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ON THE TOXIC DIET OF DAY-FLYING MOTHS IN THE SOLOMON ISLANDS (LEPIDOPTERA: ARCTIIDAE)

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Ten thousand species of tiger moths (Arctiidae), among other day-flying moths, form many warningly colored Müllerian mimicry complexes world wide, in which adult individuals have been shown to contain toxic substances. Probably due to these protective substances against bird predation, many species have been able to become diurnal fliers. It has been shown, for example, that laboratory rats die when injected with a dose of arctiid alkaloid (Schoental and Magee, 1959). Therefore, one can reasonably assume that a natural predator will at least get sick after tasting these brightly colored (and thus memorable) insects, and will avoid them in the future.

Arctiid caterpillars often feed on alkaloid-rich host plants, and it was originally thought by lepidopterists that the toxicity of both larvae and adults is determined by the noxious substances ingested with the leaves. However, it has been also suggested that the toxic substances are synthesized *de nova* by arctiids. In fact, it is the ability to neutralize their own noxious compounds that allows moths to inactivate the chemical defense of the plants (Rothschild *et al.*, 1979).

The attraction of danaid butterflies to some Boraginaceae plants has been known for a long time. Pyrrolizidine alkaloids (PA's) that are obtained through feeding on decomposing plant matter by adult butterflies are used to synthesize danaidone. This compound is found in the pheromone secretion of the hair-pencil organ in males, and serves as a sexual attractant (see Ackery and Vane-Wright, 1984, for review).

Similarly, the significance of PA's in the reproductive biology of arctiids has been studied extensively. Thus, it was shown that alkaloids ingested by the larvae of *Creatonotus gangis* (Linnaeus) influence the morphology and chemistry of coremata (large abdominal hair-covered tubes, which are expanded by a male during the courtship, emitting pheromones (Boppre and Schneider, 1989)).

The main compound responsible for the scent can be secreted only when PA's are present in the larval diet. The size and weight of coremata are also proportional to the amount of alkaloids ingested by the larva (Schneider et al., 1982). Creatonotines, alkaloids specific to *Creatonotus* moths, were proved to be synthesized from the PA's ingested by larvae in the biochemical laboratory of the adult moths' body (Hartmann *et al.*, 1990).

Recently, we observed the well known phenomenon of butterfly attraction to PA's in the Solomon Islands, when hundreds of *Euploea* danaids came to the dying leaves, branches and decomposing plant matter of Tree Heliotrope (*Tournefortia argentata*, Boraginaceae). Local people of New Georgia (one of the Solomon Islands where the congregations occurred) call the heliotrope a "butterfly tree." Amazingly, even old charred coals and half-burned branches of this coastal plant were loaded with feeding butterflies.

Besides danaids at these trees, there were hundreds of brightly colored arctiids: most were *Euchromia collaris* Swinhoe of the Old World wasp-moth subfamily Syntominae, while several species were Aganainae (Noctuidae), in the genus *Asota*. Moths also were attracted to the damaged and wilting plants, feeding on sap exuded from leaves and branches. Knowing the role of PA's in butterfly biology, one could assume that in moths the alkaloids are used for chemical defense against predators, or for pheromone production, or both.

However, elaborate experiments on several tiger moth species in Florida (Goss, 1979), suggest rather that moths are seeking PA's as nitrogen-rich nutrients, which they utilize differently depending on their sex. In Goss' experiments, the males deprived of PA's were found to have no disadvantage during sexual selection. Nor were they more defenseless against the predators. However, the egg productivity by females who were mated to PA-deprived males was significantly lower than that of females whose mates had a chance to feed on PA-containing plants.

Only young males usually feed on PA's, subsequently passing nutrients with the spermatophore to a female during the copulation. The spermatophore is then stored in the female's bursa copulatrix and is used up gradually. Unlike males, females seek PA's after they spend several days on the wing. Alkaloids apparently are metabolized by females, enhancing egg production in their nutrient-depleted abdomens. For an unknown reason, only males or only females were observed by Goss feeding on the alkaloids in the wild for each species. On the Solomons, either sex was present for species observed by us, and even mating occurred at the congregation sites.

The exact reasons for the phenomenon described above are yet to be understood. In fact, there could be multiple biochemical mechanisms, which underlie the attraction of moths to various alkaloid-containing plants. Animal-plant interactions may vary with species, as it is the case, for example, with the corremata-size dependence on alkaloids ingested by larvae. Though such dependence was proved by Boopre and Schneider (1985) for the genus *Creatonotus*, similar experiments showed no such morphogenetic effect of the diet on corremata in another arctiid genus, *Haploa*, despite the fact that the corremata were shown to play a key role there in sexual selection (Davidson *et al.*, 1997). The more field observations and experimental data which become available, the higher the chances are for the correct telling of a story of symbiosis and co-evolution between different plants and animals. *Asota* adults have not been studied for possible alkaloids, as far as we know, but they do exude fluids when held by the thorax, presumably an alkaloid fluid: these moths were once thought to be arctiids but are now classified in their own subfamily (Aganainae) in Noctuidae (some specialists even give them family status of their own).

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Fig. 1. Day-flying moths attracted to the tree heliotrope (*Tournefortia argentata*), the coastal Boraginaceae plant (lower left): a) *Asota* sp. (Noctuidae: Aganainae); b) arctiids and an *Asota* moth; c) tree heliotrope; d) a wasp moth (Arctiidae: Syntominae).

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