

Pyrrolizidine alkaloids: morphogens regulating specifically the growth of androconial organs in several arctiine moths (Lepidoptera)

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... we are in search for co-operation partners ...

Morphogenesis in *Cretonotos*

While investigating chemical communication with male pheromones in butterflies and moths, Dietrich Schneider and M.B., ('a while ago', i.e. back in 1981) found that the size of the coremata of the arctiines *Cretonotos gangis* and *C. transiens* varies with diet. Males from larvae reared on plants devoid of pyrrolizidine alkaloids (PAs) or on artificial diet had minute scent organs (core-mata), in males the larvae of which had access to PAs coremata were enormous (Figs 1, 2). There is a dose-dependent morphogenetic effect of these secondary plant metabolites, which is limited to the coremata; all other morphological features remain unaffected. However, pheromone biosynthesis also depends on PAs, i.e. tiny coremata do not emit pheromone while large ones synthesize amounts of up to 500µg/male.



Fig. 1 Male *Cretonotos gangis* displaying its coremata

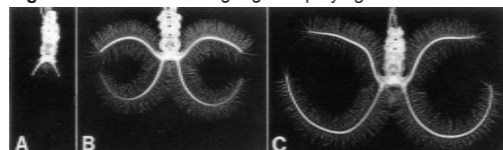


Fig. 2 Artificially expanded coremata of a male reared on food free of PAs (A) and organs of males, the larvae had consumed PAs (B, C)



Fig. 3 Caterpillar of *Cretonotos* consuming a glass-fibre disk impregnated with PAs

Thus, dietary PAs have three functions: to regulate growth of coremata, to enable pheromone synthesis, and to serve chemical protection.

For larvae of *Cretonotos*, pure PAs are feeding stimulants (Fig. 3). It is thus not only possible to bioassay the specificity of the receptor system for detecting PAs but also to make larvae consume pure PAs in known amounts. It is also possible to use PAs as an ingredient of an artificial diet.

Cretonotos store plant PAs (partly modified) for defence, and males – via spermatophores – transfer these chemicals to the females.

Much knowledge exists on structure-activity and on quantitative relationships (Boppré *et al.* unpubl.). The PA competence (sensitivity) of the epidermal corema anlage terminates with the first prepupal day. While the dietary PA specifies the size of the organ (quantitatively through the number of mitoses of its cells and of endomitotic steps of the hair cells), ecdysone is required to induce proliferation of the

Further cases

Teracotona, *Aloa* and *Pericallia* are arctiines from Africa and SE-Asia, respectively. Species of these genera have differently structured core-mata, and



Fig. 4 Coremata of *Teracotona* sp.

we observe great variation in their size; in contrast to *Cretonotos*, the morphogenetic effect is less pronounced although obvious



Fig. 5 Coremata of *Aloa* sp.

(Boppré *et al.* unpubl.). Recently, Davenport & Conner published on a morphogenetic effect in *Estigmene* and more cases are likely to be found.

Research perspectives

We have four systems of specific and dose-dependent regulation of organ growth by non-nutritional secondary plant metabolites. We can rear them routinely, PAs can be fed quantitatively, pure PAs and metabolites are available for experiments, and methods to analyse PA-metabolites are established.

In our view, these systems are ideal for studying "Shaping Cells into Organs". However, basically, we are chemocologists and have neither experience nor equipment for doing cell cultures, for working with antibodies, for genetic or enzyme studies etc. We therefore consider it wise to co-operate with a team competent in organogenesis

If you are interested in co-operating, please, contact us!

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Cretonotos

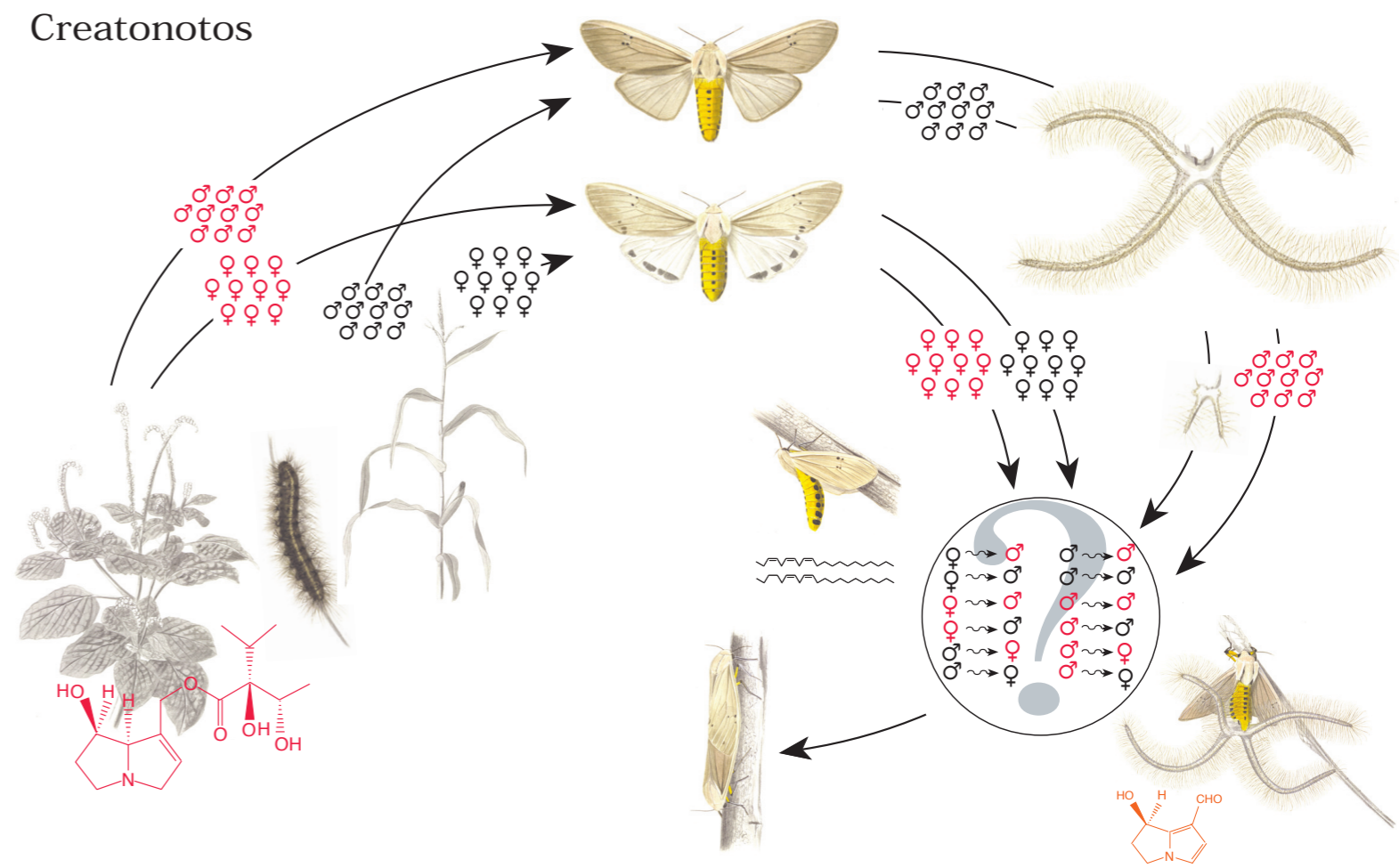


Fig. 6 Scheme of relations of *Cretonotos transiens* (Arctiidae) to pyrrolizidine alkaloids. The caterpillars are polyphagous and feed on a wide spectrum of hostplants. If they contain PAs, these secondary metabolites are being stored for protection against predators. In males, PAs specifically determine the growth of the coremata, and they serve as precursors for biosynthesis of hydroxydanaidal in addition. Courtship behaviour is not yet understood; perhaps, several mate-finding mechanisms exist, depending on the outfit of the individual with PAs, i.e. depending on the larval hostplant(s).

Pyrrolizidine alkaloids (PAs)

are a large group of ester alkaloids of diverse structure. They are composed of a necic acid and a necine alcohol forming open-chain mono- or diesters or macrocyclic diesters; in nature (in plants as well as in insects which store them) they are usually present as N-oxides. Vertebrates metabolize 1,2-dehydropyrrolizidines into "pyrroles" that are, e.g., hepatotoxic. About 370 structures of PAs have been identified in 560 species of plants, mainly belonging to the families Asteraceae (Eupatorieae, Senecioneae), Boraginaceae and Fabaceae; in general plants produce mixtures of several PAs.

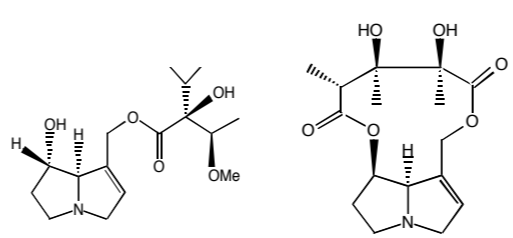


Fig. 7 Molecular structures of the pyrrolizidine alkaloids heliotrine and monocrotaline, both acting as morphogens

Androconial organs

occur in many species of Lepidoptera. There are no commonalities, except that they all are composed of glandular cells associated with scales / hairs. Androconial organs can occur as glandular scales scattered on the wings but also as brushes of hairs at almost any part of the body which can be everted directly by muscles, hydraulically, or pneumatically.

Usually, androconial organs come into play in close-range courtship behaviour; in *Cretonotos*, *Teracotona* and *Aloa*, however, the males display these organs independent of the presence of a female – probably the function is the formation of leks to which both sexes are attracted.

The coremata of *Cretonotos* are inflated pneumatically, i.e. the organ is expanded by air pumped into it through the tracheal system. Each of the up to 300 hairs on the tubes is associated with a glandular cell.

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