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DESCRIPTION OF A NEW SHIELDBUG (HETEROPTERA: PLATASPIDAE) AND ITS CLOSE ASSOCIATION WITH A SPECIES OF ANT (HYMENOPTERA: FORMICIDAE) IN SOUTHEAST ASIA

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Trophobiotic mutualism between a new plataspid shieldbug (*Tetrisia vacca* Webb sp. n.) and an ant species of the genus *Technomyrmex* was found on *Macaranga gigantea* Muell. Arg. (Euphorbiaceae) in Peninsular Malaysia. The ants feed on faeces of high sugar content voided by larval and adult bugs. In return, the ants provide the bugs with shelters and show protective and cleaning behaviour towards their partners. The observations are compared with those found in other ant-bug relationships and morphological and behavioural adaptations are discussed. The genus *Dolichisme* Kirkaldy, is found to be an unnecessary replacement name for *Tetrisia* Walker (1867a). Notes are given on the type species of *Tetrisia* (*T. bruchoides* Walker) together with a description of the new species.
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The sugary excreta produced by phloem-feeding auchenorrhynchous and sternorrhynchous hemipterans has resulted in widespread trophobiotic mutualism with ants. In Hemiptera: Heteroptera a wider range of feeding strategies is present and, in consequence, phloem feeding and ant associations in this group are less common, being found only in Pentatomoidea (Plataspidae and Pentatomidae: Discocephalinae) in the Old World and Coreoidea (Coreidae) in the New World (see below). We report here on a further trophobiotic relationship in Plataspidae, between the phytophagous bug, *Tetrisia vacca* Webb sp. n. from Malaysia and an ant of the genus *Technomyrmex* Mayr, 1872 (Hymenoptera: Formicidae), a symbiosis that was found to be very close. A taxonomic section is also included to describe the new bug species and to discuss the status and morphology of the poorly known, and previously monotypic, genus *Tetrisia* Kirkaldy. All the plataspid material examined is deposited in The Natural History Museum, London, subsequently referred to as BMNH. It has not been possible to identify the ant species, as a revision of the genus *Technomyrmex* is needed (pers. comm. Barry Bolton, BMNH).

MATERIAL AND METHODS

In January 1991, the first author found a fallen *Macaranga gigantea* Muell. Arg. (Euphorbiaceae) tree (height approximately 8 m) in secondary forest, near the Field Studies Centre of the University of Malaya, Ulu Gombak, Selangor. Large numbers of *Techno-*

Fig. 1. Trophobiotic association of *Tetrisia vacca* and *Technomyrex* sp. on *Macaranga gigantea*. Several workers keep close contact with the abdominal tips of immatures.

myrmex sp. worker ants were observed running along the trunk in both directions, attending groups of plataspid and pseudococcid bugs (Hemiptera). The bugs were only found under ant constructed shelters (carton pavilions) made of detritus combined with soil and, in the case of the plataspids, also under hood-shaped stipules at the leaf bases. Other ant species were also attending the pseudococcids. In order to make observations on the association (trophobiosis) between the plataspids and ants, we first tried to keep them on freshly cut branches of *M. gigantea*, in a container of water. However, both insects behaved in an agitated manner and the bugs stopped feeding and sought protection at the stipule bases, making further investigation impossible. We then tried to establish ant-bug associations on three ant-infested young *M. gigantea* trees (with height range 1.1-1.5 m) by attaching bug-infested branches of the original tree to branches of the new trees. However, the introduced bugs showed no signs of transferring to the new trees, and had disappeared from two of the trees after 24 hours. On the third tree, when no sign of movement to the new tree was observed, we carefully transferred all the adult bugs and immatures individually to the new host. Observations after 24 hours showed that the transfer had been successful, with intensive trophobiotic contacts between the ants and the predominantly motionless bugs. This symbiotic association remained stable for more than three months.

Observations to clarify the trophobiotic behaviour were carried out in the following manner. A leaf stipule was first carefully folded back to reveal the bugs and ants. A period of 15 minutes was allowed for the partners to interact normally and to confirm that the bugs were engaged in feeding activity. Thereafter, in 10 series of measurements, the number and rate of emission of droplets of excreta were recorded at 30 minute intervals, and behavioural data noted for both partners. Further observations on the bugs were made by simulating the antennal movements of ants. For this purpose, wooden sticks (diameter of 1 mm) with two hairs (approximately 1 cm in length) fastened to them were used. Ants were excluded from this experiment by fitting two plastic rings coated with oil to the trunk and branches (ants already within the area of observation, between the rings, were removed). Only a limited number of measurements could be taken successfully because of the extreme sensitivity of both adult and larval bugs to disturbing stimuli such as light, which caused them to cease feeding and move to new sites. In another experiment sticks of wood approximately 1 mm in diameter were used to test the ants' aggressiveness by gently touching the workers on their gasters. Their behaviour in the first 60 seconds after contact was recorded.

Field notes were taken using a dictaphone. Sugar verification tests of the bugs' excreta were conducted using Dextrostix (Merck) (maximum established concentration: 250 mg glucose/100 ml). The *Technomyrex* ant nest was found to be a rolled leaf amongst scattered leaves at a distance of four metres from the host tree. The nest was discovered by following worker ants attracted to the presentation of a highly concentrated sugar solution.

RESULTS

All reference to 'bugs' in the following account refers to the new species of Plataspidae, *Tetrisia vacca*, described below.

Number and composition of bug aggregations

Removal of the leaf stipules, from the original *M. gigantea* tree, revealed adult plataspid bugs, eggs and immatures (in all stages of development) and usually *Technomyrmex* sp. worker ants. These aggregations comprised on average, three adult bugs (range 0-15), five immature bugs (range 0-22) and nine *Technomyrmex* workers (0-22). Of 20 shelters examined, two (10%) were unoccupied and of the remainder, seven (38.9%) contained bug eggs and six (33.3%) contained empty egg shells. In only two (10 %) of the shelters were adult bugs found without ants. We estimated the total number of bug aggregations on the fallen tree to be about 300, implying a total of 900 adults and 1500 larval bugs on the tree. The newly colonized *M. gigantea* tree showed 14 sites occupied by trophobiotic ant-bug associations with more or less the same numerical composition, with the exception of the eggs, as seen on the original tree, and similar spatial arrangement.

Observations on the ant-bug interactions

Our observations on ant-bug interaction (fig. 1) revealed that there was almost constant contact between the bugs (both adults and immatures) and *Technomyrmex* sp. ant partners. The immature bugs in particular were usually completely covered by ants and when bugs changed their feeding sites they were regularly escorted by at least one worker ant. The association was so close that no other ant species had the opportunity to get food from the bugs. In response to antennal stroking by the ants, the bugs raised their rear ends, by bracing their legs, and produced drops of excreta. On analysis, the droplets proved to contain high concentrations of glucose, indicating an origin in the phloem sap. The clear liquid excrement was generally not sprayed, but remained attached to the tip of the abdomen from where it was picked up in the ant's mouth-parts. When a bug was stroked by several ants, the ant nearest the rear of the abdomen received the drops. Bugs that were excreting were extremely attractive to the ants, so that several ants were in direct contact with each bug at the moment when the excreted drops were released. Although the bugs were stroked and licked over their entire bodies this contact was most intensive at the rear of the abdomen. A distinct increase in the rate of stroking immediately prior to the emergence of a drop was observed. Analysis of 48 ant-bug encounters, with reference to antennal contact, established that the abdomen had been stroked immediately before the drops were excreted in 92% of cases.

Excretion during ant/bug interaction

Under normal conditions, bugs that had been stroked produced an average of 14.2 ± 8.0 drops per 30 minutes. No correlation between size of bug and frequency of excretion could be established. The interval between two successive drops showed high variability (range 2-478 s, mean 107.5 s, ± SD 91.2 s, n = 134).

Excretion under experimental exclusion of ant contact

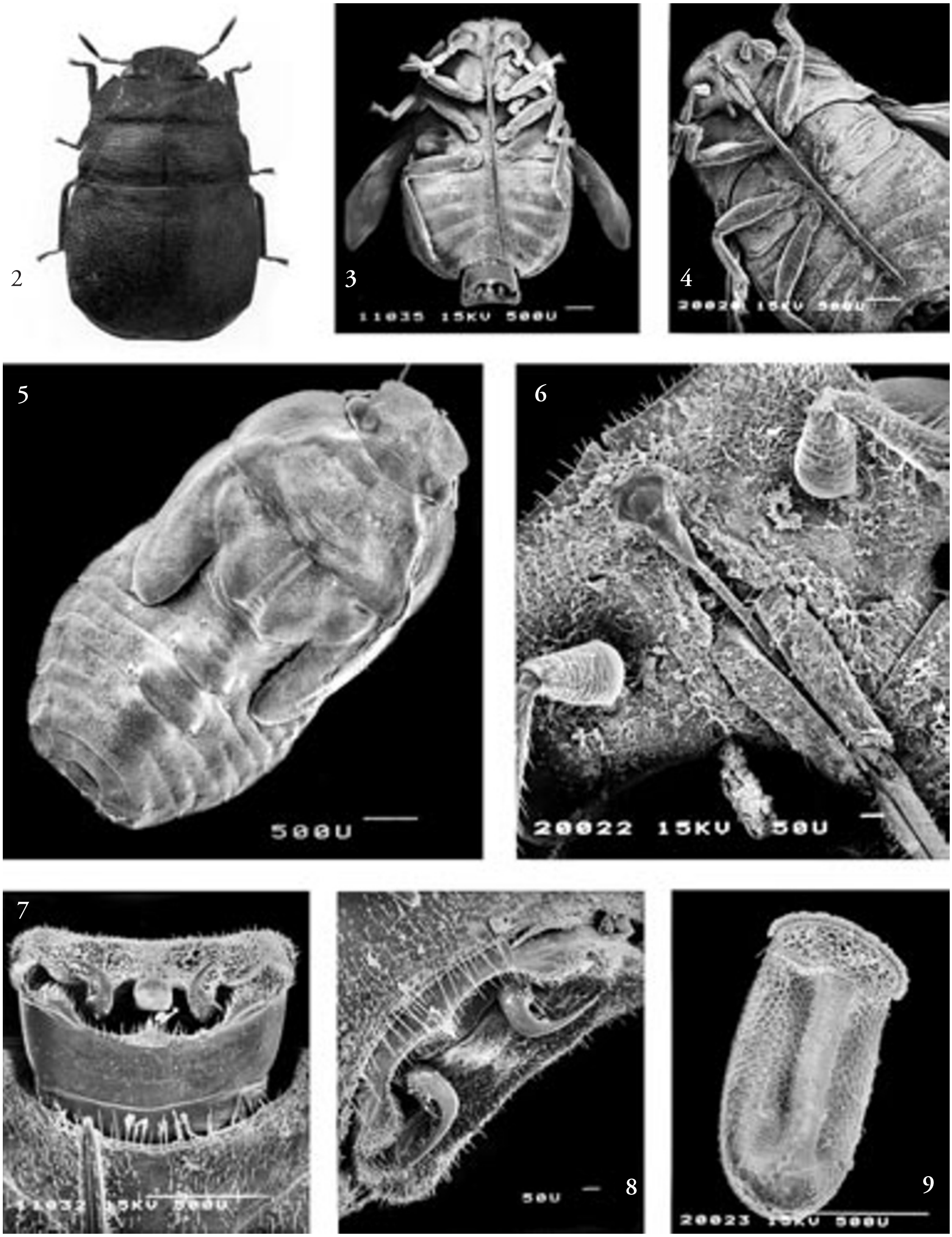
Since only 2.6% of the observed excretions took place without ant participation, it was interesting to know, if and how, the excretion behaviour of feeding bugs changed in the absence of all potential interactive partners. Although isolated groups of bugs were extremely agitated and, as a rule, individuals stopped feeding after a short time, it was still possible to carry out three complete series of measurements (see table 1). The number of drops was higher and the time between two successive episodes of excretion, in the absence of ants, was much longer than was the case with attended bugs. Also, there was no instance of a drop being produced singly by an unattended bug and in one case the excrement was sprayed away in a backwards direction. Triggering excretion by attempting to simulate the action of ants, using dummy antennae, was not successful. The bugs fled immediately they were touched.

Protection of the trophobiotic partner by *Technomyrmex*

In addition to the protection offered to the bugs by the ant-made shelters, *Technomyrmex* workers showed a high degree of protective aggression by physical and

Table 1. Comparison of defecating behaviour of *Tetrisia vacca* with and without contact with ants.

	bugs with ant contact (n = 10)	bugs without ant contact (n = 3)
No. droplets exuded per 30 minutes	14.2 ± 8.0	23.0 ± 3.5
No. of droplets per excretion act	1.0 ± 0	11.5 ± 2.7
time interval between two acts of excretion (sec)	108 ± 91.2	922 ± 164



Figs 2-9. External morphology of *Tetrisia vacca*. – 2, Habitus (female); 3, 4, underside of male; 5, nymph; 6, underside of head; 7, male genital capsule; 8, detail of male genital segment showing claspers; 9, egg.

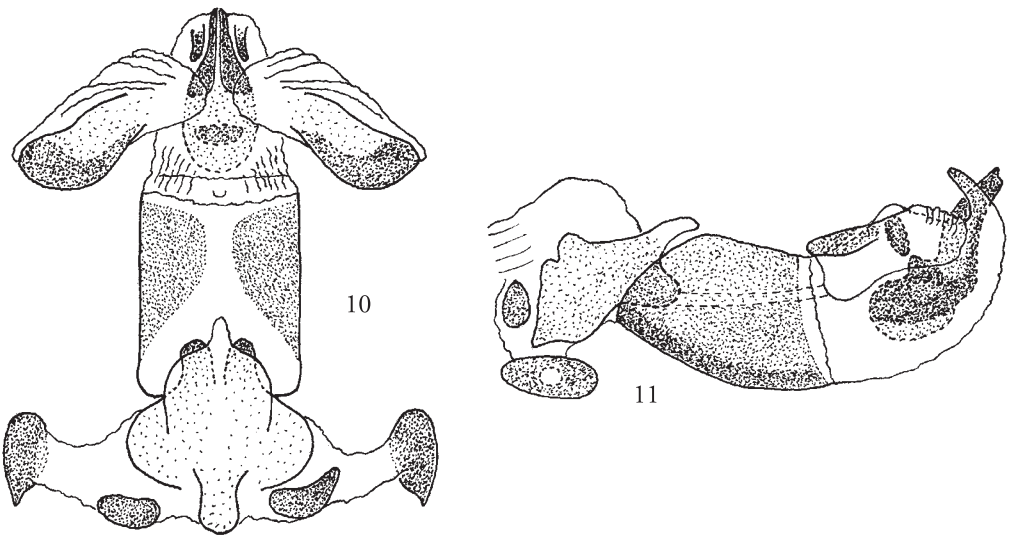
chemical means. This aggression was evident even before the experimental *M. gigantea* tree was colonized by the bugs, as the ants were already attending coccids and visiting extra-floral nectaries on the tree. *Technomyrmex* was generally dominant and numerically preponderant over other ant species of the genera *Oecophylla* and *Polyrhachis* (small Myrmicinae) on the same tree. Their mass recruitment ability contributed to their dominance with several hundred workers reaching a newly established feeding site (from the nest) within 15 minutes. Out of 25 tests of aggression in 52% the primary reaction to disturbance was an attack on the intruding object by firm biting, accompanied by application of droplets exuded from the ants' gasters. Threatening behaviour, e.g. repeated, rapid, jerky movements towards their molesters, combined with wide-open mandibles, was the response in 29% of the tests. In only 14% of the cases did the ants try to escape and 5% could not be classified.

Discussion

This is the first time that we have found the new plataspid (*Tetrisia vacca*) and its ant partner in many years of working with ant-insect symbioses, including many studies involving *M. gigantea* and other *Macaranga* species, a tree well known for its ant associations. The rarity of the find together with the fact that the only other *Tetrisia* species (*T. bruchoides* Walker) is known only from the type (from Singapore), suggests that species of this genus are not common. It is unlikely that *T. vacca* would, in all cases, be attended specifically by the *Technomyrmex* species, as such trophobiotic relationships are extremely rare in Hemiptera, compared with other organisms (Hölldobler & Wilson 1990). As with our observations of other *Technomyrmex* species in Southeast Asia, this species does not specialize in a particular trophobiosis but also attends pseudococcids and protects its bug partners by building shelters and by reacting aggressively to potential predators and competitors. Due to the closeness of the observed association between *Technomyrmex* sp. ants and *T. vacca*, it is possible that *T. vacca* is no longer able to survive in the absence of ants because of contamination by their own excrement and the products of its decomposition.

Phloem-feeding combined with trophobiosis appears to be more frequent in the Plataspidae compared to other plant-feeding Heteroptera. The first heteropteran trophobiosis to be observed (Green 1900) involved a plataspid from Sri Lanka, *Coptosoma* sp. Subsequently, China (1931) described the plataspid *Coptosomoides myrmecophilus* from Sumatra, in association with ants, and more recently two other Asian plataspid species, *Tropidotylus servus* Dolling and *T. minister* Dolling, have been found in symbiosis (Maschwitz *et al.* 1987). Other Asian plataspid species probably live in a similar manner (Maschwitz et al. 1987). A tropical African plataspid bug *Caternaultiella rugosa* Schouteden also lives trophobiotically. Its ant partners, a *Camponotus* and a *Myrmicaria* species, also build shelters and protect their trophobionts against predaceous coccinellid larvae and parasitoid wasps (Dejean et al. 2000, 2002, Gibernau & Dejean 2001). In the American tropics, where Plataspidae do not occur, the subfamily Discocephalinae of the related family Pentatomidae has many species that feed on the phloem of woody plants. Stahel (1954) reported an association in Surinam between the discocephaline *Lincus spathuliger* Breddin, feeding on the roots of coffee, and an ant, *Pheidole* sp., but did not establish that the relationship was trophobiotic. All other trophobiotic ant-bug symbioses that have been described involve the family Coreidae (Maschwitz & Klinger 1974, Maschwitz et al. 1987).

Two morphological modifications have evolved in phloem-feeding Heteroptera. In some genera a long rostrum is present and in others (with a short rostrum) long stylets are present, either coiled inside the body or housed in enlarged labial segments (China 1931 fig. 2 and Maschwitz et al. 1987, fig. 3). The plataspids, *Tropidotylus* Stål and *Coptosomoides* China, have extremely long stylets, which can be coiled in specifically developed internal structures. These bugs are able to reach the phloem vessels through the thick bark of larger trees. *Tetrisia* has a long rostrum, which in *T. vacca*, is almost as long as the bug's body (fig. 4). In spite of its relatively shorter stylets, it to is able to suck phloem sap from a tree, *Macaranga gigantea*, though only at the tips of the shoots. The trophobiotic coreid *Hygia cliens* Dolling feeds on trees with thick bark (Maschwitz et al. 1987) and has extremely long stylets (in immatures longer than the body) housed in a long rostrum when at rest. The trophobiotic coreids *Cloresmus* Stål and *Notobitus* Stål possess shorter beaks and are bamboo specialists. They can suck phloem sap from the stems of giant bamboos e. g. *Gigantochloa* spp., because of the different way the vascular tissues are arranged in these monocotyledons. It can be concluded in summary that nearly all trophobiotic heteropteran bug species known to date suck phloem from woody angiosperms and that they are of comparatively large size. Many other phloem-feeding hemipterans (especially Sternorrhyncha) tend to be smaller, so that they have access to the phloem sap of herbs, even of their leaves and flowers.



Figs. 10-11. *Tetrisia vacca*, inflated aedeagus, dorsal view (10), left lateral view (11).

Taxonomy
(M. D. Webb)

Tetrisia Walker

Tetrisia Walker, 1867a: 111-112. Type-species: *Tetrisia bruchoides* Walker, 1867a (by monotypy).
Dolichisme Kirkaldy, 1904: 280. Unnecessary replacement name for *Tetrisia* Walker

Tetrisia belongs to the '*Coptosoma*-group' of plataspid genera (Jessop 1983), in which the ocelli are situated closer to the corresponding eyes than to the midline of the head. In Jessop's other two groups of plataspid genera the ocelli are more remote from the eyes than from the midline. The distinction seems to be correlated with the fact that, in the *Coptosoma*-group, the head is narrower in proportion to the width of the body than in the other two groups. The *Coptosoma*-group is the largest of the three groups of genera, comprising approximately 31 genera and 370 species, of which about 280 belong to the genus *Coptosoma* Laporte. The whole family contains about 530 described species in 58 genera.

The genera of the *Coptosoma*-group are not well characterized. Walker's description of *Tetrisia* mentions the short, stout antennae and legs, the long rostrum, the transverse furrow of the pronotum and the 'finely scabrous' derm, in addition to the general proportions of the body and its major parts. However, his description omitted to mention the unusual four antennal segments, which is curious if the generic name, implying a characteristic of a quadruple nature, applies to this feature. Most Plataspidae have five segmented antennae, other exceptions being the four segmented ones in two of the four species of *Tropidotylus* Stål (*servus* Dolling and *minister* Dolling), which interestingly are also ant attended. *Tetrisia* species lack the swollen tylus of *Tropidotylus and* the dull, matt black appearance of the former is very characteristic.

Status of the names Tetrisia and Dolichisme

In 1867 Walker described two genera with the name *Tetrisia*, one a plataspid bug, Hemiptera (Walker, 1867a: 111-112), and the other for a noctuid moth, Lepidoptera (Walker, 1867b: 186). Kirkaldy (1904: 280) established the nominal genus *Dolichisme* to replace the Hemipteran one, presumably believing the lepidopteran name to have priority. Kirkaldy was mistaken. Although Walker's paper on Lepidoptera was read before the Linnean Society of London on 7 June 1866 it was not published until 14 September 1867. The latter date appears on his paper that formed part of the Society's zoological journal Volume 9, Part 36, for the years 1866-68 and is confirmed by reference to the listing of Linnean Journal dates by Gage and Stearn (1988: 214). Walker's Hemiptera description appeared in the first part of his catalogue of the BMNH Heteroptera collections, dated 1867. This volume has a preface by the then Keeper of Zoology (J. E. Gray), dated 17 April 1867. These catalogues were circulated by Gray after their approval by the museum trustees. Sherborn (1934), by studying the recorded

Table 2. Measurements (mm) of type specimens of *Tetrisia.*

	bruchoides holotype female	*vacca* holotype male	*vacca* paratype female (dissected)
Body			
Overall length	5.4	4.3	4.8
Greatest depth	1.6	1.3	1.3
Head			
Length in midline	1.2	1.1	1.1
Greatest width before eyes	1.2	1.0	1.0
Width including eyes	1.6	1.4	1.4
Width between eyes	1.1	0.9	0.9
Width across ocelli	0.7	0.6	0.6
Width between ocelli	0.6	0.5	0.5
Pronotum			
Length in midline	1.9	1.6	1.6
Width at anterior angles	1.8	1.6	1.6
Greatest width anterior lobe	2.6	2.4	2.4
Greatest width posterior lobe	3.1	2.6	2.7
Scutellum			
Length in midline	3.0	2.0	2.4
Greatest width	3.7	2.9	3.0
Width at posterior angles	3.3	2.6	2.8
Antennal lengths			
Segment 1	0.4	0.4	0.4
Segment 2	0.5	0.4	0.4
Segment 3	0.4	0.4	0.4
Segment 4	0.6	0.6	0.6
Total	1.9	1.8	1.7
Labium (rostrum) lengths			
Segment 1	0.5	0.4	0.4
Segment 2	0.8	0.8	0.9
Segment 3	1.6	1.3	1.4
Segment 4	0.6	0.8	0.9
Total	3.4	3.4	3.6
Genital capsule			
width	-	1.1	-

minutes of these meetings, was able to establish the exact dates upon which the Trustees saw and approved the catalogues for distribution. The date upon which they approved Part 1 of Walker's *Catalogue* was 25 May 1867. Strangely, a slightly earlier date appears as part of an accession number handwritten on the BMNH copy of the Catalogue. On the back of its facing page is written '67 5-17 2' (in circular fashion), which means the second book to be accessioned on 17th May 1867. The explanation for this earlier date may be that if the Trustees only met monthly or quarterly and their approval was only a formality, Gray may have pre-empted their official approval, and as soon as copies were received from the printers and became available, he placed a copy within the museum. Either way, it is clear that Walker's Catalogue appeared nearly four months before the Linnean Society published the paper on Lepidoptera. Neave (1940) gives the date for the Hemiptera *Tetrisia* as 1867 and the Lepidoptera *Tetrisia* as '[1867]..1868'. Therefore *Tetrisia* is the valid name for the plataspid genus and a replacement name should be given for the lepidopteran *Tetrisia.*

Tetrisia bruchoides Walker

Tetrisia bruchoides Walker, 1867a: 112.
Dolichisme bruchoides ; Kirkaldy, 1909: 322.

Relatively deeply convex (see below). Pronotum with sides of anterior lobe strongly convex. Pronotum and scutellum with no trace of a median keel. Mesosternum with median keel high and narrow throughout, slightly widened at 1st posterior extremity. Metasternum hexagonal, concave. Abdominal sternites 3-6 sulcate in midline.

Ratios. – Greatest depth of body (abdomen-scutellum) almost one-third (0.30×) overall body length. Ratio of length of antennal segments 1:2:3:4 as 1.0:1.2:1.1:1.4. Length of rostrum 0.64 times body length; ratio of labial segments 1:2:3:4 as 1.0:1.6:3.3:1.3. Labium thus with segment 3 slightly more than twice as long as segment 2 or segment 4.

Dimensions. – See table 2.

Material examined. – Holotype female Singapore, Saunders (BMNH).

Remarks

This species is probably known only from the type specimen. Apart from the catalogue entry by Kirkaldy (1909) there has been no mention of it in the literature since its original description. Nothing is known of its biology. The above notes supplement the brief original description.

Tetrisia vacca Webb, **sp. n.**
(figs. 1-11)

Type material. – Holotype male and 2 male, 2 female paratypes (+ several nymphs), MALAYSIA, Selangor, Universiti Malaya Field Studies Centre, Ulu Gombak, in secondary forest, on *Macaranga gigantea* Muell. Arg. (Euphorbiaceae), tended by *Technomyrmex* sp., January-March 1991 (BMNH).

Description

Body piceous to black, exposed areas of head, pronotum and scutellum densely and confusedly punctate, very shortly hairy, lateral margins of anterior pronotal lobe finely serrate. Body as a whole less strongly sculptured than in *T. bruchoides*. Antennae with apical half of segment 2 and whole of segments 3 and 4 pale to mid-brown, rostrum and tarsi mid-brown. Pubescense of underside and appendages more conspicuous than that of upper surface. Pronotum with lateral margin of anterior lobe convex, but less so than in *T. bruchoides*. Pronotum and scutellum with very weak median keel. Mesosternum with median keel high, soon broadening posteriorly and medially sulcate for more than half its length. Metasternum and abdominal sternites as in *T. bruchoides*. Genital capsule of male (fig. 7), parameres (fig. 8) with slender, sickle-shaped apices. Aedeagus (figs 10-11). Female abdominal sternite 7 much less densely punctate than rest of sterna, shining. Egg and larvae as in figs 5 and 9.

Dimensions. – See table 2.

Ratios. – Greatest depth of body (scutellum-sternum) in holotype 0.33× body length, in paratype female (dissected) 0.37× body length. Ratio of length of antennal segments 1:2:3:4 in holotype 1.0:1.2:1.1:1.7, in paratype female (dissected) 1.0:1.1:1.0:1.6. Length of rostrum in holotype 0.75× body length, in paratype female (dissected) 0.79× body length; ratio of length labial segments 1:2:3:4 in holotype 1.0:2.1:3.2:2.1, in paratype female (dissected) 1.0:2.1:3.2:2.0. Labium thus with segment 3 about 1.5× as long as segment 2 or segment 4.

Remarks

Differs from *T. bruchoides* Walker in its smaller size, less convex body, shape of mesosternal keel, relatively (and absolutely) longer labial segments 2 and 4, less coarse sculpture and presence of faint median keel on pronotum and scutellum.

Acknowledgements

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