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Observations on the biology of *Stethopachys papuana* Gressitt associated with the orchid *Spathoglottis rivularis* Schlecht. (Orchidaceae) in Papua New Guinea

(Coleoptera, Chrysomelidae, Criocerinae)

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Field observations on the biology and behaviour of the leaf beetle *Stethopachys papuana* Gressitt (Coleoptera, Chrysomelidae, Criocerinae) from north-western Papua New Guinea are recorded. The larvae and adults feed on the floral and reproductive parts of the native orchid *Spathoglottis rivularis* Schlecht. (Orchidaceae), a terrestrial species usually growing in clearings on hillsides in tropical rainforests. The egg, larva and adult are briefly described and detailed observations on feeding and general behaviour of larvae and adults are also provided and discussed. The biology of *S. papuana* is similar in some aspects to that of the Australian *S. formosa* Baly but differs significantly in larval feeding characteristics. The major ecological characteristics of *S. papuana* are also outlined and some are discussed in more detail.

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Introduction

The genus *Stethopachys* contains about 15 described species, of mainly bright yellow to orange beetles, marked/spotted with black, from Australia, Papua New Guinea and New Caledonia (Gressitt, 1965). Apart from the so-called Dendrobium Beetle, *Stethopachys formosa* Baly, from Queensland and New South Wales (the only species of the genus known to occur in Australia), almost nothing appears to have been recorded on the biology of the other members of the genus. Jolivet (1977, 1986, 1988) and Schmitt (1985) reviewed the general biology and host plants for the world genera of the subfamily Criocerinae and observed that *Crioceris* and *Lilioceris* (two genera very closely related to *Stethopachys)* are commonly found on species of Liliaceae (Monocotyledonae), while *Lema* and *Stethopachys* are commonly found on Commelinaceae, Dioscoreaceae, Orchidaceae and Poaceae (Monocotyledonae) as well as on the Solanaceae (Dicotyledonae). Although the European and North American fauna appear well documented, the biology and host plants of the Australo-Papuan species of Criocerinae are poorly known. A few observations on Australian *Lilioceris (Crioceris)* species (viz. *L. fuscomaculata* (Clark) and *L. camelus* (Duvivier) have been provided by Hawkeswood (1985, 1987). Some observations on *Stethopachys formosa* Baly, from the rainforests of eastern Queensland and New South Wales have been recorded by Smith (1940),

Rushton (1980) and Hawkeswood (1987). Szent-Ivany, Womersley & Ardley (1956) briefly recorded *Lilioceris (Crioceris) clarki* Baly feeding on the fresh, new leaves of a *Cycas* sp. (Cycadaceae) in the Markham Valley, northern Papua New Guinea. This present paper provides the first detailed field observations on a *Stethopachys* species from Papua New Guinea, namely *S. papuana* Gressitt (Gressitt 1965).

Materials and methods

(a) Study area, climate and vegetation

Observations and collections of beetles were undertaken during 1989 near the village of Passam (3°45'S, 143°35'E) in the East Sepik Province, Papua New Guinea. The actual study site was situated on a local plateau on the margins of tropical rainforest. The area receives an average monthly rainfall ranging from 128 mm to 225 mm and maximum daily temperatures range from 29°C to 35.5°C, while minimum daily temperatures range from 18°C to 22°C throughout the year. The first half of 1989 was abnormally wetter than usual and temperatures were cooler than average. The humidity of the Passam area remains high (usually betwen 70% and 90%) throughout the year. Higher humidity readings during December to May, correspond to larger amounts of cloud cover, which varies from 65% to 92% daily. The average altitude of the area is 960 metres.

According to Robbins (1968) the vegetation of the Passam area is composed of lowland hill (rain) forest with three main tree layers. The rainforest is of a very mixed composition with more than 60 tree species having been recorded from the canopy layer alone (Robbins 1968). Some of the common and dominant tree and shrub species of the Passam area include the following: *Canarium indicum* L. (Burseraceae), *Alstonia scholaris* R. Br. (Apocynaceae), *Intsia bijuga* (Colebr.) Kuntze (Caesalpiniaceae), *Artocarpus altilis* (Park.) Fosberg and *Ficus* spp. (Moraceae), *Spathodea campanulata* Beauv. (Bignoniaceae), *Pometia pinnata* Forst. f. (Sapindaceae), *Albizia falcataria* (L.) Back. (Mimosaceae), *Schizomeria serrata* (Hochr.) Hochr. (Cunoniaceae), *Flindersia amboinensis* Poir. (Flindersiaceae), *Euodia* spp. (Rutaceae), Celtis sp. (Ulmaceae), *Vitex cofasus* Reinw. (Verbenaceae), *Terminalia kaernbachii* Warb. (Combretaceae) and *Macaranga quadriglandulosa* Warb. (Euphorbiaceae). *Stethopachys papuana* Gressitt were associated with the large terrestrial orchid, *Spathoglottis rivularis* Schlecht. (Orchidaceae) which commonly grows on mudstone hillsides and on the tops and sides of exposed ridges in the area. This plant was growing sparsely in association with saplings or mature plants of many of the above-mentioned trees and shrubs as well as terrestrial ferns and herbs such as *Selaginella* sp. (Selaginellaceae), *Pilea* spp. (Pileaceae), *Pteris* spp. (Pteridaceae), *Pipturus argenteus* (Forst.) Wedd. (Urticaceae) and *Piper adunca* L. (Piperaceae) as well as other grasses and weeds.

(b) Observations/collections of beetles

During March to June 1989, field observations and collections of beetles were undertaken during fine sunny periods on relatively fine days for 30–50 minutes duration each day of observation. A group of 20 *Spathoglottis rivularis* Schlecht. plants were dispersed amongst other plants on a steep hillside near Passam. During 18 Mar.–3 April, samples of inflorescences from one or two plants from the group were sampled- the number of pods, flowers and flower buds remaining on the inflorescences were counted and the % pods setting seed determined by dividing the total number of pods produced over the total number of pods + flowers + buds × 100% (Table 1). Pods were carefully examined/dissected and those apparently chewed inside (or outside as well) by larvae or adult beetles of *S. papuana* were counted as well as those pods still containing larvae (Table 1). The percentage of chewed pods containing larvae were also determined by dividing the number of pods with larvae by the number of chewed pods × 100% (Table 1). During 19 March to 6 April, field observations were also undertaken on the adult population on the orchid flowers (Table 2). From the pods collected from one plant of *S. rivularis* on 1 April, the percentage of internal pod tissue chewed out by the larvae of *S. papuana* were determined roughly by eye and the presence/absence of larvae (either early or late instar) determined and recorded (Table 3). General biological/ecological data on larvae/adults were also undertaken during the study periods.

(c) Brief description of the food plant

Spathoglottis rivularis Schlecht. (Orchidaceae) is a herbaceous plant growing to about one metre high (inflorescence). At the base of the plant, a number of broad, flat, parallel-veined leaves spread outwards for up to 80 cm in length. The flowering rhachis extends upwards for about one metre in total length and contains up to 40 flowers. The lowermost flowers open first and when fertilized, result in capsules (herein referred to as pods for convenience)

being produced below younger flowers and buds at the top of the rhachis. The flowers are relatively large for a terrestrial orchid and measure about 3 cm in diameter; the petals are bright mauve-pink in colour. The pods, which are suspended on slender pedicels 22–30 mm long, take several weeks to reach full size; they are 35–42 mm long and 8–12 mm in diameter when mature and are dark green with yellowish to greenish-yellow longitudinal ribs. When fully mature, the pod splits down the length of the ribs and after the seeds and chaff are released, the pod shrivels, turns dark brown or black and falls from the rhachis.

Results

(a) Egg. The egg measures 1.6–2.0 mm long, 0.8–1.0 mm wide and is cylindrical with rounded ends, pale yellow in colour, with glossy texture, viscid and is laid singly on a petal or part of the column of the flower. The egg hatches within 4–6 days of being laid. No eggs were found on leaves or the main flowering rhachis of the host plants.

(b) Larva. The last instar larva measures 13.5–16.0 mm long with the head capsule 1.3–1.4 mm in diameter; the body (abdominal segments) measure 5.0–6.0 mm in diameter at the widest point; the cuticle (integument) is pale cream in colour, semi-transparent with a brownish-coloured longitudinal dorsal streak. Larvae were not observed on the orchid flowers in the field but were always associated with the green pods. Presumably after the young larva emerges from the egg, it migrates directly to the maturing green pods of the host orchid where it bores a hole in one end of the pod (usually the distal end) and gradually chews out the nutritive ovarial tissues inside the pod. The percentage pod set of *S. rivularis* plants varied from 37.0% to 88% (Table 1) while the percentage of pods chewed by *S. papuana* varied considerably from 7.1% to 86.7% (Table 1). It appears that most of the feeding damage caused to the pods could be attributed to the larvae since adults were rarely found on the pods (see notes on adults below). The percentage of pods chewed away inside varied from 0% to 100% (Table 1). Pods exhibiting the most damage contained one mature larva inside and no pods contained more than one larva (Table 3). Some pods with minor feeding damage but without larvae inside were also noted (pod nos. 2, 6, 7, 11, 12) (Table 3). Presumably the larvae in these pods migrated earlier to other pods, or they had suffered predation or perhaps the feeding

Table 1. Data on pod set, pods chewed by *Stethopachys papuana* Gressitt and numbers of larvae per pod for individual plants of *Spathoglottis rivularis* Schlecht. (Orchidaceae) obtained during March–April 1989 in north-western Papua New Guinea

Date	No. of pods remaining on inflorescence	Total no. of pods, flowers and buds on inflorescence	% pod and seed set	No. of pods chewed by *S. papuana*	% of pods chewed by *S. papuana*	No. of pods with larvae of *S. papuana*	% of chewed pods with larvae
18 Mar.	22	32	68.8	12	54.5	2	16.7
18 Mar.	14	23	60.9	1	7.1	1	100.0
25 Mar.	10	27	37.0	6	60.0	0	0.0
25 Mar.	15	24	62.5	13	86.7	2	13.3
1 April	22	25	88.0	15	68.2	8	53.3
2 April	17	25	68.0	5	29.4	0	0.0
2 April	15	23	65.2	3	20.0	1	33.3
3 April	24	35	68.6	7	29.2	2	28.6
3 April	14	29	48.3	5	35.7	1	20.0
Mean	17.0	27.0	63.0	7.4	43.4	2.4	29.5
± SD	4.7	4.2	14.2	4.8	25.2	1.9	31.2

Table 2. Data on the abundance of *Stethopachys papuanus* Gressitt adults on the inflorescences of *Spathoglottis rivularis* Schlecht. (Orchidaceae) obtained during March–April 1989 in north-western Papua New Guinea

Date	No. of plants examined	No. of plants with beetles	% of plants with beetles	Distribution of beetles on plants	Total no. of beetles counded	Average no. of beetles/plant
19 Mar.	17	4	23.5	2, 2, 2, 1	7	1.8
25 Mar.	15	2	13.3	2, 2	4	2.0
26 Mar.	15	4	26.7	4, 2, 1, 1	8	2.0
31 Mar.	14	3	21.4	3, 2, 1	6	2.0
1 April	12	2	16.7	3, 2	5	2.5
2 April	15	3	20.0	2, 2, 1	5	1.6
3 April	15	2	13.3	2, 2	4	2.0
5 April	15	1	6.7	3	3	3.0
Mean	14.8	2.6	17.7	–	4.6	1.9
± SD	1.4	1.1	6.5	–	2.5	0.9

Table 3. Data on feeding damage to the semi-mature/mature pods of one plant of *Spathoglottis rivularis* Schlecht. (Orchidaceae) obtained on 1 April 1989 in north-western Papua New Guinea. (* Note: e = early instar larva, l = late instar larva)

Pod no.	% of pod chewed	* No. of larvae inside pod	Pod no.	% of pod chewed	* No. of larvae inside pod
1	70	1 (l)	9	15	1 (e)
2	10	0 (l)	10	100	0
3	100	0	11	50	0
4	60	1 (l)	12	15	0
5	40	1 (l)	13	40	1 (l)
6	10	0	14	2	1 (e)
7	5	0	15	5	1 (e)
8	100	1 (1)			

damage was a result of gnawing by other insects (although this latter suggestion appears unlikely since no other pod-feeding insects were observed on the plants during the study periods). In addition, two pods (nos. 3, 10) (Table 3) were found to have been completely chewed out so that they were hollow but they did not contain any larvae. Large bore holes on the sides of these pods near the pedicel indicated that the larvae had most probably migrated successfully from the pod to another site where pupation could occur. In the laboratory, five last instar larvae were contained for further observations. They pupated during 2–3 April inside a cocoon covered in thick, white, filamentous, froth-like substance resembling polystyrene foam. The pupation process occurred during the night and was not observed. No adults emerged after several months so the cocoons were dissected. Three had formed pupae which were dead while the others had produced adults which had failed to emerge (both of them were much smaller than usual). Death could have been attributable in all cases to the larvae being placed in an unfavourable environment as well as fungal/bacterial attack. In the field, no cocoons were found on the plants but it is most likely that the mature larvae fall or crawl to the ground below the host plant where they pupate in soil, debris or amongst roots of plants. The white, foamy substance covering the cocoons deteriorates rapidly in the laboratory and in nature would probably decay even more quickly.

Fig. 1. Adult of *Stethopachys papuana* Gressitt, from Passam, East Sepik Province, Papua New Guinea. Scale line = 5 mm. (Photo: author).

(c) Adult (Fig. 1). Body length 9.8–10.0 mm, width of the head (including eyes) 1.8–1.9 mm, width of thorax 2.0–2.1 mm, length of thorax 2.0–2.1 mm, width of the elytra at widest point, 5.0–5.2 mm. Head, prothorax, legs and underside of body pale orange-yellow (darkening after death to a dull orange-brown colour), elytra mostly brownish-black with purple-black reflections and with a small triangular region of yellow colour at the base and along suture for almost one quarter the length of the elytra. Antennae and legs dark brown. Pronotum with a deep triangular groove in the centre on each side. Femur of the hind legs prominently swollen in the upper portion to at least in the middle, with a blunt, triangular spine internally, about 4/5 the distance of the femur from the trochanter. Groove present in the tibia into which the triangular process rests when the leg segments are held close together. Most adults inhabited the open flowers of the orchid where they fed on petals, the column, the ovaries and sometimes the sepals. On one occasion, two adults were observed feeding on the distal ends of separate semi-mature pods. It is possible that eggs are also laid inside the orchid pods by the female beetles after they chew out a hole, although evidence of this was not found in the field and no eggs were disclosed in the pods that were dissected. It is most likely that the adults only occasionally feed on the pods. The number of plants in the population studied with beetles on the flowers at the time of observations was fairly low, i. e. 6.7–26.7% (Table 2). The number of beetles per plant was also low and ranged from 1–4, with an average of about 2.0 per plant (Table 2). Mating took place on the flowers or pods in bright sunlight. The adults were very active and wary and if closely approached or disturbed in any way, they would rapidly fall from their resting posts in a free-fall (without opening the elytra) for a short distance before rapidly flying in a linear direction away from the area to another orchid or to other vegetation nearby. The adults stridulated vigourously when handled and often exuded a dark yellow or yellow-green solution from the mouth.

Discussion

A comparison of the main bionomic/ecological characteristics between *Stethopachys papuana* Gressitt and the related species from Australia, *S. formosa* Baly, is provided in Table 4. The biology/behaviour of *S. papuana* is similar to that of *S. formosa* in terms of pupation site, the type of pupal cell constructed and in adult behaviour such as stridulation, the exudation of defence solutions from the mouth when handled or disturbed and poorly developed cryptic coloration, but differs significantly in larval feeding characteristics and apparently in the method of larval migration to the pupation site (Table 4). The larvae and adults of *S. formosa* are less restrictive in their choice of food items than *S. papuana*, the larvae of the latter feed only on the orchid capsules, while the adults prefer the flowers and only occasionally chew the external wall of tissues of the orchid pods, whereas both larvae and adults of *S. formosa* feed on the flowers, leaves and shoots of the host orchid, thereby showing non-selectivity and an absence of niche partitioning. The method of larval migration to the pupation site appears also to differ significantly between the two species (Table 4). These apparent differences are mainly related to the life-forms of the particular orchid taxa that the beetles inhabit, i. e. terrestrial vs epiphytic, and differences in size and morphology of the plants. *Spathoglottis rivularis* flowers are borne in a dense raceme at the end of a long rhachis about one

Table 4. Comparison of some bionomic/ecological characteristics between *Stethopachys formosa* Baly from Australia and *Stethopachys papuana* Gressitt from Papua New Guinea. (Data on *S. formosa* is from Smith (1940), Rushton (1980), Hawkeswood (1987) and Bostock (1986, 1990 unpub. observations)

Characteristic	*S. formosa*	*S. papuana*
1. Egg-laying site(s)	Leaf axilis, flowers	Flowers
2. Egg hatching time	1–2 weeks	4–6 days
3. Larval food	Young leaves/shoots, flower buds and open flowers	Pods (capsules) only
4. Resulting damage of larval feeding on host plant	Skeletonization of leaves and flowers; hollowing out of stems and inflorescences	Hollowing out of pods and external damage to The thick pod wall
5. Method of larval migration to pupation site	Boring through stems	Crawling down inflorescence to ground below (?); dropping to ground inside pod
6. Pupation site	Stems, roots, compost and debris around base a host plant	Soil beneath plant or amongst debris near host plants
7. Pupal cell type	Cocoon with dense covering of white, foam-like material	Cocoon with dense covering of white, foam-like material
8. Pupal duration	ca. 3 weeks	> 3 weeks (?)
9. Adult food	Flowers, leaves, shoots	Flowers, pods (occasionally)
10. Adult stridulation	Present	Present
11. Exudation of defensive solution from mouth of adult	Present	Present
12. Cryptic coloration of adult	Poorly developed	Poorly developed
13. Hosts (genera)	*Dendrobium, Cymbidium*	*Spathoglottis*
14. Plant host biotype	Epiphytic	Terrestrial
15. Population density	High	Low

metre in length; it seems that for logistic reasons (i. e. time, distance and energy conservation) the larvae avoid boring through the centre of the rhachis in order to reach the base of the plant for pupation. The leaves of *S. rivularis* are flat, non-fleshy and possess numerous, thick longitudinal veins, between which there is only a comparatively small amount of mesophyll tissue; the mesophyll tissue in the fleshy leaves of *Dendrobium* and *Cymbidium* are much more extensively developed. Therefore it would appear that the leaves of *S. rivularis* are not attractive as food for *S. papuana* for the above reason. The large fleshy pods of *S. rivularis* filled with nutritive tissues appear to enable the full development of the larvae of *S. papuana* without the need for supplementary food items.

The population density of *S. papuana* in the field appears to be low and the populations localized, while population levels of *S. formosa*, at least under glasshouse conditions, appear to be able to reach very high levels, with often more than 100 adults per plant, depending on the species of orchid (P. Bostock, pers. obs.). Presumably under glasshouse situations where the food plants are cultivated in numbers, the beetles have a abundant food supply and little or no predation by natural predators; under these artificial conditions, the species is able to maintain a high population density. Field studies of *S. formosa* have not been undertaken but it is likely that population densities of the beetle in the field are not as high as those under artificial situations.

Table 5. Summary of the major ecological characteristics[A] of *Stethopachys papuana* Gressitt (Chrysomelidae: Criocerinae)

Phenotypic and other characters responding to selection	Determined and/or predicted[B] character states
1. Geographical range	Widespread
2. Local endemism and restriction of gene flow	Low
3. Distribution across marked elevational gradients	Moderate to high
4. Ability to occupy highly seasonal regions	Good
5. General spatial patchiness of resident populations over approx. 1.000 metre sections of a region	High
6. Dispersal ability of adults	Low to moderate*
7. Intrapopulational variation	Low
8. Interpopulational variation	Low
9. Habitat selection	Spezialized (high)
10. Main habitat	Clearings on hillsides in tropical rainforest
11. Colonizing ability	Low to moderate*
12. Local population density	Low
13. Regional breadth of larval food plants	Low
14. Relative abundance of larval food plants per unit area of suitable habitat	Low to moderate
15. Oviposition strategy	Highly restricted
16. Oviposition proneness in captivity	Unknown
17. Predation/parasitism on immature stages	Unknown
18. Overall fecundity (average per female)	Unknown
19. Egg-adult development time	1–2 months*
20. Activity of adults	Diurnal
21. Escape mechanisms	Well developed
22. Cryptic coloration	Poorly developed
23. Sex ratio of adults in random collections	Unknown
24. Diurnal rhythmicity of adult feeding	Probably not present*

A = Adapted and modified from Young (1982) for butterflies; B = Characters states marked with an asterisk are predictions

Despite the destructive damage to individual pods and flowers of *S. rivularis*, the overall effect of *S. papuana's* feeding on the survivorship of the orchid population appears to be very slight. Each orchid produces more flowers and pods than are consumed by the beetles and produces flowers and viable pods throughout the year, even during months when the beetles are not active on the plants (i. e. during July to September, Hawkeswood, pers. obs.).

A summary of the major ecological characteristics of *S. papuana* based on the observations provided in this paper are outlined in Table 5. An explanation of some of these listings is provided here. The geographic range of *S. papuana* is now known to be widespread; Gressitt (1965: 187) recorded the holotype specimen from the Goilala area, Owen Stanley Range (8°20'S, 147°06' E), Papua (now in Central Province of Papua New Guinea), so that the present record of the species from Passam in the East Sepik Province extends the known range of the beetle north-westwards some 400 miles (600 km). This means that *S. papuana* is not a local endemic and that restriction of gene flow within and between populations of the beetle is probably not restricted although resident populations are generally patchy within a region. *Spathoglottis rivularis* and other *Spathoglottis* species are very widespread throughout Papua New Guinea so food plants are probably not limiting the distribution or population numbers of *S. papuana*. The beetle appears to be restricted to tropical rainforest communities in montane areas which experience a seasonal climate (i. e. monsoonal summer (wet) alternating with dry, winter seasons). The population density of *S. papuana* in the field appears to be low and the species is presently only known from the orchid *Spathoglottis rivularis*. The oviposition strategy of the females is highly restrictive i. e. only the floral parts of the host orchid are used as egg-laying sites. Unfortunately, nothing is known of the biology of the other Papua New Guinean *Stethopachys* species so no biological comparisons can be made with them at this stage. The genus is of much biological interest and is worth further study when the opportunity arises.

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