hair at the axial surface; maxilla with two lateral hairs as in the figure. Mandible, fig. 324.

Thorax, fig. 326. Pronotum short, as long as wide at mid length, slightly narrower in front, and much wider behind. Mesonotum large, nearly as long as wide posteriorly, narrower anteriorly. Metanotum incompletely separated from the propodeum, the free part of which is about as long as wide. Coxa of fore leg (fig. 325) large, more than half as long as the femur; the femur twice as long as the tibia. Apical armature of the tibia consisting of a series of dorsal teeth, and three ventral teeth. Tibia axially as well as antaxially with stout hairs. Tarsus bimerous, although a dorsal notch in the distal segment indicates an original trimerous condition; the free segments subequal in length. Mid leg slender, the coxa slightly longer than the femur, but shorter than the clavate tibia. Tibia with long hairs; its ventro-apical edge produced into two teeth. Tarsal segments in ratio 14 : 5 : 5 : 4 : 14. Hind leg (fig. 321): the coxa but little shorter than the femur, glabrous antaxially, strongly pubescent axially, with a dorsal hyaline ridge. Femur antaxially with few short hairs, pubescent axially. Tibia three quarters the length of the femur, pubescent; the ventral armature consisting of a bidentate antaxial, and an axial tooth, which is slightly curved. Tarsus dilated, the pubescence approximately one half to five-sevenths the width of the segments. Tarsal segments in ratio 23 : 11 : 11 : 11 : 18, or the first segment slightly shorter and the tarsus wider, or the first segment slightly longer and the tarsus longer, in some specimens.



Figs. 304—316, *Ceratosolen albulus*, Borneo, 304—309, male, 304, detail of fore leg, 305, male, 306, antenna, 307, hind leg, 308, apex of hind tibia, 309, cercus of tenth urite, and paramere, 310—314, female, 310, antenna, 311, labium and maxilla, 312, mandible, 313, detail of hind leg, 314, detail of fore leg, 315, male mandible, 316, male labium and maxilla. Figs. 305, 307,  $\times 40$ ; 310,  $\times 90$ ; 304, 306, 308, 311—314,  $\times 115$ ; 315,  $\times 160$ ; 309, 316,  $\times 275$

Gaster. Cercus and paramere, fig. 322; the cercus apically with four claws. Apodemae aedeagales rather darkly sclerotized.

Length, 1.5—1.9 mm. Colour uniformly whitish yellow, darker in older specimens.

Female. Head short, not quite as long as wide across the eyes [23 : 24]. Pubescence long. Longitudinal diameter of the eye twice as long as the cheek. Antenna (fig. 318): the scape thrice as long as the pedicel, which bears approximately forty spines. Appendage of the third segment slender, rather long; the fourth segment small. Fifth segment twice as long as the fourth, with twelve long sensilla. Sixth and seventh segments one and a half times as long as the fifth, but narrower; eighth to eleventh segments gradually diminishing in size. Sixth to tenth segments with irregular, alternating rows of long sensilla: approximately twenty sensilla per segment; apical segment with twelve long and two circular sensilla. Labium with two subapical hairs. Maxilla (fig. 317) with one subapical lateral hair, and a bacilliform process, which is more than half as long as the maxilla. Mandible (fig. 320) with six ventral ridges, its appendage with nine.

Thorax. Pubescence of pronotum long. Scutum shorter than its maximal width, with six hairs along each lateral margin. Scutellum one and a half times as long as wide, its sides (except posteriorly) subparallel, with five or six hairs along each lateral edge. Metanotum with eleven hairs on each side of the mid line; propodeum with three hairs above, and about ten beneath the large peritremata. Fore wing (2 : 1), 2.1 mm long; submarginal, marginal, stigmal, and postmarginal veins in ratio 8 : 4 : 3 : 5; submarginal vein with two pustules, stigma with four. Hind wing (5 : 1), 1.4 mm long. Fore leg (figs. 327—328): the coxa two-thirds the length of the femur; the tibia not quite half as long as the femur. Tibial armature consisting of a dorsal comb of six teeth (the first blunt), and one ventral tooth. Axially, the tibia is provided with several stout hairs. Tarsal segments in ratio 11 : 5 : 5 : 5 : 7. Mid leg slender, the coxa semiglobular; the tibia not quite as long as femur and trochanter combined. Ventral edge of the tibia produced apically. Tarsal segments in ratio 25 : 10 : 9 : 8 : 12. Coxa of the hind leg (fig. 329) shorter than the femur, but wider; the femur narrow; the tibia slender, two-thirds the length of the femur. Tibial apex axially with a curved tooth, antaxially with a bidentate tooth. Tarsus pubescent, the segments in ratio 25 : 11 : 11 : 9 : 10.

Gaster. Ovipositor scarcely projecting beyond the apex of the gaster.

Length, 2.2 mm. Colour blackish brown dorsally, lighter ventrally. Extremities light yellow-brown. Old specimens are darker; young specimens sometimes have the last two or three antennal segments of an ivory-white colour. Fore wings with two dark striae radiating from the stigma.

#### Remark.

*C. humatus* is evidently related to *C. pilipes* and *C. josephi*, but the male metasternum is glabrous, and the hind tibia is not produced dorsally; the female tibial comb consists of six teeth.

I cannot find distinct constant differences between the wasps from *Ficus bec-*



*carii* and *F. subterranea*. Although the specimens from coll. no. 608 have the male hind legs slightly more slender than those of coll. no. 607, this differential character is bridged by the males from coll. no. 611. Consequently, I refer the specimens from *F. subterranea* to *C. humatus*.

*Ceratosolen bisulcatus* (Mayr) and *C. jucundus* Grandi (figs. 152, 153; map, fig. 261)

*C. bisulcatus* (Mayr) and *C. jucundus* Grandi are so similar that it is questionable whether the two should be maintained as separate species. Some differences between *C. bisulcatus* from Java and Bali, and *C. jucundus* from Luzon, are:

♀. Maxilla with a bacilliform process in *C. jucundus*, without such a process in *C. bisulcatus* (fig. 153).

♂. The head is slender in *C. bisulcatus* (one and a half times as long as wide), and bears small eyes. In *C. jucundus* the head is relatively shorter, and the form is anophthalmous.

Specimens from New Guinea are slightly longer than those from Java and Bali, and the females are darker. Specimens from Borneo are of the general facies of *C. jucundus* from Luzon, but the female maxilla does not bear a bacilliform process, or, at most, it has a small protuberance instead (in this it is similar to the form recorded from Formosa, of which I did not see examples). Distribution, see map, fig. 261. The male mouthparts (fig. 152) and genitalia (cercus of the tenth urite with two claws) are similar in the two species, and both show the oligomery in the male mid tarsi (but these are pentamerous in the specimens from Formosa, and heteromerous in those from Borneo). *C. bisulcatus* males have heteromerous hind tarsi, which I do not find in *C. jucundus*.

### *Ceratosolen bisulcatus* (Mayr)

*Blastophaga* (*Ceratosolen*) *bisulcata* Mayr, 1885, pp. 154, 161, 163, 170—171 [key ♀, ♂, descr. ♀, ♂, ex *Ficus* (*Cystogyne*) *lepicarpa* Bl. (det. Solms)<sup>1</sup>], Bogor (Java), Bot. Gdn.; type: ♂].

*Ceratosolen bisulcatus*: Karny, 1923, figs. 5—6 [♀, ♂, Krakatau, leg. K. W. Dammerman]; Grandi, 1928c, pp. 180—184, figs. XXIX—XXX [redescr. ♀, ♂, type specimens of *B. bisulcata* Mayr]; Dammerman, 1948, pp. 381—382, fig. 21 [♀, ♂, Krakatau, and Verlaten Island, IX.1920, 1933].

### Material.

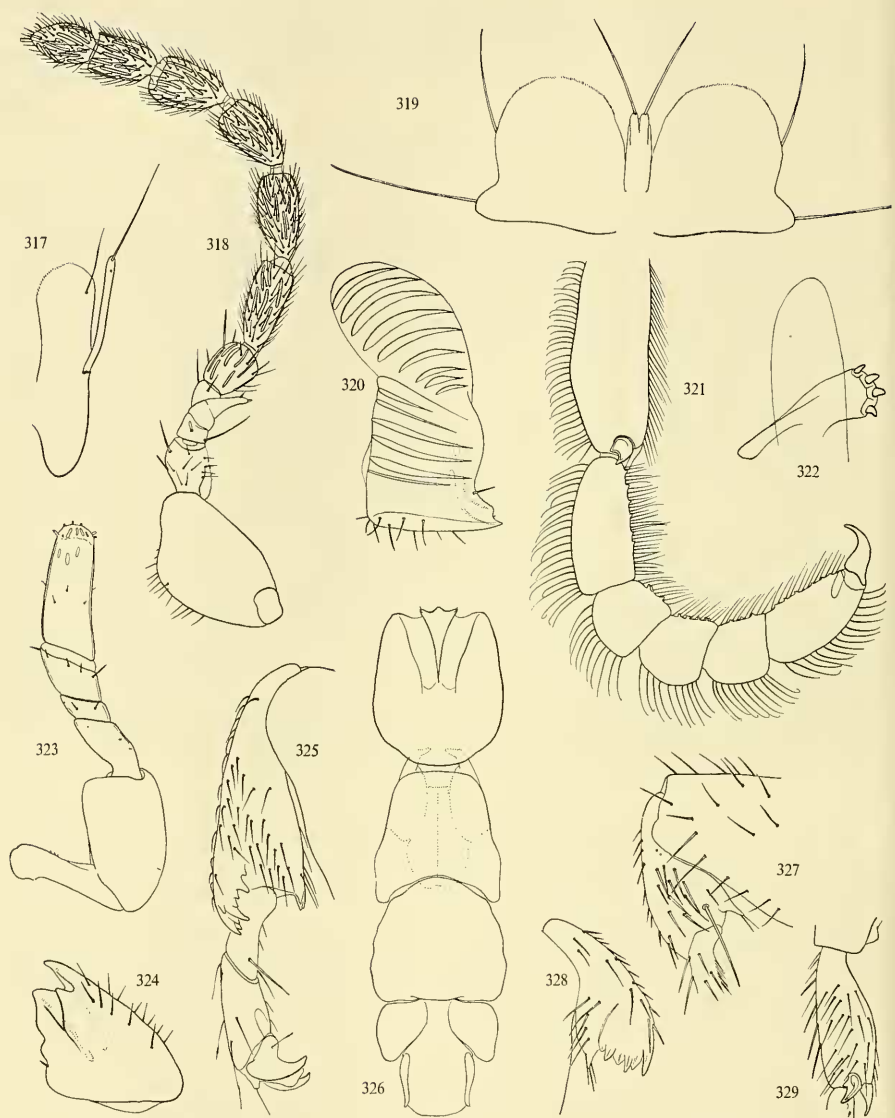
Series ♀, ♂, ex *Ficus septica* Burm. f., Bogor (Java), Baranangsiang, 24.X. 1954; coll. no. 75.

Series ♀, ♂, ex *Ficus septica* Burm. f. (det. E. J. H. CORNER), Lae (Terr. New Guinea), Erap, leg. E. J. H. CORNER, 7.IX.1960; coll. no. 544; ♂, slide 544a, ♀, 544b.

Series ♀, ♂, ex *Ficus septica* Burm. f., Sudadji (Bali, distr. Sawahan, 16 km SE of Singaradja), leg. NJOMAN TOJA; coll. no. 58; ♂, slide 58a.

Series ♀, ♂, ex *Ficus* spec., Java, leg. A. HOOGERWERF, XI.1954, no. 9; coll. no. 283.

<sup>1</sup>) SOLMS evidently confused *F. septica* with *F. lepicarpa*; see p. 98.



Figs. 317—329, *Ceratosolen humatus*, Borneo, 317, female maxilla, 318, female antenna, 319, male labium and maxillae, 320, female mandible, 321—326, male, 321, detail of hind leg, 322, cercus of tenth urite, and paramere, 323, antenna, 324, mandible, 325, detail of fore leg, 326, male, 327—329, female, 327, detail of fore leg, axial aspect, 328, fore tibia, 329, detail of hind leg. Figs. 326,  $\times 40$ ; 318, 321, 329,  $\times 90$ ; 317, 320, 323—325, 327, 328,  $\times 115$ ; 319, 322,  $\times 275$

Series ♀, ♂, ex *Ficus septica* Burm. f., Ujung Kulon (Java), leg. A. HOGERWERF, XI.1954, no. 11; coll. no. 273; ♀, ♂, slide 273a, immature specimens, 273b.

Series ♀, ♂, ex *Ficus septica* Burm. f., Ujung Kulon (Java), leg. A. HOGERWERF, XI.1954, no. 16; coll. no. 287; ♀, slide 287a, ♂, 287b.

### *Ceratosolen jucundus* Grandi

*Ceratosolen jucundus* Grandi, 1927a, pp. 320—323, Pl. 5 figs. 67—76, Pl. 6 figs. 77—83 [descr. ♀, ♂, ex *Ficus bauili* Blanco<sup>1</sup>], Mt. Maquiling (Luzon, Philippine Is.), leg. C. F. Baker; Grandi, 1927b, pp. 178—179 [descr. ♀, ♂, *C. ? jucundus*, Taihoku (Formosa), leg. F. Silvestri, 21.XI.1954].

#### Material.

Three ♀, 3 ♂, ex *Ficus bauili* Blanco<sup>1</sup>), Mt. Maquiling (Luzon, Philippine Is.), ex coll. GRANDI; coll. ML, no. 507.

Series ♀, ♂, Mt. Maquiling (Luzon, Philippine Is.); coll. USNM.

Series ♀, ♂, ex *Ficus bauili* Blanco<sup>1</sup>), Los Baños (Luzon, Philippine Is.), Coll. Agric., leg. F. X. WILLIAMS, 6.II, 21.V, and 19.VI.1921; coll. HSPA.

Series ♀, ♂, ex *Ficus bauili* Blanco<sup>1</sup>), Lake Lanao (Mindanao, Philippine Is.), leg. F. X. WILLIAMS, 2.XI.1921; coll. HSPA; coll. ML, no. 587; ♀, slide 587a, ♂, 587b.

Series ♀, ♂, ex *Ficus septica* Burm. f., (det. E. J. H. CORNER), Ranau (N. Borneo), 1800 ft. alt., leg. E. J. H. CORNER, 3.VI.1961; coll. no. 616.

Series ♀, ♂, ex *Ficus septica* Burm. f. (det. E. J. H. CORNER), Kundasan (N. Borneo), 4000 ft. alt., leg. E. J. H. CORNER, IX.1961; coll. no. 634.

#### Species incertae sedis

### *Ceratosolen* spec.

#### Material.

Immature ♀, ♂, ex *Ficus microdictya* Diels (det. E. J. H. CORNER), Papua, leg. C. E. CARR, 14.XII.1935, no. 13785; coll. no. 449.

#### Remark.

From *Ficus microdictya*, I saw some immature wasps only, which I prefer not to describe. They seem to be close to *C. armipes* and allied species.

### *Ceratosolen* spec.

*Ceratosolen ? crassitarsus*: Grandi, 1923a, p. 299 [descr. note on ♀, ♂, ex *Ficus roxburghii*<sup>2</sup>], Singapore, leg. H. N. RIDLEY; 1927b, p. 174 [note on host record].

#### Material.

One ♀, 5 ♂, ex *Ficus Roxburghii*<sup>2</sup>), Singapore, H. N. RIDLEY, 89—38; coll. BM: 5 slides.

<sup>1</sup>) = *Ficus septica* Burm. f.

<sup>2</sup>) Synonym of *Ficus auriculata* Lour., but the record is probably incorrect.

## R e m a r k.

In my opinion these specimens should be referred to a form of *Ceratosolen vechti*, rather than to *C. crassitarsus*; but the description has to wait until more and better material becomes available.

*Ceratosolen* spec.

## M a t e r i a l.

Fragments of 3 ♀, ex *Ficus stolonifera* King (det. E. J. H. CORNER), Sarawak (Borneo), leg. M. JACOBS, no. 5257; coll. no. 503.

## R e m a r k.

These specimens, taken from dried figs in the Leiden Herbarium, are too fragmentary for specific identification, but they can be recognized as belonging to a species of *Ceratosolen*. The dorsal comb of the female fore tibia consists of four sharp teeth, and it does not show the blunt tooth found in other *Ceratosolen* from geocarpic figs.

## Provisionally excluded

*Ceratosolen megarhopalus* Grandi, 1923b, pp. 103—104 [descr. ♀, at light, Fort de Kock (Sumatra), leg. E. JACOBSON, XI.1920, I.1923].

*Ceratosolen elisabethae* Grandi, 1923b, pp. 104—105 [descr. ♀, at light, Fort de Kock (Sumatra), leg. E. JACOBSON, XI.1920, I. 1923].

These two species, which are known in the female sex only, are characterized by the peculiar antennae, and the large eyes.

In the collection made by Dr. F. X. WILLIAMS in the Philippine Islands, I find a sample of females and males ex *Ficus ? longipedunculata*, Mt. Maquiling (Luzon), 23/24.VI.1921; coll. HSPA, which evidently belong to a species close to *C. megarhopalus* Grandi. The males have a very distinct *Blastophaga* facies, and this is the reason why I exclude the species of this group from the present revision of *Ceratosolen*.

Other samples ex "*Ficus longipedunculata*" (without the query; *F. longipedunculata* (Merril) Elmer = *F. chrysolepis* Miq., subgenus *Urostigma*) consist of a different species of Agaonidae.

## CLASSIFICATION AND KEY TO THE SPECIES

In this chapter an attempt is made to classify the species in groups. I am well aware that these groups must be considered provisional divisions, which show some overlapping.

It is difficult to arrive at a satisfactory conclusion as to the status of some taxa. In one instance (*C. solmsi* and *C. marchali*, cf. p. 64, Table I) it is evident that the two forms should be regarded as subspecies. In other instances this evidence is lacking or non-conclusive, due to the scantiness of the material. For the time being, pending the examination of more material from more localities, I treat the

following forms: *C. constrictus* and *C. bewitti*; *C. notus*, *C. orientalis*, and *C. calopilinae*; *C. bisulcatus* and *C. jucundus*, as full species.

### I. *C. pygmaeus* group.

In this group I place *C. pygmaeus*, *C. marshalli*, and *C. nanus*, which all have the antennal grooves in the male head half closed, the labium and the maxillae atrophied, the lateral edges of the propodeum more or less rounded, the female maxillae without a bacilliform process, and the fore tibia with no more than three teeth in the dorsal comb and without the ventral spur.

*C. nanus* is aberrant in some aspects (male antenna consisting of five segments, genitalia without cerci, female antenna of a peculiar shape, its segments with few sensilla), but the trimerous mid and hind tarsi in the male, and the tetramerous fore and mid tarsi in the female, next to the general facies, connect the species with *C. pygmaeus*.

*C. gravelyi*, although evidently related to the species of this group (facies, male tibia without spines on the disk), seems to show more connections with the *C. appendiculatus* group.

I have long hesitated about the classification of *C. constrictus* and *C. bewitti*, which show some relationships with the *C. pygmaeus* group in the general facies, the oligomery of the mid and hind tarsi, and in the absence of the ventral spur from the female fore tibia. On the other hand, they have four teeth in the combs of the male and female fore tibiae (except for the sample from N. Borneo), as in some other groups. Tentatively I place *C. constrictus* and *C. bewitti* in this *C. pygmaeus* group.

Species of the *C. pygmaeus* group:

<i>C. pygmaeus</i> Grandi,	<i>C. constrictus</i> (Mayr),
<i>C. marshalli</i> Grandi,	<i>C. bewitti</i> Waterston.
<i>C. nanus</i> Wiebes,	

### II. *C. appendiculatus* group.

The species of this group have the antennal grooves in the male head half closed; as a rule the mid and hind legs bear spines on the disks, and the shape of the propodeum is rather uniform. The female fore tibia bears a simple ventral spur, and the dorsal dentation consists of four sharp teeth.

*C. gravelyi* connects the *C. pygmaeus* group with *C. emarginatus*, which at its turn resembles *C. fusciceps* and *C. appendiculatus*. Apparently *C. appendiculatus* and *C. grandii* are closely related: both species have the male genitalia without cerci and the club of the female antenna is composed of the united apical three segments.

Species of the *C. appendiculatus* group:

<i>C. gravelyi</i> Grandi,	<i>C. appendiculatus</i> (Mayr),
<i>C. emarginatus</i> Mayr,	<i>C. grandii</i> Wiebes.
<i>C. fusciceps</i> (Mayr),	

Judging from the descriptions, the African species of *Ceratosolen* belong in this group.

III. *C. armipes* group.

*C. armipes*, *C. bianchii*, *C. boschmai*, and *C. sordidus* have in common the half closed antennal groove, the spines on the disk of the mid tibia, and the aberrant shape of the propodeum of the male, the dentation of the comb of the female fore tibia, and to some extent the general facies.

The group in which these species are united shows a rather great variation, e.g., in the shape of the male propodeum. In a way, the species resemble *C. pilipes* and its relatives, notably in the dentation of the female fore tibia.

Species of the *C. armipes* group:

<i>C. boschmai</i> Wiebes,	<i>C. armipes</i> Wiebes,
<i>C. bianchii</i> Wiebes,	<i>C. sordidus</i> Wiebes.

IV. *C. bakeri* group.

Some characters connect *C. bakeri* with the *C. armipes* group (male antenna resembling that of *C. boschmai*, male propodeum, dentation of female hind tibia), but the species has open antennal grooves and a three-segmented fore tarsus in the male.

Species of the *C. bakeri* group:

*C. bakeri* Grandi.

V. *C. abnormis* group.

*C. abnormis*, though evidently related to the species of the *C. armipes* group in some aspects (male antennal grooves half closed, segments of the fore tarsus incompletely separated, dentation of the female hind tibia), is aberrant in the male genitalia and in the armature of the female fore tibia.

It is classified here as a separate group:

*C. abnormis* Wiebes.

VI. *C. crassitarsus* group.

Characterized by the dilated hind feet of the male, the normal mouthparts — without large lateral expansions on the maxillae — and the dentation (four sharp teeth) of the comb of the female fore tibia. In some species (*C. notus*, *C. moderatus*, etc.) the male maxillae bear small lateral expansions, thus connecting the group with the *C. pilipes* group. Some other species are aberrant in the dentation of the male hind tibia, e.g., *C. nugatorius* and *C. dentifer* have a large motile spur on the disk of the hind tibia; *C. corneri* is aberrant in having very long hind feet in the male sex. Otherwise, the species of this group are very similar, and it is difficult to distinguish between the females of the various subgroups.

Species of the *C. crassitarsus* group:

<i>C. crassitarsus</i> (Mayr),	<i>C. praestans</i> Wiebes,
<i>C. gracilis</i> Wiebes,	<i>C. iodotrichae</i> Wiebes,
<i>C. booglandi</i> Wiebes,	<i>C. notus</i> (Baker),
<i>C. vechti</i> Wiebes,	<i>C. orientalis</i> Wiebes,
<i>C. nugatorius</i> Grandi,	<i>C. calopilinae</i> Wiebes,
<i>C. dentifer</i> Wiebes,	<i>C. corneri</i> Wiebes.
<i>C. moderatus</i> Wiebes,	

VII. *C. solmsi* group.

Two species with normal hind feet in the male (others with the same character, viz., *C. bisulcatus* and *C. jucundus* are aberrant in other features too and are joined to represent a distinct group IX) are difficult to be classified.

*C. solmsi* is evidently related to species with dilated hind feet, notably the *C. crassitarsus* group. In some characters, however, it is close to *C. brongersmai* (e.g., in the dentation of the male hind tibia) and in the dentation of the female fore tibia it differs from both the *C. crassitarsus* group and *C. brongersmai*.

*C. brongersmai* seems to be close to *C. albulus* and *C. humatus*, although it has the hind feet of the male not dilated and the comb of the female fore tibia is of normal constitution.

For convenience' sake the two species are here taken together in one group, which connects the *C. crassitarsus* group with the *C. pilipes* group.

The occurrence of *C. brongersmai* and *C. solmsi* among the species with dilated hind feet in the male makes it plausible that the character "dilated hind feet" may have been more than once acquired, or secondarily lost, in the evolution of the group.

Species of the *C. solmsi* group:

- C. solmsi* (Mayr), and subspec. *marchali* Mayr,
- C. brongersmai* Wiebes.

VIII. *C. pilipes* group.

Some species have the male maxilla with a very large, lateral expansion, and the female fore tibia with a blunt first tooth in the dorsal comb. *C. pilipes* and *C. josephi* have the metasternum of the male hirsute, and the apical edge of the hind tibia produced dorsally; the fore tarsus shows three incompletely separated segments. The tibial comb of the female fore leg consists of five teeth.

*C. albulus* and *C. humatus* have a glabrous metasternum, and the male hind tibia is not produced. The combs of the fore tibiae consist of six teeth in the females, and of five and nine teeth in the males of *C. albulus* and *C. humatus*, respectively.

Species of the *C. pilipes* group:

- C. pilipes* Wiebes, *C. albulus* Wiebes,
- C. josephi* Wiebes, *C. humatus* Wiebes.

IX. *C. bisulcatus* group.

*C. bisulcatus* and *C. jucundus* cannot easily find a place in any of the other groups. Apparently they are close to the species of the *C. crassitarsus* group; but they differ from all other species of *Ceratosolen* in the bilobate epistomal margin of the male.

Species of *C. bisulcatus* group:

- C. bisulcatus* (Mayr),
- C. jucundus* Grandi.

## Key to the species.

But for *C. gravelyi*, which is intermediate between the *C. appendiculatus* group and the *C. pygmaeus* group, and keys out with the latter although classified in

the former, all species groups can be identified by using the key, provided male specimens are available.

The following remarks may be helpful for identifying female specimens. Each alternative excludes the preceding one(s).

1. If the fore tibia is without a ventral spur, try no. 4 (*C. pygmaeus* group), and compare *C. abnormis* and *C. bakeri*.

2. If the comb of the fore tibia consists of more than four teeth, the first of which is blunt, try nos. 13 (*C. armipes* group) and 34 (*C. pilipes* group).

3. If the apical segments of the antenna are united (i.e., the antenna consists of less than eleven segments), try no. 10 (some species of the *C. appendiculatus* group).

4. If the apical three segments of the antenna are shaped so as to form together a club, compare *C. gravelyi* and *C. emarginatus*.

5. If the apical two segments of the antenna are shaped so as to form together a (sometimes very loose) club, try no. 18 (*C. bisulcatus* and *C. solmsi* groups), and compare the species of the *C. crassitarsus* group. The latter are not keyed out; it will be possible to arrive at a satisfactory identification only after careful comparison with the descriptions.

- |   |                     |
|---|---------------------|
| 1. ♂. Antennal grooves half closed (example, fig. 20) . . . . .   | 2                   |
| — ♂. Antennal grooves open (example, fig. 180) . . . . .  | 16                  |
| 2. ♂. Propodeum with comparatively small spiracular peritremata. ♀. Fore tibia with two to four sharp teeth in the dorsal comb . . . . .  | 3                   |
| — ♂. Peritremata of the propodeum large. ♀. Fore tibia with five to ten teeth in the dorsal comb . . . . .  | 12                  |
| 3. ♂. Mid and hind tibiae without spines on the disks ( <i>C. pygmaeus</i> group, and <i>C. gravelyi</i> ) . . . . .  | 4                   |
| — ♂. Mid tibia, and mostly the hind tibia also, with many spines on the disk ( <i>C. appendiculatus</i> group except <i>C. gravelyi</i> ) . . . . .                                 | 9                   |
| 4. ♂. Genitalia without cerci. ♀. Antenna aberrant (fig. 16), with few sensilla . . . . .   | <i>C. nanus</i>     |
| — ♂. Genitalia with cerci. ♀. Antenna normal, funicular segments with one or two rows of sensilla . . . . .   | 5                   |
| 5. ♂. Antenna consisting of four segments. Labium and maxillae atrophied. ♀. Fore tibia with three teeth in the dorsal comb . . . . .   | 6                   |
| — ♂. Antenna consisting of five segments, one of which may be annuliform. Mouthparts present. ♀. Fore tibia with two or four teeth in the dorsal comb . . . . .                     | 7                   |
| 6. ♂. Propodeum with distinctly rounded edges. Cerci of the tenth urite with one claw. ♀. Mandible with ten ventral ridges, its appendage with nine ridges . . . . .                | <i>C. pygmaeus</i>  |
| — ♂. Propodeum more angular behind (fig. 10). Cerci with three claws. ♀. Mandible, and its appendage, with four or five ventral ridges . . . . .                                    | <i>C. marshalli</i> |
| 7. ♂. Thorax constricted (figs. 1, 2). ♀. Funicular segments with two to three rows of sensilla. Maxilla without a bacilliform process. Fore tibia without a ventral spur . . . . . | 8                   |



- ♂. Thorax not as above. ♀. Funicular segments with one row of sensilla. Maxilla with a bacilliform process. Fore tibia with a ventral spur . . . . . *C. gravelyi*
8. ♂. Head and thorax rather short, robust (fig. 2). ♀. Sixth antennal segment as long as the seventh, with three rows of short sensilla; the tenth segment approximately as long as the eleventh . . . . . *C. constrictus*
- ♂. Head and thorax more slender (fig. 1). ♀. Sixth antennal segment two-thirds the length of the seventh, with two irregular rows of longer sensilla; the tenth segment approximately one and a half times as long as the eleventh . . . . . *C. beuitti*
9. ♂. Mid and hind tibiae with spines or protuberances on the disks. ♀. Apical two or three antennal segments united. Maxilla without a bacilliform process . . . . . 10
- ♂. Hind tibia without spines on the disk. ♀. Antennal segments free, but the apical three segments shaped so as to form together a distinct club. Maxilla with a bacilliform process . . . . . *C. emarginatus*
10. ♂. Antenna consisting of five segments. Labium and maxillae atrophied. ♀. Funicular segments with two rows of sensilla . . . . . *C. appendiculatus*
- ♂. Antenna consisting of four segments. Mouthparts present. ♀. Funicular segments with one row of sensilla . . . . . 11
11. ♂. Tarsal segments of the fore leg incompletely separated. Genitalia without cerci. ♀. Apical three antennal segments united . . . . . *C. grandii*
- ♂. Tarsal segments of the fore leg free. Genitalia with cerci. ♀. Apical two antennal segments united . . . . . *C. fusciceps*
12. ♂. Tibiae without spines on the disks. Genitalia with parameres only (fig. 81). ♀. Antenna with very few sensilla. Comb of the fore tibia consisting of eight to ten sharp teeth . . . . . *C. abnormis*
- ♂. Mid and hind tibiae with spines or stout hairs on the disks. Genitalia not as above. ♀. Funicular segments with one to three rows of sensilla (unknown in one species). Comb of the fore tibia consisting of five or six teeth, the first of which is blunt (*C. armipes* group) . . . . . 13
13. ♂. Antenna consisting of four segments. Fore tibia with three dorso-apical teeth. ♀. Apical two antennal segments united . . . . . *C. armipes*
- ♂. Antenna consisting of five segments, one of which may be annuliform, or incompletely separated. Fore tibia with four dorso-apical teeth. ♀. Antennal segments free, although the apical three shaped so as to form a club . . . . . 14
14. ♂. Tarsal segments of the fore leg free. ♀. Comb of the fore tibia consisting of six teeth . . . . . *C. sordidus*
- ♂. Segments of the fore tarsus incompletely separated. ♀. Fore tibia with five teeth in the dorsal comb . . . . . 15
15. ♂. Genitalia with cerci. ♀. Funicular segments with one row of sensilla. Antiaxial apical tooth of the hind tibia bidentate . . . . . *C. boschmai*
- ♂. Genitalia without cerci. ♀. Funicular segments with two rows of sensilla. Antiaxial apical tooth of the hind tibia tridentate . . . . . *C. bianchii*
16. ♂. Hind feet normal, not dilated . . . . . 17
- ♂. Hind feet dilated and hirsute . . . . . 21

17. ♂. Antenna consisting of six segments, one of which is annuliform. Fore leg with three tarsal segments. ♀. Antaxial apical tooth of the hind tibia tridentate . . . . . *C. bakeri*  
 — ♂. Antenna consisting of five segments, one of which may be annuliform. Tarsus of the fore leg consisting of two free segments. ♀. Antaxial apical tooth of the hind tibia bidentate . . . . . 18
18. ♂. Epistomal margin bilobate. ♀. Funicular segments with one row of sensilla (*C. bisulcatus* group) . . . . . 19  
 — ♂. Epistomal margin trilobate. ♀. Funicular segments with two or three rows of sensilla (*C. solmsi* group) . . . . . 20
19. ♂. Head one and a half times as long as wide. Eyes present. ♀. Maxilla without a bacilliform process . . . . . *C. bisulcatus*  
 — ♂. Head relatively shorter, the length not more than four thirds of the maximum width. Eyes absent. ♀. Maxilla mostly with a long bacilliform process, or with a small protuberance instead . . . . . *C. jucundus*
20. ♂. Maxillae with lateral expansions. ♀. Fore tibia with four teeth in the dorsal comb . . . . . *C. brongersmai*  
 — ♂. Maxillae without lateral expansions. ♀. Fore tibia with five teeth in the dorsal comb . . . . . *C. solmsi*
21. ♂. Propodeum wider than long, or subquadrate, the posterior angles rounded. ♀. Comb of the fore tibia consisting of four sharp teeth (*C. crassitarsus* group) . . . . . 22  
 — ♂. Propodeum longer than wide, the posterior angles slightly produced laterally. ♀. Comb of the fore tibia consisting of five or six teeth, the first of which is blunt (*C. pilipes* group) . . . . . 34
22. ♂. Hind leg very long, as in fig. 254 . . . . . *C. corneri*  
 — ♂. Hind leg not very long . . . . . 23
23. ♂. Hind tibia with a large dark spur (figs. 144, 157) . . . . . 24  
 — ♂. Hind tibia with the normal apical armature only . . . . . 25
24. ♂. The spur on the hind tibia is situated apically. ♀. Funicular segments with one row of very long sensilla. Maxilla with a bacilliform process . . . . . *C. dentifer*  
 — ♂. The spur is situated more proximally, on the disk. ♀. Funicular segments with two rows of normal sensilla. Maxilla without a bacilliform process . . . . . *C. nugatorius*
25. ♂. Hind tibia approximately twice as long as the metatarsus . . . . . 26  
 — ♂. Hind tibia distinctly less than twice as long as the metatarsus . . . . . 27
26. ♂. Maxillae with nearly straight lateral edges, without any lateral expansions. Length of male and female, approximately 1 and 1.5 mm, respectively . . . . . *C. crassitarsus*  
 — ♂. Maxillae large, with lateral expansions. Length of male and female, approximately 1.5 and 2 mm, respectively . . . . . *C. notus*
27. ♂. Hind tibia as long as or up to one and a half times as long as the metatarsus . . . . . 28  
 — ♂. Hind tibia approximately one and three quarters the length of the metatarsus . . . . . 32

28. ♂. Length of the apical antennal segment one and a half to one and three quarters the length of the subapical segment . . . . . 29  
 — ♂. Apical segment of the antenna approximately two and a half times as long as the subapical one, or longer . . . . . 30
29. ♂. Maxilla with a lateral expansion. Cerci of the tenth urite with five claws . . . . . *C. moderatus*  
 — ♂. Maxilla without lateral expansions. Cerci of the tenth urite with two claws . . . . . *C. gracilis*
30. ♂. Cerci of the tenth urite with seven claws. ♀. Bacilliform process one fifth the length of the maxilla . . . . . *C. praestans*  
 — ♂. Cerci of the tenth urite with three to five claws. ♀. Bacilliform process nearly half as long as the maxilla . . . . . 31
31. ♂. Apical segment of the antenna two and a half times as long as the subapical segment . . . . . *C. booglandi*  
 — ♂. Apical segment of the antenna six times as long as the subapical segment . . . . . *C. iodotrichae*
32. ♂. Apical segment of the antenna less than twice as long as the subapical segment. ♀. Bacilliform process one third the length of the maxilla . . . . . *C. vechti*  
 — ♂. Apical segment of the antenna approximately two and a half times as long as the subapical segment. ♀. Bacilliform process two-fifths the length of the maxilla, or longer . . . . . 33
33. ♂. Maxilla with two lateral hairs. Hind leg long and slender. ♀. Maxilla not quite twice as long as its bacilliform process . . . . . *C. orientalis*  
 — ♂. Maxilla with one lateral hair. Hind leg shorter, more robust. ♀. Maxilla approximately two and a half times as long as the bacilliform process . . . . . *C. calopilinae*
34. ♂. Fore tarsus consisting of three segments, the distal two of which are incompletely separated. Dorsal edge of the hind tibia produced apically. Metasternum hirsute. ♀. Comb of the fore tibia consisting of five teeth . 35  
 — ♂. Fore tarsus consisting of two free segments. Dorsal edge of the hind tibia not produced apically. Metasternum not hirsute. ♀. Comb of the fore tibia consisting of six teeth . . . . . 36
35. ♂. Cerci of the tenth urite with five or six claws, parameres curved. ♀. Pedicel of the antenna with several hundreds of small spines . . . . . *C. pilipes*  
 — ♂. Cerci of the tenth urite with three claws, parameres straight. ♀. Pedicel of the antenna with approximately one hundred and fifty spines. . . . . *C. josephi*
36. ♂. Fore tibia with a dorsal comb of five teeth. Pedicel of the antenna nearly as long as the scape. Cerci of the tenth urite with six claws. ♀. Mandibular appendage with nine to eleven ventral ridges . . . . . *C. albulus*  
 — ♂. Fore tibia with nine teeth in the dorsal comb. Pedicel of the antenna about half as long as the scape. Cerci of the tenth urite with four claws. ♀. Mandibular appendage with nine ventral ridges . . . . . *C. humatus*

THE HOST PREFERENCES OF THE AGAONIDAE<sup>1)</sup>

"Supremus Genitor Ficui propriam  
assignavit cupidinem"

(HEGARDT, 1749, p. 41)

## SPECIFICITY OF THE RELATION BETWEEN FIGS AND FIG WASPS

Theories on the evolution of the symbiosis between figs and fig wasps are necessarily highly speculative. Fossil data do not provide any clue to the problem, although a fossil fig wasp (*Tetrapus mayri* Brues, 1910, p. 16) was described from the Tertiary (Miocene)<sup>2)</sup> of Florissant, Colorado, and the presence of fossil fig leaves is known from the Cretaceous.

Presumably, the fig wasps have descended from gall-forming Chalcidoidea, or from parasitic Chalcidoidea living on other insects in the flowers or seeds of the pre-*Ficus*. The assumption that the interaction of figs and wasps secondarily became synagonistic — gradually acquiring mutual value and evolutionary significance for both participants (LEPPIK, 1957, p. 479) — is not new. Although MÜLLER (1886b, p. 63) already stated: "die Feigen (haben) einen ursprünglich einfach ihre Früchte zerstörenden Schmarotzer für ihre Kreuzung sich immer vollkommener dienstbar gemacht", all subsequent theoretical considerations deal almost exclusively with morphological features of the fig wasps (GRANDI, many papers, see 1955c; english summary in 1961). MÜLLER, for that matter, did not elaborate on his thesis either. Moreover, he was of the opinion that also parasitic and inquiline wasps could pollinate the fig flowers, especially those of isolated trees (MÜLLER, 1883, p. 312). The flight capacity of *Blastophaga*, and consequently its dispersal, was supposed to be very weak.

Probably, only the Agaonidae serve as pollinators, every species to its peculiar species of *Ficus*. The dispersal of the fig wasps does not seem to be such a problem as might be presumed: PEMBERTON (1934, p. 379) stated that both *Pleistodontes imperialis* Saunders and *P. froggatti* Mayr reached Kauai from Mahu (Hawaiian Islands) without human assistance<sup>3)</sup>. The width of the Kauai Channel is about one hundred kilometers!

As incidentally remarked above, the relation between figs and fig wasps is supposed to be highly specific, and it seems to represent a strict one-to-one relationship. Some evidence of this supposition may be found in the systematic part of this paper. More arguments, and reputed contra-evidence, objections and related considerations are discussed below.

Some authors (VAN DER PIJL, 1960, p. 415; BAKER, 1961, p. 378) pointed out the evolutionary dangers with which every narrow specialist must cope. VAN DER

<sup>1)</sup> "Agaonidae" and "fig wasps" are used here in the restricted sense (WIEBES, 1961b), without including the Sycophaginae, and thus coincide with Agaoninae auct., and Agaonini auct.

<sup>2)</sup> Lower to Middle Oligocene, according to MAC GINITIE as cited by AXELROD (1954).

<sup>3)</sup> A similar phenomenon was recorded by CORNER (1958, p. 18) for the wasps from *Ficus fistulosa* Reinw. and *F. grossularioides* Burm.

PIJL is surprised to find the genus *Ficus*, each species with its own gall wasp, still flourishing; BAKER, however, seems to change his surprise to disbelief and does not accept the specificity until more data are available (BAKER, l.c., and in litt.). Yet, I think that the evidences in favour of a specific relation are fairly sound as far as any extrapolation in biology goes. Moreover, in my opinion, the "evolutionary dangers" are not correctly understood. Admittedly a narrow specialism may endanger evolution to the extent of making the development of new major types well nigh impossible, but there is no reason why it should hamper evolution at the specific level. The great variety of related forms within the genus *Ficus*, which all are bound to the same mode of pollination, and the relatively uniform family Agaonidae, all species of which live and must develop in the gall receptacles of *Ficus*; in short: many species without any clear-cut generic intersections, are what should be expected as the result of a narrowly specialized and obligate symbiosis, where other features, as fecundity and dispersal, do not retard evolution.

The experiments on the cross pollination of *Ficus carica* Linn. and *F. pumila* Linn., which showed the perfect compatibility of these species — and which led BAKER (l.c., p. 379) to the suggestion that many hybrids might occur that are not recognized as such — are not conclusive. These experiments only show that the "choice" of the pollinating agent may be the only isolating mechanism between the fig species (which in this case, however, do not even occur sympatrically).

WILLIAMS (1928, pp. 9, 10) induced *Eupristina bakeri* Grandi, the wasp from *Ficus forstenii* Miq., to crawl into the small figs of *F. retusa* Linn. (= *F. microcarpa* Linn.f.), the normal inhabitant of which in the Philippines is *E. verticillata* Waterston:<sup>1</sup>)

"A *F. retusa* fruit was placed in a test tube containing some of the wasp pollinators belonging to *F. forstenii*, and while these wasps were not constantly watched, soon a pair of wings was observed protruding from the *F. retusa* ostiole, where the wasp's body had not altogether disappeared within, the ovipositor being flattened into some drying liquid discharged from the abdomen. This comparatively immense *E. bakeri* wasp finally worked her way within. She did nothing in the receptacle save walk about prying here and there with her head, using the now stubby antennae as a wedge apparently in an endeavor to force apart the flowers. Another similar experiment was unsuccessful."

Similar experiments were also done with *Ceratosolen notus* (Baker) — from *F. nota* (Blanco) Merrill — in *F. barnesii* Merrill (= *F. botryocarpa* Miq.), the normal pollinator of which is *C. corneri* Wiebes:

"... several wasps had succeeded in gaining complete entrance and stood free on the inner scales, their abdomen compressed and with sharp lateral angles greatly suggesting an expulsion of body fluid, and the ovipositor still projecting needle-like behind. Now to be in readiness for oviposition an effort was made to pull the ovipositor from its sheath so that it points downwards beneath the forepart of the abdomen; in this some are immediately successful, curving the abdomen, jabbing the ovipositor into the funnel-like stigma of a gall flower and then in

<sup>1</sup>) I give these and other citations at some length, because they describe the only experiments of this sort; experiments worth while to repeat with more species.

bringing the abdomen back to the natural, more or less horizontal position the ovipositor is swung forward out of its sheath; in other cases the wasp has great difficulty or even fails — possible due to abnormal conditions — in unshathing her egg-laying apparatus, bending down the tip of her abdomen and endeavoring to hook her claws into the ovipositor and draw it out.” and further:

“it seemed that very few ovipositions (?) occurred, and such as they were — for the conditions seemed unsuitable — occupied in one case about a minute.”

WILLIAMS stated that his experiments showed that it is possible to induce fig wasps to enter other than their own particular species of fig, although this would be expected to take place but rarely in nature. In view of the large number of species of wild figs that may occur in a single habitat, it is, according to WILLIAMS, not unreasonable to suppose that hybridization might have taken place there. In addition to this conclusion I may remark that in the experiments the figs were presented in closer proximity to the wasps than I presume any wasp — with the possible exception of the inhabitants of strangler figs and their victims — ever to come near a “foreign” fig receptacle. Probably, the wasps are attracted by the scent of their own *Ficus*; this scent may be produced by glands on young leaves and petioles<sup>1</sup>).

A questionable point to some authors is whether the wasps carry enough pollen from a ripe to a young fig for the development of the thousands of ovaries that may be present in one receptacle, and whether or not the pollen is used at all by the fig. In a nearly mature female receptacle of *F. roxburghii* Wall. (= *F. auriculata* Lour.), with general enlargement of the ovaries, CUNNINGHAM (1889, p. 42) found three insects with only one or two shrunken pollen-grains adhering to them. Contrarily, PEMBERTON (1921, p. 306) stated for *Pleistodontes froggatti* Mayr in *F. macrophylla* Desf. that sufficient pollen is carried over to secure ample pollination for a great many flowers in each fig. TREUB (1902, p. 137) found the pollen grains in the female receptacles in *F. hirta* Vahl: “assez nombreux pour effectuer la fécondation, sinon de toutes, en tout cas de la grande majorité de fleurs”. BAKER (1913, p. 68) described the habits of the female *Ceratosolen notus* (Baker) in the young fertile figs of *F. nota* (Blanco) Merr. as: “distributing to the stigmas the pollen with which her body was thoroughly dusted”.

CUNNINGHAM concluded from his observations that the seeds develop by adventitious embryony from the nucellus. This agamospermic reproduction needed the action of the female fig wasp, but it was independent of pollination<sup>2</sup>). Similar observations were made by TREUB. He concluded from his cytological investigations that *F. hirta* reproduces parthenogenetically. The embryogenesis presumably needed the action of the insect as a stimulus, but the embryo started its development without amphimixis.

<sup>1</sup>) In this, as in the previous part of this paper, I draw freely from data on *Ficus* given by CORNER (in litt. to VAN DER VECHT and WIEBES, and personal communication).

<sup>2</sup>) Serious criticism on the botanical data in CUNNINGHAM's paper was published by VAN DER PIJL (1934, pp. 179—181). CUNNINGHAM's remarks on the identity of the wasp species too, as well as its identification by WOOD-MASON with a species of “*Eupristis*”, are to be regarded with extreme caution.

BUSCALIONI & GRANDI (1938, p. 243) recorded that in *F. carica* Linn.: "la cellula ova non fecondato va a male".

JOHRI & KONAR (1938) contributed a short preliminary note on the embryology of *F. religiosa* Linn.

There are many more papers on this problem, an account of which may be found in the bibliography in JOSEPH (1958), mainly on normal and abnormal development in the edible fig, but new experiments on wild figs are badly wanted. Admittedly apogamy and parthenocarpy occur, but I doubt whether these phenomena are of general occurrence under natural conditions.

However this may be — whether the insects give the stimulus by stinging the stigmata, or bring the stimulus in the form of pollen, or both — there are many records of figs cultivated in foreign countries that did not fructify until their particular species of wasps were introduced (*F. carica* Linn. and *Blastophaga psenes* (L.) in California: HOWARD (1901); *F. macrophylla* Desf. and *Pleistodontes froggatti* Mayr in the Hawaiian Islands: PEMBERTON (1921), SWEZEY (1923), TIMBERLAKE (1924); *F. rubiginosa* Desf. and *P. imperialis* Saunders in the Hawaiian Islands: SWEZEY (l.c.), TIMBERLAKE (l.c.); etc.1)).

There are some records of one species of *Ficus* harbouring different species of Agaonidae, and of one species of fig wasp inhabiting different species of *Ficus*.

Although it is rather premature to discuss all these cases before the various genera have been revised, I give an annotated list of these records. Some were already mentioned by other authors, e.g., NIKOLSKAJA (1956, p. 573), and they tend to be discussed over and over again in literature. Oddly enough, however, these reputed cases do not appear to be very important. It is easily understandable that one species of *Ficus* can harbour two (sub-)species of Agaonidae in different parts of its area, or that the host of one species of fig wasp may show some geographic variation.

Some forms, both botanical and entomological, that are treated as separate species, are perhaps only subspecifically distinct. As already stated on p. 85, I treat the wasps as full species until more material from more localities gives evidence to the contrary. As to the species of *Ficus*, some of the forms, although inseparable in flower characters, are so distinct in the field that, for the time being, CORNER maintains them as separate species.

By presenting the following list I hope to attain that the attention in future be concentrated on the important records, and that all records that have no actual interest to our problem be expelled from the discussion.

1. The record of *Blastophaga brasiliensis* Mayr from several species of figs, is based on the following passage from MÜLLER (1886a, p. 57): "Hier [in Itajahy, Brazil] wurde ein und dieselbe *Blastophaga* (*Bl. brasiliensis*) in sieben verschiedenen Feigen (*Ficus* II, III, IV, V<sup>2</sup>), VI, VII, IX) gefunden; sind auch drei derselben (II, IV, VI) so ähnlich, dass sie vielleicht zur selben Art gerechnet werden

1) The statement by JUDD (1921) on the introduction of fig wasps to the Hawaiian Islands may be of some historical interest.

2) According to MAYR (1906, p. 185), MÜLLER's *Ficus* V is *F. dolaria*. *Ficus dolaria* Martinus, nomen nudum, = *F. gomelleira* K. & B.

können, so bleiben doch mindestens fünf scharf geschiedene und zum Teil weit verschiedene, am gleichem Orte wachsende Feigenarten auf eine einzige *Blastophaga* als wichtigsten<sup>1)</sup> Bestäubungsvermittler angewiesen". This statement wants confirmation.

2. GRANDI (1927a, p. 326) already discussed the case of *Blastophaga browni* (Ashmead), recorded from *Ficus ulmifolia* Lamk. and *F. heterophylla* Linn., both from the Philippine Isles. The latter species of *Ficus*, however, does not occur in the Philippines, and all Philippine specimens identified with *F. heterophylla* actually belong to *F. ulmifolia*.

3. JOSEPH (1953c, p. 267) described *Blastophaga constabularis* Joseph from *Ficus infectoria* Roxb. (India, = *F. virens* Ait.), but from the Sumatran *F. infectoria*, *B. coronata* Grandi (1928b, p. 75) was already known. Judging from the descriptions, the two are synonyms.

4. The record of *Blastophaga grossorum* Gravenhorst (= *B. psenes* (L.) from *Ficus serrata* Forsk. (= *F. exasperata* Vahl) by MAYR (1885, pp. 153, 179, "Wüste am rothen Meere") may well have resulted from the misidentification of the *Ficus*. It might have been *F. palmata* Forsk., which is close to *F. carica* Linn., and which harbours *B. vaidi* Joseph (1954, p. 401; India), which is close to *B. psenes*. MAYR (l.c.) also recorded *B. grossorum* from *F. pseudocarica* Miq. (Abyssinia) and *F. persica* Boiss. (Iran), which both are synonyms of *F. carica* Linn.

5. *Blastophaga longicornis* Grandi (1926, p. 354) was described from *Ficus rostrata* Lamk. (Sumatra, E. JACOBSON, no. 2130), *B. dubia* Grandi (1926, p. 356) from *F. rostrata urophylla* Wall. (Java, Hort. Bog., n.VII, G. 46). The identification of E. J. 2130 with *F. rostrata* Lamk. (= *F. sinuata* Thunb.) is correct; Hort. Bog. n.VII, G. 46 probably is *F. urophylla* Wall., the correct name of which is *F. heteropleura* Bl.

6. GRANDI (1916b, p. 225) described the females of *Eupristina saundersi* Grandi from *Ficus religiosa* Linn. (India), from which MAYR (1885, p. 176) described *Blastophaga quadraticeps* Mayr (Malaya). GRANDI (1923a, p. 296), JOSEPH (1953c, p. 277), and JOHRI & KONAR (1955, p. 384) recorded *B. quadraticeps* from *Ficus religiosa* in India and Ceylon, and I find the same symbiosis in a sample from Israel (probably introduced).

There is some more confusion as to the host of *Eupristina saundersi*: the males were recorded from *F. retusa* Linn. var. *nitida* King<sup>2)</sup>! GRANDI's host record of *E. saundersi* is probably incorrect, as is, most probably, his presumption (1952c, p. 96) that the host of *Pleistodontes semiruficeps* Girault (1929, p. 318: "on Banyan figs, Lord Howe Island") might be the same as *F. religiosa*. It might more likely have been *F. macrophylla* Desf., or one of its relatives.

7. I find *Ceratosolen constrictus* (Mayr)<sup>3)</sup> in *Ficus fistulosa* Reinw. (Java), and in *F. dimorpha* King (Sumatra). The latter, however, is so close to the former,

<sup>1)</sup> MÜLLER (see also 1887b, p. 163) considered the possibility that some Idarninae transmit pollen with the pubescent ovipositor.

<sup>2)</sup> *F. retusa*, as used by botanists, is *F. microcarpa* Linn.f., and it is not genuine *F. retusa* Linn., which has been known as *F. truncata* Miq.

<sup>3)</sup> For the records of the species of *Ceratosolen*, I refer to the data given in the systematic part of this paper.



that it is probably a variety only, but it is insufficiently known botanically.

I have no check on the record of *C. bewitti* Waterston from *F. chartacea* Wall. (Malaya). In the Malayan *F. fistulosa*, *C. bewitti* is found, and from *F. chartacea* I possess an undescribed species of *Blastophaga*. Here is a case of a geographic variation in the wasps (*C. constrictus* and *C. bewitti*), that is not, or less, evident in the *Ficus*.

8. *Ceratosolen emarginatus* Mayr is found in both *Ficus auriculata* Lour. and *F. oligodon* Miq. The two forms of *Ficus* are very close. Their ranges seem to be the same for the greater part, but *F. oligodon* extends further south in Malaya, and hybrids are known from Indo-China, where the forms intergrade. Here is a case of a variation in the *Ficus*, which is not evident in the wasp.

The record of *C.?* *crassitarsus*: Grandi from Malayan *F. roxburghii* Wall. (= *F. auriculata* Lour.) is probably incorrect.

9. MAYR described *Ceratosolen appendiculatus* (Mayr) from *Ficus umbellata* Hort. Bog., nec Vahl, and *C. striatus* Mayr from *F. variegata* Bl., both collected in Java. SOLMS (in MAYR, 1885, p. 193) considered *F. umbellata* Hort. Bog. to be the same as *F. birta* Vahl, from which, however, *Blastophaga javana* Mayr is known (from var. *setosa* King; Java).

One specimen in the Leiden Herbarium (sheet no. 908, 188—1895), labelled "*Ficus umbellata* Vahl, Kondang, Cult. in Hort. Bog.," was identified by CORNER with *F. variegata* Bl., which supports the suggested synonymy of *C. striatus* and *C. appendiculatus*.

The other figs, recorded to harbour *C. appendiculatus*, are very close to *F. variegata*: *F. garciae* Elmer and *F. sycomoroides* Miq. were recently recognized as varieties, and *F. viridicarpa* Corner should perhaps be regarded as a variety too. The latter is an example of a form that is so distinct in the field, although very close in structural characters to *F. variegata*, that CORNER prefers the two to be maintained as separate species.

10. *Ficus ribes* Reinw. (Java) is known to be the host of *Ceratosolen crassitarsus* (Mayr). The Philippine variety of *F. ribes*, var. *cuneata* (Miq.) Corner, harbours *C. gracilis* Wiebes. Here again a geographic variation in casu in both the *Ficus* and the wasp.

11. *Ceratosolen notus* (Baker) is recorded from *Ficus nota* (Blanco) Merrill and from *F. congesta* Roxb., both occurring in the Philippines. *F. congesta* seems to be more sylvan in habit than *F. nota*, but the two are so close that they can only with difficulty be distinguished in the field and in most cases not at all in herbarium specimens. The *Ficus nota* complex is in need of more examination botanically.

12. *Ficus hispida* Linn.f. harbours *C. s. solmsi* (Mayr) in Malaya and the Eastern Archipelago, and on the Asiatic mainland it is inhabited by *C. s. marchali* Mayr.

MAYR recorded *C. solmsi* also from *F. canescens* Kurz (? unknown to CORNER, possibly a manuscript name), and *Covellia didyma* Miq., both from Java. The latter is a synonym of *F. lepicarpa* Bl., which was (see also no. 14) obviously misidentified by SOLMS.

13. I cannot find any constant differences between the wasps from *Ficus beccarii* King var. *latifolia* Corner and those from *F. subterranea* Corner, and I refer

both to *Ceratosolen humatus* Wiebes. The figs, although very close, are distinctly different in leaf-shape, and the distinction is approximately of the same magnitude as that between *F. beccarii latifolia* and *F. uncinata* Becc. var. *strigosa* Corner, which harbours a distinct form of *Ceratosolen*, *C. albulus* Wiebes.

This problem needs further study.

14. *Ceratosolen bisulcatus* (Mayr) was described from *Ficus lepicarpa* Bl. (Java). In the receptacles of this *Ficus*, however, I find *C. vecbtii* Wiebes (Java, Sumatra). *C. bisulcatus* inhabits the figs of *F. septica* Burm.f. in Java, Bali, and New Guinea, whereas in the Philippine *F. septica*, *C. jucundus* Grandi is found. SOLMS, who identified MAYR's *Ficus*, evidently did not understand *F. lepicarpa* properly, as is, moreover, seen by his identification of the host of *C. solmsi* (see no. 12) with *Covellia didyma* (= *F. lepicarpa*).

15. *Ceratosolen fusciceps* (Mayr), known to be the symbiont of *Ficus racemosa* Linn. (from India to Queensland), was also recorded from *F. lucescens* Miq. (= *F. racemosa* var. *elongata* (King) Barrett) and *F. covellii* Roxb. (not known to CORNER).

From Australian *F. glomerata* (= *F. racemosa*), GIRAULT described *Blastophaga nigriscapus* Girault (1925, p. [2]) and *B. niveipes* Girault. Thanks to the kindness of Dr. E. F. RIEK, Canberra, I had the opportunity to study some female specimens of *B. niveipes*, which might actually belong to *C. fusciceps*. I did not see *B. nigriscapus*. Material from Queensland, ex *Ficus racemosa* (coll. WILLIAMS, HSPA), is identical with *C. fusciceps*; indeed, this species seems to be little variable over the whole of its very large range.

*Ceratosolen mysorensis* Joseph (India) is, in my opinion, identical with *C. fusciceps* (Mayr). The species was recorded from *F. mysorensis* Hayne (= *F. drupacea* Thunb. var. *pubescens* (Roth) Corner), but, a year later, *Eupristina belgaumensis* Joseph (1954, p. 409) was described from the same *Ficus*. As *F. drupacea* belongs to the group of strangler figs allied to *F. benghalensis* Linn., which all seem to harbour species of *Eupristina*, I presume the record of *E. belgaumensis* to be correct. *F. drupacea* may have been growing on a tree of *F. racemosa*, thus resulting in the confusion<sup>1)</sup> of the *Ficus* species.

16. SAUNDERS (1883, p. 6) described *Eupristina masoni* Saunders from *Ficus indica* Linn. (India). In 1928 (a, p. 81), GRANDI recorded *E. ?masoni* from *F. benghalensis* Linn., which, however, he considered to be the same as *F. indica*. From *F. benghalensis* was recorded (JOSEPH, 1953c, p. 282) *E. grassii* Grandi, of which the author stated (GRANDI, 1928c, p. 225): "è specie affine e, probabilmente, identica a *Masoni* Saunders".

In this, as in the following two problems, one must be aware of the fact that the host relations of the genus *Eupristina* can only be solved by a close cooperation between the botanist and the entomologist. The host *Ficus* are very close, and were not infrequently confused. The same is true for the species of *Eupristina*.

17. *Ficus benjamina* Linn. (Sumatra) is known to harbour *Eupristina jacobsoni*

<sup>1)</sup> Either by the collector, in taking wasps from the one species, and botanical material from the other; or by the wasp, which might be unable to distinguish between fig receptacles of the different species, once the tree is found (? cf. the experiments by WILLIAMS, discussed in this paper, p. 93).

Grandi (1926, p. 358), which is very close to *E. koningsbergi* Grandi from *F. benjamina* var. *comosa* King (GRANDI, 1917, p. 52; Java). This variety is distinguished by having a much larger, rounded fig than typical *F. benjamina*. JOSEPH (1954, p. 415) recorded *E. koningsbergi* from *F. benjamina* in India.

18. A similar problem exists in the wasp species recorded from *Ficus retusa* Linn. (= *F. microcarpa* Linn.f., see note on p. 96): *Eupristina verticillata* Waterston is known (GRANDI, 1926, p. 358) from the typical form (Sumatra, and presumably, sub *Grandiella* (WILLIAMS, 1928, p. 13), also from the Philippines), whereas ISHII (1934, p. 85) described *E. okinavensis* Ishii from the Japanese var. *nitida* Thunb. (see also this list, no. 6).

19. In 1961 (a, p. 231) I described *Agaon paradoxum modestum* Wiebes from *Ficus brachypoda* Hutch. (Uganda). The nominate subspecies is known (GRANDI, 1952a, p. 31) from *F. ovata* Vahl (West Africa). The figs, however, are so close that CORNER would not insist on the specific diversity of *F. ovata* and *F. brachypoda*.

20. For the sake of completeness I mention the cases of *Pleistodontes* spp., which were recorded from Australian figs (see GRANDI's catalogue, 1955b, p. 129). The confusion between *Ficus columnaris* Müll.<sup>1)</sup>, *F. macrophylla* Desf., *F. australis* Willd.<sup>2)</sup>, *F. rubiginosa* Desf.<sup>3)</sup>, and *F. eugenioides* Müll.<sup>4)</sup> (PEMBERTON, 1944, p. 17), recorded by various authors as hosts of *Pleistodontes froggatti* Mayr, *P. imperialis* Saunders, and *P. nigricaput* Girault, may be due to a misunderstanding of the taxonomic status of the *Ficus*, and also to some misinterpretation of the wasp species.

#### PHYLOGENETIC SPECIFICITY

Additional, indirect evidence in favour of a specific relation between fig wasps and figs is supplied by the observation that related species of figs harbour related species of fig wasps. Mutatis mutandis, this principle was expressed in "FAHRENHOLZ's Rule" of parasitologists, in which is stated (I quote from SZIDAT, 1956, p. 243), that "bei stetigen Parasiten aus der Systematik der Parasiten meist unmittelbar auch auf die Verwandtschaft der Wirte schliessen [lässt]".

Tables II and III give a survey of the data on the host records of the Agaonid genera<sup>5)</sup>, and of most species of *Ceratosolen*, respectively.

All host records of the Agaonidae known to me are incorporated in Table II. Specific records of the African fig wasps were mentioned by WIEBES (1961b, table I); specific records of the American Agaonidae will be listed in a later paper.

<sup>1)</sup> = *Ficus macrophylla* Desf.

<sup>2)</sup> = *Ficus rubiginosa* Desf.

<sup>3)</sup> *Ceratosolen silvestrianus* Grandi (1916a, p. 160) was recorded from *F. ferruginea* Desf. (Africa!), which is the same as the Australian *F. rubiginosa* Desf. (with *Pleistodontes imperialis* Saunders).

<sup>4)</sup> = *Ficus obliqua* Forst.f. The sample, from which *Blastophaga greenwoodi* Grandi (1931, p. 8) was recorded, may have been *F. prolixa* Forst.f.

<sup>5)</sup> Host records are known of species of the following genera or subgenera: *Blastophaga* Gravenhorst, *Elisabethiella* Grandi, *Waterstoniella* Grandi, *Julianella* Grandi, *Valentinella* Grandi, *Kradibiella* Girault, *Ceratosolen* Mayr, *Eupristina* Saunders, *Tetrapus* Mayr, *Allotriozoon* Grandi, *Agaon* Dalman, and *Pleistodontes* Saunders.

As to the Indo-Australian wasps I have taken into account many species in our collection that are as yet only generically identified.

Many records had to be incorporated on which I have no check. In the evaluation of the data from the tables another reservation must be borne in mind. The groups of *Ficus* and the genera or species of the Agaonidae are presented in a linear sequence, and one cannot ever hope to depict but poorly the intricate multi-dimensional relationships in a linear system.

A similar, more conclusive list of the host records should be given when more genera are monographically revised, and when the classifications of *Ficus* and the Agaonidae have been reconsidered in a joint reevaluation by the botanist and the entomologist.

The following notes may accompany this first, tentative draft of the host records of the Agaonidae.

The subgenera *Urostigma* and *Pharmacosycea*; tentative remarks on the African, American, and Australian genera of the Agaonidae

1. The relations within the subgenus *Urostigma*, as well as those in the Agaonidae, are very intricate, and they cannot be evaluated properly in this cursory review. I want to state here, that I am not satisfied with the usual generic division of the Agaonidae. In my opinion, *Elisabethiella* should not be regarded as a subgenus of *Blastophaga* s.l.; *Eupristina*, on the other hand, probably should; it appears to be the Asiatic analogon of American *Julianella*.

2. The record of *Ceratosolen silvestrianus* Grandi from the section *Malvanthera* (*Ficus rubiginosa* Desf.; Africa, see WIEBES, 1961a, p. 239) is doubtful. The record of a species of *Ceratosolen* from the section *Galoglychia* is based on the description of *C. myersi* Grandi (1955a, p. 92) from *F. rhodesiaca* Warb. (Africa). All other African species of *Ceratosolen* live in figs of the subgenus *Sycomorus*.

3. Some species of the section *Urostigma* and some of the subsection *Varinga*, subgenus *Ficus*, are known to occur in Africa, but the pollinating wasps are not known. The Indo-Malayan species harbour *Blastophaga* s.str.

4. Two species of *Elisabethiella* were recorded from figs of the section *Galoglychia*. One species (*Blastophaga* (*Elisabethiella*) *wanei* Risbec, 1951, p. 386) was recorded from *Ficus gnaphalocarpa* Steud. (subgenus *Sycomorus*), but I have reasons to assume this record to be incorrect.

5. The section *Oreosycea* harbours *Blastophaga*, but from one species (*Ficus pritchardii* Seem., of uncertain position) a species of *Ceratosolen* is known (p. 8), and from *F. vasculosa* Wall. ex Miq. (Singapore, ? cultivated) I have an insect that seems to belong to *Pleistodontes*.

6. The record of *Tetrapus* is based on the observation by MÜLLER (1887a, p. X) that *Tetrapus* appears to be limited to *Pharmacosycea*, but no specific records are available.

The subgenera *Ficus* and *Sycomorus*, and the Agaonid genera *Blastophaga*, *Kradibiella*, and *Ceratosolen*

7. As far as known, all series of the section *Ficus* harbour *Blastophaga* s.str.,

TABLE II. *Ficus* AND THE GENERA OF THE AGAONIDAE

<i>Ficus</i> Linn.	Agaonidae
Urostigma (Gasp.) Miq.	
Urostigma	Blastophaga
Leucogyne Corner	Eupristina
Conosyca (Miq.) Corner	Blastophaga, Eupristina, Waterstoniella
Stilpnophyllum Endl.	Blastophaga
Malvanthera Corner	Pleistodontes, Ceratosolen
Galoglychia (Gasp.) Endl.	Elisabethiella, Allotriozoon, Agaon, Ceratosolen
Americana Miq.	Julianella, Valentinella
Pharmacosyca Miq.	
Pharmacosyca	Tetrapus
Oreosyca (Miq.) Corner	Blastophaga, Ceratosolen, Pleistodontes
<i>Ficus</i>	
<i>Ficus</i>	
Pseudopalmeae Corner	Ceratosolen
other series	Blastophaga
<i>Sycidium</i> Miq.	
<i>Sycidium</i>	
Prostratae Corner	Ceratosolen
Pungentes Corner	Ceratosolen
Phaeopilosae Corner	Blastophaga
Copiosae Corner	Blastophaga
Scabrae Miq.	Blastophaga, <i>Kradibiella</i>
Varinga (Miq.) Corner	Blastophaga
Palaeomorpha (King) Corner	Blastophaga
<i>Rhizocladus</i> Endl.	Blastophaga
<i>Kalosyce</i> (Miq.) Corner	Blastophaga
<i>Sinosycidium</i> Corner	
<i>Adenosperma</i> Corner	
<i>Neomorpha</i> King	Ceratosolen
<i>Sycocarpus</i> Miq.	Ceratosolen
<i>Sycomor</i> Miq.	Ceratosolen

with the exception of the *Pseudopalmeae*: *Ceratosolen bakeri* Grandi lives in the figs of *Ficus pseudopalma* Blanco. This wasp has aberrant characters for the genus *Ceratosolen*, but it appears to be related to *C. abnormis* and to the *C. armipes* group. The *Ficus* was classified in the section *Ficus* because of its bistaminate male flowers, but it does show some relationships with *F. dammaropsis* Diels, the host of *C. abnormis* Wiebes.

8. The species of *Blastophaga* from the various series of the sections *Ficus*, *Sycidium*, *Rhizocladus*, and *Kalosyce* belong to several species groups. The general impression is, that there is a good correspondence between the classifications of the figs and the fig wasps, but a more positive statement cannot be given before the species of *Blastophaga* have been revised.

9. A species of *Kradibiella* was recorded from the Australian *Ficus stephanocarpa* Warb. (= *F. coronata* Spin.) by WAKEFIELD (1960), and its description will shortly be given by RIEK. I should add here, that I am not convinced of the need for a distinct genus *Kradibiella*: it would seem to represent merely a species group in the genus *Blastophaga*. The alternative to the inclusion of *Kradibiella* in *Blastophaga* is to recognize probably as many as five or six other genera.

10. The greater part of the Indo-Malayan and Papuan species of *Ceratosolen* live in figs of the sections *Neomorphe* and *Sycocarpus*, but some are known from two series of *Sycidium*. It is interesting to note that these series have usually been placed in *Sycocarpus*, and only recently have been assigned to *Sycidium*. Botanically, these groups "point to an ancestor which would combine *Sycidium* with *Sycocarpus* and *Sycomorus* [here including *Neomorphe*]" (CORNER, 1958, p. 31).

In my opinion, the wasp from the series *Prostratae* (*Ceratosolen gravelyi* Grandi, ex *Ficus semicordata* Ham. ex Smith) connects those from the section *Neomorphe* with those from the subgenus *Sycomorus* (see Table III), and the wasps from the series *Pungentes* (*C. pygmaeus* Grandi, and *C. nanus* Wiebes, from *F. minabassae* Miq. and *F. pungens* Reinw., respectively) appear to be related to the wasps from the section *Sycocarpus*. The botanical parallel is not clear.

11. In figs of the series *Phaeopilosae* and *Copiosae*, I find the grades between *Blastophaga* and *Ceratosolen* alluded to in a previous part of the present paper (p. 4). These are the groups that should be studied before the genera *Ceratosolen* and *Blastophaga* can be more exactly defined.

TABLE III. *Ficus* (*Neomorphe*, *Sycocarpus*, AND *Sycomorus*) AND THE INDO-MALAYAN AND PAPUAN SPECIES OF *Ceratosolen*

Ficus Linn.	Ceratosolen Mayr
	C. appendiculatus group
subgenus <i>Sycomorus</i> Miq. <sup>1)</sup>	
<i>F. racemosa</i> Linn.	C. fusciceps (Mayr)
do., var. <i>elongata</i> (King) Barrett	C. fusciceps (Mayr)
(subgenus <i>Ficus</i> )	
sectio <i>Neomorphe</i> King	
series <i>Auriculatae</i> Corner	
<i>F. auriculata</i> Lour.	C. emarginatus Mayr
<i>F. oligodon</i> Miq.	C. emarginatus Mayr
series <i>Variiegatae</i> Corner	
subseries <i>Variiegatae</i>	
<i>F. variegata</i> Bl.	C. appendiculatus (Mayr)
do., var. <i>garciae</i> (Elmer) Corner	C. appendiculatus (Mayr)
do., var. <i>sycomoroides</i> (Miq.) Corner	C. appendiculatus (Mayr)
<i>F. viridicarpa</i> Corner	C. appendiculatus (Mayr)
subseries <i>Laciniatae</i> Corner	
<i>F. semivestita</i> Corner	C. grandii Wiebes
sectio <i>Sycocarpus</i> Miq.	
subsectio <i>Auriculisperma</i> Corner	
series <i>Cynaroides</i> Corner	
<i>F. cynaroides</i> Corner	C. sordidus Wiebes
series <i>Theophrastoides</i> Corner	
series <i>Vitienses</i> Corner	
<i>F. salomonensis</i> Rech.	C. boschmai Wiebes
subsectio <i>Papuasyce</i> Corner	
<i>F. microdictya</i> Diels	C. spec.
<i>F. itoana</i> Diels	C. armipes Wiebes

<sup>1)</sup> For convenience' sake, I begin this table with the subgenus *Sycomorus*, although it is usually placed at the end of the botanical system (cf. Table II).

Ficus Linn.	Ceratosolen Mayr
subsectio Dammaropsis (Warb.) Corner <sup>1</sup>	C. abnormis group
<i>F. dammaropsis</i> Diels	C. abnormis Wiebes
subsectio Lepidotus Corner	
subsectio Macrostyla Corner	
subsectio Sycocarpus	
series Longetuberculatae Sata	C. crassitarsus group, p.p.
<i>F. ribes</i> Reinw. ex Bl.	C. crassitarsus (Mayr)
do., var. <i>cuneata</i> (Miq.) Corner	C. gracilis Wiebes
<i>F. botryocarpa</i> Miq.	C. corneri Wiebes
do., var. <i>subalbidoramea</i> (Elmer) Corner	C. corneri Wiebes
series Tuberculifasciculatae Sata	
subseries Praestantes Corner	C. praestans Wiebes
<i>F. praestans</i> Corner	
subseries Calopilinae Corner	C. calopilinae Wiebes
<i>F. calopilina</i> Diels	C. hooglandi Wiebes
<i>F. bernaysii</i> King	C. iodotrichae Wiebes
<i>F. iodotricha</i> Diels	C. nugatorius Grandi
<i>F. obpyramidata</i> King	
subseries Congestae Corner	C. notus (Baker)
<i>F. congesta</i> Roxb.	C. notus (Baker)
<i>F. nota</i> (Blanco) Merrill	C. orientalis Wiebes
<i>F. subcongesta</i> Corner	C. ?orientalis Wiebes
do., var. <i>symmetrica</i> Corner	
subseries Hispidae Corner	C. solmsi group, p.p.
<i>F. hispida</i> Linn.f.	C. solmsi (Mayr)
<i>F. moderata</i> Corner	(C. crassitarsus group, continued)
<i>F. hispidioides</i> S. Moore var. <i>succosa</i> Corner	C. moderatus Wiebes
subseries Axillares Corner	C. dentifer Wiebes
<i>F. lepicarpa</i> Bl.	C. vechti Wiebes
subseries Fulvidulae Corner	C. pilipes group, p.p.
<i>F. cereicarpa</i> Corner	C. pilipes Wiebes
<i>F. francisci</i> Winkler	C. josephi Wiebes
<i>F. treubii</i> King	(C. solmsi group, continued)
subseries Geocarpicae Corner	C. brongersmai Wiebes
<i>F. uncinata</i> Becc. var. <i>strigosa</i> Corner	(C. pilipes group, continued)
<i>F. beccarii</i> King var. <i>latifolia</i> Corner	C. albulus Wiebes
<i>F. subterranea</i> Corner	C. humatus Wiebes
<i>F. stolonifera</i> King	C. humatus Wiebes
subseries Tuberculifasciculatae	C. spec. (group?)
<i>F. fistulosa</i> Reinw.	C. pygmaeus group, p.p.
do.	C. constrictus (Mayr)
do., var. <i>tengerensis</i> O.K.	C. hewitti Waterston
<i>F. dimorpha</i> King	C. constrictus (Mayr)
<i>F. septica</i> Burm.f.	C. constrictus (Mayr)
do.	C. bisulcatus group
	C. bisulcatus (Mayr)
	C. jucundus Grandi

<sup>1</sup>) By CORNER (1960, p. 38) placed between subsections *Auriculisperma* and *Pomifera* (now, pp. = *Papuasyce*, and p.p. = *Lepidotus*; see CORNER, 1962, pp. 395—396).

12. The wasps from the sections *Neomorphe* and *Sycocarpus* and the subgenus *Sycomorus* are listed in Table III.

The species of the *Ceratosolen appendiculatus* group live in the receptacles of the section *Neomorphe* and in those of the subgenus *Sycomorus*, and one species is known from the series *Prostratae* (see no. 10). The occurrence of a group of so closely related species, as the *C. appendiculatus* group apparently is, in the figs of both dioecious *Neomorphe* and monoecious *Sycomorus*, would suggest that the floral characters in which *Neomorphe* is very close to *Sycomorus* are more important than the distribution of the flowers in the receptacles. A parallel is found in *F. microdictya* Diels, which is the only monoecious species in dioecious *Sycocarpus*.

13. The wasps from the section *Sycocarpus* can be classified in two large divisions, which coincide with the first three subsections of *Sycocarpus* (no records are known from the subsections *Lepidotus* and *Macrostyla*), and the subsection *Sycocarpus*, respectively.

Some characters of the species of the *C. armipes* and *C. abnormis* groups, which form the first large division, suggest of a relationship with *C. bakeri* (see no. 7). I am inclined to regard the common character of the *C. armipes* group and the *C. pilipes* group, the tibial comb of the female fore leg, as the result of a parallel evolution, and not as an indication of a close relationship.

14. The second large division of *Ceratosolen* contains the *C. crassitarsus*, *C. solmsi*, *C. pilipes*, and *C. bisulcatus* groups.

In this assemblage, the *C. pilipes* group is aberrant in the female and (less) in the male sex, and the *C. solmsi* and *C. bisulcatus* groups are distinct in the male sex only.

In general, the classifications of *Sycocarpus* and the groups of *Ceratosolen* run parallel, be it that the two species of the *C. solmsi* group break the sequence. *C. solmsi*, however, seems to be closest to the species of the *C. crassitarsus* group, amongst which it is listed, and *C. brongersmai* shows some connections with the *C. pilipes* group. I will not insist on the value of the *C. solmsi* group, which had to be established on the entomological evidence, but may prove to be redundant when more data are available.

The same reservation must be made for the *C. bisulcatus* group, which is based on the bilobate epistomal margin of the males. The subseries *Tuberculifasciculatae* contains, next to *Ficus septica*, the hosts of *C. constrictus* and *C. hewitti*, which I classify with the *C. pygmaeus* group. The connections with two series of the subsection *Sycidium* (see no. 10) and with *F. pritchardii* (see no. 5) are not clear botanically. The problem of the relationships between *C. constrictus* and *C. hewitti* on the one hand, and *C. bisulcatus* and *C. jucundus* on the other hand, is the more confusing as in the Philippines *F. fistulosa* seems to grade into, or hybridize with, *F. septica*.

The figs of the subseries *Fulvidulae* and *Geocarpicae* harbour *C. brongersmai*, already mentioned above, and the species of the *C. pilipes* group. The *C. pilipes* group consists of two pairs of species, which correspond with the subseries of the hosts. A fifth species, from *F. stolonifera*, could not be described on the scanty and badly preserved material, but it does not show what I assume to be the most



important character of the *C. pilipes* group, viz., the blunt tooth in the dorsal comb of the female fore tibia.

The sequence in which I listed the species of the *C. crassitarsus* group, and in which I tried to depict some of the relationships, does not correspond with the list of hosts as classified by CORNER. Although the correlation might be better in a multidimensional system, some species of wasps defy the classification suggested by the botanist. *C. corneri*, for instance, is so abnormal in the male sex that it is difficult to accept its classification with *C. crassitarsus* and *C. gracilis*, which, moreover, do not support the close relationship between their hosts.

The wasps of *Ficus calopilina*, *F. nota*, and *subcongesta* are so close that I am doubtful of their specific diversity, although the figs are classified in two distinct subseries.

*Ceratosolen nugatorius* and *C. dentifer*, finally, both show the peculiar tibial spur in the male hind leg, but it may be that these spurs are not homologous. I could accept the classification as suggested in the botanical system.

#### Tentative remarks on the Agaonidae

15. Omitting all doubtful cases, a general survey would show the species of the genus *Blastophaga* as pollinators in three subgenera of *Ficus*, viz., *Urostigma*, *Pharmacosycea*, and *Ficus*. In all three, different types have evolved: several subgenera of *Blastophaga* in Asia (*Blastophaga*, *Eupristina*, *Waterstoniella*), *Pleistodontes* in Australia, *Julianella*, *Valentinella*, and *Tetrapus* in America, and *Elisabethiella*, *Agaon* and *Allotriozoon* in Africa<sup>1</sup>). The parallel evolution of fig wasps with long faces and denticulate mandibles in the female sex, in Australia (*Pleistodontes*), Africa (*Agaon*), and America (*Tetrapus*), is mentioned here as a curious fact, well worth of closer research and comparison.

*Ceratosolen* appears to consist of three original stocks, roughly coinciding with *Neomorphe* and *Sycomorus*, the first part of the section *Sycocarpus*, and the subsection *Sycocarpus*, respectively. The genus *Ceratosolen* appears to be a derivate of *Blastophaga*, and seems to be still connected with it in the wasps from the subsection *Sycidium*.

#### CONCLUDING REMARKS

I shortly summarize the line of thought which led to the research on figs and fig wasps as presented in the preceding chapters.

To find in a taxonomical revision of a group of fig wasps a high specificity in the close relation between fig wasps and their hosts is to ask the question whether or not this absolute specificity is of general occurrence in the family. It appears that most host records confirm to the principle; others do not, but these are either not documented, and therefore they have no evidential value, or there is reason to doubt the taxonomical evidence.

The next problem is the nature of the specificity. In the chapter relating to this matter it was suggested that there exists a phylogenetic specificity, in other words, *Ficus* and the Agaonidae are supposed to have evolved together. The evidences in

<sup>1</sup>) *Blastophaga* s.str. is not yet known from Africa, except for the introduced *Blastophaga psenes* (L.).

favour of a phylogenetic specificity are convincing, as seen in the classification of the larger groups. The parallelism in the classification of the smaller divisions, and in that of the species, is less satisfactory. This, however, does not affect the hypothesis of the phylogenetic specificity, as both the botanical and the entomological classifications should be reconsidered later. For the time being, CORNER and myself try to base our classifications of figs and fig wasps, as much as possible, exclusively on botanical and entomological evidence, respectively. In the long end we search for a classification that satisfies both the entomologist and the botanist. Should such a system be found we may turn the argument and open the discussion on the principles of our classification and on the evolution of the symbiosis. This is, of course, what we have in mind and what was stated before by VAN DER VECHT (1956, p. 103) and CORNER (1960, p. 370). Our taxonomic revisions are intended to be means to that end.

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