Egg hatching: One mechanism for life-cycle partitioning in Plecoptera and Ephemeroptera

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Extended Summary

The partitioning of life cycles ensures that closely related species do not compete for food and space in the same biotope. Partitioning may depend upon the different environmental requirements of different life-cycle stages (egg, larva, pupa, adult) of closely related species. The present review has shown how this partitioning can be maintained through the adult and egg stages, and has demonstrated the importance of the timing of the life-cycle parameters for the segregation of life cycles. The timing of the flight period determines the egg laying period and the egg stage determines when eggs start to hatch, the number of days over which the eggs are hatching and how many larvae emerge. Water temperature is probably the chief environmental factor influencing these life-cycle parameters. A theoretical framework has been proposed to show how these different parameters can interact to ensure segregation of the life cycles of closely related species (Fig. 1), and as quantitative information is now available for several closely related British stonefly and Austrian and British mayfly species, the interrelationships of these parameters could be examined to explain the mechanisms that ensure life-cycle partitioning.

It was shown that the different thermal requirements for the incubation and hatching periods in combination with different flight periods are chiefly responsible for the different timing of the life cycles of closely related species occurring in the same biotope. The different thermal requirements can be used to classify groups of species into cold or warm stenotherms or eurytherms. One consequence of these different thermal requirements is that species respond differently to similar thermal conditions. Species that spend a very short time in the egg stage are successful under favourable environmental conditions because their eggs develop at a fast rate and hatch more or less all at once, resulting in a dense initial larval cohort. However, under unfavourable environmental conditions, these species are very vulnerable, resulting in a high mortality of eggs or newly hatched larvae. Other species use another strategy and show under the same conditions a delayed egg development with a long hatching period. As the recruitment of larvae occurs over a long period of time, these species can survive unfavourable environmental conditions without a marked effect on the initial larval density. An extreme of this strategy is the so called "seed bank" effect.

Apart from the interspecific differences which are responsible for the life-cycle partitioning, the different populations of the British species did not show intraspecific differences in the parameters for egg development, apart from discrepancies between the lake and river populations of both *Diura bicaudata* (LINNAEUS, 1758) and *Ecdyonurus dispar* (CURTIS, 1834). Furthermore, intraspecific differences between British and non-British populations were not found in some species, but may occur between populations of

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Protonemura praecox (MORTON, 1894), *P. meyeri* (PICTET, 1841), *Nemoura cinerea* (RETZIUS, 1783), *Leuctra hippopus* KEMPNY, 1899, *Perlodes microcephalus* (PICTET, 1842), *Dinocras cephalotes* (CURTIS, 1827) and *E. venosus* (FABRICIUS, 1775). These comparisons are limited because different authors have studied only some of the egg development parameters, and/or have not always tried to apply mathematical models to their data, or did not always provide measurements of precision for the parameter estimates when models were used. The reasons for these possible intraspecific differences cannot be explained at present, and there is clearly a need for similar work on egg hatching for different populations of the same species, so that the extent of intraspecific differences can be assessed both within and between countries in Europe.

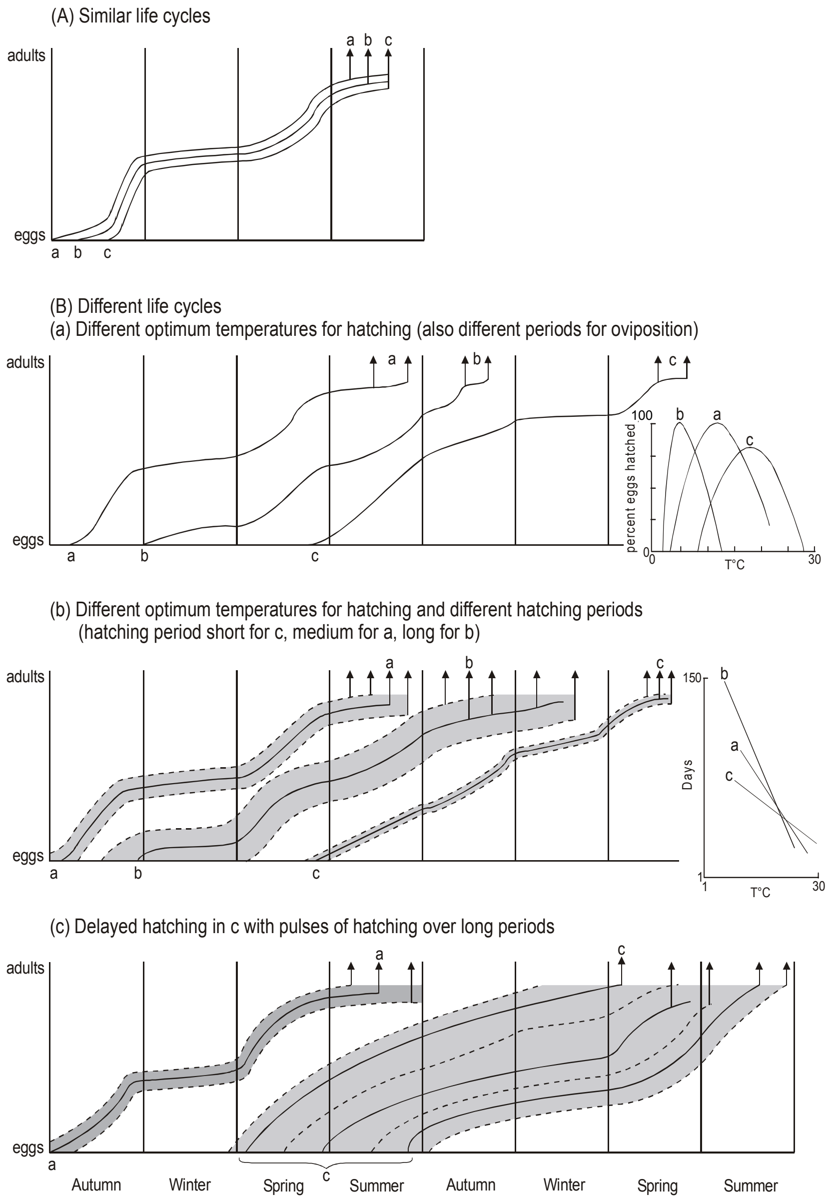

Fig. 1 - Theoretical life cycles as a consequence of different interacting life-cycle parameters, such as optimum temperatures for hatching, periods for oviposition (flight periods), incubation periods, hatching periods. (A) Similar life cycles; (B) Different life cycles.

Reference

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