Digging for the offspring, or how to bury an orthopteran underground
(Insecta: Dictyoptera: Mantodea)

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Abstract

The females of several Mantodea bury their orthopteran underground. Some species do so regularly, mainly those living in arid habitats, most likely to protect the eggs from heat and drought. Four morphologically distinct types of digging devices have been recognized independently. Although the structures have been recognized before, their morphology is here compared in detail for the first time.

Introduction

Mantodea (praying mantids) are predatory poly- neopterous insects, comprising little more than 2,300 species, currently categorized in 15 “families” (Eisner 2002). The internal phylogenetic relationships are not yet completely understood, and autapomorphies for taxa within Mantodea have seldom been named. Evidence for the artificial nature of many of the major traditional groupings is based on molecular data (Sydenstricker & Whiting 2004). Mantodea living in arid habitats such as deserts and savannas face the problem of extreme heat and drought during the day and often extremely cold at night. While the nymphs and adults are adapted to such climatic conditions by morphological and behavioural traits (e.g. Chopard 1938), the mantodean ootheca are generally fixed to some kind of substrate (stones, wood, etc.) and have to endure the climatic conditions. Some species that usually lay their eggs above ground have been shown to bury them occasionally underground in captivity if the climatic environment is not suitable for egg development (e.g. Humbertiella cyanica Saussure, 1869; Müller 2001). The females of other Mantodea that bury their ootheca regularly underground (probably attached to a stone: Andrews 1941; Chopard 1941) have evolved special abdominal structures that help them to do so (Figs 1-5, 7). Although the presence of such structures has been recognized before (e.g. Green 1982; Chopard 1941; Chopard 1941), they are wider and shovel-like in appearance. They protrude from the tip of the abdomen and point dorsal. Morphological analysis revealed that the hooks originate from the distal parts of the gonapophyses of the eighth abdominal segment (i.e. the ventral valves). The two-parted hooks consist of a shorter, straight dorsal part and a longer ventral part that is curved dorsal.

Material & Methods

The external morphology of the following species was studied: Choristacris argiopus (Ogilby, 1844) (♂ & ♀), Eremiaphila typhon (Bates & Eastwood, 1859) (♂ & ♀), Ligaria trigonalis (Allant & Roux, 1826) (♂ & ♀), Ligariella trigonalis (Neumayer, 1889) (♂ & ♀). Specimens were studied from the following institutions: Zoologisches Museum der Universität Berlin (ZMB), Naturhistorisches Museum der Universität München (NHM), Zoologisches Museum der Universität Zürich (ZMB), Muséum National d’Histoire Naturelle, Paris (MNHN), and Lechevalier, Paris (Lc).

LITERATURE CITED


Discussion

The morphological origin of the digging devices (sternite 6, (medial) sternite 7, (dorsal) sternite 7, gonapophyses VIII) implicates that these structures have evolved independently at least four times. The Eremiaphilidae-like is synapomorphic for Eremiaphila and Humbertiella and strongly supports the monophyly of the group. While the hooks on the gonapophyses VIII support the monophyly of Eremiaphila and Humbertiella, the occurrence of a distinct digging device in Choristacris puts the monophyly of the traditional Choristacridae (that also encompasses the four former genera) in question. The Eremiaphilidae-like and the Rivetina-type are found mainly in the palaeartic region, whereas species exhibiting the Choristacridae- and the Ligerida-type can be found predominantly in the Afrotropics. The distributions of species exhibiting the different types of digging devices adjoin or overlap in western Africa (Eremiaphilidae-, Rivetina- and Ligerida-type in Senegal) and in eastern Africa (Eremiaphilidae- and Ligerida-type in Ethiopia, Kenya, Somalia). In South Africa, species of the Ligeridae- and the Choristacridae-type occur sympatrically. Several Mantodea that have been observed in captivity while depositing their ootheca underground exhibit digging movements with the tip of their abdomen in order to create a depression in which the ootheca is laid and covered with sand (Eremiaphila argiopus, Humbertiella cyanica, Humbertiella cyanica, see Müller 2001; Elaea, Rivetina, see Eisner 2002). Observations on Ligaria sp. (Schütte, pers. comm. 2008) support the occurrence of the depression but, although the typical sweeping behaviour has not been confirmed yet. Choristacris has not been observed to create a depression in captivity. While the morphological and phylogenetic structure of this type may hypothetically that the spines function as digging devices. Some Mantodea that usually deposit their ootheca above the ground choose to bury the ootheca underground if climatic conditions do not fit the requirements for proper embryogenesis (e.g. Humbertiella cyanica, see Müller 2001), even though they do not exhibit any related morphological structures (pers. obs. in Humbertiella sp. and Elaea marshalli). The wiping movements of the abdomen in order to dig a depression into the ground are apparently similar in species that exhibit specialized morphological digging structures (Eremiaphila, Rivetina) and in species that lack them (e.g. Elaea, Humbertiella, see Eisner 2001). Therefore, it can be hypothesized that in species that generally dig in the ground for egg deposition, supporting structures are positively selected in order to be thoroughly observed if the aforitropical taxa exhibit an egg-laying behaviour similar to that of the palaeartic species. A putative further type of digging device may be present in the monotypic Rivetina fraterna (Saussure, 1871), of which the females carry two spines on the posterior edge of both sternite 6 and sternite 7 (La Greca 1977; 24; Eisner 2002: 314). This case may provide further insight in the evolution of digging structures in Mantodea, but unfortunately specimens of Rivetina could not be studied yet.

Tentative Mantodea species from the Central Asian, North and South Americas, or Australian deserts, respectively, do not exhibit similar structures for burying ootheca below the surface. Future studies may reveal interesting insights into mantodean adaptations - both morphological and behavioural - to the life in and habitat.