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# PRESENT STATE, THREATS AND CONSERVATION OF DRAGONFLIES (*ODONATA*) IN POLAND

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**Abstract:** 72 species of dragonflies have been recorded in Poland so far. The present state of knowledge of *Odonata* is generally moderate and unequal with reference to the particular regions. The main current topics in Polish odonatological studies are briefly presented. The current picture of dragonfly fauna has been drawn, with special attention to the increased abundance and the broadened ranges of some Mediterranean and southeastern species (e.g. *Aeshna affinis*, *Orthetrum albistylum*), and to the falling numbers, the increasing scatter of localities and the narrowing ranges of some other species, mainly stenotopic (e.g. *Nehalennia speciosa*, *Coenagrion armatum*, *Coenagrion ornatum*). Threats and their mechanisms of affecting dragonflies are analysed in all the main water habitats in Poland. The species typical of small running waters and habitats connected with *Sphagnum* are the most endangered. It must be stressed, however, that generally the state of Polish dragonfly fauna is fairly good. The main forms of conservation of dragonflies, currently used or proposed for use in Poland, are analysed: passive (species and territorial protection, red list, umbrella species) and active (reintroduction, creating new waterbodies, interference in succession of waterbody). The choice of species protected in Poland is partly inappropriate in comparison with the present situation of dragonfly fauna. The Polish Red List, comprising 16 species, is discussed in comparison with the red lists of other European countries. It is stressed that no species has become extinct in Poland. The proposed list of umbrella species for particular habitats is given. The Wildermuth's rotation model is suggested for the management of some habitats. All issues described in the article are presented synthetically and illustrated with the data and examples from Poland.

**Key words:** *Odonata*, diversity, zoogeography, habitats, life factors, threats, conservation, Poland

## INTRODUCTION

In Poland, as in the world, the conservation of biodiversity has been treated as an unusually important task in recent years (Andrzejewski and Weigle 1993; Gliwicz 1992; Głowaciński 1994; Hillbricht-Ilkowska 1998; Jażdżewski 1999). As far as particular taxa are concerned, the fulfilment of this task is very demanding. At first, the precise recognition and description of the state of a particular taxon in a particular area and accurate definition of threats to it are necessary. Only on this basis, can protective activities and assessment of their effectiveness be undertaken. The omission of one of these elements, e.g. in the case of uncritical imitation of patterns from other areas, could result in paradoxical situations, even dangerous in our opinion, falsifying the real picture and undermining the sense of the protective activities undertaken (cf. below – the choice of protected species in Poland).

The aim of this article is to analyse this topic with regard to dragonflies (*Odonata*) of Poland: at first to draw the current picture of dragonfly fauna, then to analyse the main threats to dragonflies in all the main water habitats and to propose and discuss the passive and active forms of conservation. The studies of these insects have been carried out for more than two centuries (in Poland for more than 150 years, e.g. Charpentier 1840; Hagen 1839) and the knowledge of this group is relatively good (in Poland more than 350 publications) in comparison

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with many other insect taxa. Due to this fact such an analysis gains credibility and can be useful as an example and may assist in similar work in other insect orders. The current publication is an overview based on the literature and the authors' unpublished data (up to 2002 inclusive).

## THE CURRENT PICTURE OF DRAGONFLY FAUNA OF POLAND

The state of knowledge of dragonflies of Poland is moderate compared with that of the rest of Europe and unequal with reference to the regions of the country. Wielkopolska, central Poland and Lubelszczyzna (the Lublin region) are the best investigated, with rich data from the last decade. This covers the main areas of current odonatological studies. The knowledge of dragonflies is also relatively large in Górny Śląsk (Upper Silesia) and in some mountain areas (the Tatry, Pieniny, Gorce and Bieszczady mountains, and some ranges of the Beskidy mountains). However, in the case of Upper Silesia and the Beskidy mountains there are mainly old data, collected before 1966. The northern regions – the coast of the Baltic Sea, the Pomeranian Lake District, lake districts of NE Poland – and Mazowsze (Mazovia), Dolny Śląsk (Lower Silesia) and the Sudety mountains have been odonatologically explored only locally and to a much lesser degree.

Such an unequal and unsatisfactory state of knowledge results from the fact that only few specialists worked in the present territory of Poland up to the end of the 1980's (as a rule only 2-4 concurrently and, in addition, only locally). Faunistical studies prevailed and only some researchers studied also the biology of dragonflies (e.g. Fudakowski 1930, 1932; Münchberg 1932, 1938; Mielewczyk 1969; Łabędzki 1982). Only from the beginning of the 1990's has the intensity of studies significantly increased. Ca. 10 specialists (professionals and amateurs) work at present. More than 90 articles and notes (at least partly concerning dragonflies of Poland) and 50 abstracts and summaries from symposia (frequently with original data) were published between 1990 and 2002. In total, this constitutes more than in the preceding 50 years.

The main current topics in Polish odonatological studies are:

1. Distribution of species. 'White spots' on the odonatological map of Poland have been investigated recently to include in the Atlas of distribution of dragonflies in Poland (scheduled for 2005-2006).
2. Biology, autecology of:
   - stenotopic species (mostly relict and/or endangered): *Cercion lindenii* (Sél.) (Bernard 1999, 2000a), *Coenagrion armatum* (Charp.) (Buczyński 2000a, in press), *Nehalennia speciosa* (Charp.) (Bernard 1998, in press a), *Cordulegaster boltonii* (Donov.) (Bernard 2000b, in press b), *Somatochlora arctica* (Zett.) (Buczyński 1998; Buczyński and Tończyk in press), *Aeshna subarctica elisabethae* Djak. (Bernard *et al.* - unpubl. data);

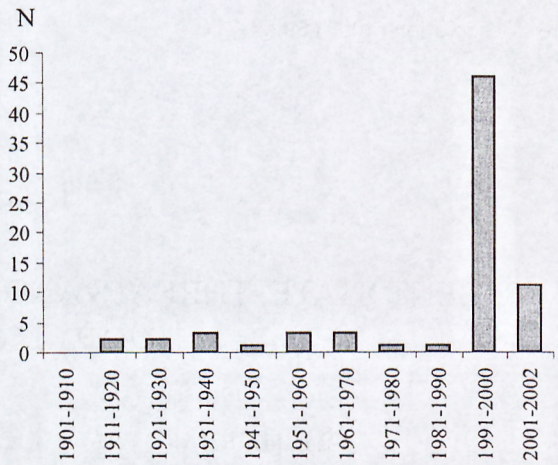


Fig. 1. Number of records of *Aeshna affinis* in Poland by decades (1 record = 1 locality/year).

   - southern and southeastern expansive species, enlarging their ranges northwards, e.g. *Aeshna affinis* Vander L. (Bernard and Samoląg 1994, 1997), *Orthetrum albistylum* (Sél.) (Buczyński et al. 2002b), including nomadic and invading species, creating short-lived bridgehead populations, e.g. *Hemianax ephippiger* (Burm.) (Bernard and Musiał 1995).
3. Synecological investigations in chosen habitats, especially in *Sphagnum* bogs and waterbodies bounded by *Sphagnum* (e.g. Buczyński 2001a), running waters (e.g. Tończyk 2001) and anthropogenic waterbodies, such as gravel and sand pits (e.g. Buczyński 1999a; Buczyński and Pakulnicka 2000).

In Poland, 72 species of dragonflies have been recorded so far (Mielewczyk 1990, 1997a), while 131 species are known in Europe (Wasscher and Bos 2000; Marinov 2001) and over 5400 throughout the world (Tsuda 2000). Such a small representation of world fauna is typical of thermophilous groups of animals whose centre of occurrence is in the tropics and subtropics. The discovery of 1-2 further species is still possible in Poland, especially of those which have been expanding their ranges recently.

It seems that the number of species occurring in the present territory of Poland has not changed in the period of odonatological studies there. The broadening of the list of species was only a result of the discovery of previously overlooked species. Only two species have been added to this list since 1929 (Schmidt 1929), *Cercion lindenii* and *Hemianax ephippiger*, both discovered in the 1990's (Bernard 1993; Bernard and Musiał 1995; Burbach 1995). It is also noteworthy that no species has become extinct in Poland, omitting *Coenagrion scitulum* (Ramb.) for which only one record of a probably stray individual (Zaćwilichowski 1927) is known.

The species composition of Polish *Odonata* is typical of central Europe, with a characteristic mixing of Siberian and Mediterranean elements. However, it must be stressed that in comparison with other Central European countries the number

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of localities and abundance are significantly higher in West Siberian and Siberian species and slightly lower in Mediterranean species.

In the last 10-12 years population numbers and frequency of records of southern and southeastern species (representing mainly Mediterranean elements) have significantly increased in Poland, and a range expansion of some of these species northwards has also been noticed. This concerns mainly: *Erythromma viridulum* (Charp.) (Buczyński and Czachorowski 1998; Buczyński unpubl. data; Czachorowski et al. 1998; Lewandowski 1994; Michoński 2003), *Aeshna affinis* (e.g. Bernard and Samoląg 1994, 1997; Buczyński 1999a; Bernard, Buczyński, Samoląg, and Tończyk – rich unpublished data) (Fig. 1), *Hemianax ephippiger* (Bernard and Musiał 1995; Buczyński 1999a; Burbach 1995; Łabędzki 2000, 2001, 2002), *Orthetrum brunneum* (Fonsc.) (e.g. Bernard 2002; Buczyński 1996, 2000b; Jödicke 1999; Łabędzki 2002; Bernard, Buczyński, and Samoląg – rich unpublished data), *Orthetrum albistylum* (Buczyński et al. 2002b; Buczyński unpubl. data) (Fig. 2), *Crocothemis erythraea* (Brullé) (Bernard and Samoląg 2000; Czekaj 1994; Kalkman and Dijkstra 2000; Theuerkauf and Rouys 2001), *Sympetrum fonscolombii* (Sél.) (e.g. Bernard 1996, 1997a; Bernard and Musiał 1995; Buczyński 1999a; Buczyński and Czachorowski 1999; Buczyński and Pakulnicka 2000; Czekaj 1994).

Some of these species, such as *H. ephippiger*, *S. fonscolombii*, 'move into' these areas only temporarily, creating short-lived (one season) bridgehead populations (Bernard and Musiał 1995; Lempert 1997). In *Aeshna affinis*, it seemed that also

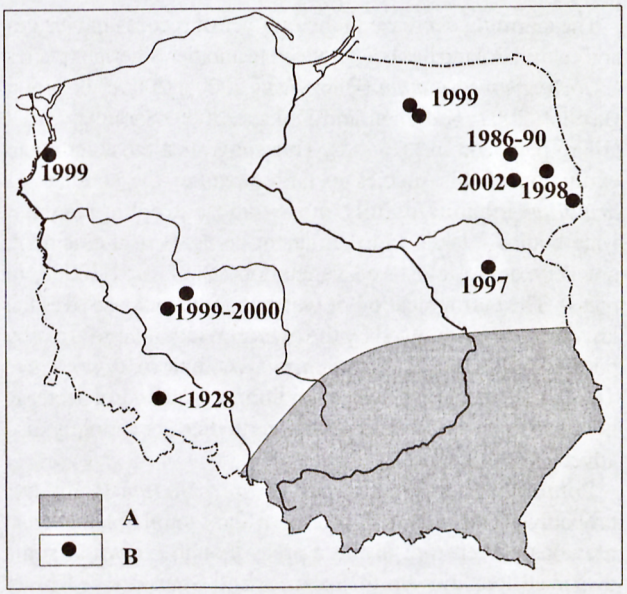


Fig. 2. Changes in the distribution of *Orthetrum albistylum* in Poland. A – main, compact area of occurrence (according to the data up to the mid-90s of the 20th century), B – localities out of compact range

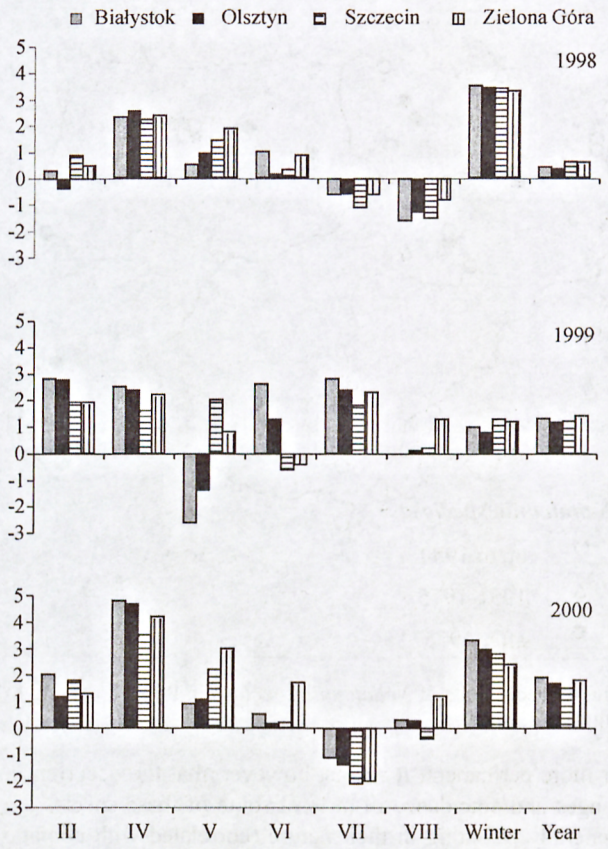


Fig. 3. Deviations of average air temperatures (absolute values) recorded between 1998 and 2000 from many-year average values (1961-1990) in some regions of Poland. III-VIII – months, March-August.

only one-year-long (at most some-year-long) populations existed, mostly dependent on migrants from the South (Bernard and Samoląg 1997). However, in the last decade the existence of more stable autochthonous populations has been observed, e.g. in the environs of Poznań where this species has occurred continuously at least from the mid-90's, in some years (1995, 2001, 2002) even fairly numerously (Bernard and Samoląg 1994, 1997 and unpubl. data).

An increase in the frequency of records of these species only partially results from the intensification of studies. It is largely an effect of actual processes related to climatic changes in the last 10-15 years (Ott 2000, 2001). In practice, these changes are expressed in mild winters, early warm springs and a high percentage of days with high temperatures and insolation in spring and summer. The deviations of average air temperatures recorded between 1998 and 2000 from many-year average values (1961-1990) show a good example of these changes (Buczyński et al. 2002b) (Fig. 3). At present, it is not possible to conclude whether such a state of climate, and the picture of dragonfly fauna resulting from it, are temporary (short-term)

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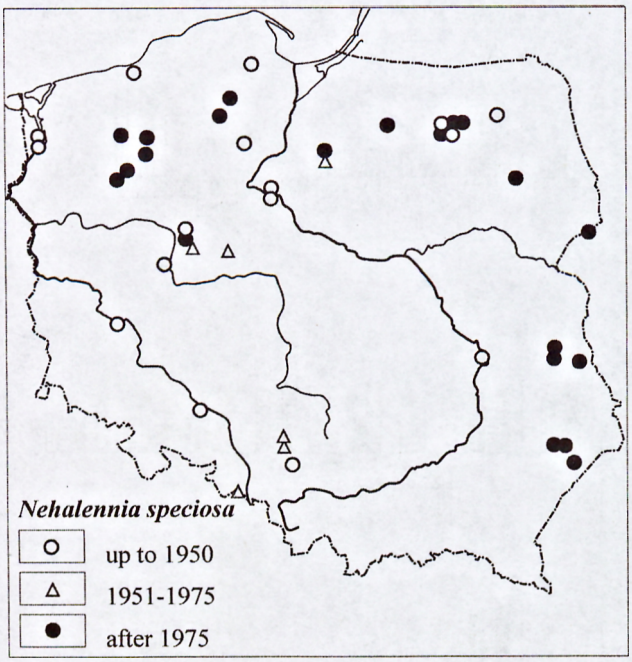


Fig. 4. Occurrence of *Nehalennia speciosa* in Poland; data up to 2002.

or more permanent. It seems, however, that the occurrence, ranges and abundance of at least some of these species are generally pulsating in their nature (correlated with climatic changes), both in Poland and in the whole northern part of central Europe (Bernard 1997b). According to this interpretation, the last decade is a typical example of such a 'pulsation' favourable to thermophilous southern species.

No negative consequences of an increased presence of southern species for typically native dragonflies have been observed so far, which results, among others, from the fact that the newcomers have occupied partly the habitats which had been fairly poorly or even poorly inhabited by natives. This suggests that some niches must have been free there. Especially in anthropogenic habitats (ditches, waterbodies in gravel and sand pits, small artificial pools), with fast succession and artificial restoration, many niches are continuously or temporarily free. This allows allochthonous species to become a component of native fauna. Typical examples could be: a) *Orthetrum brunneum*, a pioneer species preferring shallow waters with poor or no vegetation, frequently freshly cleaned ditches and meadow streams, and b) *Aeshna affinis*, inhabiting mainly small, strongly insolated, wind-protected, astatic or even temporarily drying out, forest and field pools and stagnant ditches. The coexistence of auto- and allochthonous dragonfly species seems to be peaceful also due to the fact that some newcomers (e.g. *H. ephippiger*, *S. fonscolombii*) are nomads. They inhabit the localities irregularly or rarely and only for a short time (at most some months). However, conditions suitable for the entry of new species, without negative consequences for residents, can occur also in some stable habitats with a richer native fauna. For example, *Erythromma viridulum* has broadened its range northwards probably due to both climatic changes and the increased abundance of *Ceratophyllum* (as a result of increased trophy of waters). The coexistence of *E. viridulum* with other species, e.g. *Cercion lindenii*, *Erythromma najas* (Hansem.), using submerged vegetation periodically appearing on the surface (*Ceratophyllum*, *Myriophyllum*), is possible due to partial temporal and spatial segregation of their niches (Bernard 1999).

The current picture of the dragonfly fauna of Poland has also been drawn by the falling number and increasing scatter of localities, and narrowing ranges of some species, mainly stenotopic. Siberian, relict *Nehalennia speciosa*, very sensitive to habitat changes, has almost completely withdrawn from southern and central Poland during the last few decades (Bernard 1998, in press a) (Fig. 4). For example, in the Wielkopolska region, where the species was known from a few localities, the last record (1 specimen) was made in 1977 in the Zielonka Forest near Poznań (Łabędzki 1987); at present, *N. speciosa* does not occur there. Searches for this species in many areas in this region in the last decade have not been successful. It currently occurs only in lake districts of N Poland and in some areas of the mideastern part of the country. Additionally, some narrowing of its habitat spectrum has been noticed. At present, the species is limited to very specific conditions occurring mainly in small dystrophic lakes (in the border zone of *Sphagnum* mats and water), rarely also in the *Sphagnum* bogs with a high water level (Bernard 1998, in press a).

The alarming decrease in the number of records in western and central Poland has been noticed in another Siberian species – *Coenagrion armatum* (Buczyński 2000a, 2001b, in press; Bazyluk 2002; Kalkman and Dijkstra 2000; Samoląg 2002; Gilard pers. comm.) (Fig. 5). This suggests almost complete extinction of this species in large areas of the country. *C. armatum* inhabits mainly meso- and eutrophic stagnant waterbodies – lakes and permanent pools, rich in emergent, not very dense, clustered vegetation (Buczyński 2000a, in press). The eutrophication of waters, on the increase over the last decades, is followed by the overgrowing of large areas by poor in species, dense vegetation, unfavourable for *C. armatum*. The changes in general water conditions resulting in a decrease in number of small permanent waterbodies are certainly also adverse for this species.

Ponto-Mediterranean *Coenagrion ornatum* (Sél.) has probably become extinct in northern and central Poland. It had previously been rare in these areas though known at some dispersed localities up to Szczecin and Słupsk (e.g. Krüger 1925; Schmidt 1954; Urbański 1957). Despite intensification of studies and special search for this species, it has not been found in these parts of the country for more than 40 years (excluding a single specimen in a foreign habitat to the species

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– cf. Musiał 1986). What is more, *C. ornatum* has probably become very rare in southern Poland: after 1965 only 3 localities have been recorded there (Łabędzki 1995, data repeated in Borkowski 1999; Żak and Żak 1981). It seems that the main reason for this decline is the degradation and drying out of the habitats of *C. ornatum* – small, incompletely overgrown, insolated, warm, slowly running and clear meadow streams and ditches.

*Cordulegaster boltonii*, the species of clearwater, fairly fast running small rivers and larger streams, mostly very poor in vegetation and frequently at least partly shaded, is another example of this group of species. In the 20th century – the time of the strongest anthropopressure, this species became extinct in some intensively used and largely transformed areas in Poland, e.g. in Upper Silesia. Probably the last population, unfortunately doomed to extinction, was observed in the 1960's there (Bernard 2000b, in press b).

The occurrence of *Somatochlora arctica* in Poland is clearly relict. More numerous populations of this inhabitant of *Sphagnum* bogs have been preserved only locally in the eastern part of the country (in the Roztocze and Kotlina Sandomierska regions), and single localities in some other regions (Buczyński 1998; Buczyński and Tończyk in press).

The situation of three stenotopic mountain species: *Aeshna caerulea* (Ström), *Somatochlora alpestris* (Sél.) and *Cordulegaster bidentata* Sél. is very interesting. *A. caerulea* was recorded only at one certain locality – the peat bog located in Równia pod Śnieżką (plateau under the top of Mt Śnieżka)

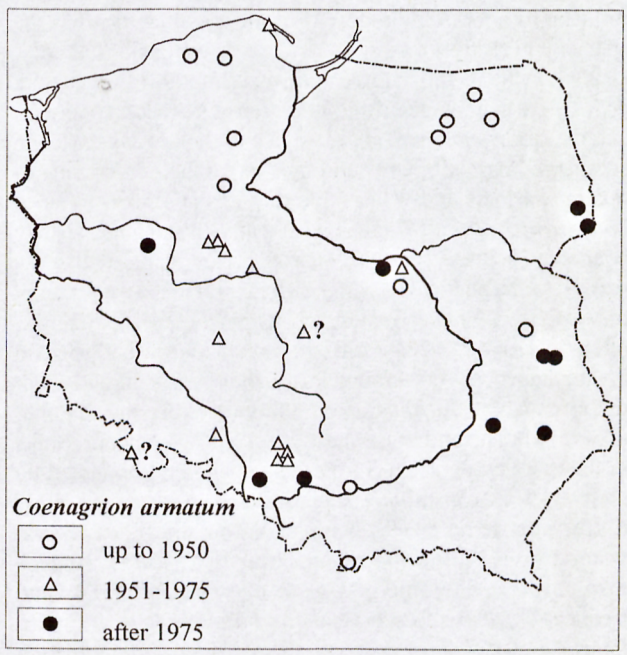


Fig. 5. Occurrence of *Coenagrion armatum* in Poland; data up to 2002. ? – uncertain data

(Mielewczyk 1969, Łabędzki's later observations, pers. comm.), and *S. alpestris* at ca. 25 localities (Mielewczyk in press). *C. bidentata* is widespread although it occurs locally (Buczyński et al. 2002a). These species, even if rare, do not seem to be in a deep regress; their situation is fairly stable. The relative rarity of *A. caerulea* and *S. alpestris*, as well as their qualifying for high categories in the Red list (Bernard et al. 2002), results mainly from a small number of appropriate habitats. Moreover, in the authors' opinion, some of their localities are still undiscovered.

The current picture of the dragonfly fauna of Poland is significantly influenced by the increasing scatter of local populations and weakened or broken relationships between them. This has been most probably followed by the decreased genetic stability of the whole Polish population. This concerns mainly the fauna of *Sphagnum* bogs but also that of small running waters, lakes of lower trophy and small waterbodies. Results of these processes have been significantly visible at local and regional levels so far. The high significance of anthropogenic waters (fish ponds, man-made pools in peat bogs, waterbodies in gravel, sand and clay pits, ditches, canals) is easy to understand in this context. They are important secondary habitats for these species which originally were related to natural waters: small waterbodies, littoral of lakes and smaller running waters, e.g. *Anax imperator* Leach, *Aeshna isosceles* (O.F. Müll.), *Leucorrhinia caudalis* (Charp.), *Leucorrhinia albifrons* (Burm.), *Sympetrum pedemontanum* (All.), *Sympetrum depressiusculum* (Sél.). For some of these species anthropogenic waters have become equally or even more important than natural ones. These species are most probably much more widespread and/or abundant at present than in the original picture of fauna. A typical example is *Anax imperator*, originally a species of small waterbodies, occurring also in lake bays. In the first half of the 20th century it was still considered as fairly rare or even rare in many regions of Poland, e.g. in Wielkopolska (e.g. Urbański 1934). At present, in the habitat spectrum of *A. imperator* different small anthropogenic waterbodies (pools in gravel and clay pits, pools in peat bogs and fens, fish ponds) prevail and the species is widespread and common at least in southern and central Poland. However, anthropogenic water habitats, mostly unstable, are a subject of fast succession. Without human interference (renewing, cleaning) they lose their value for part or even the majority of dragonfly species. Hence, dragonfly fauna of such waters is characterized by the significant variability in time.

## THREATS

It seems that none of the dragonfly species is currently in direct danger of extiction in Poland. Also the level of threats to dragonfly fauna is, in comparison with central and western Europe, at most moderate, although diversified in the regional, species and habitat context.

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There are three main kinds of processes which could result in extinction of species: climatic changes, processes related to demography and resources of the gene pool of population, and processes resulting from human activity. Two former kinds seem to be currently of small importance in Poland. The global climatic changes (observed warming) are frequently prolonged processes. Their current effects (in Poland a significant increase in the abundance of southern dragonfly species) are considered as an example of fluctuating changes rather than permanent ones (Bernard 1997b; Godet 1998; Hughes 2000). None of the dragonfly species seems to be significantly endangered by these processes at present. However, hot and dry summers, if occur year by year, may cause the significant fall in the water table in *Sphagnum* habitats and, consequently, negatively influence the abundance of some species, e.g. *Nehalennia speciosa*. Similarly, intrapopulation processes are currently not a serious danger for native species, possibly with the exclusion of few species occurring at very rare localities in Poland (*A. caerulea*, *S. alpestris*) or very scattered and being in a deep regress (*N. speciosa* – a species with very limited abilities to disperse).

Anthropopressure is a much more important threat to *Odonata* of Poland. In this context, threats could be divided into direct and indirect. The potential direct dangers are the collection of dragonflies and scientific studies. The former threat is not great at present because of very limited interest of Polish amateur entomologists. However, this situation may change after joining the European Union. The increased exploration of Poland by German, Dutch and French odonatologists has been observed for some years. It would be acceptable but some negative examples of the mass catching of some endangered species (e.g. *Nehalennia speciosa*) by foreigners are known to us. Scientific studies, due to the low number of specialists can be treated only as a marginal problem in Poland.

The indirect threats – changes in habitats caused by human activity – are the most important danger to Polish *Odonata*. In the analysis given below, only the main processes related to changes in water environment have been considered.

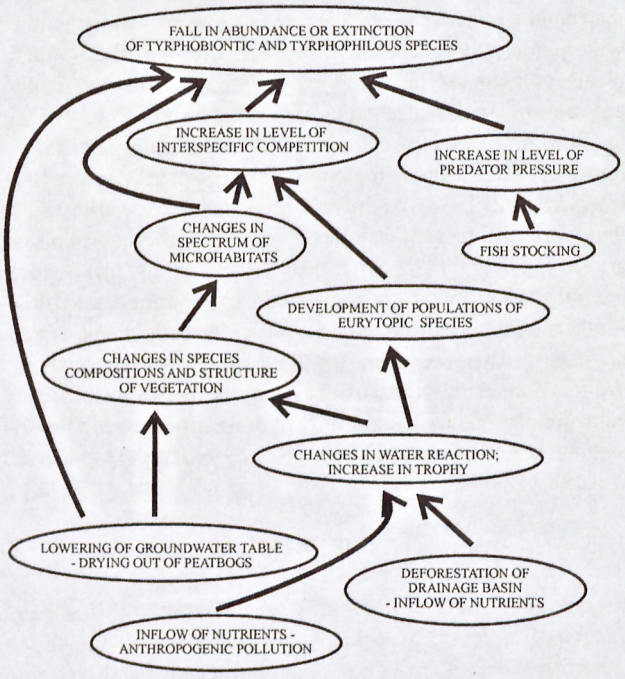


Fig. 6. Main factors and processes threatening dragonfly species related to *Sphagnum* bogs and waterbodies bounded by *Sphagnum*.

*Sphagnum* bogs and waterbodies bounded by *Sphagnum*

The species of dragonflies related to *Sphagnum* waters are more or less stenotopic, so sensitive to habitat changes. Therefore, they are considered, besides the species of running waters, as the most endangered dragonflies. In regions with more natural conditions preserved (northern and eastern Poland, and mountains in the south) this fauna is not very endangered. However, local declines in the number of localities and some negative changes in the habitat structure have also been observed. A much worse situation is in western, central and partly southern Poland, the more industrialized and more intensively used for agriculture regions. The survived *Sphagnum* bogs and waterbodies bounded by *Sphagnum* are significantly rarer and more transformed there.

Processes resulting in extinction of tyrphobiontic and tyrphophilous species go various ways (Fig. 6). Influx of nutrients, changes in trophy and pH of water only rarely influence dragonflies directly. They most frequently affect the species indirectly through a decrease in water transparency, changes in the species composition and structure of vegetation, an increase in interspecific competition and predator pressure.

Larvae of *Nehalennia speciosa* live in shallow water rich in submerged parts of *Carex* and mosses, in the border zone of *Sphagnum* mats and water table of pools and lakes, rarer in *Sphagnum* bogs with a high level of water. Its imagines, strictly connected with vegetation, clearly prefer plants with very narrow stems and leaves which correspond to the eye spacing of *N. speciosa*. Teneral and less active imagines, when in danger, often sidle round a stem or leaf to hide their narrow body behind it. Simultaneously, due to similarity in the eye spacing and width of the leaf/stem, the imagines continuously keep the ability to observe from behind it (Bernard 1998). Such behaviour results in the fact that *N. speciosa* prefers vegetation dominated by narrow-leaved *Carex limosa* and/or *C. lasiocarpa*, more rarely *C. rostrata* (Bernard 1998, in press a). A significant increase in water trophy limits the occurrence of *C. limosa* and *C. lasiocarpa* to the emerged parts of *Sphagnum* mats and frequently leads to total extinction of these sedges, at first *C. limosa*, then *C. lasiocarpa*. Also the narrowing or elimination of the belt of floating mosses in the shore zone takes place. The extinction of *N. speciosa* follows these habitat changes. The majority of *Sphagnum* pools and small lakes in Poland

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are already inappropriate for this species.

An example of another mechanism of changes, clearly based on an increase in interspecific competition, was given by Buczyński (2001a). Larvae of *Somatochlora arctica* occurred in the peat bog in Boreczki (Kotlina Sandomierska) in a temporarily drying out ditch, densely overgrown by *Sphagnum*. *S. arctica* was the only dragonfly species there. Then, between 1997 and 1998, this ditch did not dry out. Therefore, it was inhabited by 10 other species of dragonflies, both related to *Sphagnum* bogs and eurytopic. *S. arctica* vanished rapidly: its last larvae were collected in the autumn of 1997, only half a year after the beginning of the colonization of this ditch by other species.

The predator pressure of fish can be another limiting factor. For example, larvae of *Leucorrhinia dubia* (Vander L.), attacked by fish, try to escape and are usually eaten unlike larvae of dragonfly species coexisting with fish, which in such a situation use thanatosis. Hence, in waterbodies with fish, *L. dubia* is closely related to the floating *Sphagnum* where dragonflies hide (Henrikson 1984, 1993). If this microhabitat is rare or lacking (because of processes described above) the species also becomes rare or extinct.

### Marshes, fens and swamps

Marshes, fens and swamps, frequently connected with river valleys, are the subject of very fast degradation as a result of drainage. Their vanishing, increased in western Europe, is not so significantly marked in Poland. Many such areas are still preserved in good condition, especially in northeastern part of the country.

The mechanism of change, related to the lowering table of groundwater, results in drying out of soils, rotting of plant debris and the release of significant amounts of nutrients. This is followed by fast changes in the species composition and structure of vegetation. The small waterbodies and swamps dry out or at least become shallow and often shaded by willow shrubbery. Such changes cause the decline of the species diversity and abundance of dragonflies.

The poorness of *Odonata* of fens and swamps has been observed through many years in the Kampinoski National Park. The drainage of these habitats, located alongside (zonally) the valley of the Wisła (Vistula) river, has resulted in negative changes of their water conditions (towards drying out) and in a significant decrease in the abundance of dragonflies. The potential capacity of these areas for dragonflies was observed after the flood in the summer of 1997. The widely spilled waters of the river, which persisted to the autumn of the next year, restored to a large extent the natural conditions of these areas. Already in the summer of 1998 a significant increase in the number of larvae of such species as *Libellula quadrimaculata* L. and *Sympetrum danae* (Sulz.) was observed. Although these species had been recorded frequently in the Park their larval populations had never been so large and numerous (Tończyk unpubl. data).

### Lakes

The lake dragonflies seem to be endangered generally in Poland only to a low degree although the level of danger is regionally diversified. It is much lower in the forest areas of lake districts in northern Poland than in intensive agricultural areas of the Wielkopolska and Kujawy regions, where the lake dragonfly fauna is frequently poorer than in the former regions.

Eutrophication, significantly accelerated by human activity and extending even to politrophy, is the main reason for changes in the species composition of lake dragonfly assemblages (Fig. 7). An increase in trophy is accompanied by oxygen deficit, a decrease in water transparency, changes in the nature of bottom sediments and, in consequence, changes in the species composition and structure of vegetation (at first submerged vegetation becomes less abundant and much poorer). As a result, a decrease in number or extinction is observed at first in the case of dragonfly species requiring clear transparent water and/or rich submerged vegetation: at first *Leucorrhinia albifrons*,

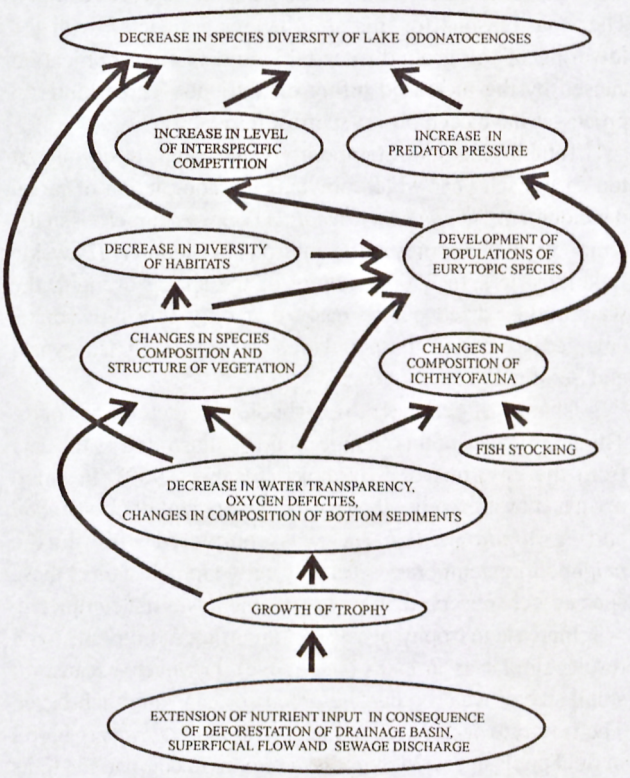


Fig. 7. Main factors and processes causing a decrease in species diversity of lake odonatocenoses.

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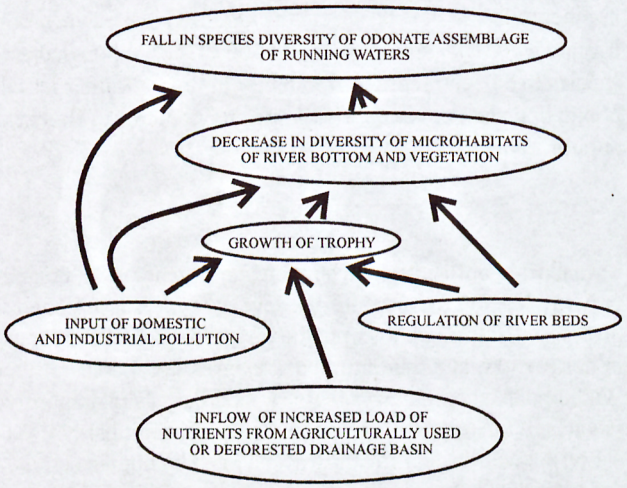


Fig. 8. Main factors and processes negatively influencing dragonfly assemblages of running waters.

then *Leucorrhinia caudalis*, and then *Enallagma cyathigerum* (Charp.). In the end, the dragonfly fauna consists only of few eurytopic species, relatively insensitive to habitat degradation.

Small natural waterbodies in open landscapes

*Odonata* of these habitats are endangered in the whole country. The main reasons for this are changes connected with the lowering of the groundwater table and fast eutrophication caused by the increased influx of nutrients. Three kinds of processes have been observed most frequently:

1. Total drying out of temporary waterbodies or drying out too early each year which prevents the completion of larval development. *Sympetrum flaveolum* (L.) was numerous in the temporary waterbodies in the environs of Siemiany (Iławskie Lake District). In 2000, because of the spring drought, the waterbodies dried out so early that only few individuals emerged. Up to 2002 this population was not rebuilt (Buczyński and Serafin 2002).

2. Change of permanent waterbodies into temporary ones. The significance of this change could be illustrated by the data from the environs of Mikołajki (Fischer 1959). In small permanent waterbodies the larval development of *C. armatum* and *C. lunulatum* (Charp.) was completed while in the neighbouring temporary ones only early larval instars of these species were observed; their development was not completed.

3. Increase in trophy because of an influx of nutrients, with results similar as in lakes (see above), however, because of small size of waterbodies the processes can run much faster. The very rare occurrence of *Leucorrhinia pectoralis* (Charp.) in field pools in the Wielkopolska region, in comparison to its potential possibilities (locally the high number of waterbodies), seems to be a good example of the effects of such changes.

Small running waters (small rivers, streams, ditches)

The dragonflies of these habitats, besides the species of *Sphagnum* bogs, are generally the most threatened in Poland. The processes of habitat changes and their causes are similar to a large degree in forest and open areas (Fig. 8) but running waters differ there significantly in their fauna.

A. Small forest running waters

The main causes of changes are: deforestation of the nearest neighbourhood, pollution by sewage and high amounts of nutrients (also influx of water and sediments from fish ponds), regulation of the riverbed and riverbanks. The effects are: changes in light and temperature conditions, an increase in trophy, a decrease in water transparency, a hydrological instability, changes in the nature and structure of bottom sediments from a mosaic pattern to much more unified (most frequently to muddy), overgrowing of the riverbed by the larger amounts of vegetation. Microhabitats appropriate for dragonfly species (typical of forest waters) become rare or lacking. In consequence, the species preferring cooler and at least partly shaded clear waters and sandy-gravely bottom, at most partly covered with some amounts of detritus, such as *Cordulegaster boltonii*, *Onychogomphus forcipatus* (L.), *Calopteryx virgo* (L.), become rare or extinct (cf. e.g. Bernard 2000b). The specificity of an assemblage significantly declines because it becomes predominated by less stenotopic, less sensitive to habitat changes and more common species, as *Calopteryx splendens* (Harr.), *Platycnemis pennipes* (Pall.), *Gomphus vulgatissimus* (L.) (Tończyk 2001).

B. Small running waters in open areas

Originally, the most common features of these habitas were: clear water, relatively low trophy, vegetation not overgrowing densely the whole bed but frequently rich in species. The species typical of such small rivers and streams (and also anthropogenic habitats – ditches), as e.g. *Coenagrion ornatum*, *Orthetrum coerulescens* (Fabr.), *Sympetrum pedemontanum* (All.), become endangered or extinct because of pollution and regulation of these running waters, dense overgrowing of their beds, shading by shrubs and drying out (ditches). Only the species less sensitive to such habitat changes remain, as e.g. *Pyrrhosoma nymphula* (Sulz.), *Sympetrum vulgatum* (L.), *S. sanguineum* (O.F. Müll.). The discontinuation (noticeable in the last two decades) of the regular cleaning of the beds of most ditches and mowing of vegetation overgrowing their beds and banks has significantly strengthened these negative changes, especially in lowlands.

The extinction of *Sympetrum pedemontanum* in the regulated meadow stream in Ciechanki Łańcuchowskie by Łęczna (the Lubelska Upland) could be a good example of these negative trends (Buczyński 1995 and unpubl. data). The probable total extinction of *Coenagrion ornatum* in Polish lowlands (see chapter 'The current picture of odonate fauna of Poland') seems to be also a result of the described changes. The positive role

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of the mowing of vegetation in the bed and on the banks of ditches could be observed e.g. in a ditch in Bociniec near Gołuń (ENE of Poznań) where a population of *Orthetrum coerulescens* has survived due to these activities, which have prevented complete overgrowing (Bernard unpubl. data).

### Medium-sized and large rivers

Pollution and regulation of rivers cause a decrease in the quality of water and in the number of appropriate microhabitats (Fig. 8). In consequence, the odonatocenoses become poor (only few species) and predominated by the less sensitive species with the broadest habitat spectrum, such as: *Calopteryx splendens*, *Platycnemis pennipes*, *Gomphus vulgatissimus* (Tończyk 2001).

It must be stressed, however, that degradation of dragonfly fauna of large rivers has never been so significant in Poland as in the part of Europe west of Poland. Museum collections and scarce literature data from the rivers Wisła, Pilica and Warta indicate that even in the period of the highest emission of pollution in Poland (in the 1970's), the river species were not in a deep regress (cf. Biesiadka and Kasprzak 1977; Tończyk unpubl. data). What is more, the studies, also carried out in Poland by the authors, reveal that the species inhabiting rivers, e.g. *Ophiogomphus cecilia* (Fourcr.), *Gomphus flavipes* (Charp.), are not so highly sensitive to water pollution as it is generally believed (e.g. Corbet 1993, 1999; Suhling and Müller 1996; Tończyk 1996). They sometimes occur even in fairly polluted waters.

### Anthropogenic waterbodies (in peat bogs, fens, gravel, sand and clay pits)

Although these secondary habitats are an artificial element in landscape they have been present for such a long time and are so important for dragonflies that they should be treated with the same attention as natural habitats. Three principal threats to them should be considered (Fig. 9):

A. Legal duty of reclamation of sand or gravel pits. It is in practice tantamount to filling them in with solid material, which results in the liquidation of small waterbodies inhabited among others by the pioneer species (*Ischnura pumilio* (Charp.) and *Libellula depressa* L.) and thermophilous ones, e.g. *Orthetrum albistylum*. Out of 10 sand pits with waterbodies, studied in the Lublin region between 1997 and 1999, only 6 remained up to 2002 (Buczyński 1999a and unpubl. data).

B. Fast succession of vegetation. Small and shallow waterbodies in pits are overgrown very fast and, in effect, they frequently vanish. Therefore, their dragonfly fauna is ephemeral and becomes poor after a short time.

C. Fishing (Ott 1995). A large increase in the number of waterbodies used by anglers has been noticed in Poland in the recent decade. Stocking waterbodies with fish, mowing and destroying water vegetation and using large amounts of lure to entice fish (which results in growth of water trophy) could negatively influence dragonflies:

– directly, because of the introduction of such fish which prey on macroinvertebrates, among them larvae of dragonflies,
– indirectly, through a decline in variety of microhabitats.

The extinction of some dragonfly species and a decrease in numbers of some others have been noticed in 2002, in comparison with observations from 1994-95, in a pond located next to the municipal dump in Poznań (Bernard 1996, 2002 and unpubl. data). In the meantime this waterbody started to be used as an angling pond. It seems that this fact has been mainly a result of a decrease in the variety of microhabitats because of anglers' activity.

### Final remarks

The main threats to dragonflies of central and northwestern Europe, i.e. eutrophication and acidification of waters, drainage, regulation of running waters, pollution, deforestation, afforestation (van Tol and Verdonk 1988), mostly coincide with those observed in Poland. Only acidification and afforestation of shores of waterbodies do not play such a significant role in Poland as in some other regions of Europe. However, a very general presentation of threats by van Tol and Verdonk does not allow a detailed comparison to be made.

In the authors' opinion, based on their own and literature data, the state of dragonfly fauna of Poland is generally fairly good. This results from the fact that it comprises mostly the species widely distributed and relatively common, with a broad or fairly broad habitat spectrum, in many cases inhabiting also

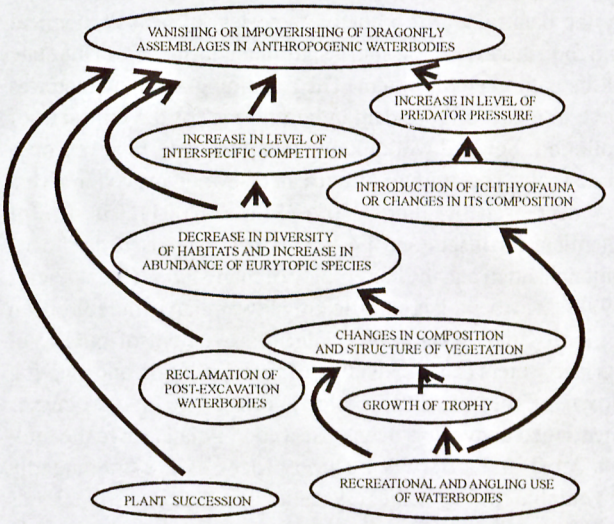


Fig. 9. Main factors and processes resulting in the impoverishment and vanishing of dragonfly assemblages in anthropogenic waterbodies.

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anthropogenic habitats. A large number of species are not sensitive to eutrophication and its consequences if these processes are not highly advanced. The most difficult is the situation of stenotopic species preferring the habitats preserved to a large degree in a natural state, mainly waters connected with *Sphagnum* and small current waters.

The lower level of negative changes in dragonfly fauna in Poland is worth noting compared with western Europe and other countries of central Europe. This is related to lower anthropopressure in the past. However, the level and kind of threat is regionally much diversified in Poland. The highest danger, comparable to other countries of central and western Europe, is observed in Wielkopolska (Great Poland) and Śląsk (Silesia), the regions which have been influenced by intensive agricultural and industrial economy over a long period. The environment in other regions, especially eastern, and partly southern and northern, is not so transformed and destroyed. These differences reflect to a large degree the different economic policies adopted in the three parts of Poland under German, Russian and Austrian rule during the long period 1794-1918. This division between some of the German districts, more intensively used, and less transformed Russian and Austrian parts is still surprisingly readable. Therefore, it would be better to analyse threats on a regional level but the state of knowledge is still insufficient to do this, e.g. a local red list has been prepared only for the Lublin region so far (Buczyński 1999b).

A complete analysis of trends of changes in the dragonfly fauna of Poland is very difficult because the period of precise data collection has been too short. It seems, however, that the situation of dragonflies in Poland in the last 10 years possibly even has improved due to improvement of natural conditions. Changes in management and economy in this period, followed by the bankruptcy of outdated factories (of heavy, chemical and food industry) have had a significant influence on the state of the natural environment. The remaining and new factories have to observe more demanding norms for the emission of pollution. Sewage works have been built and renewed on a large scale. The amount of untreated sewage moved in rivers has decreased by almost 70% (Filipek 2001). The use of chemical fertilisers and pesticides has decreased due to its rationalization and the bankruptcy of many farms (Stankiewicz 1998); at present, it is significantly lower than in the European Union (Kułakowski 2000). The improvement of quality of surface waters (i.e. the decline of their pollution and slowing down of their eutrophication), related to the processes mentioned above, has been observed in Poland since the mid-1980's (Burchard 1999). These processes are undoubtedly favourable to dragonflies. It seems that these positive trends will be continued in industry but in agriculture most probably will be inverted. The negative changes have already begun in agriculture, they are especially important in the previously less transformed eastern and part of southern areas of Poland. The present extensive agriculture, based on a large number of small farms producing to a large extent for farmers own needs will be turned into more intensive methods of production. This will be followed by the deterioration in the quality of waters and, consequently, by the regress of some dragonfly species related to small waterbodies and running waters of open landscape.

## CONSERVATION – THE CURRENT STATE AND PROPOSALS

Three levels of conservation of dragonflies could be distinguished (Wildermuth 1994): the species (prohibition of catching and killing), the habitat (especially important for larvae) and the whole environment (waters, air, soils etc.). To realize them, passive and active forms of conservation could be used.

### PASSIVE CONSERVATION

#### Species protection

Up to the mid-1990's, vertebrates were the main subject of species protection in Poland. Out of invertebrates only few *Mantodea*, *Coleoptera*, *Lepidoptera* and *Hymenoptera* were protected (Rozporządzenie ... 1983). Only in 1995, due to the ratification of the Bern Convention by Poland, 7 species from its Appendix II were qualified as the species protected in Poland (Rozporządzenie ... 1995). Unfortunately, this set of species, compiled previously mainly for the part of Europe situated west of Poland, did not reflect the situation in Poland and did not meet the needs of conservation here. In 2001, 4 further species were added (Rozporządzenie ... 2001), partly after taking into consideration the opinions of odonatologists. At present, *Sympecma paedisca* (Brau.), *Coenagrion ornatum**, *Nehalennia speciosa**, *Gomphus flavipes*, *Ophiogomphus cecilia*, *Aeshna caerulea**, *Aeshna viridis*, *Somatochlora alpestris**, *Leucorrhinia albifrons*, *Leucorrhinia caudalis* and *Leucorrhinia pectoralis* are protected (* the species added in 2001). Unfortunately, 3 highly threatened species which should be protected are not covered, i.e. *Coenagrion armatum* (category CR in the Red list of threatened animals in Poland), *Somatochlora arctica* (VU) and *Cordulegaster boltonii* (VU) (Bernard et al. 2002). In contrast, among protected species there are 3 species of lower risk: *A. viridis* (LC), *L. albifrons* (LC) and *L. caudalis* (NT) and even 4 which are not endangered in Poland at all (!): *S. paedisca*, *O. cecilia*. *G. flavipes* and *L. pectoralis* (cf. Bernard et al. 2002). This paradoxical situation is a consequence of the ratification of the Bern Convention and not taking into consideration the opinion of native specialists. As a result, labour and funds are wasted on unthreatened species while the species requiring real care are omitted.

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Table 1. The Red list of dragonflies of Poland.

| Species | Ex | CR | EN | VU | NT | LC | DD |
|---|---|---|---|---|---|---|---|
| *Coenagrion armatum* (Charpentier, 1840) | | x | | | | | |
| *Coenagrion ornatum* (Sélys, 1850) | | x | | | | | |
| *Nehalennia speciosa* (Charpentier, 1840) | | | x | | | | |
| *Cercion lindenii* (Charpentier, 1840) | | | | | | x | |
| *Aeshna affinis* Vander Linden, 1820 | | | | | | x | |
| *Aeshna caerulea* (Ström, 1783) | | | x | | | | |
| *Aeshna juncea* (Linnaeus, 1758) | | | | | | | x |
| *Aeshna subarctica elisabethae* Djakonov, 1922 | | | | | x | | |
| *Aeshna viridis* Eversmann, 1836 | | | | | | x | |
| *Cordulegaster boltonii* (Donovan, 1807) | | | | x | | | |
| *Somatochlora alpestris* (Sélys, 1840) | | | x | | | | |
| *Somatochlora arctica* (Zetterstedt, 1840) | | | | x | | | |
| *Orthetrum brunneum* (Fonscolombe, 1837) | | | | | | x | |
| *Orthetrum coerulescens* (Fabricius, 1798) | | | | | | | x |
| *Leucorrhinia albifrons* (Burmeister, 1839) | | | | | | x | |
| *Leucorrhinia caudalis* (Charpentier, 1840) | | | | | x | | |
| the total number of species – | 0 | 2 | 3 | 2 | 2 | 5 | 2 |

## Red List and Red Book

The assessment of the situation of threatened species in Poland was given in the Red List (Bernard et al. 2002) (Table 1). 16 species are included (22.2 % of the whole dragonfly fauna), 7 of them (9.7 %) into higher categories: CR – 2 species, EN – 3, VU – 2. Five species (out of these 7) are elaborated on in the Polish Red Book scheduled for 2004 (Bernard in press a, in press b; Buczyński in press; Buczyński and Tończyk in press; Mielewczyk in press).

The Polish Red List of dragonflies is an example of a narrow (in our opinion = realistic) treatment of this subject, similar to that presented e.g. in the Swedish Red List (Sahlén and Norling 2000). In contrast, other specialists (e.g. German) approach this problem in a different way. Many more species – in some cases even more than 60% of the whole fauna – are included in the national or regional red lists prepared by them (e.g. Ott and Piper 1998; Sternberg 1999). The analyses of literature from these areas indicate that such wide treatment and the attribution of higher categories to some species are frequently unfounded and too alarmist. A good example is the case of *Cordulegaster boltonii* in Baden-Württemberg. It is known from over 480 localities there, in a large part recorded after 1980. Despite this fact, the species has been qualified to the relatively high category 3 which is an equivalent of the category VU (Sternberg 1999; Sternberg et al. 2000).

It must be stressed that when taking these different approaches into consideration only some aspects of red lists are comparable (to some extent), e.g. the number and percentage of extinct species or proportions of zoogeographical elements. The comparison of the situation of dragonflies, even only in terms of percentage of extinct species, between Poland (Bernard et al. 2002) and other European countries (BDS 2003 – Great Britain; David 1999, Bulanková and Blaškovič 2003 – Slovakia; De Knijf and Anselin 1996, Goffart 2000 – Belgium; Dolmen and Olsvik 1999 – Norway; Dommanget 2002 – France; Gonseth et al. 2002 – Switzerland; Hanel and Zelený 2000, Dolný 2001 – the Czech Republic; Holmen 2002 – Denmark; Kalkman et al. 2002 – the Netherlands; Ott and Piper 1998 – Germany; Proess and Gerend 1998 – Luxembourg; Sahlén and Norling 2000 – Sweden) (Fig. 10) confirms our opinion that the situation of Polish *Odonata* is relatively good. The same comparison indicates that a large part of extinct and most endangered dragonfly fauna in particular countries includes the species being at their range limits. These are Mediterranean species in Scandinavia (e.g. Dolmen and Olsvik 1999) or Siberian and West Siberian species

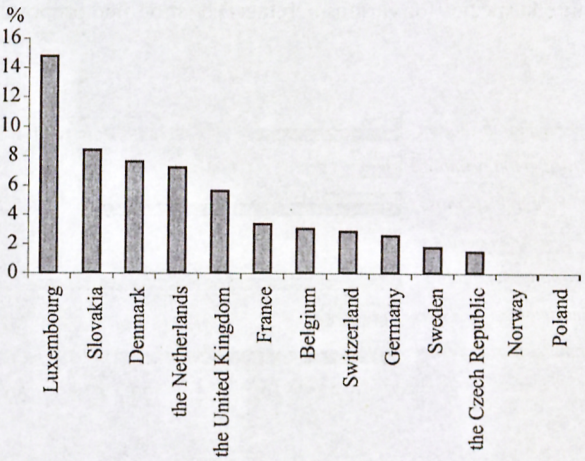


Fig. 10. Percentage of extinct species in the dragonfly fauna of particular European countries (according to the literature cited in the text; typical migrants occurring only temporarily have not been counted).

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in the western part of central Europe and in western Europe (cf. e.g. Gonseth et al. 2002; Kalkman et al. 2002; Ott and Piper 1998). In this context, in Poland, as in a transitional country, the Siberian and West Siberian species are much less endangered than in the countries situated further west, and the Mediterranean element is significantly less threatened than in Scandinavia. The large area of Poland and its high diversity of habitats also decrease the risk of extinction of species.

In practice, red lists and red books are of indirect significance. They are, however, very important because they allow localities to be evaluated. The localities most valuable for the species can be selected and covered with legal protection. Therefore, the adequacy of these lists to the real level of threats is very important.

### Umbrella species and local nature refuges

The name "umbrella species" is proposed for the species typical of particular habitats, frequently relatively easy to identify (even for a non-specialist) and visually attractive. They do not have to be rare or red-listed. Due to protection of their localities also many other co-occurring species, sometimes very valuable but more difficult to find, are under the protective umbrella (Czachorowski et al. 2000). This method is intended mainly to assign, in cooperation with local authorities and organisations, locally valuable localities which demand care but cannot be protected as reserves. Thus, the umbrella species could serve to create in local communities the feeling of pride and care of valuable nature objects. A good example is the successfully operating system of local nature refuges in the area covered by the Club of Naturalists in Świebodzin (cf. Jermaczek and Stańko 1998).

Czachorowski et al. (2000) proposed a list of dragonfly umbrella species for various habitats. The modified proposal,

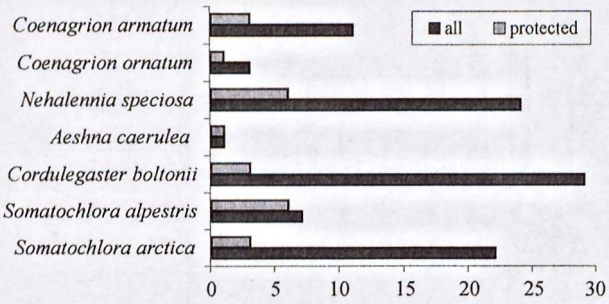


Fig. 11. Number of protected (= situated in nature reserves and national parks) localities of the most endangered species in Poland in comparison with all known localities of these species (only localities found after 1975 are considered).

after a preliminary verification in practice, is given below:

- *Sphagnum* bogs and waterbodies bounded by *Sphagnum* – *Nehalennia speciosa*, *Aeshna caerulea*, *A. juncea*, *A. subarctica elisabethae*, *Somatochlora arctica*, S. *alpestris*, *Leucorrhinia albifrons*, *L. dubia*, *L. pectoralis*;
- fens, swamps and marshes – *Aeshna juncea*, *Leucorrhinia pectoralis*;
- lakes – *Cercion lindenii*, *Epitheca bimaculata* (Charp.), *Leucorrhinia albifrons*, *L. caudalis*;
- small natural waterbodies in open landscape – *Coenagrion armatum*, *C. lunulatum*;
- small forest running waters – *Ophiogomphus cecilia*, *Onychogomphus forcipatus*, *Cordulegaster boltonii*;
- small running waters in open landscape – *Coenagrion ornatum*, *Orthetrum coerulescens*, *Sympetrum pedemontanum*;
- middle and large rivers – *Gomphus flavipes*, *Ophiogomphus cecilia*;
- anthropogenic waterbodies: peat pools – *Leucorrhinia albifrons*, *L. caudalis*, *L. pectoralis*; gravel, sand and clay pits – *Aeshna isosceles*, *Anax imperator*, *Orthetrum albistylum*; fish ponds – *Anax parthenope* (Sél.).

### Territorial protection (reserves, national parks)

The localities of 7 most threatened species (categories VU-CR, Bernard et al. 2002), recorded after 1975, have been analysed (Fig. 11) (Bernard in press a, in press b; Buczyński in press; Buczyński and Tończyk in press; Łabędzki 1995, data repeated by Borkowski 1999; Mielewczyk 1969 (and later observations by Łabędzki – pers. comm.), in press; Musiał 1986; Samoląg 2002; Żak and Żak 1981). Apart from *A. caerulea* and *S. alpestris*, the number of protected localities of these species is highly insufficient. In our opinion, all localities with large and stable populations of these species should be protected. However, in the case of some of these species, mainly *C. ornatum* and *S. alpestris*, rather partial reserve protection should be used than full because some activities maintaining the state of habitat (= stage of succession) necessary for the species are possible then. For example, to protect the habitat of *S. alpestris* (small pools in *Sphagnum* bogs) it is necessary to limit its overgrowing by *Sphagnum* and overgrowing of shores by *Pinus mughus* (Mielewczyk in press).

## ACTIVE CONSERVATION

### Reintroduction

Reintroduction could be planned mainly for the most threatened species, e.g. *Coenagrion armatum*, *C. ornatum*, *Nehalennia speciosa*, *Cordulegaster boltonii*. The lack of published data on this method, considering dragonflies, is surprising because theoretically it seems to be fairly easy. The biology of the species

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given above is sufficiently known and rearing or catching of their larvae is mostly easy and cheap. A pilot programme of (re)introduction of *N. speciosa* into some localities in N Poland has just been prepared.

## Creating new waterbodies

Creating new waterbodies, as a way to enrich the species diversity, is popular and frequently used in western Europe. In Poland this method has just been born, the first experiences are mostly rather accidental than planned. Small waterbodies, created on private grounds or on grounds bought by organisations of naturalists, are a great chance in the areas transformed by anthropopressure, and should be restricted mainly to such areas. Providing a variety of niches and permanent human interference to maintain them in the favourable condition are the crucial factors for the success of this method.

Such artificial waterbodies are inhabited mainly by the species which are most often common and eurytopic or with some preference for small waterbodies. It must be stressed that this method is not orientated at rare species but rather at an increase in the species diversity (not only of dragonflies). Due to the great abilities of dragonflies to colonize freshly created waterbodies (cf. e.g. Buczyński 1999a; Chovanec et al. 1993; Martens 1991; Mielewczyk 1997b; Tończyk 2001 and unpubl. data) an odonatocenosis rich in species could be generated in favourable conditions even during a few years (Buczyński 1999a). If the diversity of niches is very high the number of species can even reach more than 40 species in one artificial waterbody (Bilek 1952). However, to maintain the high species diversity for a longer time, it is necessary to interfere in the succession of the waterbody.

## Interference in succession of waterbody

A highly recommendable method is the rotation model (Wildermuth 1994, 2001) for the management of small waterbodies, such as clay and gravel pits, artificial peat pools and even meadow streams and ditches. This method was successfully tested e.g. in Switzerland (Wildermuth 2001). Its core is maintenance of maximal diversity of habitats (= various succession stages) in one waterbody or in a complex of waterbodies. Human interference (i.e. transferring the larval habitat back to the pioneer phase of succession) at different moments in various parts of a waterbody or in various small waterbodies leads to a spatial mosaic of different stages of succession: they exist at the same time (Wildermuth 1994).

This method has not been used to conserve dragonflies in Poland so far. However, studies in sand and clay pits have indirectly brought some data in this matter. Due to the abandoning of old pits which are filled up by the ground and

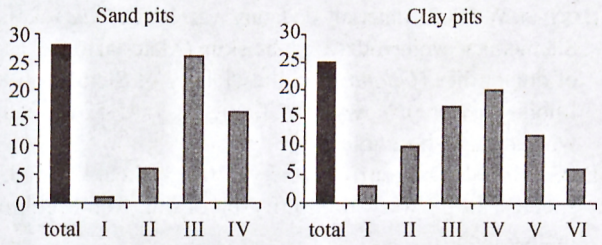


Fig. 12. Number of dragonfly species (only those whose larvae were found) occurring in particular stages of succession of sand pits in the Lublin region and clay pits in the valley of the Grabia River (central Poland). I-IV, I-VI – stages of succession.

rain water, and digging new ones, a mosaic of waterbodies of different age occurs. The data on sand pits in the Lublin region (Buczyński 1999a) and on a complex of clay pits in the valley of the Grabia River (central Poland, Tończyk 2001 and unpubl. data) are the most complete. In both cases the succession of dragonfly fauna was similar and strictly related to the succession of vegetation (changes in its species composition and structure), changes in the nature of bottom sediments and an increase in trophy. The succession of dragonfly fauna began from assemblages poor in species (mainly pioneer) and ran through rich and highly diversified assemblages of moderately overgrown waterbodies (rich in habitats) up to assemblages again poor in species, typical of overgrown and vanishing waterbodies. In the studied sand pits, 4 stages of succession of dragonfly fauna were recognized, in clay pits – 6 (Fig. 12). This difference could be explained by a significantly slower succession of vegetation in clay pits which is, among other reasons, connected with their greater depth. The same processes of overgrowing can run much longer in clay pits than in sand pits. The diagram (Fig. 12) illustrates changes in the number of dragonfly species (only those whose larvae were found) during the succession of these waterbodies. Also the density of larvae underwent changes according to a similar pattern (Buczyński 1999a). So, the waterbodies in moderately advanced stages of succession were characterized by the greatest diversity of dragonflies. What is more, they included the highest number of most valuable species (ecologically and zoogeographically) (Buczyński 1999a; Tończyk 2001 and unpubl. data).

Summing up, anthropogenic waterbodies, used for the conservation of dragonflies, should be maintained paralelly in the early and moderately advanced stages of succession. Its last stages are undesirable because of qualitative and quantitative poorness of dragonflies, represented mainly by eurytopic species, the least sensitive to unfavourable habitat conditions.

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