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On the term describing the post-embryonic development of Diaspididae female (Sternorrhyncha Coccoidea)

Abstract - The term catametabolism is here reintroduced and redefined in order to describe the post-embryonic development of diaspidid females. The three-stage scheme has been considered, until now, erroneously as neoteny. This stress the striking difference between catametabolism and neoteny as from the literature and from observation. Catametabolism is defined as a post-embryonic developmental scheme showing an early specialization through a morphological simplification; life cycle shortening is considered part of the catametabolic process indeed. The occurrence of catametabolism in all the known species of Diaspididae suggests that this term should be reported in the diagnosis of this taxon. The occurrence of neoteny and catametabolism in other Families of the Coccoidea is suggested.

Key words: Pupillarial forms, phylogeny, armoured scale.

PREFACE

Post-embryonic development follows different schemes in many taxa of insects. Coccoidea show deep changes in life history so that the typical post-embryonic scheme of heterometabolous insects does not fit the expected sequence. Moreover the females of Diaspididae develop through a peculiar series of three strongly modified instars.

Recent reports of this topic are by Sehnal (1985), Takagi (1990), Ben-Dov (1990) and Koteja (1990) who consider the females of Diaspididae to be neotenic. All seems to be based on a paper of Börner (1910).

Neoteny is a term describing the development scheme into which a larval soma stops its development before expected, develops a *fully functional reproductive apparatus* and becomes able to give birth to young while retaining its juvenile appearance. This phenomenon is well known in biology (both in zoology and botany) and some researchers consider it to be a major step in evolution (Taktajan, 1991; Willmer, 1991). The description reported by Sehnal (l.c.) fits well to insects, in fact in *Duliticola* (Coleoptera: Lycidae) the reproductive female maintains the larval shape and does not pass a pupal stage.

The post-embryonic development scheme of many Coccoidea (i.e. mostly lecanoid groups) respects the definition of neoteny but that of Diaspididae does not. Some observations and discussions about the use of the term Catametabolism to describe the post-embryonic scheme of Diaspididae follow.

SOME OBSERVATIONS

In my opinion several aspects of the morphology of the "adult" female of armoured scales reject the use of the term neoteny to describe the post-embryonic development of this taxon. In fact the diaspidid "adult" female cannot be credited to retain a juvenile appearance because of its body shape, legless condition and reduced antennae, which are all clearly definitely different from their homologues in the first-instar nymph. The adult female diaspidid is definitely different from its crawler.

Another clear difference between neoteny and catametabolism is that the former acts *at the end of post-embryonic development* whereas the latter acts *at the start*. In short, there is a factual difference between neoteny and catametabolism: a neotenic "adult" is morphologically a large nymph and represents the last instar after the abbreviation in life-cycle (a reproductive lecanoid female is an example), whereas a catametabolic adult is definitely different from its first-instar nymph (and a diaspidid reproductive female is an example).

From a practical point of view, we ca easily discern between a second instar larva of Diaspididae and that one of Pseudococcidae while to distinguish between second instar larva of Pseudococcidae and (i.e.) Eriococcidae is not so easy.

A SHORT DISCUSSION

On the basis of the above observations, the use of the somewhat forgotten term "catametabolism" is here re-proposed to describe the type of post-embryonic development that gives rise to a simplified adult, as occurs in Diaspididae, in agreement with Grandi (1945, 1969). Even retaining the term of Grandi, for a matter of usefulness (it is widely used by Italian students; Tremblay, 1982), a couple of topics suggest the need for a re-touching of Grandi's description of catametabolism, as reported below from the version published in 1969:

"Catametabolism" (1) - A type of metamorphosis characteristic of some heterometabolous and holometabolous insects, which during postembryonic development undergo an *involutional process* of one or more organs, which induces the formation of an *adult less differentiated in its body structure* than its preimaginal instars, or, at least, so formed that it is not possible to consider its ontogenetic

(1) cata- a prefix, from the Greek κατα =down, downward, away; metabolism - from Greek μεταβολη, ης =change.

evolution arrested and, hence to regard it neotenic. These *retrograde metamorphoses*, well-known in other Metazoa and particularly in the crustaceans, are undergone, for instance, by the females of some Pseudococcini, Margarodini and by those of the, Diaspini among the Coccidae (Rhynchota Homoptera), by the females of the Heterogynidae and of some Psychidae among Lepidoptera; by the females of the Stylopoidea among Strepsiptera, etc."

The questionable statements are in underlined italics (my emphasis) in the upward above descriptions. My personal opinion on them follows:

The retained *involutional process* means to me something of degenerating and approaching the death of the individual. Moreover the so described *adult less differentiated* in its body structure seems to be a definitely incorrect statement: the diaspidid adult female is very differentiated and evolved. In fact differentiation is just expressed by simplification rather than by complication. The last, but not the least, the *retrograde metamorphoses* is a strange concept: metamorphoses is a process of transformation from one morph to another, so that it is virtually impossible to retrogress during development. Clearly Grandi's statement was written from the viewpoint that more complex meant more evolved. Such a view no longer pertains in either ontogenetic or evolutionary studies. On the contrary there is, today, a general agreement that "reduction is a major trend in evolution", and according to this we can consider the secondarily simplified (as well as the specialized) taxa more evolved.

A PROPOSAL

A re-touched description of catametabolism is proposed:

Catametabolism(2) - A type of metamorphosis of some heterometabolous and holometabolous insects, which - during postembryonic development - undergo a simplification process. Such a process gives rise to an adult much more specialized in its body structure than its preimaginal instars. The catametabolic individual is so modified that it is impossible to consider it simply the result of a terminally abbreviated ontogeny and, hence, to regard it as neotenic. This kind of metamorphosis describes a morphological specialization and a phylogenetic pathway. Classical examples are: females of Diaspididae (Rhynchota: Cocccoidea), females of some Heterogynidae and Psychidae (Lepidoptera) and females of the Stylopoidea (Strepsiptera).

Other examples from scale insects are female of: *Limacoccus*, *Halimococcus* and *Phoenicococcus*.

The table below reports a proposed scheme of post-embryonic development for all the Coccinea that are arranged in families following Kosztarab (1996). The Taxa was retained to be Neotenic by the presence of more or less developed legs and antennae in adult female. Taxa with no legs and very reduced antennae with a three instar scheme

(2) The *derivatio* of the term Catametabolism is the same as in Grandi. Catametabolic is suggested as adjective, i.e. "catametabolic species".

are retained catametabolic. In this arrangement Asterolecaniidae show considerable convergence with the catametabolic pattern.

Diaspididae	Catametabolic
Beesonidae	Catametabolic (Foldi, 1995);
Halimococcidae	Catametabolic (Stickney, 1934; Deitz, 1979);
Phoenicococcidae	Catametabolic (Stickney, F.S.; 1934);
Kerridae	Neotenic (Chamberlin, 1923);
Micrococcidae	Neotenic (Sivestri, 1939);
Coccidae	Neotenic (Matile-Ferrero, 1997);
Aclerdidae	Neotenic (Kosztarab, 1996);
Stictococcidae	Neotenic (Sivestri, 1939);
Lecanodiaspididae	Neotenic (Howell & Kosztarab, 1972);
Cerococcidae	Neotenic (Lambdin & Kosztarab, 1977; Howell et al. 1971);
Asterolecaniidae	Neotenic (Kosztarab, 1996);
Dactylopiidae	Neotenic (Pérez Guerra & Kosztarab, 1992);
Kermesidae	Neotenic (Bullington & Kosztarab, 1985; Baer & Kosztarab, 1985);
Cryptococcidae	Neotenic (Kosztarab 1996);
Eriococcidae	Neotenic (Leonardi, 1920);
Pseudococcidae	Neotenic (Leonardi, 1920);
Phenacolechiidae	Neotenic (Morrison & Morrison, 1922);
Concaspididae	Neotenic (Williams, 1992);
Ortheziidae	Neotenic (Leonardi, 1920);
Carayonemidae	Neotenic (Richard, 1986);
Margarodidae	Neotenic (Leonardi, 1920).

SOME FINAL CONSIDERATIONS

The fact that all Diaspididae undergo this kind of specialized metamorphosis strongly suggests that the occurrence of catametabolism should be added to the diagnosis of this taxon. The phenomenon of catametabolism has phylogenetic relevance because it occurs in all Diaspididae, suggesting that the Diaspidiae had a catametabolic ancestor. The same trend toward reduction does exist in all Coccoidea, although with a different meaning: it has phylogenetic relevance in direct comparation between taxa.

Accepting that the trend in ontogeny (Porcelli & Di Palma, 2000) of Diaspididae is toward the reduction of the soma, one can question the position of pupillarial forms. The only reasonable answer, on the basis of the simplification trend, is that pupillarial forms symbolize extreme evolutionary specialization: an attempt to reduce, and finally erase, even the third female instar.

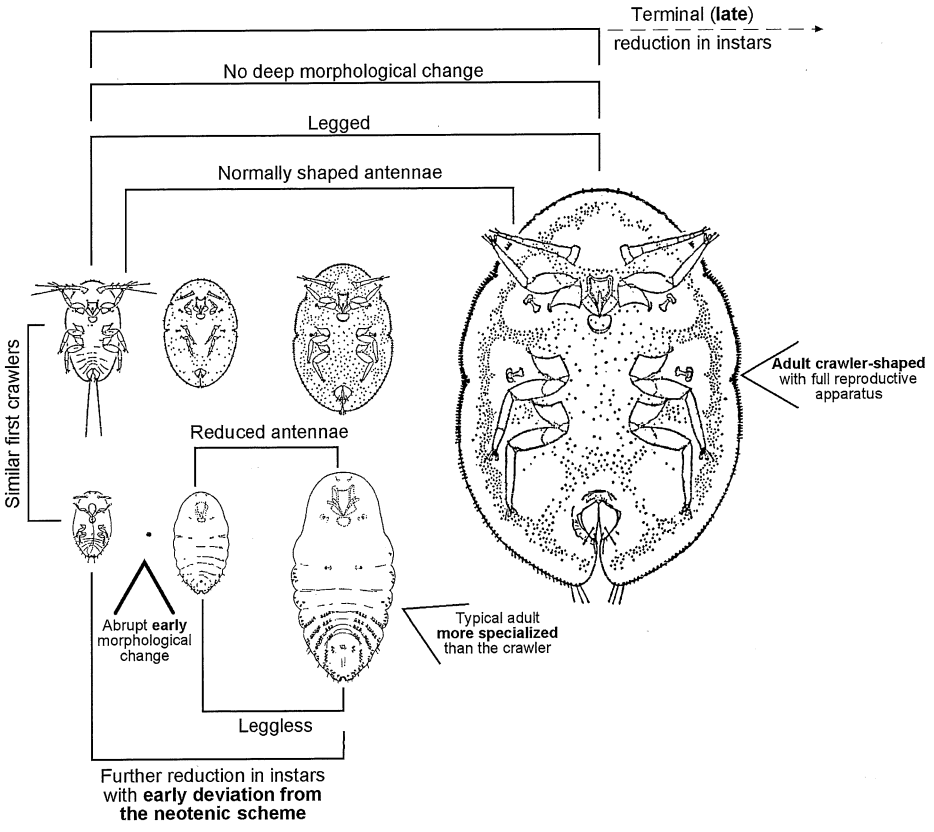

Fig. 1 - Schematic drawing to show the main differences between neotenic and catametabolic post-embryonic development in Coccoidea.

CONCLUSION

The proposal here reported stresses the evident discrepancy in the use of the single term (neoteny) to describe two really quite different modes of postembryonic development: one mode is present in most scale insects, wheras in comparison with the other one occurs mainly in Diaspididae. Two different names are needed to describe two different ontogenies.

REFERENCES

BAER, R.G.; KOSZTARAB, M.; 1985 – A Morphological and Systematic Study of the First and Second Instars of the Family Kermesidae in the Neartic Region (Homoptera: Coccoidea). - Research Division Bulletin 85-11, Virginia Polytechnic Institute and State University, 119-261.

BEN-DOV Y., 1990 - Diagnosis and phylogenetic relationships. - In: "Armored scale insects their biology, natural enemies and control"; World Crop Pest 4A, Rosen, D. Ed. Elsevier, Amsterdam. 3-4.

BÖRNER C., 1910 – Parametabolie und Neotenie bei Cocciden. - Zoologischer Anzeiger, 35: 553-561.

BULLINGTON S.W., KOSZTARAB M.,1985 – Revision of the Family Kermesidae (Homoptera) in the Neartic Region Based on Adult and Third Instar Females. - Research Division Bulletin 85-11, Virginia Polytechnic Institute and State University, 1-118.

CHAMBERLIN J.C., 1923 – A systematic monograph of the Tachardiinae or Lac Insects (Coccidae). - Bulletin of Entomological Research, XIV(2): 147-212.

DEITZ L.L., 1979 - Two new species of *Colobopyga* (Homoptera: Halimococcidae) from the Australian region. - New Zealand Journal of Zoology. 6: 453-457.

FOLDI I., 1995 - A taxonomic revision of *Limacoccus* Bondar with a cladistic analysis of its relationships with other scale insects (Hemiptera: Coccoidea). - Systematic Entomology. 20(4): 265-288.

GRANDI G., 1945 - Nuove proposte nella terminologia zoologica. - Mem. Accad. Scienze Istituto Bologna. Classe Scienze Fisiche, Sezione Scienze Naturali, X(II): 3-7.

GRANDI G., 1969 - Nuove proposte nella terminologia zoologica II. - Bollettino dell'Istituto di Entomologia di Bologna. XXIX: 241-254.

HOWELL J.O., KOSZTARAB M., 1972 - Morphology and Systematics of the adult Females of the Genus *Lecanodiaspis*. - Research Division Bulletin 70, Virginia Polytechnic Institute and State University, 248 pp.

HOWELL J.O., WILLIAMS M., KOSZTARAB M., 1971 - Morphology and Systematics of *Cerococcus parrotti* (Hunter) with notes on its Biology (Homoptera: Coccoidea: Asterolecanidae). - Research Division Bulletin 64, Virginia Polytechnic Institute and State University, 23 pp.

KOSZTARAB M., 1996 – Scale Insects of Northeastern North America. -Virginia Museum of Natural History Special Publication 3, 650 pp.

KOTEJA J., 1990 - Life history. In: "Armored scale insects their biology, natural enemies and control". - World Crop Pest 4A, Rosen, D. Ed. Elsevier, Amsterdam. 243-254.

LAMBDIN P., KOSZTARAB M., 1977 – Morphology and Systematics of the adult females of the Genus *Cerococcus*. -Research Division Bulletin 128, Virginia Polytechnic Institute and State University, 252 pp.

LEONARDI G., 1920 – Monografia delle cocciniglie italiane. - Portici, Ernesto della Torre, 555 pp.

MATILE FERRERO D., 1997 – The Adult Female. In: "Soft Scale Insects – Their Biology, Natural Enemies and Control". Ben-Dov, Y.; Hodgson, C.; Eds. Elsevier, Amsterdam: 5-21.

MORRISON H., MORRISON E., 1922 - A redescription of the type species of the genera of Coccidae based on species originally described by Maskell. - Proceedigs of the United States National Museum. 60(12): 1-120.

PÉREZ GUERRA G., KOSZTARAB M., 1992 – Biosystematics of the Family Dactylopiidae (Homoptera: Coccinea) With Emphasis on the Life Cycle of *Dactylopius coccus* Costa. -

Research Division Bulletin 92-1, Virginia Polytechnic Institute and State University, 90 pp.
PORCELLI F., DI PALMA A., 2000 - On the reduction of the antenna of *Diaspis echinocacti* (Bouché) during ontogenesis. - Proceedings International Entomology Congress, 20-26 August, Iguassu, Brasil n. 3175, II: 801.
RICHARD C., 1986. Carayonemidae famille nouvelle *Carayonema orousseti*, n. gen., n. sp. de Guyane française (Homoptera, Coccoidea). - Annales de la Société Entomologique de France 22(2): 268-273.
SEHNAL F., 1985 - Growth and Life Cycle. - In: "Comprehensive insect physiology biochemistry and pharmacology". Kerkut, G.A.; Gilbert, L.I.; Eds. 2, Postembryonic development: 1-86.
SIVESTRI F., 1939 – Compendio di Entomologia Applicata, Parte speciale, I. - Tipografia Bellavista, Portici, 977 pp.
STICKNEY F.S., 1934 - The external anatomy of the red date scale *Phoenicococcus marlatti* Cockerell, and its allies. - U.S.D.A. Technical Bulletin 404, 163 pp.
TAKAGI S., 1990 - The adult female. In: "Armored scale insects their biology, natural enemies and control". - World Crop Pest 4A, Rosen, D. Ed. Elsevier, Amsterdam. 5-20.
TAKTAJAN A., 1991 – Evolutionary Trends in Flowering Plants. - Columbia University Press, 241 pp.
TREMBLAY E., 1995 - Entomologia applicata. - Liguori Editore. II(1). 407 pp.
WILLIAMS D.J., 1992 - A new genus and species of Conchaspididae (Hemiptera: Coccidea) from Florida, remarkable in lacking legs. - Journal of Natural History. 26: 1325-1331.
WILLMER P., 1991 - Invertebrate relationships: patterns in animal evolution. - Cambridge University Press, 400 pp.

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