A New Genus of Seed-infesting Micropterygid Moths

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THE SUPERFAMILY MICROPTERYGOIDEA constitutes the most primitive group of the Lepidoptera. Like the other superfamily of the suborder Homoneura, the Hepialoidea, it is characterised by the venation in the fore and hind wings being almost identical. They are like certain Trichoptera in wing venation and in the presence in the pupae of large functional mandibles. The adult mouth parts show a gradation between the mandibulate type in the Micropterygidae and the haustellate type, characteristic of most Lepidoptera, in the Mnesarchaeidae. The Micropterygidae are of world-wide distribution and the larvae are external feeders on mosses and liverworts. The Eriocraniidae are not known from the Southern Hemisphere and their larvae are leaf miners on Betulaceae and Cupuliferae. The Mnesarchaeidae are confined to New Zealand, their larval habits being unknown. The Neopseustidae from India and Formosa are also unknown in their larval habits.

In February, 1947, I received some seed of *Agathis vitiensis*, a species of Kauri pine, from B. E. V. Parham of the Department of Agriculture of Fiji, with a request that I endeavour to rear out and identify the insect with which they were infested. Several of the larvae present pupated in September, 1948, and the pupal characters established the species as a micropterygoid moth. Parham also informed me that there was a similar larva in the seed of Queensland Kauri and A. R. Brimblecombe of the Queensland Department of Agriculture later sent me larvae and pupae of this species. The detailed morphology was studied with adult material extracted from the pupae. No success was obtained in attempts to secure emergence of the moths of the Fijian species and Brimblecombe was successful in obtaining emergence of the Queensland species only after many years of effort.

The association of these insects with Kauri pines (*Agathis* spp.) opens an interesting field for research since pines of this genus occur from the Philippines and Indo-China through the Malay Peninsula and Archipelago to New Guinea, the Solomon Islands, Eastern Queensland, New Caledonia, Fiji, and New Zealand. The genus *Agathis* is regarded as centred in Malaysia, and the Pacific representatives, of which *Agathis vitiensis* from Fiji is at the easternmost limit of distribution of the genus, are regarded as of Malaysian affinities and derivation. It seems likely that related micropterygoid moths will be found to be associated with *Agathis* elsewhere and particularly in Malaysia. There is at present no evidence of the occurrence of a related insect in the seed of the New Zealand Kauri (*Agathis australis*) or in those of the Moluccas, New Caledonia, Borneo, and the Philippines. The two species, one from Fiji and the other from Queensland, which I describe here, present points of considerable interest. The Fijian species is the first record of any micropterygoid moth from a really oceanic Pacific island although they are recorded from Formosa. The habit of feeding and pupating within

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seeds has not previously been reported within the superfamily.

These two species of micropterygoid moths are congeneric. The weight of evidence from morphological and biological sources would indicate that they are more nearly allied to the Micropterygidae than to the Eriocraniidae and, as they do not fit existing micropterygid genera, a new genus is created for them.

Agathiphaga new genus

ADULT: Ocelli absent; mandibles present; labial palps 4-segmented, sensory process on basal segment absent; maxillae with galea present but not modified to form short haustellum, lacinia present, maxillary palps 5-segmented. Forewings with Sc unbranched and with closed cubito-medial cell in addition to closed radial cell. Legs: Tibiae I with strigil at mid-length and a single short apical spur; tibiae II and III with two spurs at mid-length and two apical spurs; femora I and II with two small setae or spurs on tip. Male with paired glandular processes on fifth abdominal sternite. Male genitalia with claspers large, exserted and curved dorsad. Female genitalia eversible, terminal segment with single median Y-shaped rod, not heavily sclerotized or adapted for piercing.

PUPA: Head with four pairs of long frontal setae; beak absent. Mandibles hypertrophied, apex truncate with scalloped edge but without large teeth apically. Mandibles asymmetrical, both toothed externally but left mandible with single tooth on non-serrate ental margin. No strap-like process on dorsum of meso- and metathorax and first abdominal segment. All tarsi 2-clawed. No abdominal setae. Claspers of male genitalia exserted and curved dorsad.

LARVA: Antennae short. Compound eyes absent. Apodous. Integument spinulose, setae very short. Internal feeders in seed of *Agathis* spp.

GENOTYPE: *Agathiphaga vitiensis* n. sp. Fiji.

Agathiphaga is separated from all other micropterygid genera by the presence of two apical spurs on the middle tibia, the absence of the sensory process on the basal joint of the labial palp, and (except for the Australian species of *Sabatinca*) the 4-segmented labial palps.

Agathiphaga vitiensis n. sp.

ADULT: Forewing 4.0 mm. long, dorsally dark greyish-brown with fine white hairs, a light yellowish-brown patch on anal area and a smaller patch of similar colour distad of this on the posterior margin before mid-length; ventrally dark scaled with lighter brown fringes. Venation as in Figure 3. Forewing with R_1 branched and Cu_{1a} arising from M_3. Lateral lobes of labrum with 3–4 setae on each side. Third and fourth segments of labial palps sub-equal in length. Apical segment of maxillary palp small, sub-globose. Male genitalia as in Figures 4*a–c*, 5*a–f*. Forked median rod of female genitalia 1.0 mm. long. Tooth on ental margin of left pupal mandible at about half-length, i.e., behind or cephalad of the external tooth.

SPECIMENS: Two male and three female pupae obtained from larvae within seed of *Agathis vitiensis*, Fiji, per B. E. V. Parham. *Holotype*, male, on slide mounts deposited in Entomology Section, Department of Agriculture, Suva, Fiji.

MORPHOLOGY

ADULT: The head capsule is strongly sclerotized and pigmented, with the exception of the stippled areas shown in Figure 1*a*, which bear the tufts of scales. A median epicranial suture runs from the posterior margin of the occiput to a point level with the antennal sockets. From the posterior third of the epicranial suture, a suture runs anterolaterally to a point behind mid-length of the inner margin of the eye. The ocelli are absent. The antennae are 5 mm. long and consist of about 47 segments of which the large basal one is 0.4 mm. long. The labrum (Fig. 1*b*) is tri-

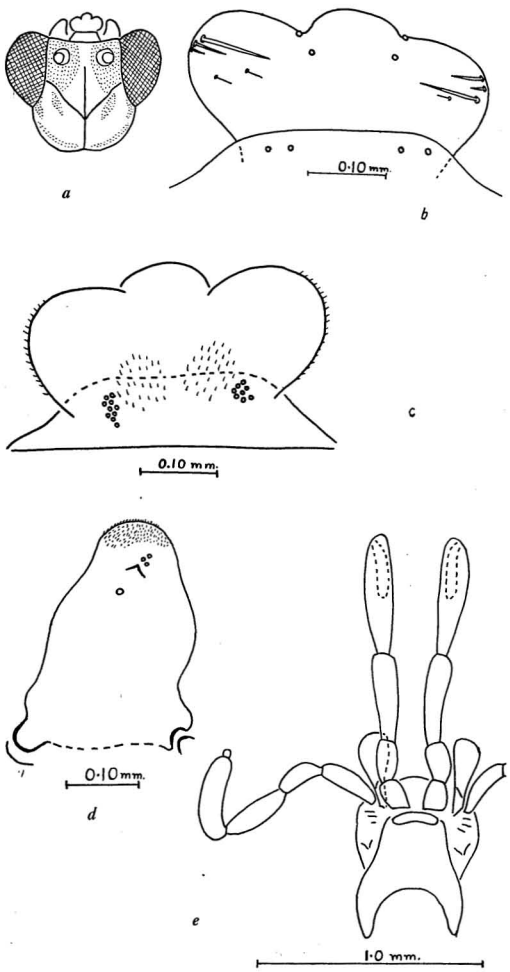

FIG. 1. *Agathiphaga vitiensis*, structures of adult. *a*, Dorsal aspect of head; *b*, dorsal aspect of labrum; *c*, epipharynx; *d*, external face of mandible; *e*, ventral view of labium.

lobed, with two sensory pores on each side between the lateral and median lobes, and one large and two smaller setae on each side at mid-length of the lateral lobe. The epipharynx (Fig. 1*c*) has a group of sensory pores on each side with scattered setae anterior to these. The clypeus or post-labrum has two sensory pores on each side. The mandibles (Fig. 1*d*) are present and, to the extent that the ginglymus and condyle are present, could be described as functional. They are reduced to a lobe or finger-like form and bear on the external face an obsolete but quite distinct tooth, with a large sensory pore basad of this and three smaller pores distad. There is a finely setose or spinulose area at the apex. The labium (Fig. 1*e*) has a transverse mental plate. The labial palpi are 4-segmented, the second segment slightly longer than the first, the third twice as long as the second, and the fourth slightly longer than the third with a sensory groove extending back to mid-length. There is no finger-like sensory process arising from the first segment of the palp. The hypopharynx is similar to that of *Agathiphaga queenslandensis* (Fig. 8*b*). The maxillary cardo and stipes (Fig. 2) are not clearly separated. The stipes bears mesally a sclerotized lacinia with a single dorsal seta; laterad of this is the thin leaf-like galea which is as long as the first joint of the maxillary palp. The maxillary palps are long, folded, and 5-segmented with the first, third, and fourth segments sub-equal in length, the second shorter, and the fifth small and sub-globose. The pattern on the forewing is shown in Figure 3*a* and the venation of both wings in Figures 3*b*, *c*. The unbroken lines represent veins in which the

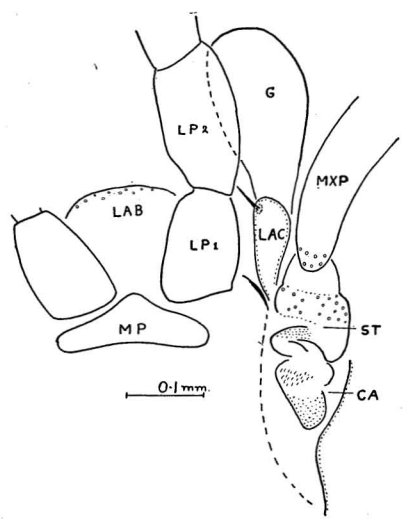

FIG. 2. Ventral view of maxilla and base of labium of adult *A. vitiensis*. MP, Mental plate; LAB, labium; LP_1, LP_2, segments of labial palp; CA, cardo; ST, stipes; LAC, lacinia; G, galea; MXP, first segment of maxillary palp.

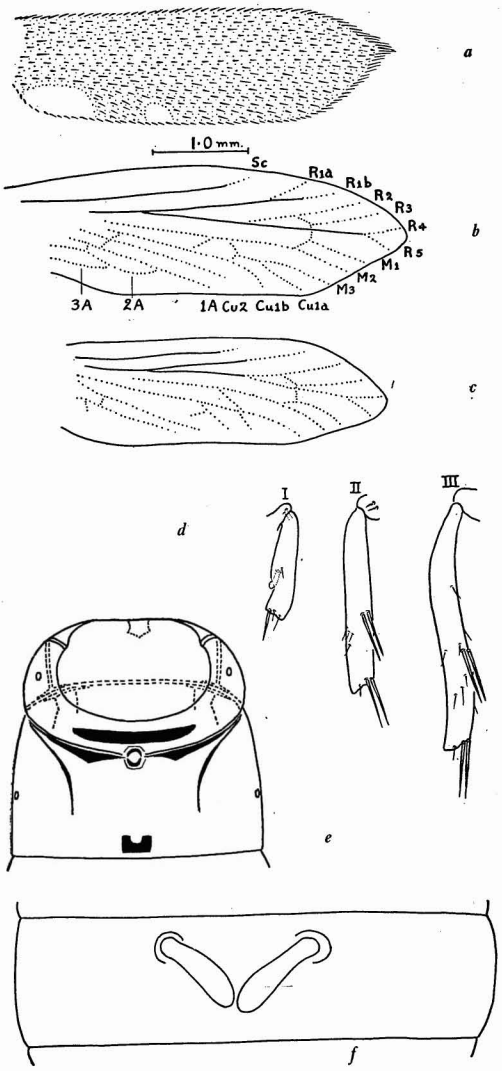

FIG. 3. Structures of adult *A. vitiensis*. *a*, Forewing showing markings; *b*, venation of forewing; *c*, venation of hind wing; *d*, pro-, meso-, and metatibiae; *e*, first and second abdominal segments in ventral view; *f*, fifth sternite of male showing glandular processes.

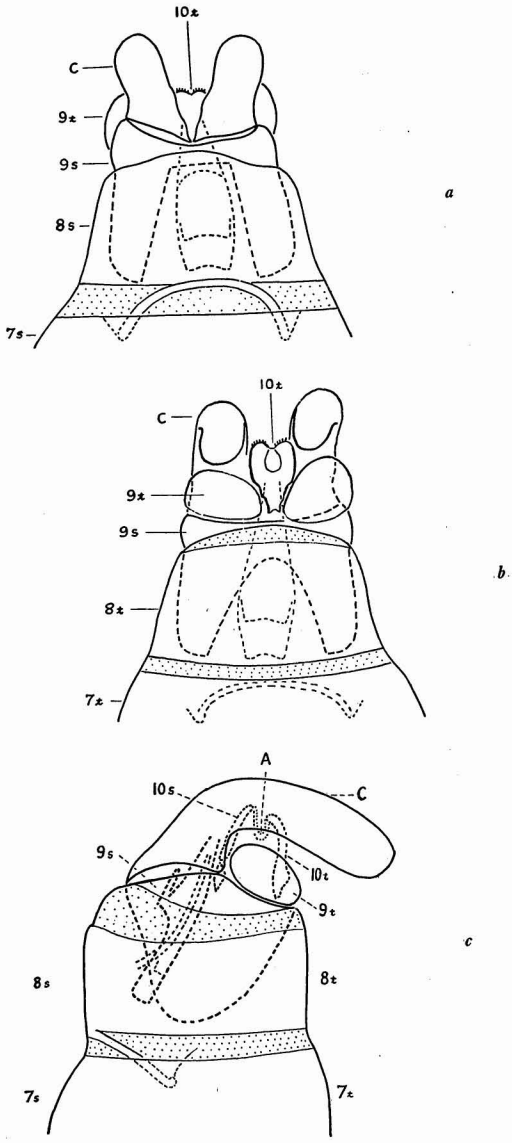

FIG. 4. *A. vitiensis*, terminal abdominal segments of male. *a*, Ventral; *b*, dorsal; *c*, lateral. 7s, 8s, 9s, 10s, Sternites; 7t, 8t, 9t, 10t, tergites; A, anus; C, clasper.

antecedent tracheation is still visible. The wing length given is that of the unexpanded wing removed from the adult within the pupa, and observations on the following species would indicate that the length of a normally expanded wing may be about 8 mm. The tibiae are shown in Figure 3*d*. The abdomen has eight unmodified segments with spiracles present on the first seven. Vestiges of spiracles are present on the eighth segment of the female. Dorsally the first abdominal segment (Fig. 3*e*) has a subpentagonal median sclerite anteriorly; laterad of this on each side is a stout rod-like longitudinal sclerite which, at its end on the posterior margin of the segment, has mesal and lateral branches. Ventrally the first sternite is much reduced, the

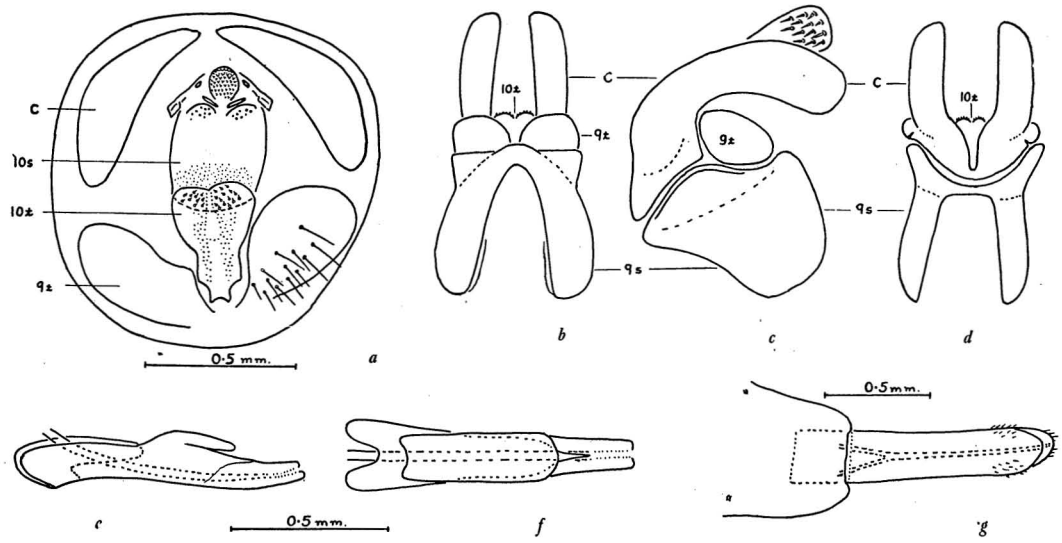

FIG. 5. *A. vitiensis*, male and female genitalia. *a–d*, Male: caudal, dorsal, lateral, and ventral aspects; *e*, *f*, aedeagus, lateral and ventral aspects; *g*, female. Abbreviations as in Fig. 4.

principal element being a narrow transverse sclerite. On the venter at the junction of the first and second abdominal segments the membrane is invaginated, and on the opposed surfaces are two elliptical sclerites, the tips of one articulating with those of the other and with the tip of a transverse sclerite on each side which is angular posteriorly. A narrow curved sclerite, or rod, runs from the anterolateral margin of the second sternite to a point midway between the median line and the spiracle. In a posteromedian position on the second sternite there is a small rectangular sclerite, concave anteriorly. On each side of the anterior margin of the second tergite, two short longitudinal sclerites, or rods, run posteriorly. In the male there is a pair of glandular processes (Fig. 3*f*) on the fifth sternite. Also in the male there are two lateral processes (Fig. 4*a*) from the anterior margin of the eighth sternite, which are withdrawn into the seventh segment.

In the male the basal piece of the genitalia (ninth sternite) forms a complete ring posteriorly (Fig. 4), but both dorsally and ventrally this piece is deeply emarginate, and the two lateral wings thus formed are deeply sunken within the eighth segment. Caudad of the basal piece on the dorsum are two paramedian lobes (9 t), and between and behind them is a grooved median pigmented sclerite (10 t) which is bilobed and bears short setae posteriorly (Fig. 5*a*). Between this and an opposing ventral sclerite is an invagination which may be the site of the anus. Between this sclerite (10 s), which has anteriorly a circular area with scale-like imbrications, and the bases of the claspers is the genital opening through which is protruded the aedeagus. The large claspers (Fig. 5*b-d*) have dense stout setae on their internal faces and articulate with the ventral part of the basal piece. The aedeagus is shown in Figure 5*e*, *f*.

In the female the ninth segment forms the long narrow ovipositor (Fig. 5*g*). It is strengthened by a single median rod which is forked anteriorly.

PUPA: The pupa is shown in dorsal and ventral views in Figure 6*a*, *b*. The mandibles are shown in Figure 6*c* and the clypeus and labrum in Figure 6*d*. There are two pairs of long setae or hairs on the frontal region and two pairs on the occipital region. The clypeus bears three setae on each side. The pupal skin of the type has nine setae on the labrum, four on one side and five on the other. There are

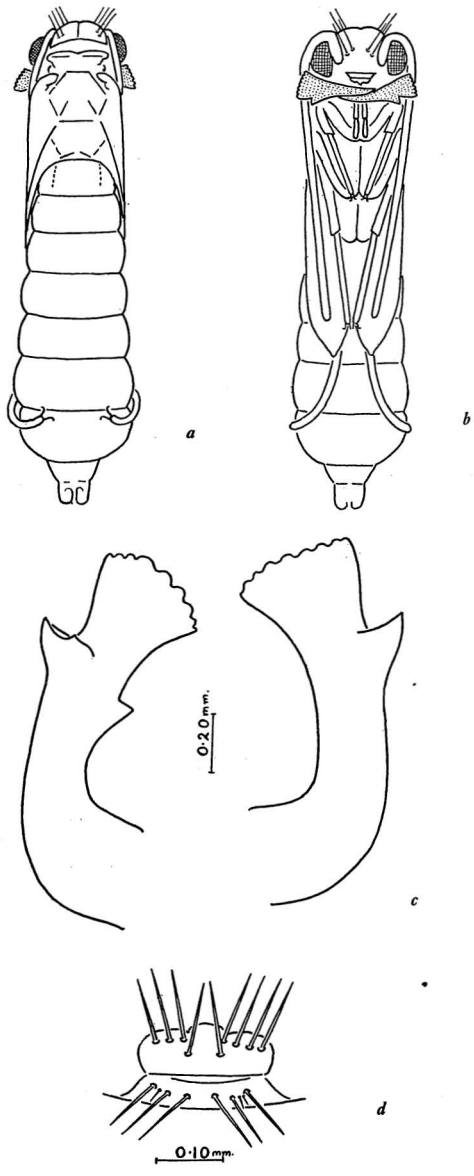

FIG. 6. Pupa of *A. vitiensis*. *a*, Dorsal aspect; *b*, ventral aspect; *c*, mandibles; *d*, clypeus and labrum, dorsal aspect.

no setae on the thorax and abdomen.

LARVA: The full-grown larva is 6 mm. long and 2.5 mm. wide. It is stoutly built and not flattened. The body width is more than twice that of the head capsule. Living larvae are yellowish in colour with the exception of the mouth frame and trophi, which are dark brown. Legs are absent. The thoracic and abdominal integument is finely and densely spinulose and without sclerotized or pigmented plates. Body setae are present but are small, and their arrangement is difficult to discern. There are nine pairs of spiracles, one prothoracic and eight abdominal. The head (Fig. 7*a*) is widest behind mid-length and is not flattened. It is emarginate posteriorly in the middorsal line where the epicranial halves meet. In both this and the following species, neither the frontal suture nor the adfrontal suture is evident, and I am unable to determine the position of the anterior tentorial pit. The disposition of the dorsal setae on the head is shown in Figure 7*a*. The antennae (Fig. 7*b*) are enclosed in a pigmented ring and consist of one prominent sclerotized and pigmented segment on the apex of which are borne three finger-like processes, three setae, and one seta with a thickened collar. External to and posteroventrad of the antennal ring is a pigmented spot probably representing an ocellus. The labrum (Fig. 7*c*) is transverse, slightly emarginate anteriorly, and bears four setae in a line across the disc and another seta behind these on each side of the lateral margin. On each side of the anterior margin are two setae with a third beneath them. The mandibles (Fig. 7*d*) are quadridentate and bear on the external face two setae. There is no bunch of long, branched hairs at the base of the cutting edge. Ventrally the head is deeply divided by the foramen (indicated by a broken line in Figure 7*a*) which consists of an anterior foramen separated by a slender tentorial bridge from the posterior foramen. Posteriorly the foramen (Fig. 7*e*) has on each side a triangular extension with the apex extending toward the posterolateral angle of the head capsule. The ventral mouth parts are shown in Figure 7*f*. The mentum bears no setae nor sensory pits and is separated from the maxillary stipes on each side by a pigmented bar. The labium is large and conical and bears posteriorly a pair of short setae and, anterior to these and somewhat farther apart,

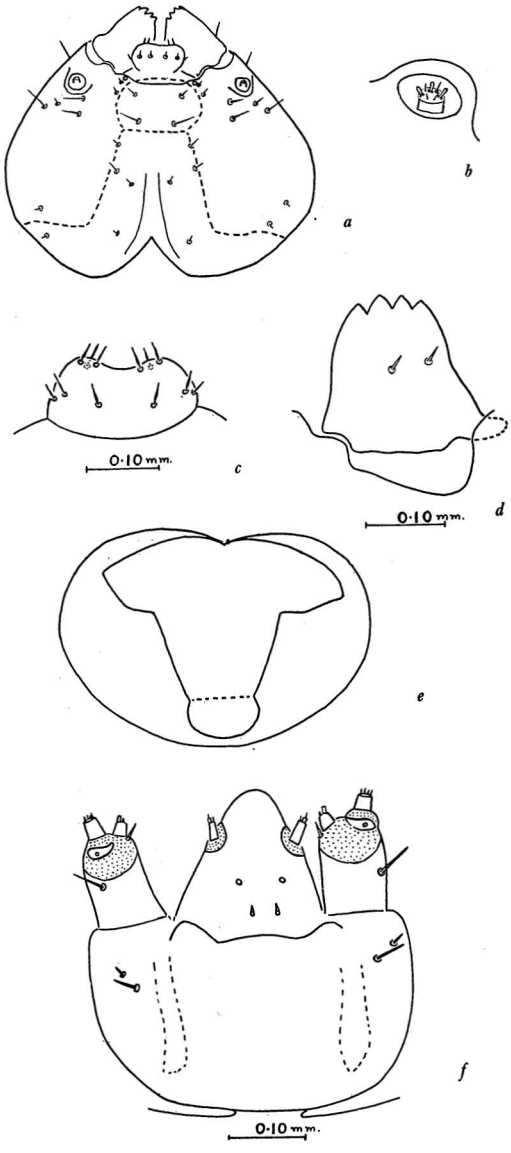

FIG. 7. Larval structure of *A. vitiensis*. *a*, Dorsal aspect of head; *b*, detail of antenna; *c*, dorsal aspect of labrum; *d*, mandible; *e*, caudal aspect of head capsule; *f*, ventral aspect of ventral mouth parts.

a pair of sensory pits. The labial stipites are not differentiated. The labial palp is 2-segmented, the basal segment is truncate-conical and pigmented and bears apically the small second segment and a small seta or process. The second segment bears a small process apically. The maxillary stipes bears two setae. The maxillary palpiger bears a single seta laterad at mid-length. The maxillary palp is 2-segmented. The basal joint is transverse with a single sensory pit, and the distal segment is cylindrical and bears processes apically. The lacinia is borne on the palpiger mesad of the maxillary palp and is 1-segmented with an apical process. At the base of the lacinia mesally are one or two spines, or processes, possibly representing the galea or digitus laciniae but smaller and shorter than that shown in *Mnemonica auricyanea* Wals. by Busck and Boving (1914: Pl. XI, Fig. 8). In general the larva is similar to that of *M. auricyanea*.

Agathiphaga queenslandensis n. sp.

ADULT: Unexpanded forewing of adult extracted from pupa 3 mm. long. Forewing of naturally emerged adult female 6.5 mm. long. Forewing unicolorous, without spots or pattern. Venation as in Figure 9*a*, *b*. Vein R_1 in forewing unbranched and Cu_{1a} arising from cubitomedial cell and not from M_3. Lateral lobes of labrum with numerous setae on each side. Fourth segment of labial palp short, conical, three or four times as long as wide. Forked median rod of female genitalia 0.6 mm. long. Male genitalia (aedeagus not seen) very similar to that of *Agathiphaga vitiensis*. Tooth on ental margin of left pupal mandible nearer apex than mid-length, i.e., nearly opposite external tooth.

SPECIMENS: Four female and one male pupae from seed of *Agathis robusta* from Como(?), Queensland, and several naturally emerged adults in poor condition from seed of *A. robusta* from Maryborough, all sent by A. R. Brimblecombe. *Holotype*, female, on slide mounts deposited in Queensland Museum, Brisbane, Australia.

MORPHOLOGY

ADULT: The adult of this species is generally similar to that of *Agathiphaga vitiensis*, except in size and in the absence of wing pattern. On the head the median epicranial suture is

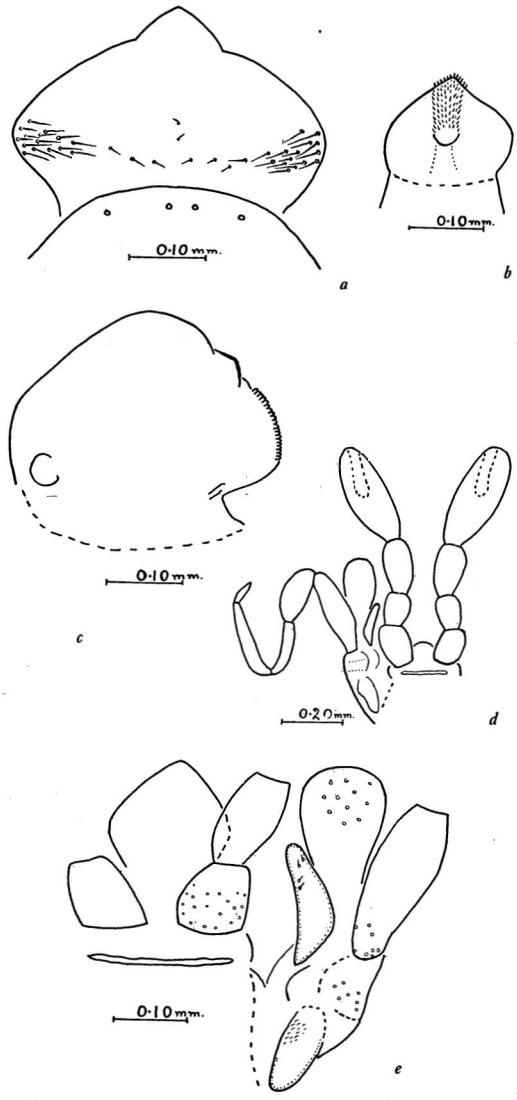

FIG. 8. *Agathiphaga queenslandensis*, structures of adult. *a*, Labrum, dorsal aspect; *b*, hypopharynx; *c*, mandible; *d*, labium and maxilla, ventral aspect; *e*, detail of maxilla and base of labium.

present but the two lateral sutures are absent. The unsclerotized scale-bearing areas are similar to those of *A. vitiensis*. The labrum (Fig. 8*a*) is distinguished by the more numerous setae, concentrated at the sides but extending across the disc. The epipharynx is similar to that of *A. vitiensis*. The mandibles (Fig. 8*c*) have an obsolete tooth and their apices have a finely toothed or crenellated area. The hypopharynx (Fig. 8*b*) has what appears to be an orifice at mid-length and, anterior to this, a broad median setose band. The mental plate is absent or represented by a very narrow transverse sclerite. The labial palps (Fig. 8*d*) are 4-segmented, the first and second subequal in length, the third one-half as long again and the fourth twice as long as the third with the sensory groove extending back to mid-length. The maxillae (Fig. 8*e*) have the lacinia present and bearing four short setae, galea present, maxillary palps 5-segmented and folded. The first and fourth segments are sub-equal, the second and third sub-equal and shorter than the first, the fifth short about one-third the length of the fourth, sub-conical and about three times as long as wide. The differences in the wing venation are seen in Figure 9*a*, *b*. The figures of the venation in this and in the preceding species are based on the study of the unexpanded wing of the adult extracted from the pupa. I was later able to study the wings of naturally emerged moths of *A. queenslandensis*. In the forewing the humeral vein is sometimes absent or indistinct. In one specimen Sc has a short branch. The cross vein Sc-R_1 is absent or indistinct. R_5 is 2-branched in some specimens as also is M_3. The cross veins Cu_2–Cu_{1b} and 1A–Cu_2 are absent. In the hind wings I am unable to check the veins of the anal area owing to the condition of the specimens, but the rest of the wing coincides with the figure given. The female genitalia (Fig. 9*c*) are similar to those of *A. vitiensis*. The male genitalia are essentially similar to those of *A. vitiensis*. The aedeagus is missing in the single male specimen available. The principal differences are in the structure of the tenth tergite and tenth sternite (Fig. 9*d*).

PUPA: The main difference between *A. queenslandensis* and *A. vitiensis* is in the mandibles (Fig. 10*a*), as mentioned in the descriptions. The number of long setae on the clypeus and labrum is variable. In the pupal skin of the type there are only 4 setae asymmetri-

cally arranged on the clypeus and 10 symmetrically arranged setae on the labrum. Another specimen has 6 setae on the clypeus and 10 on the labrum.

LARVA: The larva is very similar to that of *A. vitiensis* except in its smaller size. The main point of difference is in the shape of the lateral extensions of the posterior foramen (Fig. 10*b*) which are not triangular but ovoid owing to the constriction produced by dorsal and ventral processes from the epicranium. The only other difference is in the labral setae (Fig. 10*c*). On each side, at the anterior margin, two setae project anteriorly, while beneath these are two others instead of the single seta present in *A. vitiensis*. The mandible is shown in Figure 10*d*.

SYSTEMATIC POSITION

The Micropterygidae are characterised by the possession of functional toothed mandibles, a maxillary lacinia, and an unspecialised

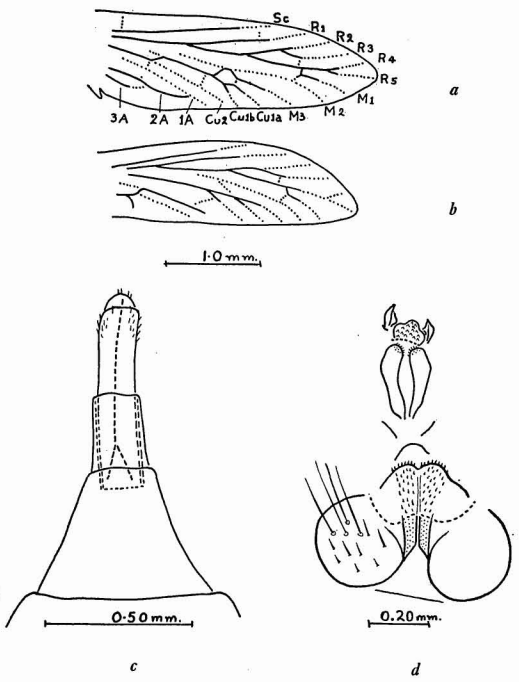

FIG. 9. Wings and genitalia of *A. queenslandensis*. *a*, Venation of forewing; *b*, venation of hind wing; *c*, female genitalia; *d*, male genitalia, caudal aspect (fragmentary).

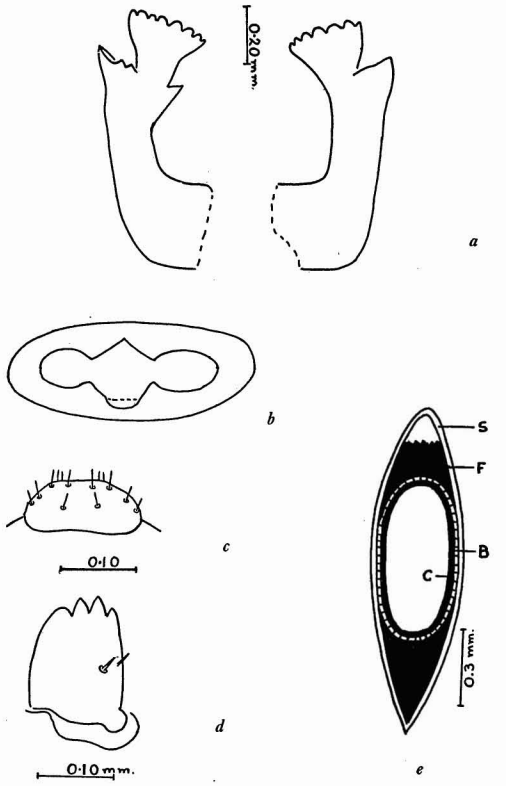

FIG. 10. Pupal and larval structures of *A. queenslandensis* and diagram of infested seed of host. *a*, Pupal mandibles; *b*, head capsule of larva, caudal aspect; *c*, labrum of larva, dorsal aspect; *d*, mandible of larva; *e*, longitudinal section (diagrammatic) of infested *Agathis* seed: B, buff layer; C, wall of pupal cell; F, filling material; S, seed coat.

galea. One pupa, that of *Sabatinca incongruella* Walk., has been described by Tillyard (1923*a*: 445–448). It has a triangular mandible. The larvae of *Micropteryx calthella* L. and *M. aureatella* Scop. have been described by Chapman (1894: 341–344; 1916: 313) and that of *Sabatinca barbarica* Philp. by Tillyard (1923*a*: 440–445). These three larvae have long antennae, compound eyes (at least in *Sabatinca*), thoracic legs, abdominal prolegs, and flattened body processes. They are external feeders on mosses and liverworts. The family is represented in most regions of the world except the oceanic islands of the Pacific, the Australian and New Zealand representatives belonging to the genus *Sabatinca*.

The Eriocraniidae possess mandibles which are reduced and nonfunctional, the lacinia is absent, and the galea is modified to form a short haustellum. The pupa of *Eriocrania purpurella* Haw. has been described by Chapman (1893: 255–258) and that of *Mnemonica auricyanea* Wals. by Busck and Boving (1914: 155–158). They have truncate clubbed mandibles which are toothed or scalloped apically. The larva of *M. auricyanea* has been described by Busck and Boving (*op. cit.*), that of *Chapmania sparmanella* Bosc. by Grandi (1933: 145–150), and that of *Eriocrania sangi* Wood. by Jayewickereme (1940: 89). They have short antennae and simple body setae and the compound eyes, thoracic legs, and abdominal prolegs are absent. These larvae are leaf miners in the leaves of Betulaceae and Cupuliferae. The family is not represented in the Southern Hemisphere.

The Neopseustidae are said by Hering (1925: 143–147), who removed the genus *Neopseustis* from the Eriocraniidae, to lack the jugum and to have both mandibles and haustellum present. The larva and pupa are unknown as also is the food plant. The two known species occur in India and Formosa.

The Mnesarchaeidae have the mandibles and lacinia absent and the galea forming a long haustellum. The larva, pupa, and food plant are unknown. The family is confined to New Zealand.

The adult morphology of this superfamily, especially the mouth parts, venation, and genitalia, have been studied by Busck and Boving (1914), Tillyard (1919 and 1923*b*), Philpott (1924 and 1927), and Issiki (1931). As will be seen from the foregoing short account of the families, the larval and pupal stages and the food plants and habits of these insects are known in relatively few cases. In fact, Chapman's (1894: 337) comment, "I was much impressed with the resistance of the Eriocephalidae to investigation . . . I had little idea that they would continue this resistance for so many years," is still apropos.

Agathiphaga cannot be placed in the Mnesarchaeidae as defined by Tillyard (1926: 411–412), as the mandibles are present and the haustellum absent, and, while vein R_1 is unbranched in *A. queenslandensis*, R_2 and R_3 are separate veins in both *A. queenslandensis* and *A. vitiensis*. In Viette's (1947: 25) key to the families, *Agathiphaga* would run to the Neopseustidae, but it cannot be placed in this family because the jugum is present, there are two apical spurs on the middle tibiae, and the haustellum is absent. There is some evidence of affinity with the Eriocraniidae, such as the reduction of the mandibles, the presence of two apical spurs on the middle tibia, the absence of the sensory process of the basal segment of the labial palps, and the absence of the asymmetrical hair brushes on the epipharynx. The form of the pupal mandibles is similar to that of the known eriocraniid pupae. The larvae, with short antennae and no compound eyes, thoracic legs, abdominal prolegs, or flattened body processes, resemble the eriocraniids.

The genus appears to conform more closely with the Micropterygidae than with any of the other families. The mandibles, though reduced, are apparently functional and have at least one reduced tooth present, the maxillary lacinia is present, and the galea is present but not elongated. The radial cell is present, as it is in all micropterygid genera except *Palaeomicroides* and *Neomicropteryx*. It is also present, however, in the eriocraniid genus *Eriocraniella*.

Agathiphaga does not fit the emended family diagnosis of the Micropterygidae given by Issiki (1931: 1037–1038), in that ocelli are absent, and there is no branch of Sc. The sensory process on the labial palps, figured by Tillyard (1923*b*: 189) in *Sabatinca*, by Busck and Boving (1914: pl. xv, fig. 6) in *Micropteryx ammanella* Aub., and by Issiki (1931: 1035) in Japanese micropterygids, is absent, as are the epipharyngeal hair brushes figured by Tillyard (1923*b*: 183), and Issiki (1931: 1033). The female genital apparatus is unlike that of the micropterygids in the long

exsertile ovipositor, but it lacks the cutting and piercing adaptations present in the Eriocraniidae.

The *Agathiphaga* pupa has four pairs of frontal hairs as against two pairs in the eriocraniids, but it lacks the lateral abdominal hairs. It also lacks the dorsal abdominal hairs of *E. purpurella* Haw. and the frontal beak and the strap-like band on the meso- and metathorax of *Mnemonica auricyanea* Wals. Tarsal claws are present in the *Agathiphaga* pupa but are not recorded in the two eriocraniid pupae. They are also present in some trichopterous pupae.

The larvae of *Agathiphaga*, as mentioned above, also differ from those of the other known micropterygids and approach the eriocraniid condition, but this could be a result of the specialised larval habitat.

Hinton (1946*a*: 1–4) has proposed a new classification for the Lepidoptera. The Micropterygidae are given ordinal rank as the Zeugloptera and are regarded as more primitive than the Trichoptera, which also retain ordinal rank. The Eriocraniidae remain with the Lepidoptera and, together with the Mnesarchaeidae, comprise the suborder Daconympha. The characters of *Agathiphaga*, intermediate as it is between the Micropterygidae and the Eriocraniidae, make it difficult to sustain the proposed classification.

The weight of morphological evidence is for the inclusion of *Agathiphaga* as a specialised genus of the Micropterygidae. The seed-infesting habit could have arisen as a specialised development of the micropterygids, and this is perhaps more likely than that it is a further development of the leaf-mining habit of the eriocraniids. Also the eriocraniids are not known to be represented in the Southern Hemisphere. Morphologically the adults of *Agathiphaga* are in several respects intermediate between the Micropterygidae and the Eriocraniidae, but whether *Agathiphaga* is on the direct line of evolution of the Eriocraniidae is uncertain. The fact that the food plant of *Agathiphaga* is also intermediate in the line of plant evolution between the known food plants of these two families cannot be regarded as significant in the absence of evidence as to the age of the association between insect and plant in each case.

BIOLOGY AND DISTRIBUTION OF AGATHIPHAGA

According to Petrie (undated: 14), the female cones of *Agathis robusta* are fertilized in September, but the seed takes 15 months to mature. At the same time, there are present on the tree the maturing cones of the previous crop, and these drop their seed in late December or early January. It is not known when the moths fly and lay their eggs or how long the larva is in the seed before it is fully fed. As the infested seed is not markedly smaller than uninfested seed, it might be assumed that the seed is not infested until it is nearly mature. Some support is given to this thesis by Petrie's note (undated: 13) that seed collected in October was apparently not infested whereas seed collected in December and January was infested. I have no information on the date of pupation of *A. queenslandensis*, but the larvae of *A. vitiensis* pupated in the spring. Petrie (undated: 9) notes that no external hole is seen in infested seed. The ovipositor of *A. queenslandensis* is not adapted for piercing the tissues of the cone, and it is likely that the eggs are laid on the cone surface, perhaps at the junction of contiguous scales, or thrust into crevices between the scales. The flaccid, yellowish, mature larvae are reported by Brimblecombe to be able to remain alive in the seed for as long as 3 years, but it is not known what factors terminate the diapause. Infested seeds (Fig. 10*e*) of *Agathis robusta* are completely hollowed out. At both ends of the seed is a filling, or plug, of hard black pitchy material. Between these is the pupal cell formed by a thin dark reddish-brown layer of uniform thickness, smooth on the inner surface. The external surface of this layer is pale brown or

buff. The seed of *Agathis robusta* is 11 to 12 mm. long in the median line, and the pupal cell is 6 mm. long by 2.5 mm. wide and elongate-ovoid. Seeds from which *Agathiphaga queenslandensis* had emerged were kindly sent by Brimblecombe. They were found to have subcircular emergence holes 1.5 mm. in diameter.

It is doubtful if the tips of the long pupal mandibles can be apposed within the confines of the pupal chamber. The structure of the mandible makes it apparent that the emergence hole is made by a gouging or chiselling action of the teeth on the periphery of the circular, truncated, concave apex. Two holes are present in some seeds, indicating that the two mandibles may not be able to work at the one point on the wall of the pupal cell. The movement of the pupal mandibles must be produced by the muscles of the adult mandibles, in a manner similar to that described by Hinton (1946*b*: 284) in the pupa of the trichopteron *Rhyacophila dorsalis* Curt. The alternative is that torsional movements of the whole body enable the mandibles to make an emergence hole, and this seems very unlikely. It is evident from the material sent by Brimblecombe that the pupa emerges completely, or nearly so, from the seed before the emergence of the adult, since the pupal skins were free and not enclosed in the seed. The possession of tarsal claws by the pupa must greatly facilitate its emergence from the seed.

Brimblecombe informs me that *Agathiphaga queenslandensis* may destroy up to 20 per cent of the fertile seed of the Queensland Kauri Pine, *Agathis robusta*. Petrie (undated: 9) mentions a loss of the order of 90 per cent of the seed.

The seed of *Agathis palmerstoni* is also infested by *Agathiphaga*, but it is not clear whether this is *A. queenslandensis* or another species as I have not seen material which is definitely from *Agathis palmerstoni* seed. There was some doubt about the origin and identity of the seed recorded as from Como (?), but adults from this material, except for minor variation in the venation, were identical with those from *A. robusta* seed from Maryborough.

There is, of course, a possibility that *Agathiphaga* may infest the seeds of pines of the genus *Araucaria* which, in Queensland (but not in Fiji), occurs in the same areas as *Agathis*.

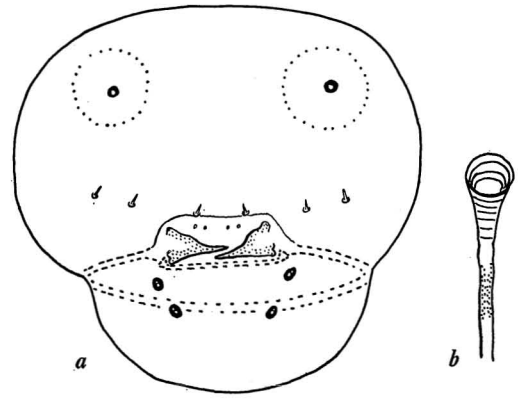

FIG. 11. Hymenopterous parasite of *A. queenslandensis*. *a*, Facial aspect of head of larva; *b*, larval spiracle.

A hymenopterous parasite attacks *Agathiphaga queenslandensis*. Two infested seeds were found to contain only the head capsule of the moth larva and four or five dead larvae of the parasite. The head capsule and the prothoracic spiracle of this parasitic larva are shown in Figure 11 to facilitate future identification. The parasitised larvae did not exceed 1 or 2 per cent of the total number examined. I have no information on the distribution of *Agathiphaga vitiensis* in Fiji or the extent to which it damages *Agathis vitiensis* seed there. Seeds containing living larvae were sent to me and 18 months later, in mid-September, pupae were present. No emergence of adults occurred even when the living pupae were removed from the seeds and kept in moist conditions, though the adults were fully developed inside the pupal case. The pupal head and forelegs were freely movable, but I did not observe any movement of the mandibles.

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