# SURVIVAL OF ADULT *SOMATOCHLORA ARCTICA* (ZETTERSTEDT), A DRAGONFLY SUMMER SPECIES, ON SNOWFIELDS (ANISOPTERA: CORDULIIDAE)

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**Abstract** – On Mutnovskaya Sopka, Kamchatka, E. Russia, alt. 1300 m, 7 living individuals were found on the snow surface, July 21-23, 1991. Two specimens were taken for a closer examination. One of these survived at the temperature of about -1°C to -5°C. Arguments for and against the need for cold hardness are discussed, and it is concluded that dragonflies lack specialisation, but can avoid freezing. More males survived than females.

## Introduction

Arthropod fallout and insect records on snow surfaces have been noted from various geographic regions, viz. North and South America (summarized in EDWARDS, 1987), northern Europe (KAISILA, 1952; ELTON, 1925; ASHMOLE et al., 1983), Central European mountains (e.g. LISTON & LESLIE, 1982), Australia (EDWARDS, 1974), Central Asia (SWAN, 1961) and even northern Africa (ASHMOLE & ASHMOLE, 1988). During a field trip on the Kamchatka peninsula in northeastern Asia, insects were observed on snowfields, amongst them living adults of *S. arctica*. This is the first record of adult corduliid dragonflies surviving frost, although it has been reported in larvae of *Somatochlora semicircularis* (WILLEY & EILER, 1972), *S. arctica* (STERNBERG, 1989) and *S. alpestris* (STERNBERG, 1989; JOHANSSON & NILSSON, 1991). The observations are shown in detail because very little is known about the effect of snow on dragonfly survival strategies, particularly during their adult stages.

## Locality

The Kamchatka peninsula (eastern Russia) is a subarctic area roughly situated between 155° E and 165° E. The precise observation area, the active volcano Mutnovskaya Sopka (2323 m), is at about 58° N and 158° E (Fig. 1). Below 800 m, birch forest (*Betula ermani*) predominate. Above this (up to 1200 m) there is an alder zone

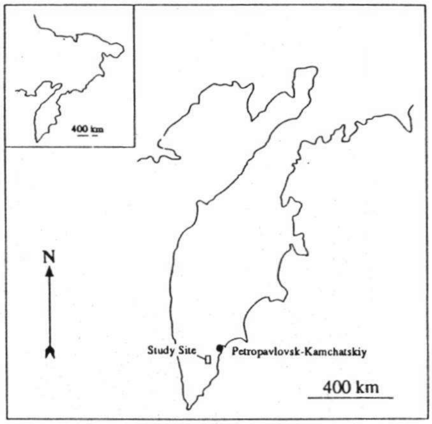


Fig. 1. Location of the study site.

(*Alnus kamtschatica*). Alpine meadows extend to about 1600 m. Unusually for this area, there were snow falls throughout June and the first two weeks of July 1991. Only patches of vegetation appeared above the snow and no sites for potential development of dragonflies were found. Ponds of melt water were frozen at night during the study period, when temperatures were approximately -1°C to -5°C.

## Observations

On the 21st-23rd and 26th-27th July 1991, a large number of insects were found near a plateau on the snow, at about 1300 m a.s.l. These insects were found in obvious pathways. In particular, moths (Geometridae), chrysomelid beetles (*Melasoma tremulae*), carabid beetles (*Leistus* spp. and *Nebria* spp. – R. Predel leg). as well as hymenopterans (Cimbicidae and Symphyta) occurred on the snow surface. Furthermore, two dead specimens of *Aeshna subarctica elisabethae* Djakonov and about 40 both dead and alive individuals of *S. arctica* were found between 21st and 23rd July. The two specimens of *A. subarctica* had folded legs, those of *S. arctica* showed a different pattern. The legs of all dead specimens were extended. Some specimens tipped on their sides whilst others were tipped on their abdomens or their heads. Of those specimens recovered, which were tipped on their heads, small melted hollows were noted directly under the head region. No individuals appeared to be injured.

Of the 40 individuals observed, only 7 were still alive, sitting free on the snow. Surprisingly, all of the surviving specimens were males. A total of 23 (10 ♂, 13 ♀) were collected during the study period.

On the evening of 26th July I searched specifically for living individuals located on the top of the snow. Two individuals were located and examined. Although one specimen showed signs of physical weakness, the other individual appeared to be in a relatively healthy condition. Both specimens were returned to the snowy substrate and examined after the nocturnal frost. On examination early the next morning, it became evident that the weak indvidual had died. The surviving dragonfly was placed in an area which received maximum exposure to the morning sunlight. The dragonfly was observed at 15 min intervals. One hour after exposure to the direct sunlight, the dragonfly had flown away. From intitial observations it can be calculated that this individual was associated with the frosty substrate for at least 10 hours.

An increase in the number of flying specimens and individuals basking on alder shrubs during the day was clearly associated with a rise in temperature levels. This is in general agreement with the observations of MIDTTUN (1977) who recorded that flight activity in western Norway never occurred below air temperature of 14-15°C. Only males were identified with certainty.

**Discussion**

Relatively few published records exist of dragonfly mortalities on snowfields. Of those available, only *Sympetrum flaveolum* (FUDAKOWSKI, 1930), *Sympetrum sanguineum* (LISTON & LESLIE, 1982), and *Aeshna juncea mongolica* (WOJTUSIAK, 1974) have been mentioned in detail. Herewith *A. subarctica* and *Somatochlora arctica* can be added to this list.

Results from previous studies suggest that dragonflies do not play an important role in the arthropod fallout (SPALDING, 1979). The most important components of arthropod fallout are members of the Homoptera, Diptera, Coleoptera, and Hymenoptera (EDWARDS, 1987), occasionally also spiders and bugs (e.g. CRAWFORD & EDWARDS, 1986). According to EDWARDS (1972, 1987), EDWARDS & BANKO (1976), MANN, EDWARDS & GARA (1980) and PAPP (1978) two guilds are always present, the allochthonous fallout and the attracted predator guild. The activity of the predators and scavengers has been noted within different adult arthropod communities, notably in collembolans (e.g. AITCHISON, 1989; BLOCK & ZETTEL, 1980; LEINAAS, 1981), spiders (e.g. AITCHISON, 1989; HUHTA & VIRAMO, 1979; KOPONEN, 1983, 1989), beetles, and in the Boreidae among the mecopterans (e.g. KOPONEN, 1983). Although carnivorous, *S. arctica* can hardly be assigned to the latter group because of the rare occurrence of ground feeding (CORBET, 1962). Also the flight activity takes place about 2-8 m above the ground rather than on the surface (MIDTTUN, 1977).

It may also be incorrect to use the term fallout in this situation for two reasons: firstly, although not observed, the fallout must have come from lower altitudes due to the occurrence of birch breeding cimbicid wasps and the Symphyta. Some of the dragonflies probably accompanying the hymenopterans did not die by freezing. Secondly, they showed normal activity. EDWARDS (1987), in an earlier study, suggested that "to be fit in the alpine environment an organism must either accommodate or evade the extrema". It is interesting to note that *S. arctica* might follow both strategies, although it does not belong to either the fallout or attracted predators but to a third group, the temporary residents (sensu EDWARDS, 1987). The extended legs recognized in *Somatochlora* might implicate a landing on the snow, thus a trial and error behaviour in this cold withstanding. In *Aeshna*, however, the folded legs could mean an overcome by cold during the flight. The evidence suggest that *S. arctica* possesses cold resistance. This may also infer the production of a cryoprotectant by individuals found within the whole geographical area covered by this species. Evidence for this may come along three lines. Firstly, 7 of the 40 specimens (17%) of *S. arctica* survived the low frost at night. Secondly, sub-zero temperatures are not unusual at the end of August in some higher parts of central Europe (e.g. the Harz and Krkonose mountains, or the Alps), in northern Norway or on the Kamchatka peninsula. Thirdly, since there are morphological differences between geographic populations (SCHMIDT, 1957), there may also be physiological differences. Mechanisms for cold hardiness in insects usually depend on high concentrations of a substance of low molecular weight (BAUST & ROJAS, 1985).

While other observations of cold hardiness in dragonflies have been concerned with larvae (BEUTLER, 1989; DABORN, 1971; JOHANSSON & NILSSON, 1991; SAWCHYN & GILLOT, 1975; WILLEY & EILER, 1972), it is rare for adult dragonflies to survive under frost conditions, except in *Sympecma*. Other exceptions are restricted to the subpolar and the alpine regions. CORBET (1962) defines the terms spring and summer species. The summer species may be divided into early and late summer forms. For the latter, frost contacts in the temperate latitudes are not unusual in species flying until the late autumn (JÖDICKE, 1991), including e.g. oviposition on the ice cover of ponds (BISCHOF, 1992), or emergence while the surrounded waters are frozen (Mirskich, *in* PETERS, 1987).

*S. arctica*, which I observed to survive frost, is considered, a summer species in Siberia (BELYSHEV, 1973). In western Norway the adult season is largely restricted to June and July (MIDTTUN, 1977). The latest record in central Europe is the 16th September (1982) (ANSELIN, 1983). Thus, the species obviously belongs to the early summer forms which seldom experience frost (except at high altitudes). This suggests that there is no need for cold hardiness and the production of a cryoprotective molecule.

In conclusion, I suggest the observed cold avoidance on the Kamchatka peninsula to be the "normal" reaction. A slow habituation to the low temperatures which is of less physiological stress (SCHMIDT-NIELSEN, 1979) might have taken place. Furthermore, the haemolymph of insects does not freeze except below -5°C (EDWARDS, 1987). The relatively high daytime temperatures cause an increase in body temperature. The observed small melted hollow below the head region may indicate the loss of temperature in dead individuals.

Although females of *S. arctica* are generally more difficult to observe (Dr. K. Sternberg, pers. comm.), only males were found to have survived the frost conditions. Using pitfall traps on snow, KOPONEN (1983, 1989) found in spiders and flies and in some mecopterans that 85-100% of those active on the snow were males. Like KOPONEN (1983, 1989), the present paper cannot give an explanation of this phenomenon. Differences in the physiological adaptation of male insects to frost conditions and its implication for the ecology of dragonflies remain unstudied, although differences in the allocation of energy for reproductive processes may be implicated.

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