Effects of Climatic Changes on Odonata: Are the Impacts likely to be the Same in the Northern and Southern Hemispheres?

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The effects of climatic changes are different in the northern and southern hemispheres – but to date, no formal comparison has been carried out to determine whether climate change has comparable effects on the distribution patterns and the ecology of dragonfly species in the two hemispheres. Here we present some first results using Odonata species as model organisms.

Expansion of geographical ranges of dragonfly species

The expansion of geographical ranges of dragonfly species is well documented for the northern hemisphere, where studies are available e.g. for Europe, United States and Japan (Ott 2001, submitted). In Europe, some Mediterranean species have expanded their ranges within the last two to three decades over as much as several hundreds of kilometers, and have even been sighted or established on some islands (UK, Ireland), as well as Scandinavia. Recently, some African species have now also colonized southern Europe and are expanding their ranges northwards (Ott, this atlas, pp. 82f.).

The situation in southern Africa appears to be very different. One of the reasons for this is that in this region, there have been many climatic bottlenecks as well as climatic cycling, including El Niño events. It seems that many of the savanna species at least are highly opportunistic and habitat-tolerant, moving readily in response to changing conditions, and tolerating very different winter conditions in comparison with those in summer (Van Huyssteen & Samways 2009). The greatly changing climatic conditions from one year to the next, and even one decade to the next, often means that certain species retract their geographical ranges in dry years, and then, opportunistically, expand again in wet years. One example, is the relatively rare *Orthetrum robustum*, which retreats to permanent lake refugia in wet years and then moves into recently-flooded pans in wet years. Like the also rare, *Urothemis luciana*, it is a strong flier and ready colonizer. Yet, of surprise has been the movement capabilities and ready establishment by seemingly weak-flying damselflies. *Lestes virgatus* has a very dynamic population spatial distribution, readily colonizing new and appropriate ponds as formerly suitable ones dry out. *Aciagrion congoense* showed even more extreme population spatial dynamics, moving south, over some 300 km, to St Lucia in South Africa from Mozambique during the huge floods in the year 2000. Yet it had never before been observed so far south. Then, by 2005, it had disappeared again from St Lucia, during the dry phase of the climatic cycle.

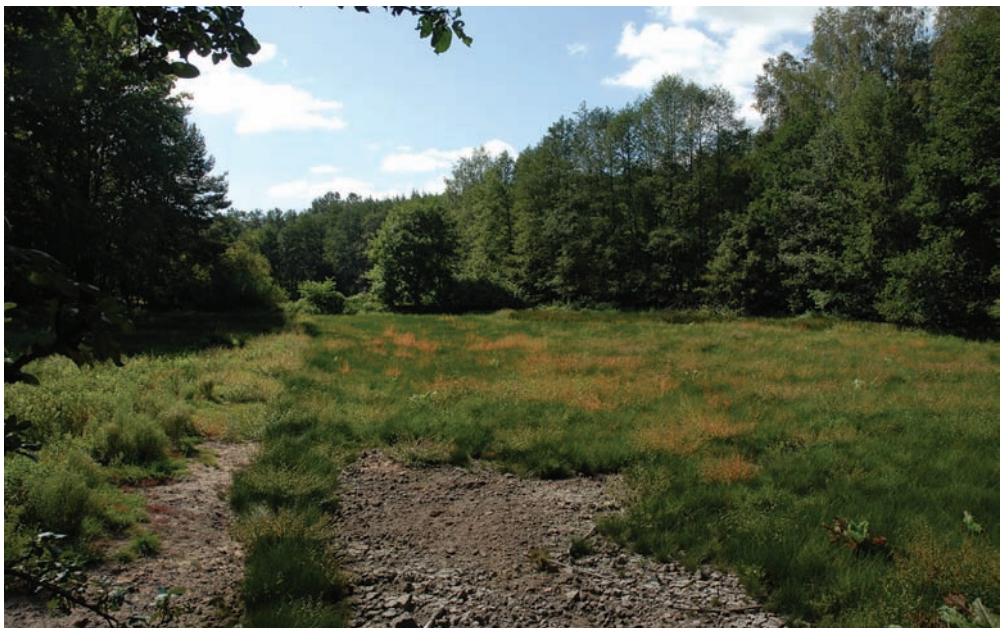

Figure 1. Dried out water body near Kaiserslautern (Germany) in 2006: once a habitat of the endangered mooreland species *Coenagrion hastulatum*. Photo: J. Ott.

Figure 2. The parthenogenetic Crayfish *Procambarus* sp. – in Germany an alien species e.g. found in the Palatinate – preying upon a dragonfly larva (*Libellula quadrimaculata*). Photo: J. Ott.

Expansion of dragonfly species to higher elevations

Besides geographical range expansion, movements to higher elevations have also been recorded, which has increased local Odonata diversity (Oertli et al. 2008). With continuing climate change, there may also be a reduction of sensitive, montane species loosing their preferred biotopes in higher elevations with a typical temperature regime and with perhaps increasing predominance of habitat generalists (Ott submitted). At least in the southern hemisphere, it is difficult to determine whether there has been an increase in elevational ranges of odonates, as the background 'noise' of prehistoric climate change and the current strong climatic cycles appear to mask local anthropogenic effects.

There is, however, very good evidence that certain species are confined to climatic refugia, when formerly they were likely to be more widespread. Today, for example, *Chlorolestes fasciatus* confined to the Mountain Zebra Park (as well as other mountain ranges) yet surrounded by the highly unsuitable and arid habitat of the Karoo (Samways 2008). There is no doubt, however, that certain narrow-range endemic species would be in a very precarious state should climate warming continue. One species is the recently-discovered *Syncordulia serendipator*, which only lives in the high reaches of the Cape mountains, with no elevational flexibility should conditions become too severe.

Changes in the phenology of Odonata

Changes of the dragonfly phenology are well documented in the northern hemisphere (Ott 2001, submitted, Hassel et al. 2007): earlier emergence takes place and there is a clear tendency to changes in voltism (e.g., a trend to bivoltism in some species in northern countries where these species formerly had only one cycle per year) and some species also show a prolonged flight season. If this process continues, more and more de-synchronisation of emergence may occur (e.g., emergence of spring species in late fall) which may have negative effects on the species survival. Again, as with issues of change in geographical range and in elevation, the situation in the southern hemisphere is masked by great differences in phenology, both in geographical area (Samways & Grant 2006) and from year to year, with even overwintering of some species from one year to the next at sometimes but not at others (Samways 2008).

Species turnover of Odonata in water bodies

Monitoring in the northern hemisphere has shown that there is an increasing number of Mediterranean species dominating certain water bodies (Ott submitted).

Effects of drying out of water bodies on the Odonata assemblages

Drying out of water bodies leads to a complete change, and even total elimination, of the Odonata assemblages. Short term drying out favours species with high colonising ability and a short

life cycle (r-strategists, such as *Ischnura pumilio, Lestes barbarus, Libellula depressa*) but when water bodies dry out for weeks or even months, the dragonfly species – in particular, the species of running waters with long-lasting larval stages – are eliminated (Ott submitted). As the southern hemisphere has been subject to great variations in droughting and flooding from one year to the next, the issue of odonate pond colonization is more about spatial population dynamics and suitability of habitat than about gradual accumulation or loss of certain species. Certainly, there are no assembly rules for dragonfly species establishing at new ponds, with species arriving as and when conditions are suitable for them, and then leaving when conditions become unsuitable.

Possible synergistic effects of climatic changes with intensive land-use and emissions

The eutrophication and acidification as a result of ongoing emissions lead to a continuous stress for aquatic biotopes in the northern hemisphere, even if in recent years in many areas water quality has improved.

Possible synergistic effects of climatic changes with alien invasive species

To date, little is known of synergistic effects in the northern hemisphere, but it seems that in particular the dragonfly larvae are negatively affected by invasive fish and crayfish (Figure **2**), as many species prey upon larvae. In particular, many alien crayfish species – a consequence of stocking by fishermen, for commercial use, or set free by aquarists – have now established as large populations in nearly all types of standing and running waters. Alien invasive species, mostly alien trees, play a major role in determining which dragonfly species can inhabit a particular water body, at least in South Africa (Samways & Taylor 2004, Samways 2007). When the alien riparian trees are removed, there is a rapid and significant recovery of the dragonfly fauna (Samways et al. 2005). While no doubt the alien trees change the water quality of the larval habitat, by far the most significant factor is the adverse effect of shade, which has been shown to be experimentally to be the critical factor. From circumstantial evidence, alien trout are considered also to have an impact on the southern hemisphere odonates in montane areas. The evidence is not strong, but there have been instances where certain endemic odonate species occur above waterfalls but not below them where trout are present.

Which species / species groups are at risk?

In both the northern and southern hemispheres, the species most at risk are those of sensitive habitats – such as moorland and montane species, as well as species requiring stable environmental conditions (e.g., water level). Species with small populations and a patchy distribution or isolated populations within these groups are even more threatened.

Figure 3. Alien invasive and planted pine trees caused a major decline in dragonfly species by shading out the habitat. Endemic species like *Syncordulia venator* were locally extirpated. Shown here is the removal of the pines and the regrowth of the local fynbos vegetation. Photo: M. J. Samways.

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Figure 4. Shown here is a fully restored stream after alien pines had been removed. The recovery of the local odonate fauna has been remarkable, indicating how their populations can be restored once a key threat has been addressed. Photo: M. J. Samways.

Figure 5. *Syncordulia venator*, a threatened endemic species which has benefited enormously from the removal of alien trees. Photo: M. J. Samways.