

Mouthparts and nectar feeding of the flower visiting cricket *Glomeremus orchidophilus* (Gryllacrididae)



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ABSTRACT

Glomeremus orchidophilus (Gryllacrididae) is a flower visiting cricket on the tropical island La Réunion. This species is the only Orthoptera shown to be a pollinator of a plant. We studied its nectar feeding behavior and mouthpart morphology in detail. Since *G. orchidophilus* possesses biting-and-chewing mouthparts, our objective was to find behavioral and/or structural specializations for nectar-feeding. The comparative analysis of feeding behavior revealed that fluid is taken up without movements of the mouthparts in *Glomeremus*. A comparative morphological examination of two *Glomeremus* species, together with several representatives of other Gryllacrididae and other Ensifera taxa revealed subtle adaptations to fluid feeding in *Glomeremus*. All representatives of Gryllacrididae were found to possess a distinct patch of microtrichia at the tip of their galeae. However, in *Glomeremus* a channel is formed between the distal components of the maxillae and the mandibles on each side of the body. Micro-CT and SEM examination revealed a longitudinal groove that extends over the galea beginning at the patch of microtrichia in the studied *Glomeremus* species. We hypothesize that the microtrichia take up fluid by capillarity and the action of the cibarium and pharyngeal pumps transports fluid along the channels between the maxillae and mandibles into the preoral cavity. These mouthpart features allow nectar uptake from flowers that is unique in Orthoptera.

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1. Introduction

Most flower visiting insects belong to the Holometabola; a pattern that applies in particular to numerous representatives of the Hymenoptera, Lepidoptera, Diptera and Coleoptera (Kevan and Baker, 1983; Proctor et al., 1996; Wardhaugh, 2015). Many holometabolous taxa possess specialized mouthparts to access floral rewards, usually nectar and pollen (Krenn et al., 2005). Non-holometabolous insects, such as representatives of the Plecoptera, Blattodea, Orthoptera or Heteroptera, have rarely been reported to be recurring flower visitors and potential pollinators (Porsch, 1957; Schuster, 1974; Nagamitsu and Inoue, 1997). These non-holometabolous insects may facultatively feed on flowers and floral rewards but use unspecialized biting-and-chewing mouthparts or piercing-and-sucking proboscides. Mouthpart specializations to

the floral food source never have been described in these non-holometabolous insects. Recent reports of a cricket that is a recurring flower visitor and pollinator of an orchid (Micheneau et al., 2010; Hugel et al., 2010) warrants a detailed morphological and behavioral study to find putative specializations of the feeding apparatus and feeding activities.

The recently discovered cricket, *G. orchidophilus* HUGEL, 2010 (Gryllacrididae, Orthoptera), currently represents the only recorded nectar feeding and pollinating cricket (Micheneau et al., 2010; Hugel et al., 2010). This non-flying nocturnal tropical Raspy Cricket (Rentz, 1996) is attracted to the flowers of the orchid *Angraecum cadetii* where it imbibes nectar from short nectarial spurs. During flower visits, *G. orchidophilus* is able to remove pollinia of the orchid (Fig. 1A) and transport these structures to other conspecific flowers. This insect was demonstrated to be the obligate pollinator of the *A. cadetii* on the island La Réunion in the east-central Indian Ocean (Micheneau et al., 2010). Presently, this is the only confirmed case of a pollinating Orthoptera species. Other Ensifera, such as wetas from New Zealand, seem to live in close

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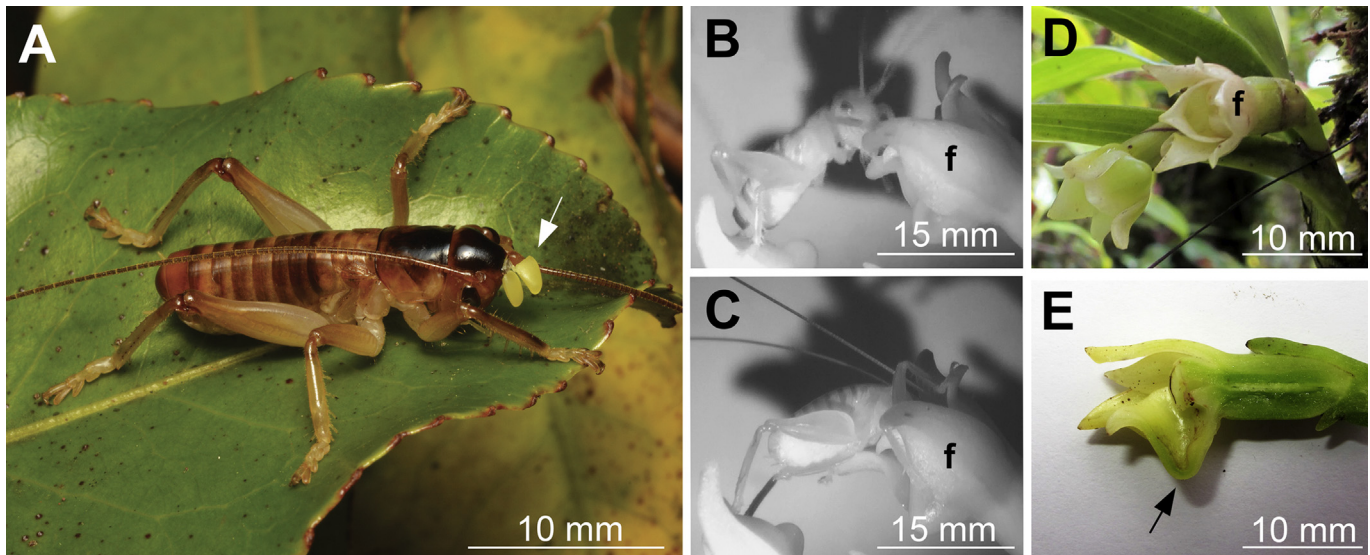


Fig. 1. Flower visiting behaviour of *Glomeremus orchidophilus* (Gryllacrididae), a nocturnal cricket of the tropical island La Réunion; (A) *G. orchidophilus* carrying pollinia (arrow head) of an orchid; (B) *G. orchidophilus* approaching a flower (f) of *Angraecum cadetii* (Orchidaceae), from screen shots of video footage (IR illumination); (C) *G. orchidophilus* inserts its head into *A. cadetii* orchid flower (f) to take up nectar, from screen shots of video footage (IR illumination); (D) Flower of the orchid *A. cadetii* growing in its natural habitat (Basse Vallée, Parc National de La Réunion); (E) A laterally opened flower displaying the shallow nectarial spur of the labellum (arrow).

relationship to particular flowers (Lord et al., 2013). However, it remains unclear if wetas are effective pollinators and what they actually feed on during their flower visits.

In general, other species of Gryllacrididae feed on plant material, such as seeds, fruits, and leaves, in addition to small arthropods (Hale and Rentz, 2001). An analysis of the alimentary tract and the gross morphology of the mandibles in Gryllacrididae indicate an omnivorous feeding preference (Rentz and John, 1990). Likewise, *G. orchidophilus* was regarded to be omnivorous, in principle, because of its biting-and-chewing mouthparts which take up and process various kinds of food in addition to floral nectar (Micheneau et al., 2010). Detailed morphological studies of the mouthparts and feeding behaviour of *G. orchidophilus* are absent, and it is unknown whether there are micromorphological specializations of the mouthparts to this uncommon food resource of crickets.

The aim of this comparative study is to examine the mouthparts in *G. orchidophilus* in context with nectar feeding behavior. We compared the mouthpart morphology of species from the genus *Glomeremus* with related representatives of the Gryllacrididae, as well as representatives from other taxa of Ensifera. These comparisons enabled a search for morphological differences that could be interpreted from a functional perspective as advantageous for fluid feeding.

2. Material & methods

2.1. Video analysis of feeding behavior

A total of 9 individuals (4 males and 5 females) of *G. orchidophilus* (Fig. 1A) were collected in Forêt de Mare Longue (350–450 m a.s.l., 21°21'01" S, 55°44'31" E to 21°20'47" S, 55°44'24,3" E) and in Basse Vallée (600–750 m a.s.l., 21°20'29" S, 55°43'23" E to 21°20'20" S; 55°42'39" E) both in the Parc National de La Réunion between February 5th and February 12th in 2014. All crickets were collected at night, brought to the Mare Longue Station (St. Philippe, La Réunion) and were video recorded during the following night.

The nocturnal behavior of *G. orchidophilus* (N = 9) was documented using a Sony HDRxr550ve hard-disc video camera

equipped with a night shot function and infrared light (IR) that did not disturb the insects. One or two individuals of *G. orchidophilus* were placed in a transparent plastic box (20 × 13 × 13 cm) which contained one flower of the orchid *A. cadetii* (Orchidaceae). The video camera was attached to an opening on one side of the box. Videos were taken from about 7 p.m.– 4 a.m. over a period of several nights in the laboratory of the Mare Longue Station (St. Philippe, La Réunion). From a total of 36 h of video footage, 65 min of feeding behavior could be analyzed. In total, 4 individuals were observed to visit the orchid flowers (Fig. 1B, C). A total of 15 flower visiting events were filmed. Three flowers of *A. cadetii* (Fig. 1D) were collected by J. Fournel in the Forêt de Mare Longue. In a round, transparent, plastic container (6 × 2 cm) 4 individuals were observed during uptake of water, diluted honey (water to honey ratio approximately 1:1) or squashed banana food. The crickets were filmed from below using a close up lens mounted on the front lens of a Sony HDRxr550ve hard-disc video camera. *Acheta domesticus* (LINNAEUS, 1758) and *Glomeremus paraorchidophilus* HUGEL, 2010 (collected by S. Hugel in Mauritius) were studied during the uptake of apple, squashed banana, water and diluted honey (1:1) as control species using the same Sony camera in the laboratory of the Department of Integrative Zoology (University of Vienna) during November of 2013.

2.2. Morphological analyses

After the feeding experiments, all individuals of *G. orchidophilus* (N = 9) were preserved in 80% ethanol for morphological studies. In addition, several ethanol-preserved specimens of Gryllacrididae of the following species were examined: *G. paraorchidophilus*, *Pissodogryllacris* sp., *Niphetogryllacris reunionis* (KARNY, 1932), *Prosopogryllacris sechellensis* (BOLIVAR, 1895). These four species previously were collected by S. Hugel in La Réunion, Mauritius, and Seychelles Islands, respectively. For morphological comparisons, ethanol-preserved specimens of other taxa of Ensifera were prepared and examined from the insect collection of the Department of Integrative Zoology of the University of Vienna (Table 1). At least one male and one female of the non-gryllacridid Ensifera were used to

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