

The life cycles of carabid beetles (Coleoptera, Carabidae) in dry, open habitats north of 69°N, Northern Norway

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Andersen, J. 2013. The life cycles of carabid beetles (Coleoptera, Carabidae) in dry, open habitats north of 69°N, Northern Norway. *Norwegian Journal of Entomology* 60, 140–158.

The life cycle of 23 carabid beetle species of dry and mesic, open habitats in the lowland of Troms was studied by elucidating the reproduction period and the seasonal occurrence of larvae, tenerals and fully hardened adults. Nine species breed in spring–early summer, have summer larvae and hibernate exclusively as adults. Nine species mainly breed in summer/autumn (June–September) and larvae as well as adults hibernate. The latter group of species frequently seems to need more than one, but not two full years to complete their development. However, *Amara bifrons* (Gyllenhal, 1810) which belongs to the group with winter larvae, may exclusively have an annual life cycle. The same also partly applies to *Calathus melanocephalus* (Linnaeus, 1758) in periods with favourable climatic conditions. Third stage larvae of *Amara torrida* (Panzer, 1797) and *A. apricaria* (Paykull, 1790), which overwinter, were unable to fulfill their development at high temperatures ($\geq 24^{\circ}\text{C}$) in the laboratory in autumn and obviously have a larval diapause in Northern Norway. The adults of the species with winter larvae have no aestivation period in summer which is the case for at least some of the species in Central Europe. The species with winter larvae therefore start to reproduce much earlier in the season in Northern Norway than farther south. Eggs and/or pupae as well as larvae and adults of three further species hibernate. Based on marking of larval holes, it was estimated that *Cicindela campestris* (Linnaeus, 1758) needs at least 3 years to fulfil its development in Troms. In the alpine and arctic zones, the proportion of species with summer larvae is significantly lower than that of species with winter larvae indicating that the first group is more dependent on a favourable summer climate. The period 2002–2011 was warm. Earlier reproduction and eclosion of adults was conspicuous in this period. Possible changes in altitudinal and latitudinal distribution and in the life cycles of carabid beetles because of global warming are discussed.

Key words: Carabidae, life cycle, dry, open habitats, Northern Norway.

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Introduction

Larsson (1939) divided the Scandinavian carabid beetles into two main life cycle categories: a) spring breeders with summer larvae and imaginal hibernation and b) autumn breeders with larval hibernation. Species of the latter category may also hibernate as adults and a few species were assumed to have life cycles lasting more than one year. Later studies of life cycles have documented

a complex pattern among carabid beetles. Thus, several species have two reproduction periods, one in spring and another one in autumn. Furthermore, eggs of some species hibernate and the life cycle traits of a species may vary much with climate (e.g. Lindroth 1945, 1985–86, Refseth 1986, 1988, Butterfield 1996, Sota 1996, Killengren 2002, Hodkinson 2005, Filippov 2006, Matalin 2007). The most important factors regulating annual rhythms are photoperiod and temperature