Supplement 6. Latitudinal and phenological patterns in seasonal regulation – a summary

Phenology within the WCS model

For early emergence, the WCS is large, and regulatory development aim at a last winter in F-0 (spring species; Figure 1a, c, g). For the earliest possible emergence even a winter in a late pre-apolysis stage within F-0 can be attained (Norling, 1984b, c). If the WCS is small, and regulatory development largely prevents a last winter in F-0, emergence is later, summer species fashion (Figure 1a, c, g).

A bigger picture (Figure S6)

At lower temperate latitudes the end of the flight season can be governed by a late critical time (Figure 1a). In Figure S6 a sequential transition in phenology from bi- and multivoltine populations at such low latitudes to spring species is shown by thin black arrows at the bottom, indicating critical time (horizontal) and critical size (vertical). The critical size, governed by the predictive size range, may at first be relatively constant while the critical time is receding towards spring. When the critical time is in spring, the WCS model operates, and the critical size (now WCS) is successively increased up towards F-0 to form the spring species pattern with regulatory responses concentrated to very late stadia (short vertical arrow). Towards the spring species end of this transition, it is reasonable that prediction of emergence is extended into what is here considered as late early development and implemented in a pre-hibernation cohort split.

This sequence can represent a transition to higher latitudes and shorter seasons in an asynchronous summer species, eventually forced into a spring species pattern by the short season, for example during colonization of higher latitudes of this tropical group. If reversed, it may represent a possible adaptive and plastic outcome of a warming scenario, although phenology should be diversified among species after warming due to a longer season. The sequence can also represent a phenological spectrum between asynchronous summer species and synchronous spring species at the same latitude.

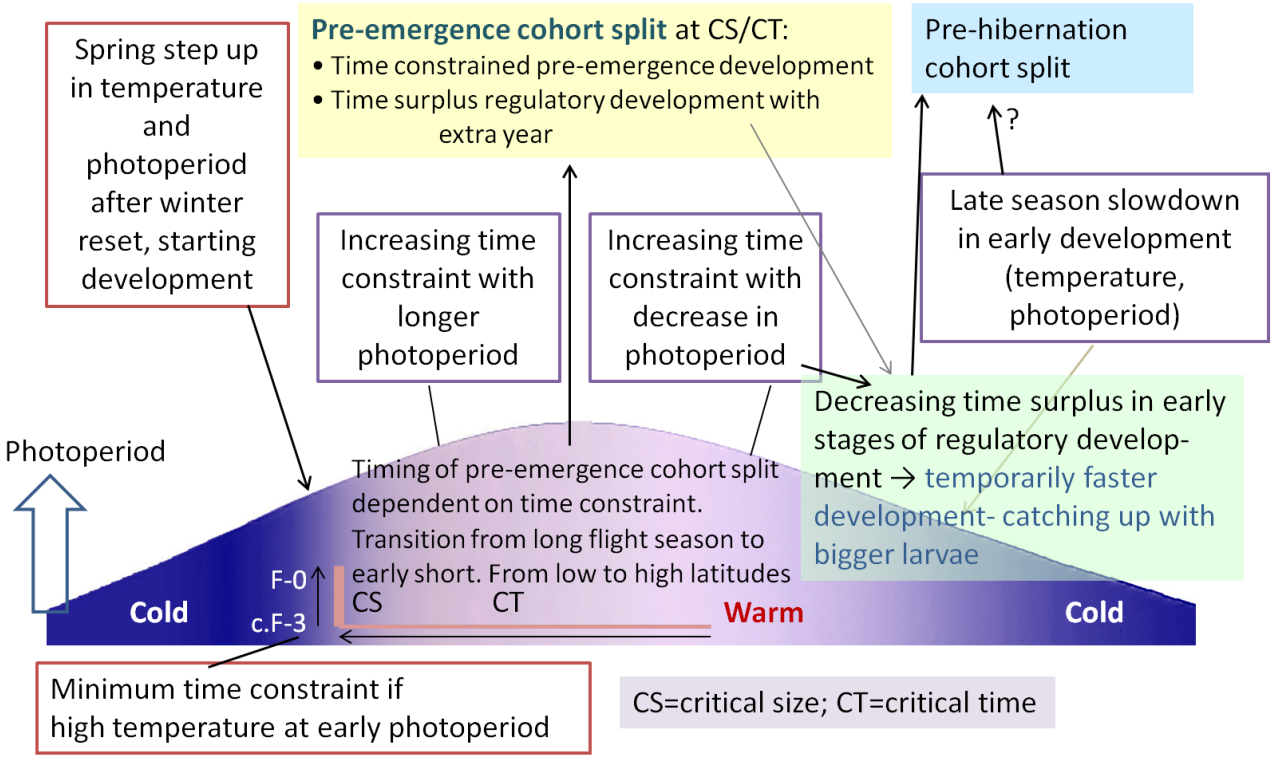

Figure S6. Comprehensive, largely hypothetical graphical overview of seasonal regulation and response patterns during the season, from winter to winter. Photoperiod is shown vertically, and temperature is colour-coded. Slightly modified from a presentation at the European Congress on Odonatology 2016, Tyringe, Sweden.