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REVIEW OF CAVERNICOLOUS FULGOROIDEA (HOMOPTERA AUCHENORRHYNCHA)

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ABSTRACT

So far eleven species of obligate subterranean Fulgoroidea representing five families (Hypochthonellidae, Delphacidae, Kinnaridae, Meenoplidae, Cixiidae) have been described. Recent findings of Cixiidae and Meenoplidae in subtropical and tropical caves (Hawaii, Western Samoa, Canary Islands, Thailand, Australia) have nearly tripled this number. For the first time in Fulgoroidea, varying degrees of cave adaptation (ranging from fully flighted epigean species to entirely flightless, blind and unpigmented forms) were observed in the monophyletic Australian cixiid genus *Solonaima* Kirkaldy from north-east Queensland.

KEY WORDS

Cixiidae, Solonaima, Australia, limestone caves, lava-tubes.

In total eleven Fulgoroidea species representing the families Hypochthonellidae, Delphacidae, Kinnaridae, Meenoplidae and Cixiidae have so far been reported not only to dwell but also to complete their life-cycle in subterranean habitats. It is hardly surprising that the majority of these cavernicolous species is found in Cixiidae: this group seems to be pre-adapted to life underground as the immature stages live in close vicinity to or within the soil feeding on roots. Recent investigations in caves on the Hawaiian Islands, the Canary Islands, Western Samoa, Thailand and Australia by Dr. F.G. Howarth (Honolulu, Hawaii), Dr. F.D. Stone (Hilo, Hawaii), the GIET (Grupo de Investigaciones Espeleológicas de Tenerife, La Laguna, Spain) and ourselves have shown that far more Fulgoroidea species have changed to a life in permanent darkness and are far more widespread than was previously assumed.

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[2] First results of these studies are (or will be) published in: Hoch & Howarth (in press), Howarth et al. (in prep.), Howarth & Stone (in prep.), Izquierdo et al. (1986), Remane & Hoch (in press).

New cave-dwelling Meenoplidae could be found in the laearctic (Canary Islands), in South-East Asia (Thailan the Pacific (Western Samoa) and in Australia (Queenslan New cavernicolous Cixiidae were found in Hawaii, the Can Islands and in Australia (Queensland).[2]

For the first time in Fulgoroidea, varying degrees cave adaptation were observed among six closely related sp cies of the Australian cixiid genus *Solonaima* Kirkaldy (Hc & Howarth, in press). By means of the special configurati of male and female genital characters this genus is mc likely monophyletic. *Solonaima* is represented with sev species in the epigean fauna of Queensland. The six new c vernicolous species occur allopatrically in different, is lated caves on the Cape York Peninsula. They are the resu of at least four separate cave invasions and show gradu adaptation to the cave environment:
S. sullivani shows virtually no modification from the su face relatives (besides slight eye-reduction) and is cons dered a facultative (troglophilic) cave species. *S. pholet* and *S. stonei* display some eye- and wing-reduction, but a still flighted and also regarded facultative (troglophilic cave species. *S. halos* and *S. irvini* are nearly blind; th wings are reduced and non-functional. These species are pig mentless and considered obligate (troglobitic) cave species *S. baylissa* is eyeless, pigmentless and the wings are stron gly reduced; this species is an obligate (troglobitic) cav species. All species are well separated morphologically b the male genital structures; the existence of a hybrid bel between epigean and cavernicolous populations can thus b excluded. The geology of the caves is complex and range from greater than 5 million years old caves in Silurian-age limestone (Chillagoe Karst; Mt. Mulgrave region) to 190,00 year old lavatubes within the Undara lavaflow. Surprisingly, no correlation exists between the geologic history or ages of the caves and the degree of cave adaptation. The troglomorphies displayed are strongly correlated with the physical environment: the three facultative cave species are generally found in open caves, the two intermediate obligate cave species are found in deeper caves and the most highly modified species is restricted to passages with high CO_2-concentration and saturated atmosphere.

These findings suggest that the varying degree of troglomorphy among *Solonaima* species is due to different selection pressures brought about by different environmental conditions. It is still unclear, however, why these species gave up life above ground. Today the climate in this part of Australia is highly seasonal of alternating humid or arid tropical type (Ford, 1978) with extremely dry winters (april to october). The surface vegetation is of open savannah-grassland type. Epigean *Solonaima* species are found today in rainforest biotopes along the mountain ranges parallel to the east coast of Queensland. Palaeoclimatic data suggest that rainforest cover was widespread in the early Miocene. From middle Miocene on the climate became drier, the rainforest was locally replaced by grasslands, and in the late Miocene rainforest vegetation retreated rapidly. This vege-

tation shift might be related to increases of aridity associated with Antarctic ice expansion (Kemp, 1981). Both the retreat of the rainforest and the climatic changes might have urged *Solonaima* populations to seek possibilities for survival (e.g. food, moisture) within caves where they acquired cave adaptations after their surface relatives had either died out or retreated together with their rainforest habitats. Further studies must show whether or not the relict species model applies to the cavernicolous *Solonaima* species.
It is worth mentionning that so far only comparatively few caves both in limestone and in lavaflows in Australia have been investigated. In the Karst around Chillagoe there are many more caves, and many of them are known to contain roots as the essential food ressource for cavernicolous Fulgoroidea. Moreover, there are more than 300 isolated limestone towers exposed in a line from south of Chillagoe north over 150 km to near Palmerville. Each of these towers might have its own cave-dwelling *Solonaima* species.

Similar situations may also be found in other parts of the world. Considering the fact that the investigations of only the last seven years have increased the number of cavernicolous Fulgoroidea for nearly 200%, we should expect a further increase of this number in the future, provided that more investigations are carried out both in lavatubes and limestone caves. Especially oceanic islands seem to to promising as recent discoveries on Hawaii, Western Samoa and the Canary Islands have shown.

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