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A NEW CRAB FLY FROM CHRISTMAS ISLAND, INDIAN OCEAN (Diptera : Drosophilidae)

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Abstract: A new drosophilid fly, *Lissocephala powelli*, from Christmas I., Indian Ocean, breeds on the land crabs *Gecarcoidea humei* and *Birgus latro*. *Geograpsus crinipes* is another probable host, and the fly oviposits also on *Cardisoma carnifex* but does not complete its life cycle on that crab. This is the third crab-breeding drosophilid. No flies were found on these or related crabs on islands of Micronesia.

Two species of *Drosophila* which breed on land crabs of the genus *Gecarcinus* have recently been described from the West Indies : *D. carcinophila* Wheeler (1960) and *D. endobranchia* Carson & Wheeler (1968). Both are referable to the subgenus *Drosophila* but they belong to quite different species groups. Parasitism of any sort is exceedingly rare in the family Drosophilidae (Carson 1971). Thus, the very existence of the two species gives evidence of separate but strikingly parallel evolutionary events.

In a search of the literature dealing with parasitic associates of members of the land crab family *Gecarcinidae*, a short note by Keilin (1921) came to light. The author described and figured a small dipteran larva recovered from the red crab (*Gecarcoidea humei*) of Christmas Island, Indian Ocean. This appears to be the only published record of dipteran associates of land crabs outside of the islands of the West Indies. Nevertheless, examinations of specimens of *Gecarcoidea* in the U. S. National Museum revealed the presence of dipteran larvae in land crabs from Silino Island, Mindanao Sea, Philippine Islands and from Andaman Islands, Bay of Bengal. The identity of these specimens remains unknown.

The present note reports the results of the examination of land crabs from several island groups in the tropical North Pacific Ocean (Western Caroline and Marshall Islands) and from Christmas Island, Indian Ocean. At the latter location, the new species of drosophiline here described was discovered in July 1972. The fly belongs to the genus *Lissocephala* Malloch (1929), consisting at present of 12 species from Africa, Southeast Asia, and Micronesia. Accordingly, this represents noteworthy evidence for a third independent evolution of a drosophiline into a parasitic association with land crabs.

The species of *Lissocephala* are remarkably shiny, with mirror-like metallic iridescence of bronze, bluish or greenish hues on the head, mesonotum and abdomen ; the scutellum is contrastingly dull to velvety. A few species, including the type-species, *L. unipuncta* Malloch from Africa, have a prominent dark apical wing spot ; the rest lack this spot but possess a dark crossband near the wing base. Body length ranges from 1.5 to 2.5 mm.

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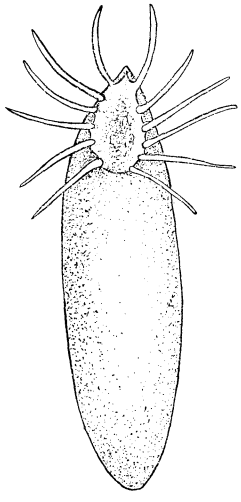

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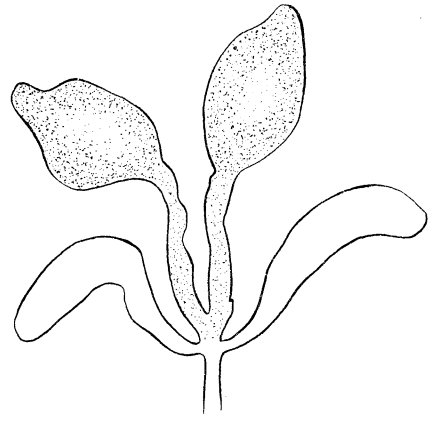

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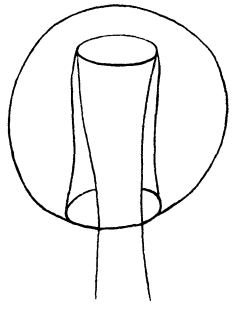

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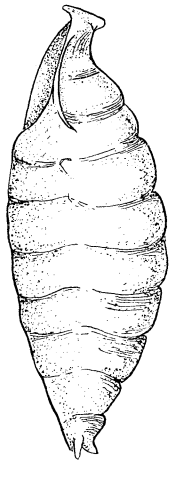

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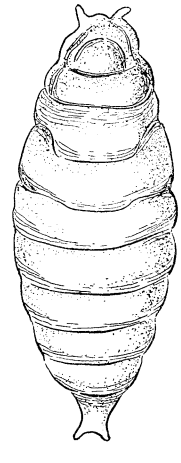

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Fig. 1-5. *Lissocephala powelli*, n. sp.: 1, egg, ×112; 2, testes (shaded) and accessory glands; 3, spermatheca; 4, lateral and ventral; 5, view of puparium, ×25.

Lissocephala powelli Carson and Wheeler, new species Fig. 1-5.

A small iridescent fly with a continuous wing-waving habit; very similar in appearance to *L. metallescens* (de Meijere), differing especially in the pleural coloration and in the male genitalia.

♂, ♀. Arista usually with 3 dorsal and 2 ventral branches in addition to the terminal fork. Antennae tan; front tan to light brown, anteriorly with about 16 well-developed hairs. Face, cheeks and proboscis yellow, bristles black, the clypeus brown, very narrow. Middle orbital bristle about 1/4 length of posterior orbital. Carina prominent, pale yellow. Cheek very narrow. Eyes bright red in live flies. A single prominent oral bristle. Palpi tan with 3-4 prominent subapical bristles.

Mesonotum brown with iridescent greenish to bluish metallic sheen, strongly polished. Legs yellow, hind tibiae sometimes slightly darkened. Pleura pale below, with a shiny brown stripe above; this stripe runs posteriorly from below the humeral callus, below the wing base where it is somewhat broader, and continues on to the metanotum. Just anterior to the wing base the notopleura is also shiny brown, contrasting with the much paler humeral callus. Halteres tan. Acrostichal hairs 8-rowed; anterior and posterior dorsocentral about equally long; scutellum dull, the apical bristles long and crossed, the basal pair about 1/2 length of apicals, all four convergent.

Wings with extremely heavy costal margin. Wings pale except for a prominent black streak near base, from 2nd costal break to anal lobe; when the wing is raised, this streak forms a continuous line with the pleural stripe. Third costal section with the small black bristles on the apical 4/5. Costal index 1.0 to 0.9, the 2nd and 3rd costal sections being nearly equally long. Last section of 5th vein 2-2.5 × length of posterior crossvein.

Abdomen polished black with bluish reflections when seen from certain angles.

Body length about 1.8 mm, some females larger.

Male genital structures mostly brown. Hypandrium quadrate; clasper with a row of about 12 teeth, becoming longer apically, and with a cluster of longer bristles apically. One pair of short, stout parameres, bifid apically and bearing a row of sensilla along one side. Apex of aedeagus round, gradually narrowing apically to form a stout, black, horn-like process; this process can often be seen on pinned specimens. Testes elliptical (Fig. 2).

Spermatheca of moderate size, very dark brown, round and with a prominent, broad introvert; apex not indented (Fig. 3). Stalk of spermatheca dark on its basal half, pale on its distal half. Ovipositor plates rather short, narrow, and pointed, brown, bearing about 24 stubby teeth and one long bristle.

Eggs with 11-14 filaments (Fig. 1) usually 12 or 13 (see Table 7), their length about 1/5th the egg length. Anterior spiracles of puparia very short, essentially sessile (Fig. 4, 5).

Distribution and *Types*: Known only from Christmas Island, Indian Ocean. Type specimens were aspirated directly from the carapace, legs and mouthparts of the land crab, *Gecarcoidea humei*, from Smith Point, Christmas Island, 17 July 1972, altitude 120 m. Holotype ♂ (BISHOP 9924), allotype, and 5 paratypes deposited in the Bishop Museum, Honolulu, Hawaii. Additional paratypes are in the collections of the U.S. National Museum, Washington, D. C. and the Genetics Foundation, University of Texas at Austin.

For other hosts and details, see Tables 1-8. Specimens were also obtained from Poon San (120 m), Ross Hill Garden (90 m), Rocky Point (24 m), Grant's Well (300 m), Murray Hill (280 m), The Dales (18 m), and Waterfall (15 m).

This species is named in honor of Mr David A. Powell, naturalist extraordinary of Christmas Island.

Ecology and Life History

Christmas is a single isolated island, about 180 square km in extent; it lies 320 km west of Java in the Indian Ocean. The island is oceanic, with a basaltic base capped by limestone. It rises to about 360 m above sea level at Murray Hill and supports a high tropical rainforest typical of the Malay archipelago. Rainfall on the plateau is about 225 cm per year. The overstory is made up of such lofty trees as *Eugenia gigantea*, *Hernandia peltata*, *Inocarpus edulis*, *Celtis cinnamonea* and *Dysoxylum amooroides*. *Pisonia excelsa* is common in the understory. *Erythrina indica* and *Pisonia grandis* are numerous on the coastal terraces. A few endemic species, such as the palm, *Arenga listeri*, are found. Many relevant details on the flora and fauna of the island will be found in Andrews (1900).

Despite extensive strip-mining for phosphate in the present century, considerable forest remains and, due to the absence of agriculture or grazing animals, much of it is still in a pristine state. The red land crab *Gecarcoidea humei* is abundant in every part of the island except the denuded phosphate quarries. It appears to subsist on a variety of litter on the forest floor, especially leaves and fruit. During the stay of the senior author (14–25 July 1972), one could count 15–20 crabs on the forest floor at almost any place in the forest, when standing in a single spot. The crabs excavate shallow burrows in the soil beneath rocks and tree roots; they retire to these during the heat of the day. If on the surface, as they frequently are, they move rather slowly and may be easily captured.

Everywhere on the island that *G. humei* is found, *Lissocephala powelli* can be observed moving about on the crabs, either on the carapace or legs or around the mouthparts. When the crab is captured or disturbed, the flies leave the crab and rest nearby, being somewhat reluctant to return. General sweeping or baiting in about any part of the island results in the capture of many crab flies; closer visual inspection reveals that they are resting and feeding in many places other than on the crab itself (Table 1).

Table 1. Sites on which *Lissocephala powelli* was observed resting or feeding. Christmas Island, July, 1972.

Resting (no feeding observed)
carapace and legs of *G. humei*, *C. carnifex* and *B. latro*
leaves of a low solanaceous plant
Guano of frigate birds
dry leaves on forest floor
15 cm high terrestrial composite
Feeding
around nephric grooves and third maxillipeds of *G. humei* and *C. carnifex*
fallen fruits of papaya and pomelo (grapefruit)
rotting tomatoes on forest floor (bait)
fallen Pandanus fruits
rotting trunk of papaya tree
fallen fruits of *Hernandia peltata*, *Dysoxylum amiooroides* and *Eugenia gigantea*
5 cm diameter terrestrial mushroom
white ruffle-like fungus on log surface
fallen bracts of banana flowers

From several fungi, another obviously different species of the genus *Lissocephala* was collected along with *L. powelli*. It seems to have no relationship to the crabs; it is predominantly black in color.

Land crabs of five species were captured and subjected to examination for eggs and/or larvae (Table 2). The presence of these immature stages in the three species other than *Gecarcoidea* is wholly unexpected and represents the first time that these widely distributed species have been found to have dipteran associates.

Table 2. Incidence of infection of land crabs by *Lissocephala powelli* based on observation of eggs and/or larvae. Christmas Island, July, 1972.

Species of crab	Number examined	Number infected	Per cent infected
Gecarcoidea humei	83	79	95.2
Birgus latro	17	17	100.0
Cardisoma carnifex	34	17	50.0
Geograpsus crinipes	6	4	66.7
Geograpsus grayi	4	0	0.0
Total	144	117	81.2

In *Gecarcoidea*, eggs of *Lissocephala powelli* are laid in large numbers at the base of the second antennae and along the edge of the carapace directly above the mouthparts. The size of the egg counts (Table 4) seems remarkable in view of the fact that the eggs have no adhesive quality and easily wash or flake off the slick, waxy surface of the crab. A smaller number of eggs are laid at the lateral edges of the third maxillipeds; such eggs have not been included in the counts given in Table 4.

Larvae of all instars are abundant in the hairs at the apical end of the third maxillipeds, with most of them only partially concealed. This area is continually saturated by fluid excreted from the green gland, in much the same manner as in *Gecarcinus ruricola* of the West Indies (see Carson 1967). Examination of the visceral organs of the crab reveals that some of these larvae make their way back into the gills, wherein they may be widely distributed (Table 3).

L. powelli adults were also observed on the Robber or Coconut crab (*Birgus latro L.*). That the species can breed on this host is documented in Table 2. Eggs which are closely similar to those found on *G. humei* (Table 7) are found in large numbers at the base of the second antennae. In the case of *Birgus*, however, no external nephric groove exists and larvae are accordingly found only in the gills. Gill infections in *Birgus* are very heavy. This species has about 10 gills on each side and most infections show about 5 larvae in each gill; this amounts to approximately 100 larvae per crab, about three times the mean number in *Gecarcoidea*. Every specimen of *Birgus* examined showed a substantial infection.

Although *Gecarcoidea* is almost everywhere on Christmas Island, *Birgus* is found principally in deep moist forest, somewhat sheltered from the southeast trade winds, and especially where the palm, *Arenga listeri*, is abundant. Even more restricted in

Table 3. Distribution of *Lissocephala* larvae in *Gecarcoidea humei* Smith Point, Christmas Island. July, 1972.

Crab Number	*Number of larvae*		
	under maxillipeds	in gills	total
1	40	3	43
2	55	3	58
8	30	10	40
9	18	6	24
10	0	7	7
11	15	15	30
Total	158	44	202
Per cent	78.2	21.8	
Mean number of larvae per crab			33.8

Table 4. Numbers of *Lissocephala* eggs on *Gecarcoidea humei*. Ross Hill Garden. Christmas Island, July, 1972.

Crab Number	Number of hatched eggs	Number of unhatched eggs	Total
11	—	—	80
79	2	1	3
80	33	8	41
81	20	3	23
82	11	4	15
83	32	1	33
84	179	10	189
85	8	4	12
86	3	0	3
87	4	3	7
88	71	6	77
89	1	6	7
90	18	15	33
91	21	1	22
92	23	14	37
93	12	4	16
94	3	12	15
Total	441	92	613
Per cent	82.7	17.3	
Mean number of eggs per crab			36.1

distribution is the blue land crab, *Cardisoma carnifex*. Like other species of this widespread genus, *C. carnifex* is dependent on an abunbant source of fresh water where it can make its chimney-like burrows in the mud.

In three places on Christmas Island (the Dales, Waterfall and Ross Hill Garden) small watercourses emerge at the level where the limestone rests on basalt. *Cardisoma carnifex* is virtually confined to these areas. Inspection soon revealed that *Lissocephala powelli* can be observed on *C. carnifex* in numbers comparable to those on *Gecarcoidea*. Aspirations of flies directly from *Cardisoma* confirmed that the fly is indeed the same species as found on *Cardisoma* and *Birgus*. Evidence of parasitism was again obtained by searching for eggs and larvae ; the incidence of infection is somewhat less than in the other two species (Table 2).

Notice was immediately taken of the fact that, despite moderately large numbers of eggs on the buccal ledge and at the base of the first antenna, larvae were exceedingly few (Table 5). Of the 9 larvae found in 17 crabs, only 2 were diagnosable as second instar. The remainder were first instar larvae found on the ledge or at the margin of the very large external nephric pad characteristic of this genus. Thorough post-mortem searches were made of all viscera of all infected crabs ; no larvae were found in the gills or any other visceral organ. We conclude from these data that although *L. powelli* oviposits readily on *Cardisoma*, the infection rarely proceeds further and that completion of the life cycle on this species is not possible at least under the circumstances existing in July 1972.

L. powelli infections were found on a fourth species of land crab, *Geograpsus crinipes*

Table 5. Eggs and larvae of *Lissocephala powelli* on *Cardisoma carnifex*. Christmas Island, July, 1972.

Crab number	number of hatched eggs	number of unhatched eggs	Total eggs	number of first instar larvae
35	—	—	3	0
36	—	—	1	0
39	—	—	3	0
56	4	17	21	0
64	—	—	10	3
65	—	—	2	0
67	0	0	0	2
69	—	—	1	3*
71	11	13	24	1*
95	0	55	55	0
96	3	13	16	0
97	0	3	3	0
98	1	0	1	0
99	0	15	15	0
101	—	—	3	0
109	—	—	2	0
110	—	—	2	0
Total	19	116	162	9

* one larva was second instar

Table 6. Eggs and larvae of *Lissocephala powelli* on *Geograpsus crinipes*. Christmas Island, July, 1972.

Crab number	number of eggs	number of larvae
104	5	0
105	3	0
111	3	0
113	0	1
Total	11	1

(Tables 2, 6). The nephric pad of this species has only sparse hairs and is wholly exposed, as in *Cardisoma*. Larvae do not occur on this pad. The single larva that was found in this species was a well-developed and healthy third instar stage in the gills. From this it may be surmised that *L. powelli* can occasionally complete the life cycle on this species. *Geograpsus crinipes* is found only on the rocky limestone terraces not far above the sea (the "shore terrace" of Andrews 1900). All specimens examined came from The Dales area, where five species of land crabs are running together in the same forest.

No puparia were found attached to any of the crabs. On the theory that third instar larvae leave the crab and pupate in the soil, groups of *Gecarcoidea* or *Birgus* were isolated in large tins containing about two inches of damp beach sand which had been thoroughly washed in fresh water. After an interval of from one to two days, the crabs were removed and the sand washed out. Many pupae were floated out and recovered from both species of crab (Table 8). These were concentrated in vials of

damp sand and emergence of *Lissocephala powelli* from both species confirmed.

Third instar larvae were obtained by placing the crabs overnight in large heavy-calibre plastic bags and then searching washings from the bags. No satisfactory chromosome preparations were obtained.

Christmas Island appears to have only a few species of *Drosophila*. In about 10 days of active collecting at 11 localities on the island, extensive use was made of fruit baits, both indigenous and introduced. At the same time, general sweepings were made as well as visual examination of fruits, fungi and decaying logs. These efforts resulted in the capture of only 11 species of the family. *L. powelli* was the most ubiquitous and abundant species, being found in all localities. The melanogaster-group species *D. ananassae* was quite common and *D. parabipectinata* and *D. serrata* were each caught in two localities. The rest of the species, with the exception of a species of *Dettopsomyia* are flies of the deep forest. The sparseness of this fauna seems unusual in view of the tropical position of the island and its rich natural vegetation. Even more remarkable is the fact that, despite the presence of a human population of 3500 and a full complement of introduced tropical fruits and garden plants, the usual cosmopolitan species of Drosophila were not obtained. Conspicuous by their absence are such species as *D.*

Table 7. Number of filaments on the eggs of *Lissocephala powelli* from different hosts

Crab number	species	number of filaments per egg				
		11	12	13	14	Total eggs
43	*G. humei*	3	1	1	2	7
56	*C. carnifex*	0	3	7	0	10
57	*B. latro*	2	2	1	0	5
	Total	5	6	9	2	22

Table 8. Number of pupae and third instar larvae of *Lissocephala powelli* obtained from captive crabs.

Crab species and locality	number of crabs	date isolated	number of larvae	number of pupae	date recovered
G. humei	12	17 July	0	3	18 July
The Dales			0	54	20 July
			6	0	22 July
			3	2	23 July
G. humei	16	21 July	0	5	22 July
Ross Hill Garden					
Total, *G. humei*			9	64	
B. latro	11	20 July	0	0	21 July
The Dales			0	23	22 July
			0	10	23 July
Total, *B. latro*	11		0	33	

melanogaster, *D. simulans*, *D. immigrans*, *D. hydei*, *D. busckii* and *D. repleta*.

In view of the widespread drosophiline infection of land crabs on Christmas Island, it seems worthwhile to record here data which indicate the lack of infection among similar species of crabs collected in several areas of the tropical North Pacific, namely in the Marshall and Caroline Islands. These island groups are approximately 10 degrees north of the equator and are thus comparable in climate to Christmas Island, which is 10 degrees south. The principal relevant crab species, *Gecarcoidea humei*, is closely similar to *G. humei natalis* of Christmas Island.

Results of examinations of land crabs in the Marshall Islands are given in Table 9, whereas Table 10 gives details for the Caroline Islands. The numbers given in the

Table 9. Land crabs from the Marshall Islands, Micronesia, examined for dipteran parasites. All were negative.

Locality	Number of crabs examined								
	Gecarcoidea humei	*Cardisoma*		*Birgus latro*	*Geograpsus*		*Ocypode*		
		carnifex	*rotundum*		*crinipes*	*grayi*	*ceratophthalma*	*cordimanus*	
Eniwetok Atoll									
Igurin I.	—	—	—	26	6	—	12	—	
Rigili I.	—	—	—	4	38	10	15	20	
Majuro Atoll									
Rairik I.	9	3	9	1	5	5	—	—	
Enenelip I.	20	1	4	—	3	2	—	—	
Bok I.	44	—	—	—	7	1	—	—	
Kwajalein Atoll									
Ennylabagen I.	21	—	5	2	6	3	—	—	
Total	94	4	18	33	65	21	27	20	282

Table 10. Land crabs from the Western Caroline Islands, Micronesia, examined for dipteran parasites. All were negative.

Locality	Number of crabs examined		
	Gecarcoidea humei	*Cardisoma carnifex*	*Birgus latro*
Palau			
Koror	0	1	0
Urukthapel I.	54	1	0
Auluptagel I.	17	4	0
Ngerugelbtang I.	28	6	2
Eil Malk	2	0	0
Peleliu	0	6	0
Yap			
Fanif	5	0	0
Total	106	18	2

tables refer to those specimens which were specifically examined microscopically (post mortem) for eggs, larvae or pupae on cephalothorax, gills and mouthparts. The only exception to this are 106 crabs from Igurin and Rigili Islands which were examined externally for adult flies only. No stage of the life cycle of any Diptera was found on these 282 crabs.

Conclusions and Summary

Lissocephala powelli, a new species of the family Drosophilidae, is described from Christmas Island, Indian Ocean. The fly is exceedingly abundant in all parts of the island. It breeds on the land crabs *Gecarcoidea humei* and *Birgus latro*. A probable third host is *Geograpsus crinipes*. Although it oviposits readily on *Cardisoma carnifex*, the life cycle apparently cannot be completed on this species. Crabs of the same or related species in several areas of the tropics of the North Pacific have no dipteran associates. The fly species represents a third independent evolution into a land-crab breeding site by members of the Drosophilidae, the two others being unrelated species found in the West Indies.

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