ECOLOGY AND DIVERSITY OF CANOPY ASSOCIATED CERATOCANTHIDAE (INSECTA: COLEOPTERA, SCARABAEOIDEA) IN AN AFROTROPICAL RAINFOREST

Alberto Ballerio[1] and Thomas Wagner[2]
[1] *Viale Venezia 45, I-25123 Brescia, Italy, E-mail: alberto.ballerio.bs@numerica.it*
[2] *Universität Koblenz-Landau, Institut für Integrierte Naturwissenschaften – Biologie, Universitätsstr. 1, D-56070 Koblenz, Germany, E-mail: thwagner@uni-koblenz.de*

Abstract: Within a survey of canopy arthropods made by insecticidal fogging in the Budongo Forest, a semideciduous rainforest in Western Uganda, during the rainy season and the dry season, an unusually large number of Ceratocanthidae (Coleoptera: Scarabaeoidea) was collected. Five species were found: *Callophilharmostes fleutiauxii* (Paulian, 1943), *Petrovitzostes guineensis* (Petrovitz, 1968), *Philharmostes (Holophilharmostes) badius* Petrovitz, 1967, and *Philharmostes (Philharmostes) adami* Paulian, 1968, all recorded for the first time from Uganda, and *Carinophilharmostes vadoni* (Paulian, 1937). This is the best documented evidence of an association of Ceratocanthidae with the canopy of understory trees and the first time that this phenomenon is discussed. Furthermore, observations about seasonality, reproductive biology, sex ratio and abundance are presented.

Key words: Forest canopy; Uganda

1. INTRODUCTION

The Ceratocanthidae (formerly known as Acanthoceridae) comprise about 340 described species in 40 genera. They are small beetles (2–12 mm), usually very convex, capable of rolling their body up, with all body parts perfectly fitting together to form a compact ball. This group exhibits a pantropical distribution, with the majority of species occurring in tropical rainforests. The 15 genera and 73 species described from the Afrotropical

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region are distributed into four main centres of diversity, the Guineo-Congolian rainforest block, the Eastern Arc rainforests of Kenya and Tanzania, Madagascar and the afrotemperate forests of South Africa (Ballerio, unpubl. data). Most of the biology of these beetles is unknown. Most species are found in dead logs and leaf litter. They are supposed to feed on soft food, probably fungi (Scholtz, 1990). In recent literature (Choate, 1987; Hammond, 1990; Davies et al., 1997; Ballerio, 2000a) and in museum material (Ballerio, unpubl. data) there is scattered evidence of the existence of canopy dwelling species, collected by beating leaves at forest edges or glades, by canopy fogging or by netting, but this evidence has never been discussed or adequately highlighted.

Extensive collecting by canopy fogging in a semideciduous rainforest in Uganda provided sound evidence of an association of some ceratocanthid species with the forest canopy. It was possible to collect about 660 ceratocanthids belonging to five species. The aim of this paper is to discuss the results and to infer some data on the biology of canopy associated Ceratocanthidae.

2. METHODS

Research was carried out by Th. W. in the Budongo Forest Reserve in Western Uganda, around the field station of the Budongo Forest Project (1°45'N, 31°35'E), 1250 m a.s.l. This is a semideciduous rainforest consisting of logged compartments next to old primary forests and swamp forests (Wagner, 2000). The mean annual rainfall is about 1600 mm, with a relatively constant precipitation from March to November and a strong dry season from December to February.

Four tree species (*Rinorea beniensis* (Welwitsch ex Olivier), *Trichilia rubescens* Olivier, *Cynometra alexandri* C. H. Wright and *Teclea nobilis* Delile) were fogged in three different stands, as primary, secondary and swamp forest. Per site and season, eight conspecific trees were fogged, which is subsequently named "collecting unit". Trees were neither flowering nor fruiting and belong mainly to the understory with fogged tree heights between 7-20 m. Insecticidal fogging was made during the rainy season (June/July 1995) and during the dry season (January 1997) in primary, secondary and swamp forest, where 64 and 48 trees respectively were fogged. Further details can be found in Wagner (2000, 2001). Specimens were then prepared and labelled, and identified, dissected and sexed by A. B.

3. RESULTS

3.1 Taxonomic composition, diversity and abundance of the ceratocanthid community

The following five Ceratocanthidae species were collected by canopy fogging: *Callophilharmostes fleutiauxii* (Paulian, 1943) (Fig. 3b), first record for Uganda, *Carinophilharmostes vadoni* (Paulian, 1937) (Fig. 3a), *Petrovitzostes guineensis* (Petrovitz, 1968) (Fig. 3c), first record for Uganda, *Philharmostes (Holophilharmostes) badius* Petrovitz, 1967 (Fig. 3d), first record for Uganda, and *Philharmostes (Philharmostes) adami* Paulian, 1968, first record for Uganda. A total of 665 individuals were collected, which equals 1.45% of all beetles collected. Cerathocanthids are the most important scarab group to be collected, and this is the largest sample of Ceratocanthidae by canopy fogging ever found at one site. Apart from *Philharmostes (Philharmostes) adami* of which only two individuals were collected, of all other species gained by canopy fogging we found unusually high numbers (Fig. 1). Among mycophagous beetles, Corylophidae, Phalacridae and Latridiidae were common in the samples. The latter were the most abundant of all beetles collected (Wagner, 2000).

3.2 Specificity to tree species, forest type and seasonality

There is no evidence of association of any of the collected ceratocanthid species with any particular tree species. All ceratocanthid species have been collected in all three forest types and from all tree species examined (Fig. 1). *Rinorea* yielded the largest number of individuals, but most trees fogged belong to this tree species. In both wet and dry seasons, the secondary forest yielded the largest numbers of individuals.

The species composition of the ceratocanthid community does not seem to be significantly affected by seasonality, although the total number of individuals strongly decreased in the dry season compared to the wet season (dry season: 225 individuals, wet season: 488 individuals (53 individuals from *Teclea* and *Trichilia* trees, which were not collected during the dry season were eliminated from this comparison). We observed about the same species composition in the dry and wet seasons. However, the correspondence analysis highlights a stronger seasonal change in the primary forest (Fig. 2), while data from the secondary and swamp forest show no clear seasonal pattern. The secondary forest proved to be much richer in individuals and species during the dry season than the primary forest (182 individuals, four species, secondary forest; 21 individuals, two species,

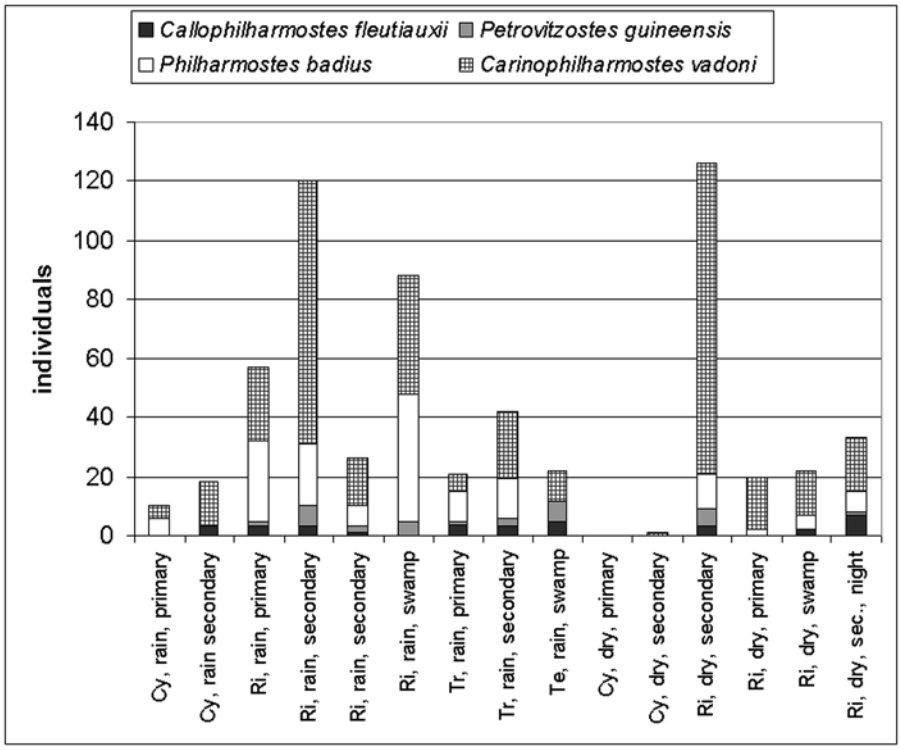

Figure 1. Number of ceratocanthid individuals collected by insecticidal tree fogging on eight con-specific trees (collecting unit: Cy: *Cynometra*, Ri: *Rinorea*, Tr: *Trichilia*, Te: *Teclea*) per season (rain, dry) and forest type (secondary, primary swamp).

primary forest). Another remarkable result is that the Ceratocanthidae during the dry season have been collected almost exclusively from *Rinorea beniensis* trees which are relatively small trees, offering a dense shady crown, which favours maintenance of humidity (Wagner, 2001). *Rinorea* trees growing in the secondary forest have also on average a smaller stature and denser leaf cover than in the other forest types. All these factors create a comparatively wetter microhabitat that can explain accumulation of Ceratocanthidae on these trees.

3.3 Effect of ant dominance on Ceratocanthidae abundance

In Budongo Forest ants are the dominant arthropod group, with 29.0% of all arthropods collected (Schulz and Wagner, 2002). This abundance of ants

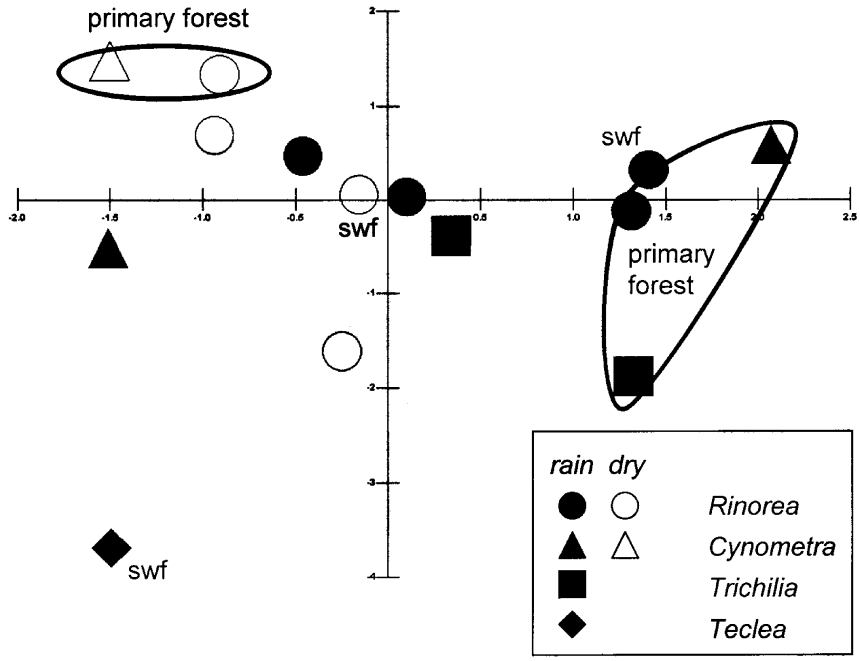

Figure 2. Correspondence analysis for five species and 665 individuals of Ceratocanthidae. Primary forest collecting units outlined, three collecting units from swamp forests marked (swf), all other markings from secondary forest.

seems to have a strong effect on beetle assemblages. The high number of individuals of Ceratocanthidae in Budongo Forest could possibly be explained by their capability of rolling up and avoiding ant attacks.

4. DISCUSSION

4.1 Species diversity and biogeographic patterns

The five species of Ceratocanthidae collected in Budongo Forest belong to the *Philharmostes* genus-group, which is endemic to tropical Africa and Madagascar (Ballerio, 2000b, 2001). The species of this group represent about one half of the Afrotropical ceratocanthid fauna and are usually found in leaf litter, in termite nests or by beating leaves in forests. The species found in Budongo show a typical Guineo-Congolian distribution, occurring from the Guinea Gulf countries eastwards to Uganda. They all are volant and

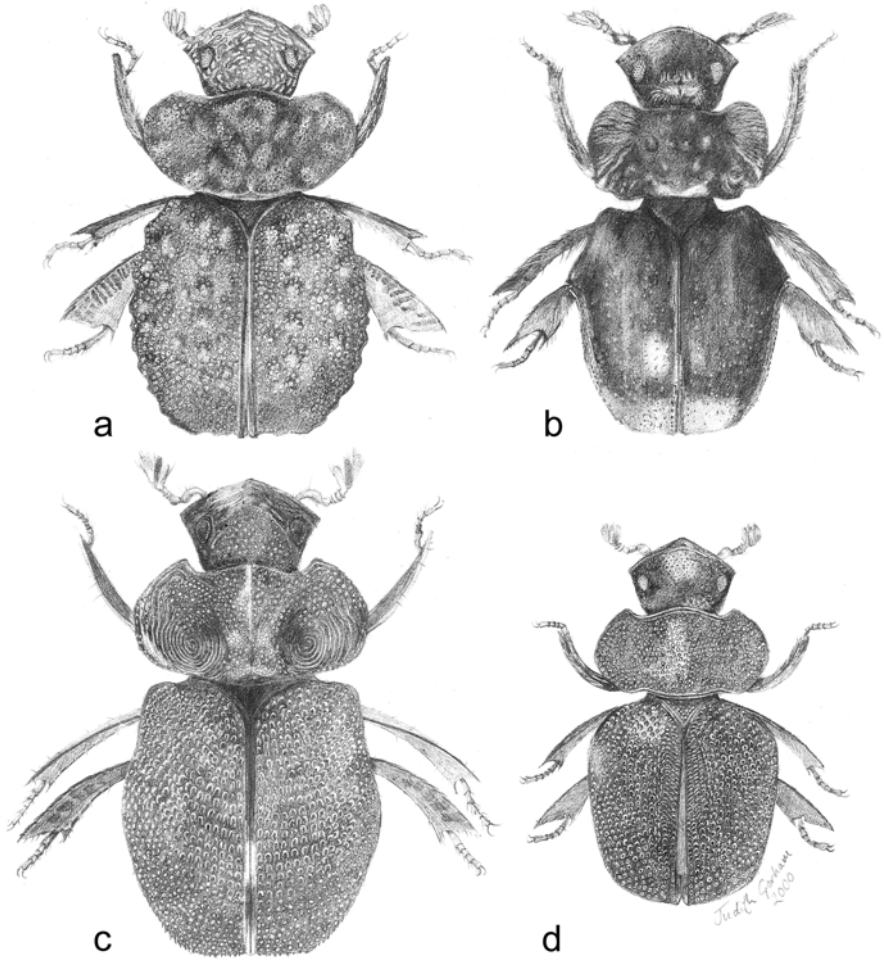

Figure 3. Habitus of *Carinophilharmostes vadoni* (a), *Callophilharmostes fleutiauxii* (b), *Petrovitzostes guineensis* (c) and *Philharmostes badius* (d).

seem to occur often syntopically all over their range. We are aware of at least four localities where all or at least three of these species occur together, i.e. the Budongo Forest (present paper), the Nimba Mountains (Paulian, 1993), Nkolentangan in Ecuatorial Guinea (Paulian, 1977) and the Kindamba region in Democratic Republic of Congo (Paulian, 1968, 1977).

4.2 Abundance and seasonality

There are no available data on the phenology of Ceratocanthidae, and this is probably the first time that quantitative data are recorded from both dry

and wet season for these beetles. Since there is no clear seasonal pattern, with exception of the primary forest, it may be that a dry season of two months in Budongo Forest is too short to cause a real change in beetle diversity and life cycle. The large number of individuals seems to be a distinctive trait of Budongo Forest, since canopy fogging with the same techniques in various other sites belonging to the same biogeographic and ecological region, such as gallery forests along the Akagera River (East Rwanda), Irangi (Congo) and Semliki Forest (Uganda), did not yield any Ceratocanthidae but one single specimen of *P. guineensis* from Irangi.

4.3 Sex ratio and reproduction cycle

We did not notice any significant difference in sex ratio between rainy and dry seasons. Particularly interesting is the observation that the majority of dissected females from both seasons had a very large spermatophore inside the bursa copulatrix. This indicates that mating had just occurred and this means that the reproductive season could be very extended or that there could to be two distinct reproductive seasons.

5. CONCLUDING REMARKS

Up to now, there are about ten genera of canopy associated Ceratocanthidae known, occurring in different parts of the tropics. Some of them show morphological and biological adaptations to life in the forest canopy, like *Eusphaeropeltis* Gestro, 1899 (Oriental Region) and *Ceratocanthus* White, 1842 (Neotropical Region), which represent two lineages with the most evident adaptations to arboreal life. The Guineo-Congolian genera found in Budongo Forest do not show such strong adaptations. Probably they live in rotten leaves and soil portion on larger branches and possibly feed on fungi growing on leaves and trunks, but this will be the topic of further research.

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