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FIELD RECORDS AND OBSERVATIONS OF INSECTS ASSOCIATED WITH CANTHARIDIN

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ABSTRACT

This paper reports on insect species not previously associated with cantharidin, the terpenoid defense mechanism of blister beetles (Meloidae). Species from the following taxa were observed and collected: Miridae (Hemiptera); Endomychidae, Pyrochroidae, Anthicidae (Coleoptera); Ceratopogonidae, Sciaridae (Diptera); and Braconidae (Hymenoptera). In addition to listing the associations, a discussion of cantharidin orientation is presented along with preliminary hypotheses to explain these intriguing examples of coevolution.

A recent review (Young 1984) attempted to draw together all published associations between insects and cantharidin or the meloid beetles which are known to produce the compound. In this paper, a large number of insect-cantharidin records are reported for species not previously associated with cantharidin.

METHODS

Many of the records listed below came from a cantharidin baiting technique I developed during my studies on North American *Pedilus*. Baits were made by dissolving cantharidin crystals in acetone, and then pipetting the solution onto filter paper disks. For the sake of uniformity, a 10^{-2} *M* solution of cantharidin in acetone was utilized and 0.5 ml were added to each piece of Whatman #2, 5.5-cm filter paper. The acetone quickly evaporated, leaving the cantharidin impregnated between the fibers of the filter papers which were kept in plastic petri dishes (two to a dish).

More recently a "jar-trap" was utilized. The baited filter papers were prepared as above, but then suspended by thin wires from a window screen funnel in the opening of a wide-mouthed quart jar. When live-trapping, the bottom of the jar was left empty or covered with dampened tissue paper. Otherwise, ethylene glycol was added as a killing and temporary preservation fluid. For both the baits and jar traps, controls were prepared and run on numerous occasions by going through the same preparation steps as outlined above, without adding cantharidin to the acetone. In general, a collection record was considered valid if three or more specimens of the species in question were recovered from two or more baits (or traps) within the same site on a given date, or from a given site on two or more dates, or from two or more sites. Records are accompanied by state or province distribution data. Voucher specimens are deposited in the collections of the author, other individuals, and the entomological research collections at Michigan State University and the University of Wisconsin.

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NEW RECORDS OF INSECTS ASSOCIATED WITH CANTHARIDIN

HEMIPTERA

MIRIDAE

Orthotylinae

Hadronema breviata Knight, California.
H. princeps Uhler, Wyoming. Of 12 specimens only one is a male. (R. T. Schuh, in litt.).
H. uhleri VanDuzee, MEXICO, Baja California. All 13 specimens are females (R. T. Schuh, in litt.).
H. uniformis Knight, California.

Bryocorinae

Caulotops spp., Arizona; MEXICO, Baja California.
Eurychilella sp. near *pallida* Reuter, MEXICO, Oaxaca.
Halticotoma valida Townsend, Colorado.
Halticotoma sp., Idaho.
Pycnoderes quadrimaculatus (Guerin-Meneville), Florida, Michigan; MEXICO, Oaxaca.
Pycnoderes sp., Michigan.
Sixeonotus brevirostris Knight, Louisiana.
Sixeonotus sp. near *brevirostris* Knight, Idaho.
S. insignis Reuter, Michigan, New York.
S. tenebrosus (Distant), Florida.
Sixeonotus spp., California, Idaho, Michigan; MEXICO, Oaxaca, Puebla.
Sysinas linearis Distant, MEXICO, Puebla.

COLEOPTERA

ENDOMYCHIDAE

Eumorphinae

Aphorista laeta (LeConte), California, Idaho.
A. vittata (Fabricius), Michigan.
Lycoperdina ferruginea LeConte, Massachusetts, Michigan, Wisconsin; CANADA, Saskatchewan.

Stenotarsinae

Danae testacea (Ziegler), Michigan, Ohio, Wisconsin.

PYROCHROIDAE

Pyrochroinae

Neopyrochroa femoralis (LeConte), Michigan, Ohio, Wisconsin. Only males have been taken at cantharidin.
Schizotus cervicalis Newman, Michigan, Wisconsin; CANADA, Quebec. Specimens were observed between mid-morning and early afternoon; all were males.

ANTHICIDAE

Anthicinae

Acanthinus scitulus (LeConte), New Mexico.
Anthicus punctulatus LeConte, California.
A. sonoranus Werner, MEXICO, Baja California.
Formicilla munda LeConte, New Mexico.

Formicomus consul LaFerté, THAILAND.
Formicomus sp. (*lewisi* Marseul?), THAILAND.
Mecynotarsus falcatus Chandler, New Mexico.
M. obliquemaculatus Marseul, THAILAND.
M. vagepictus Fairmaire, THAILAND.
Notoxus bifasciatus (LeConte), Michigan.
N. filicornis Casey, Florida.
N. photus Chandler, Arizona.
N. seminole Chandler, Florida.
Sapintus javanus (Marseul), THAILAND.
S. plectilis (Pic), THAILAND.
Tomoderus spp., Florida, Illinois, Missouri.

DIPTERA
CERATOPOGONIDAE
Forcipomyiinae

Atrichopogon geminus Boesel, Louisiana, Michigan.
A. levis (Coquillett), Arkansas, Idaho, Illinois, Michigan.
A. maculosus Ewen, Louisiana.
A. websteri (Coquillett), California, Louisiana, Michigan.
Atrichopogon sp. near *websteri* (Coquillett), Michigan.

SCIARIDAE

(undetermined sciarids), California, Michigan.

HYMENOPTERA
BRACONIDAE

Blacus ruficornis (Nees), California. All of the nine specimens were male (S. Shaw, in litt.)
Streblocera near *pulvillicornis* Walley and MacKay, Michigan. All were females.
Syrrhizus agilis (Cresson), California, Michigan. All were females.

DISCUSSION

Pinto (1978) concluded his paper on mirid "parasitization" of meloids by suggesting that the mirids were primarily phytophagous, and that their relationship with meloids was ancillary to their primary food sources. If plant feeding on the part of cantharidin-orienting Miridae represents a plesiomorphic character state, then Miller's (1956) hypothesis relative to the evolution of a predaceous life style merits stating:

> "The adoption of a carnivorous habit probably has its origin in the ease in which a primitive phytophagous bug could alternate the sucking of plant sap with the piercing of small insects associated with the same host plant."

There would, at this incipient stage of predatory development, appear to be little selective pressure relative to gross modifications of such complex structures as the mouthparts, as has been noted for many predaceous Heteroptera. In this regard, it should be pointed out that cantharidin-orienting mirids appear to possess no such modifications. However, they clearly orient to the chemical even when meloids and host plants are entirely removed as variables. If cantharidin receptors evolved in response to the presence of meloids, I would suggest that Pinto's conclusion might be better stated in reverse: the cantharidin-orienting mirids appear to be near obligate, free-living ectoparasites which may still rely upon plant juices in an ancillary way.

Unfortunately, I have frequently collected large numbers of bryocorine mirids at can-

tharidin under circumstances wherein they would rarely if ever encounter meloids. For these taxa, one or more of the following hypotheses bear consideration:

1) Cantharidin receptors evolved in an ancestral lineage which preyed upon meloids. While the species in question may no long rely upon meloids as a primary food source, the sensory apparatus persists.
2) Cantharidin, or a related compound, is utilized by the mirids as a pheromone, defensive compound, or both.
3) Cantharidin, or a related compound, is present in the host plants with which the mirids coevolved.

With respect to the first hypothesis, it should be noted that species richness for both meloids and cantharidin-orienting mirid taxa is greatest in the tropics. Although meloid predation might be common in the tropics, some of our temperate mirids could have secondarily lost their reliance on this food source as they radiated northward and explored new resources.

The second and third hypotheses share the notion that cantharidin, or a closely related compound, is produced by organisms totally unrelated to meloids. Within the Ranunculaceae, a number of species have been reported to cause cantharidin-like blistering of epithelial tissue (Mitchell and Rook 1979). The vesicant, protoanemonin, is believed to be produced from the glycoside, ranunculin. Protoanemonin is the precursor of anemonin, a compound characterized by Mitchell and Rook as being related to cantharidin.

The handsome fungus beetles frequent fungi and molds on which they feed and mate. Endomychids have been observed mating and apparently feeding on the cantharidin-baited filter papers. Since cantharidin is a terpene and such compounds abound in the plant kingdom, it seems plausible that cantharidin mimics some terpenoid fungal metabolite which certain endomychids may in turn utilize to locate a potential host fungus. The same hypothesis may account for the sciarids observed at cantharidin.

Few evolutionary hypotheses regarding cantharidin orientation in Pyrochroidae and Anthicidae have been proposed. However, these families, together with the Oedemeridae, Meloidae, and several others, are all thought to be closely related in a phylogenetic sense. Perhaps cantharidin or a closely related compound was present in the ancestral stock which eventually gave rise to these taxa. Clearly, the chemical has evolved largely as a defense mechanism in the Meloidae and Oedemeridae. The proponderance of male pyrochroids and anthicids orienting toward cantharidin would seem to imply that the compound serves, at least in part, as a sex pheromone as Abdullah (1965) suggested for the anthicids. An alternative, or additional, function might be that of an aggregating pheromone, as has been suggested for some of the Meloidae (Richard Selander, pers. comm.) and Anthicidae (Abdullah 1965).

Scott Shaw (in litt.) suggested that the *Blacus* (Braconidae) may represent an accidental catch since males of *ruficornis* are known to swarm. However, the nine specimens came from several different baits over the course of three days. While not directly involving cantharidin, *Syrrhizus agilis* has been demonstrated to develop as an endoparasitoid in adult *Notoxus anchora* Hentz in Ontario (Loan 1972).

My wife and I noted oviposition behavior by an unidentified female braconid on an adult *Notoxus cavicornis* LeConte from Mariposa County, California; the observations were made while the specimens were on a cantharidin bait. A similar situation was reported by R. A. Wharton (in litt.) in El Dorado County, California, for a presumed *Syrrhizus* female and an unidentified *Notoxus* adult. Thus, both of these braconids appear to utilize adult anthicids (*Notoxus* spp.) as hosts. They also orient toward cantharidin whether anthicids are present or not. These observations support the hypothesis that at least certain species of Anthicidae contain cantharidin or a closely related compound.

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