Studies on the Australasian stick-insect genus Extatosoma Gray (Phasmida: Phasmatidae: Tropoderinae: Extatosomatini)

Author: Brock, Paul D.

Source: Journal of Orthoptera Research, 10(2) : 303-313

Published By: Orthopterists' Society

URL: https://doi.org/10.1665/1082-6467(2001)010[0303:SOTASI]2.0.CO;2
Studies on the Australasian stick-insect genus Extatosoma Gray (Phasmatida: Phasmatoptera: Tropoderinae: Extatosomatini)

PAUL D. BROCK

“Papillon”, 40 Thorndike Road, Slough, SL2 1SR, England. E-mail: Paul@pbrock40.fsnet.co.uk

Abstract

Studies on the genus Extatosoma Gray 1833 have revealed that there are two valid Australasian species represented by Extatosoma tiaratum tiaratum, Extatosoma tiaratum bufonium stat. n., Extatosoma popa popa, and Extatosoma popa carlbergi stat. n. A lectotype has been designated for Extatosoma bufonium. The male of Extatosoma popa popa is described for the first time. Adults (including differently shaped female specimens) and eggs of the two Extatosoma species are figured for comparison. Variation within species is discussed, which includes size, color, degree of spination, shape of legs and expansions on abdominal segments. A literature review and summary of distribution records are provided.

Key words

Phasmatodea, Phasmatoptera, Cheleutoptera, Macleay’s Spectre, Giant Prickly Stick Insect, Phasmatidae.

Introduction

One of the main taxonomic problems in the Phasmida is that variation can be extreme. Without examination of eggs and/or the rearing of a series of specimens, it is sometimes difficult to realize the extent of variation within individual species.

The large, spiny Extatosoma are one of the most spectacular genera of stick insects cultured. Specimens collected in north Queensland, Australia have been commonly reared since the 1960s and are often displayed in zoos and insect farms worldwide (Brock 2000). Specimens from various parts of southeast Queensland in Australia, Irian Jaya and Papua New Guinea have also recently been cultured. There have been a number of published papers on Extatosoma tiaratum, covering aspects such as behavior and biology. Gurney (1947) provided a useful synopsis of the genus, including a key to females, which I have updated in this paper. Carlberg (1987) includes useful notes on biology, with differences in development between cultures kept in Australia and Europe. Brock (1992) gives rearing notes and details/illustrations of defensive behavior.

Following the collection and rearing of similar Australian Extatosoma laying differently shaped eggs, there has recently been some doubt as to how many species were associated with that country (Beccaloni 1993, Brock 1999a). Further studies have uncovered wide variation within the single Extatosoma species now recognized as valid. The same remark applies to the only other Extatosoma species found in Irian Jaya and Papua New Guinea.

Details of the commoner leaf mimics and differently shaped lichen mimics are given in the keys. The downgrading of two Extatosoma species to new subspecies is proposed, and a lectotype designated for one species. Following a key to adults and eggs of the taxa, the species are presented with a full listing of synonyms beneath each valid species. For type material, which has been examined by me (except for paratypes of E. carlbergi in BPBM), details are given.

Abbreviations for Depositories

AMSA Australian Museum, Sydney, Australia
ANIC Australian National Insect Collection, Canberra, Australia
BMNH Natural History Museum, London, United Kingdom
BPM Bernice P. Bishop Museum, Hawaii, Honolulu, USA
MMUS Macleay Museum, University of Sydney, Sydney, Australia
NHMW Naturhistorisches Museum, Wien, Austria
OXUM Oxford University Museum, Oxford, United Kingdom
RMNH Nationaal Natuurhistorische Museum, Leiden, Netherlands
RSME Royal Scottish Museum, Edingburgh, United Kingdom
ZMAN Zoologisch Museum, Amsterdam, Netherlands
ZMUC Zoologisk Museum, Copenhagen University, Denmark

Key to adult females of Extatosoma (Figs 1-4)

1 Lateral expansions of abdominal segments 5-7 large and often overlapping. Segments 2-4 and 8-10 usually without lateral expansions. Generally green or brown; not mottled. Dorsal expansions of mid and hind femora, usually not arcuate (leaf mimicking insects)

2 — Lateral expansions of abdominal segments 5-7 small, non-overlapping. Segments 2-4 and 8-10 usually bearing lateral expansions. Body color green or brown, heavily white and black mottled. Dorsal expansions of mid and hind femora usually arcuate (lichen mimics)
2. A conspicuous V-shaped pale mark nearly always present on mesonotum; metanotum and first abdominal segment each with a pair of erect, well-developed lamellae. Dorsal lamellae of abdominal segments 5-6 each occupying about one-third length of segment, the base of each scarcely wider than apex and not extending in front of middle of segment; a compound lamellate spine on mesonotum between bases of tegmina. Body color pale to dark brown. Body length 116-150 mm. Distribution: Irian Jaya, Papua New Guinea.

— No V-shaped pale mark on mesonotum (or very faint); median lamellae of metanotum and first abdominal segment absent or weakly developed; spines separate or weakly confluent basally. Dorsal lamellae of abdominal segments 5-6 extending in front of middle of segment; the base of each lamella wider than apex; individual spines at base of mesonotum. Body color green or brown (rarely yellow). Body length 100-160 mm. Distribution in Australia: New South Wales, southeast and north Queensland.

— No V-shaped pale mark on mesonotum (or very faint); median lamellae of metanotum and first abdominal segment absent or weakly developed; spines separate or weakly confluent basally. Dorsal lamellae of abdominal segments 5-6 extending in front of middle of segment; the base of each lamella wider than the apex; individual spines at base of mesonotum. Body length 120-130 mm. Distribution in Australia: New South Wales, Lord Howe

3. A conspicuous V-shaped pale mark nearly always present on mesonotum; metanotum and first abdominal segment each with a pair of erect, well-developed lamellae. Dorsal lamellae of abdominal segments 5-6 each occupying about one-third length of segment, the base of each scarcely wider than apex and not extending in front of middle of segment; a compound lamellate spine on mesonotum between bases of tegmina. Body length 116-165 mm. Distribution: Irian Jaya, Papua New Guinea.

— No V-shaped pale mark on mesonotum (or very faint); median lamellae of metanotum and first abdominal segment absent or weakly developed; spines separate or weakly confluent basally. Dorsal lamellae of abdominal segments 5-6 extending in front of middle of segment; the base of each lamella wider than the apex; individual spines at base of mesonotum. Body length 120-130 mm. Distribution in Australia: New South Wales, Lord Howe

Fig. 1. E. popa popa ♀.

Fig. 2. E. tiaratum tiaratum ♀ holotype, Australia (scale: 10 mm); almost certainly from Parramatta, New South Wales (reproduced from Macleay 1826).
Key to adult males of *Extatosoma* (Figs 5-6)

1 Hindwings plain, with only outer margin dark. White V-shaped mark on mesonotum. Body length 82-91 mm ....
   — Hindwings chequered; dark brown/blackish with whitish bands. No white V-shaped mark on mesonotum ..........
   2 Body length 81-115 mm. Distribution: New South Wales, Lord Howe Island, southeast and north Queensland.....

Note: males of lichen mimics do not differ from normal leaf mimics.

Key to eggs of *Extatosoma* (Figs 7-9)

1 Micropylar plate with conspicuous lateral arm either side of the micropylar cup area. Capsule length 5.06-5.31 mm, height 4.42-4.56 mm, width 3.71-3.84 mm ..............
   — Micropylar plate lacking conspicuous lateral arm either side of the micropylar cup area. Capsule length 4.5 mm or less ................................................. 2
2 Capsule slightly glossy; with brown-pointed capitulum. Micropylar plate reaching operculum rim, where it is expanded. Capsule length 3.3-4.2 mm, height 3.5 mm, width 2.9-3.2 mm. Distribution in Australia: New South Wales, southeast Queensland ............................ *tiaratum*
   — Capsule on average larger, glossy; with broad, whitish capitulum. Micropylar plate reaching operculum rim, where it is slightly expanded. Capsule length 3.7-4.5 mm, height 3.5-4.2 mm, width 2.8-3.1 mm. Distribution: in Australia: north Queensland ......................... *tiaratum*
Fig. 5. *Extatosoma popa popa* ♂.

Fig. 6. *Extatosoma tiaratum tiaratum* ♂.
Notes: eggs laid by leaf mimics and lichen mimics within each species are identical. Egg coloration is very variable and no two eggs are exactly alike. The capitular cap shrivels with age and may disappear entirely. Smaller eggs, which often do not hatch, may be parthenogenetic, or are laid by smaller-sized females; if they do hatch, development is much slower than if eggs are fertilized.

Key to newly-hatched nymphs of Extatosoma (Fig. 10)

1 Largely brown or black, but head either red or brown; legs mottled in different shades. Sometimes with white mark on mesonotum. .............................................................. 2
— Completely black, except for a conspicuous white V-shaped mark on mesonotum. ......................................... popa

2 Head dark brown. Body light orange/brown; abdomen dark brown/black. Distribution in Australia: New South Wales, southeast Queensland ..................... tiaratum
— Head red or dark brown. Body dark brown or black (if dark brown, abdomen black). Distribution in Australia: north Queensland ......................................... tiaratum

Within days, nymphs which have been feeding change color. For example, in E. tiaratum from north Queensland the red heads become dark brown, along with the body; E. tiaratum from New South Wales and southeast Queensland darken up and resemble the north Queensland insects.

[Note: for color illustrations of 1st instar nymphs see Brock 2001].

Extatosoma Gray

Extatosoma Gray 1833: 23.

Type species.— Phasma tiaratum Macleay 1826: 455, by subsequent designation of Kirby 1904: 380 (after Burmeister 1838 listed E. hopei as a synonym of E. tiaratum, there was only one Extatosoma species 1838 to 1873).

Phasmatidae Gray 1835: 29 (incorrect subsequent spelling).

Extatosoma Gray; Brull, 1836: 113 (incorrectly listed as a synonym of Tropidoderus Gray 1835).

Characteristics of the genus.— Large; body broad and spineous in female, slenderer and less spineous in male. The male is winged, female with rudimentary wings. Head prognathous, dorsal apex conical and spineose. Three ocelli distinct in male, lacking in female. Antennae simple, of moderate length (much longer in male), pubescent. Mesonotum dilated in female, not twice length of pronotum. Forewings shortened. In male, oval, as long as metanotum; in female, broader, but little over half length of metathorax. Hindwings of male large, reaching to around apex of abdomen. In female shrivelled and rudimentary (shorter than forewings). Abdominal segments greatly expanded laterally, particularly 5th-7th segments. In female, paired median lamellae present on abdominal segments. Legs moderately long to short; femora and tibiae spineose, trigonate, broadly dilated, particularly in female. Mid and hind tibiae with apical hooked spine. Female with large boat-shaped operculum extending well beyond end of abdomen; valves long, filamentous, apically curved. Subgenital plate in male boat-shaped. End of abdomen a closed tube. The large eggs are very conspicuous. Capsule oval, with broad, slightly raised micropylar plate, extending full length of dorsal surface. The eggs were first described by Kaup (1871), who figured the egg of Extatosoma tiaratum. Although later authors have not remarked on the clearly different appearance of E. tiaratum eggs figured, the best descriptions are by Korboot 1961 (New South Wales/southeast Queensland) and by Heather 1965. Clark 1976 covers E. tiaratum from north Queensland, also illustrated by Key 1970. Sellick (1997) established the monotypic tribe Extatosomatini and figured a normal and an abnormal egg.

Extatosoma tiaratum tiaratum (Macleay) (Figs 2, 6, 9)


* Described in Appendix B of King’s survey. The insects collected during Captain King’s voyages came from all parts of the Australian coast; no locality specified. However Gray (1833) stated that Allan Cunningham (a botanist who collected on King’s voyages) informed him “they are found on
Fig. 10. Young nymph of lichen mimic *Extatosoma tiaratum bufonium*, which has been eating and is close to moulting. This is the characteristic posture of all *Extatosoma* nymphs, with the abdomen curled over the body.

Fig. 11. *Extatosoma tiaratum bufonium* lichen mimic ♂ (same as *tiaratum tiaratum*).
sapling gum-trees in the neighbourhood of Paramatta. The locality, correctly spelt Parramatta, is in New South Wales (near Sydney) and therefore may almost certainly be regarded as the type locality.

*Extatosoma tiaratum* (Macleay); Gray 1833: 23; Westwood 1859: 170; Kirby 1904: 380.

*Extatosoma tiaratum* (Macleay); Gray 1835: 29; Redtenbacher 1908: 380.

*Extatosoma hoppii* Gray 1833: 23, pl. 8: 1. Holotype /H20040, AUSTRALIA (OXUM), synonymised with *tiaratum* by Burmeister 1838: 576 spelt *hopei* in the key on p. 25, assumed to be Gray’s intended spelling.

*Ectatosoma hopiei* Gray; Gray 1835: 29.

**Distribution.** — Widespread in parts of New South Wales, southeast and north Queensland. Historically reported from Tasmania (and possibly Victoria), but records considered to be in error (Froggatt 1922). Old records from New Guinea are repeated from de Haan 1842, where his “var.” was later described as *E. popa*. Specimens occur at various altitudes, with the lichen mimics often found at higher altitudes.

There is a possibility that further studies will reveal that the north Queensland insects are distinct from those from New South Wales and southeast Queensland. Whilst eggs and first instar nymphs differ (see key above), it is conceivable that these insects have evolved to closely match local ants. It is known that ants are attracted to the capitulum of phasmid eggs, and the eggs then carried to the nest; consequently buried eggs suffer reduced rates of parasitism by wasps (Hughes & Westoby 1992). See Windsor *et al.* (1996) for a review of the literature.

---

**Extatosoma tiaratum bufonium** Westwood stat. n. (Figs 4, 8, 10, 11)

*Extatosoma bufonium* Westwood 1874: 174. Holotype ♀ nymph, AUSTRALIA (OXUM)

*Extatosoma (♀) bufonium* Westwood; Kirby 1904: 381.

*Extatosoma bufonium* Westwood; Redtenbacher 1908: 381.


**Distribution.** — Widespread in parts of New South Wales and southeast Queensland and occasionally reported in the Atherton area, north Queensland. In the majority of cases, these localities are high altitude, which seldom overlap with *tiaratum tiaratum*. There is a old museum specimen collected from Lord Howe Island, New South Wales.

*Extatosoma popa popa* Stål (Figs 1, 5, 7, 12)


*Ectatosoma popa* popa Stål; Redtenbacher 1908: 381.

**Distribution.** — Widespread in Irian Jaya and Papua New Guinea. Beccaloni (1993) pointed out that *E. p. carlbergi* mainly occurs at higher altitudes (1100-1600m) than *E. p. popa* (to 1200m). In 1999 Herwaarden (pers. comm.) found specimens of both “forms” feeding on *Casuarina*, between Kelila and Bokondini, Central Mountain Range, Irian Jaya (1500m), indicating that leaf mimics can also occur at high altitudes.
**Extatosoma popa carlbergi** Beccaloni stat. n.  
(Fig. 3)


**Distribution.**—Widespread in Irian Jaya and Papua New Guinea. This subspecies mainly occurs at higher altitude (1100-1600 m) than *E. popa popa*, although there is occasionally an overlap.

**Non-type material examined.**—Selected material examined in detail (measurements recorded) is listed below. In addition, reared material and specimens deposited in many museums in Europe and Australia have been examined.


*E. tiaratum bufonium.*—Lichen mimics, formerly known as *E. popa popa*. All from PAPUA NEW GUINEA (PNG) or IRIAN JAYA (IJ). ♂, Wau, Morobe Province, golf course, 1150 m, 6.x.1999, H.C.M. van Herwaarden & O. van Gorkom (AMSA). From PAPUA NEW GUINEA (PNG) or IRIAN JAYA (IJ). ♂, Wau, Morobe Province, c. 1150 m, 6.x.1999, H.C.M. van Herwaarden & O. van Gorkom (AMSA). From PAPUA NEW GUINEA (PNG) or IRIAN JAYA (IJ). ♂, Wau, Morobe Province, c. 1150 m, 6.x.1999, H.C.M. van Herwaarden & O. van Gorkom (AMSA). From PAPUA NEW GUINEA (PNG) or IRIAN JAYA (IJ). ♂, Wau, Morobe Province, c. 1150 m, 6.x.1999, H.C.M. van Herwaarden & O. van Gorkom (AMSA). From PAPUA NEW GUINEA (PNG) or IRIAN JAYA (IJ). ♂, Wau, Morobe Province, c. 1150 m, 6.x.1999, H.C.M. van Herwaarden & O. van Gorkom (AMSA).
end of abdomen; plain, with outer margin dark brown. Pre-nal part of hind wings rather mottled with various shades of brown and black flecks.

Abdomen: slender, segments 5-7 with well developed lateral expansions, with a slight gap between segments. Subgenital plate broad, end rounded with a deep central incision. When viewed laterally, last third raised, with central lobe. End of anal segment triangularly produced ventroposteriorly. Cerci slender, rounded at tip.

Legs: lateral leaf-like dentate expansions developed on all tibiae and femora. Those on fore femora split into three lobes. Fore tarsi with distinct basal lobe.


Notes on variation within species.— (Fig. 12) There are several ‘variations’ within both Extatosoma species. Firstly, size: the length of specimens varies considerably, both in the wild and in culture. E. popa is usually longer than E. tiaratum, although some giants have been reported for the latter species. The longest I know of is a 160 mm female from Kuranda, north Queensland, which was not preserved. I have reared a 150 mm specimen. There is some evidence that females of E. tiaratum from north Queensland are longer than those from New South Wales and southeast Queensland. The size difference is, perhaps, not surprising in view of a larger egg capsule in addition to a hotter climate and different foodplants in some cases. However, even in north Queensland much smaller specimens around 100 mm occur. There does not appear to be much difference in average size between the lichen mimics and normal leaf mimics, although, once again, individual specimens can vary considerably in length.

Color is another very variable factor. No two eggs are exactly alike in color. Adults are often a similar shade of brown and black flecks. With tiaratum, in the wild there are more green female specimens than occur in culture stocks; foodplant is probably a major factor in this. Although captive-bred stocks of males are nearly always brown, in north Queensland males around Garadanga range from dark brown, to grey, pale green, and orange (Jack Hasenpusch, pers. com.) In the same locality, mottled females have occasionally been reared, apparently resembling lichens (but still keying out to tiaratum tiaratum); an example is illustrated in Breedon (1995), but this specimen and others changed color to normal when kept in different conditions. The true lichen mimics also vary considerably in degree of mottling, and it is difficult to find two specimens exactly alike. Some other research has been undertaken on color changes (Korboot 1961), where light-adapted insects are yellow or green, dark-adapted insects orange or brown; rhythmic color change occurred diurnally: dark at night, light in the morning.

The number and size of body and abdominal spines varies, particularly in females, although the key features discussed earlier are consistent. Taking E. popa popa as an example, the foliose expansions on abdominal segments 5-7 may vary considerably in length and number. Whilst these lateral expansions usually overlap, sometimes they have gaps between them, although not to the same degree as lichen mimics (Fig. 12). The legs also vary; some specimens have more arcuate dorsal expansions of the femora than others. Although a generally reliable key feature to distinguish between E. popa and E. tiaratum, I have an E. popa carlbergi female from Watut, Wau Valley lacking a V-shaped pale mark on its mesonotum.

The first records of gynandromorphism in tiaratum were reported by Rumbucher 1974. One of the two gynandromorph specimens reared was a halved gynandromorph, the other a mixture of male and female characteristics, with large hindwings as in the male. Carlberg (1981) gave details of a gynandromorph with mainly male characteristics. No gynandromorphs have yet been reported in E. popa.

Although there seldom appears to be an overlap of the commoner leaf mimics and lichen mimics, several records are known, as follows: E. tiaratum tiaratum and E. tiaratum bufonium in Australia: Gosford, New South Wales; Mt. Nebo, south-east Queensland; Atherton, north Queensland. E. popa popa and E. popa carlbergi overlap in Papua New Guinea: Wau, Morobe Province and nearby Menyamya, in Irian Jaya, between Kelila and Bokondini, Central Mountain Range, 1500 m. So far, collectors have located the lichen mimics at higher altitudes, where leaf mimics are seldom found. The leaf mimics are normally strongly represented at lower altitudes, in gardens and in the bush.

Conclusion

Although E. tiaratum from north Queensland has been reared since the 1960s, until recently no comment was made on clear egg differences in comparison with eggs from southeast Queensland and New South Wales cultures.

The range of E. tiaratum shows a large gap in central Queensland where there are no records of this species (Fig. 13). In view of differences between the eggs and first instar nymphs of culture stocks from north Queensland, compared with other localities, it cannot be ruled out that they may at least represent different subspecies, albeit the adults are identical. It may take some time to research these aspects, by attempting crosses between culture stocks and analyzing the results, in addition to undertaking genetic studies. There is scope to make important studies in the wild, such as reviewing habitats, particularly as the north Queensland specimens may have evolved to more closely resemble ants in the area.

The degree of variation between leaf mimics and lichen mimics is wide within both species. However, each subspecies is usually consistent in shape, if not in color. Other phasmands use different colors to better match their surroundings, but rarely occur in a significantly different “form” as seen in Extatosoma. It is possible that this strategy is used to help ensure survival, on the basis that predators may learn to distinguish leaf mimics, but not lichen mimics, or vice versa. This is the view put forward by H. van Herwaarden (pers. com.), following observations in the field in Irian Jaya on E. popa popa and E. popa carlbergi, but I am not convinced...
that there is a major overlap of the subspecies. As a back-up, both *tiaratum* and *popa* have similar, elaborate defensive behavior. Few localities are known where populations of leaf mimics and lichen mimics have been found together. It is possible that these originate from eggs laid by the same female, but initial culturing indicates that lichen-mimic eggs, hatching into females, develop into female lichen mimics. In many years of rearing leaf mimics of *tiaratum*, I have never reared a lichen mimic or heard a report of this (except for occasional females in north Queensland, which still key out to normal specimens). This compares with leaf-insects such as *Phyllium bioculatum* Gray (1832), a species in which one can rear variably-shaped females from eggs laid by a single female [for background see Brock (1999b) who accordingly listed *Phyllium pulchriorifolium* Serville, 1838, as a synonym of *bioculatum*].

During my research, it became apparent that the majority of lichen mimics are found at higher altitudes, typically where the rainforest has a higher species density of ferns, mosses and lichens. This may account for the scarcity of records of lichen mimics in some cases, particularly in north Queensland where leaf mimic females are often found at low altitudes. This supports Beccaloni’s views (1993), who noticed that the mottled patterns of lichen mimics resemble foliophile epiphytic lichens such as *Usnea*, or leaves covered with epiphyllous growth. Whilst it is possible that lichen mimics have been overlooked by collectors searching at lower altitudes, this appears to be unlikely.

**Acknowledgements**

I wish to thank the following contacts for assistance in providing specimens or observations: S. Fellenberg (Sydney, New South Wales), J. Hasenpusch (Australian Insect Farm, Garradunga, Nr. Innisfail, Queensland), H. van Herwaarden (Goirle, Netherlands), T. Hiller (Mt. Glorious, Queensland), M. Humphrey (Macleay Museum, Sydney, New South Wales), J. Marshall (Natural History Museum, London, UK), G. Milledge, M. Moulds (Australian Museum, Sydney), D. Rentz (CSIRO, Canberra). Ronald Baxter (Ilford, UK) kindly permitted reproduction of egg sketches commissioned for his forthcoming book. Curators of several museums kindly allowed access to the collections.

**Literature cited**


Macleay W.S. 1826. Annuloso, Catalogue of Insects, collected by Captain King, R.N. In: Captain Phillip P.King, Narrative of a survey of the Intertropical, and Western Coasts of Australia performed between the years 1818 and 1822. Vol 2., appendix B, Pp. 438-469, Table B.
Sellick J. 1997. The range of egg capsule morphology within the Phasmatodea and its relevance to the taxonomy of the order. Italian Journal of Zoology 64: 97-104.

Fig. 13. Distribution of Extatosoma in Australia.