Classification of dystrophic ponds by means of the TWINSPAN algorithm for an ecological characterisation of the Odonata habitats in the Hohe Venn /Hautes Fagnes (Germany/Belgium)

M. Aletsee

Introduction

Dystrophic ponds are a common feature of the Hohe Venn (Hautes-Fagnes) on the German-Belgium border. Among them, it is especially the so-called palsa that are very important habitats for some rare and endangered species of Odonata (SCHMIDT, 1983). To be exact, these water bodies are relicts of palsa. Belgians use the word lithalsa, while the Germans call them Palsen or Frosthügelrelikte. In former times, they were interpreted as relicts of pingos. They are present in large numbers in the bog landscape of the Hohe Venn. Nowadays, palsa relicts are visible as a depression in the soil containing water and bog vegetation, and surrounded by a mineral wall. Unique geomorphological relicts of the postglacial period in Central Europe, they started developing in the Late-Glacial (Upper Dryas, 10,000-11,000 BP, PISSART & JUVIGNÉ, 1983) as frozen soil rising to the surface, the result of ice-segregation in the mineral soil (MEIER, 1987). After thawing in the postglacial period (Preboreal), the relicts of palsa were mired at varying rates by terrestrialisation (MULLENDERS & GULLENTOPS, 1969; FIGURE 1).

With the steady and copious precipitation, and the lack of nutrients in the cambric weathered clay, most of the water bodies that developed

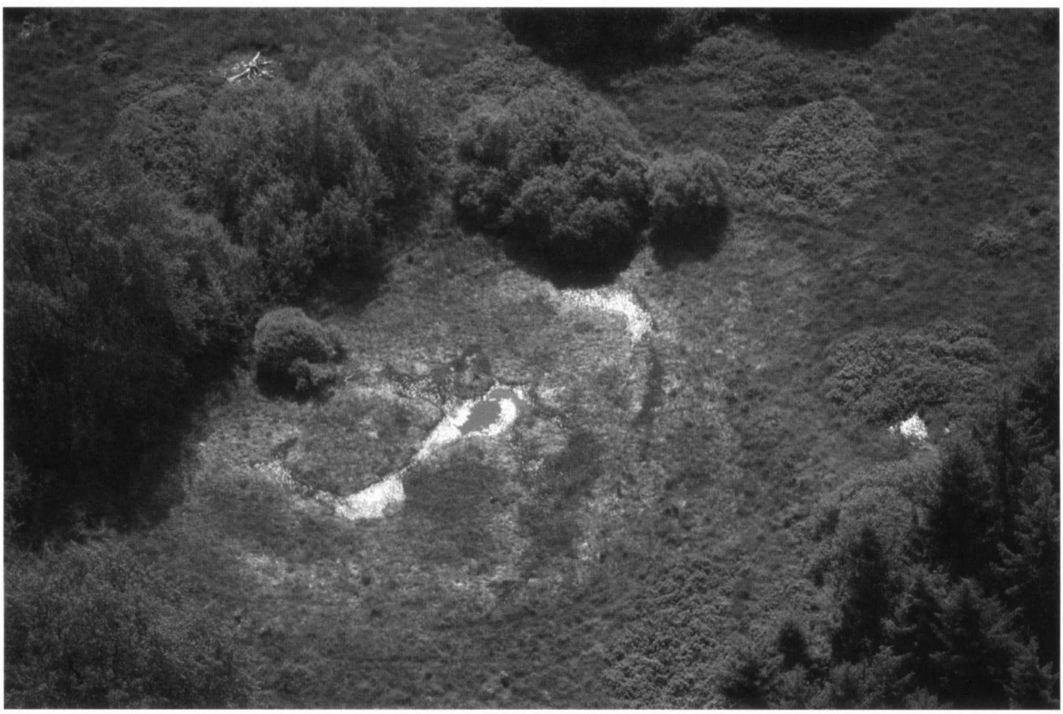

Figure 1. Mired palsa in the Wollerscheider Venn near Lammersdorf (Photo: M. Aletsee).

Table 1

Calculation of total, example (e = number of exuviae collected= reproduction, i = number of imagos observed

pond number	10	10	10	10	10	10	10	10	10	10	10	10	10	10	sum
status	e	e	e	e	e	e	e	i	i	i	i	i	i	i	∑e x 3+∑i
date	250501	240602	220801	230502	300702	180802	130703	250501	240602	220801	230502	300702	180802	130703	
Lestes sponsa			1			10				10		6	12	1	**62**
Pyrrhosoma nymphula								2	1						**3**
Coenagrion puella														3	**3**
Aeshna cyanea										1					**1**
Aeshna juncea						5				2			3	2	**22**
Aeshna subarctica					1										**3**
Libellula depressa															**0**
Libellula quadrimaculata		1		3				5						1	**18**
Sympetrum danae			3			1							2		**14**
Libellula dubia	6	2		3					1					1	**35**

Table 3

Classification by the TWINSPAN algorithms (sp-Schlenke ; kp-Kolk ; r-restored palsa; pr-primary (natural) pond, s-secondary (anthropogenic) pond; B-Belgium; G-Germany)

pondgroup (ecotop)		1				2							3								4			
pondtyp (morpho-genetic)	sp	sp	sp	sp	kp	kp	kp	sp	kp	kp	r	r	kp	kp	r	kp	r	p	p	p	p	p	p	r
origin	pr	pr	pr	pr	pr	pr	pr	pr	pr	pr	s	s	pr	pr	s	pr	s	s	s	s	s	s	s	s
country	B	B	B	B	G	B	G	G	B	G	G	G	B	B	G	G	G	G	G	G	G	G	G	G
number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Orthetrum cancellatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Sympetrum sanguineum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
Ischnura elegans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Ischnura pumilio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-
Libellula depressa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	4	-	-
Cordulia aenea	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	2	2	-	-	-	3
Anax imperator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	3	1	1	-	2
Enallagma cyathigerum	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	5	4	5	5	3	2	3
Coenagrion hastulatum	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	-	-	-	-	1	-	-	-	5
Lestes sponsa	-	-	-	-	-	-	-	-	5	5	-	5	-	3	3	-	-	5	5	5	4	5	-	5
Libellula quadrimaculata	-	-	-	-	-	-	-	2	5	4	1	3	2	-	5	3	5	-	1	-	5	3	3	5
Sympetrum danae	-	-	-	-	2	-	-	-	5	3	4	5	3	3	3	2	-	-	-	1	5	5	4	5
Coenagrion puella	-	-	-	-	2	-	-	-	3	2	3	2	-	2	3	-	2	2	-	5	5	5	3	5
Aeshna cyanea	-	-	-	-	-	1	-	-	2	1	2	-	-	-	-	-	2	3	2	4	2	-	1	2
Aeshna juncea	-	-	-	-	5	2	5	-	4	4	-	3	2	2	-	-	-	5	4	5	5	-	4	2
Pyrrhosoma nymphula	-	-	-	-	5	1	-	-	3	2	4	4	-	2	4	-	1	4	5	5	5	2	5	4
Leucorrhinia dubia	-	-	-	-	5	4	5	2	5	5	5	2	5	4	-	-	-	5	5	5	5	1	2	2
Aeshna subarctica	-	-	-	-	5	2	5	5	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Somatochlora arctica	5	2	2	2	2	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

were nutrient-poor; some ombrotrophic bogs also developed. The palsa were mired (overgrown) with several types of bog; several mixed stages, as well as a variety of transitional stages were present. The type of bog formed in the palsa depended on its diameter and depth, the altitude at which it was situated, the precipitation and evaporation during the period of peat formation, as well as whether the spring water feeding the bog was supplemented with soligenic water.

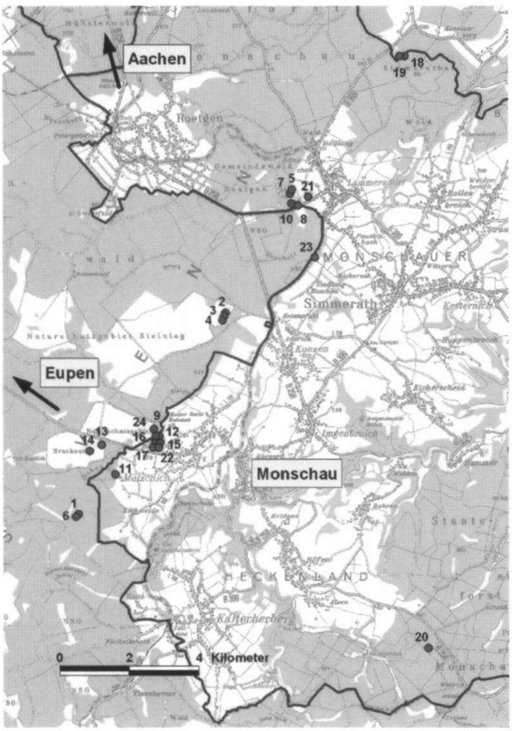

Figure 2. Area of investigation – the Hohe Venn (Hautes Fagnes)

The mired palsa can be divided in two types: those with a permanent water body and those with temporary, shallow water, and with regard to the zoenotic, or species composition of the Odonata, the differences are obvious.

During the last decades of the 19th century, and the early 20th century, human activity changed the open landscape of the Hohe Venn drastically. Many fens and bogs were drained and forested with spruce (Picea abies) (Kamp, 1962). Especially in the 1930s, a lot of palsa were drained by cutting their ring walls, which led to a partial or complete degeneration of the mire vegetation during the following decades. At the beginning of the nineteen nineties, some of these palsa were restored by refilling the drained palsa using autochthonic clay, or with plastic. The result was a rise in the water level, regeneration of peat building vegetation and the establishment of a marginal zone with a high nature conservation value (Aletsee, 2005). This study also investigates pools and artificial ponds of dystrophic character. Such ponds mostly came into being as part of a compensation scheme for land lost to new buildings or business areas.

We attempt to answer the following questions:

1. How do the dragonfly communities differ in the various pond types? Is it possible to visualise the zoenotic of dragonflies with a TWINSPAN analysis?
2. Do man-made ‘protection ponds’ or ‘restored palsa’ ponds offer a chance of (re)colonisation to rare and endangered species?
3. How long does it take for a rare species to (re)colonise?

Area of investigation

The ponds we studied are located at altitudes of between 550 and 650 metres above sea level in the Hohe Venn on both sides of the German-Belgian border (figure 2). The Hohe Venn, a southwest-northeast running ridge, is the first barrier for the humid Atlantic winds from the west. The annual precipitation is on average between 1000 and 1200 mm and the average July temperature is 14°C (Schwickerath, 1944, and weather station Simmerath-Strauch 1975-2003). In the years 2001 to 2004, a total of twenty-four dystrophic ponds were investigated within an area of 100 km², sixteen on the German side (g) and eight on the Belgian side (b).

Methods

The abundance of adult dragonflies in each of the twenty-four ponds was registered exactly for numbers up to ten. When there were more, we recorded them as belonging to a class of 15, 20, 30, 50 or 100. Exuviae were collected on every visit. We used Askew (1988), Bellmann, (1987) and Heidemann & Seidenbusch (1993) to identify

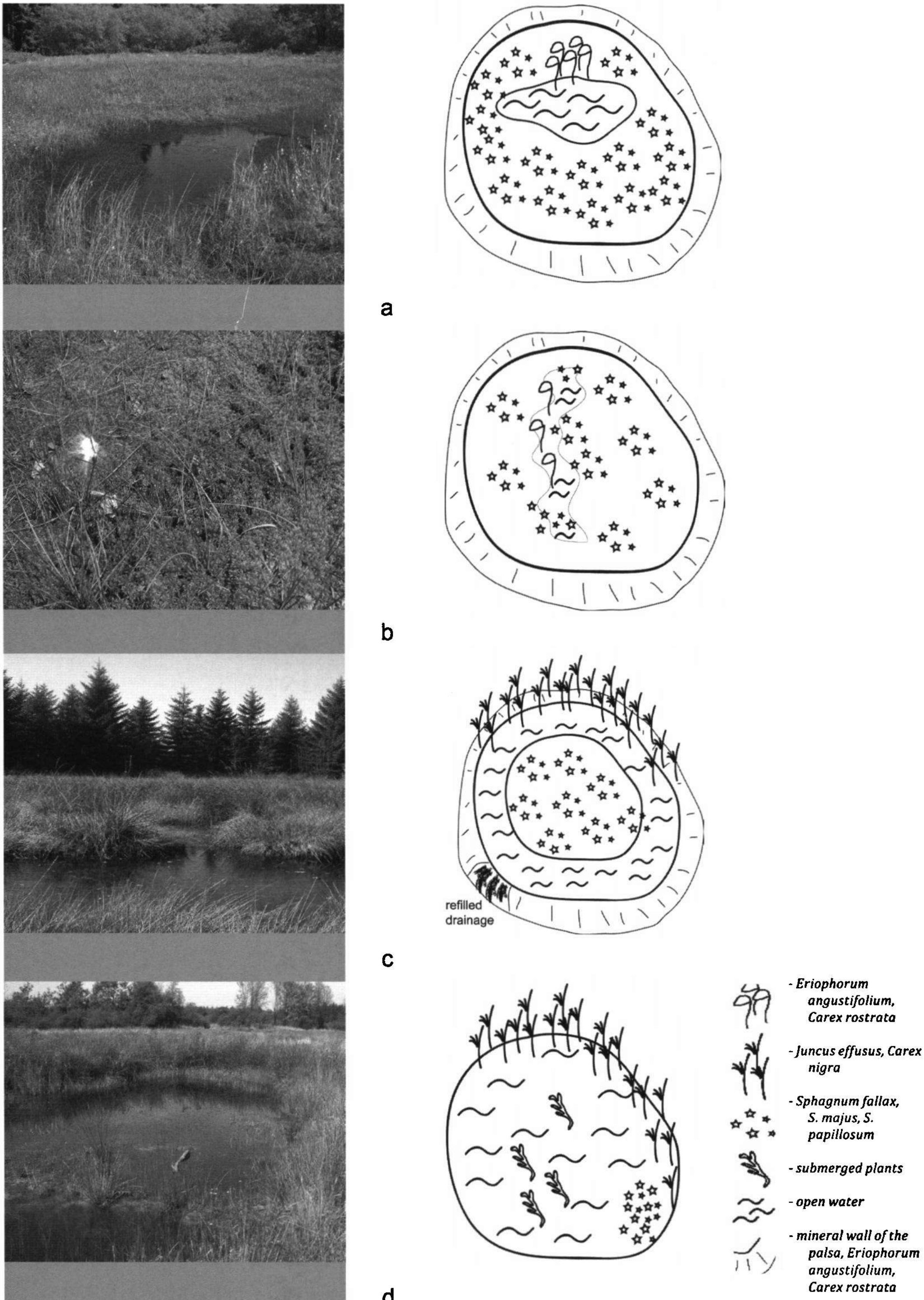

Figure 5. A-d morpho-genetic types of dystrophic ponds in the Hohe Venn (Photos: M. Aletsee, illustrations: A. Poetschke).

Table 2

Absolute and relative abundance of recorded species of Odonata in the Hohe Venn (Hautes Fagnes). RL: state of endangering in North Rhine-Westphalia (NRW), Germany (LÖBF, 1999) and Wallonia, Belgium (Goffart, 2006).
3-vulnerable, 2-endangered, 1-critically endangered

species		Nachweis		frequence	RL Wallonia	RL NRW
	Belgium	Germany	sum	[%]	(Belgium)	(Germany)
Lestes sponsa	2	10	12	0,50	-	-
Pyrrhosoma nymphula	3	13	16	0,67	-	-
Coenagrion hastulatum	1	3	4	0,17	1	2
Coenagrion puella	2	12	14	0,58	-	-
Enallagma cyathigerum	-	8	8	0,33	-	-
Ischnura elegans	-	1	1	0,04	-	-
Ischnura pumilio	-	1	1	0,04	3	3
Aeshna cyanea	2	9	11	0,46	-	-
Aeshna juncea	4	10	14	0,58	3	3
Aeshna subarctica	2	4	6	0,25	1	1
Anax imperator	-	6	6	0,25	-	-
Cordulia aenea	2	3	5	0,21	3	3
Somatochlora arctica	4	3	7	0,29	2	1
Libellula depressa	-	3	3	0,13	-	-
Libellula quadrimaculata	2	12	14	0,58	-	-
Orthetrum cancellatum	-	1	1	0,04	-	-
Sympetrum sanguineum	-	1	1	0,04	-	-
Sympetrum danae	3	11	14	0,58	-	-
Leucorrhinia dubia	4	13	17	0,71	3	3

the imagos of the species, and Clausen (1984) to identify the exuviae of *Aeshna subarctica* . Then we added up all the data (n = 95) of the four years of investigation for each species.
Reproduction, deduced from the number of exuviae found, or freshly emerged individuals observed, was valued three times, the observation of an adult dragonfly once (table 1). By classification with the TWINSPAN algorithms (Hill, 1979), we generated a sorted table, that formed the basis for further interpretation of the collected data. Using morphologic, genetic, hydrologic, trophic and phytocoenotic characteristics, all habitats of the Odonata investigated were then classified into four morphologic-genetic pond types.

Results and discussion

The Odonata of the Hohe Venn

All together nineteen species of Odonata were recorded at the twenty-four ponds investigated during the years 2001-2004 (table 2). *Pyrrhosoma nymphula, Lestes sponsa* and *Coenagrion puella* are the most dominant of a total of seven damselfly (*Zygoptera*). Also present, is a population of *Coenagrion hastulatum*, the only one in the Rhineland area; this very rare species occurs in the Hohe Venn at the western border of its range.

Figure 3. Larval skin of Aeshna subarctica *(Photo: G. Abbingh).*

Characterisation of the morpho-genetic pond types

The ponds we investigated can be divided in four morpho-genetic types (figure. 5 a-d), that clearly differ in their hydrology and flora.

a) Kolk (kp) pool in a hollow, primary pond in a mired palsa

Origin: residual pond in mired palsa?

Morphology: water surface< 1 m² - 10 m²; water depth > 30 cm – 60 cm

Hydrologic properties: permanent water body; water level hardly oscillating; oligotrophic-dystrophic

Vegetation: submerged, not present; littoral, *Carex rostrata, Eriophorum angustifolium, Sphagnum papillosum, S. fallax*

b) Schlenke (sp) hollow, primary pond in a mired palsa

Origin: natural, more or less slow-flowing gully in mired palsa?

Morphology: water surface < 1 m²; water depth < 20 cm

Hydrologic properties: temporary, water-level hardly oscillating, oligotrophic-dystrophic

Vegetation: submerged, when flooded *Sphagnum fallax*, or dry (recent peat) often patchily grown with *Eriophorum angustifolium;* littoral, *Sphagnum papillosum, S. fallax, S. majus*

c) Restored palsa (r) secondary water, secondary lagg

Origin: anthropogenic by restoration (ca. 1990) of palsa that were drained in former times (ca. 1950)

Morphology: water surface < 2 m² - 20 m²; water depth > 30 cm – 60 cm; marginal zone around the central residual mire

Hydrologic properties: permanent, water level sometimes oscillating, oligotrophic-dystrophic to mesotrophic

Vegetation: submerged, sometimes

Figure 4. Somatochlora arctica *(Photo: M. Aletsee).*

Potamogeton polygonifolius; littoral, *Carex rostrata, C. nigra,*
C. canescens, Juncus effusus, Glyceria fluviatilis, sometimes *Sphagnum fallax* or *Eriophorum angustifolium*

d) Pond (p) secondary water
Origin: anthropogenic by damming of soil depressions or by digging (1990-1995)
Morphology: water surface < 5 m² - 50 m²; water depth > 30 cm – 80 cm
Hydrologic properties: permanent, water level oscillating, minerotrophic-dystrophic or mesotrophic
Vegetation: submerged, *Juncus bulbosus, Utricularia vulgaris agg.;* littoral, *Carex rostrata, C. nigra, C. canescens, Juncus effusus, Glyceria fluviatilis,* sometimes *Sphagnum fallax, S. inundatum*
Characterising and distinguishing the pond groups (ecotopes)
Using a suitable classification (sum = <2,<8,<15,<25, >25; table 1), the table sorted by the TWINSPAN algorithm leads to a differentiation of the investigated ponds into groups, which are characterised and distinguished by the presence or absence of a specific species, respectively, groups of species (table 3). Thus, the exclusive presence of *Somatochlora arctica* characterises the first group of ponds. The additional presence of *Aeshna juncea, A.subarctica* and *Leuchorrinia dubia* is the criterion for group two. The absence of *S. arctica*, the partial absence of *A. subarctica* and the presence of mesotrophic species, together characterises the third group. Group 4 is characterised by the additional presence of *Enallagma cyathigerum* and *Anax imperator.*
Comparison of the pond groups with morpho-

genetic pond types

The pond groups are comparable with the described morpho-genetic pond types. Group 1 includes more or less the pond type Schlenke and in the same way group 4 includes the pond type 'pond'. In contrast, group 2 includes only a part of pond type Kolk and group 3 includes not only the type kolk but also 'restored palsa'.

Remarkable is that group 1 and group 2 include only primary, respectively, natural mired palsa whereas group 4 includes exclusive secondary, respectively, artificial ponds.

Regarding the Odonata, we can conclude that by using the TWINSPAN algorithms a more ecological classification is possible. For example, a huge water body of the group 'pond' (p) develops a submerged vegetation of, for example, *Utricularia vulgaris, Juncus bulbosus* or *Potamogeton polygonifolius*, a precondition for establishing populations of such Odonata species as *Enallagma cyathigerum* or Anax imperator. Pond number 24, a restored palsa (r), in comparison with other restored palsa, also contains *Potamogeton polygonifolius* in the large marginal water zone. In its ecological constitution, this restored palsa shows the same conditions as the type 'pond'. Consequently, it will be counted in the same group by using the TWINSPAN algorithm. As a result, the various pond groups can be called ecotopes.

Colonisation of 'bog species' either by the restoration of palsa or by creating artificial ponds

In the Hohe Venn, two species which are critically endangered in North Rhine-Westphalia, *Aeshna subarctica* and *Somatochlora arctica,* only reproduce in ponds of Sphagnum mires. The classification by the TWINSPAN algorithm shows that for both species the ecological conditions in the restored palsa are probably more appropriate for colonisation than the anthropogenic ponds. This is however more apparent for *A. subarctica* than *S. arctica*. We could say that the restoration of palsa will not be an advantage for *S. arctica*. But although there are ponds (9, 10) in the ecotope group 3 colonised by *A. subarctica*, we have to conclude that there will be a long way for not only recolonisation but reestablishing restored palsa by this species. The reason for this is that the optimum for reproduction of *A. subarctica* can be found in ecotope group 2. This means an exclusion of reproduction of the more euryoecious species, such as *Sympetrum danae* and *Libellula quadrimaculata*.

More difficult to analyse are the reproduction habitats of the endangered species *Coenagrion hastulatum* (figure 6), because these include several morpho-genetic types without one being dominant (Aletsee, 2004). However, the autecological demands of this species cannot be adequately described by classification in ecological groups. The reason for this may be that habitat development is a continuous process, especially in the restored palsa. Furthermore, data may be insufficient. However, it must be concluded that the restoration of palsa can be an important step for protecting the population of *C. hastulatum*. Successful recolonisation by this species was possible within just 10 years.

Conclusion

The structure of Odonata habitats can be divided by appearance into morphological or morpho-genetic types, for example ditch, pond or pool. They can be grouped more objectively by using the TWINSPAN algorithm; the habitat groups, or ecotopes, allow more accurate predictions concerning potential recolonisation.

Acknowledgements

I would like to thank Richard Ottermanns for the productive discussion about TWINSPAN algorithm, Ulrike Weber and Anika Poetschke for correcting the English version, Anika Poetschke for the illustrations and Olaf Op den Kamp for translating the abstract into Dutch.

Manfred Aletsee
Obersteinstraße 38
D-52223 Stolberg
Germany
aletsee@rwth-aachen.de

References

Aletsee M., 2004. Erfassung der Libellenfauna ausgewählter Gewässer im Nationalpark Eifel. Studie im Auftrag des Nationalparkforstamtes Eifel, unpubl.

Aletsee M., 2005. Schutz und Renaturierung der „Palsen" als Grundlage für den Erhalt der Moorvegetation und gefährdeter Libellenarten im deutsch-belgischen Hohen Venn. Telma, 35: 93-109.

Askew, R.R., 1988. The Dragonflies of Europe. Harley Books.

Bellmann, H., 1987. Libellen, beobachten – bestimmen. Neumann - Neudamm, Melsungen.

Clausen W., 1984. Die Exuvien der Torfmosaikjungfer (*Aeshna juncea* L.) und der Hochmoormosaikjungfer (*Aeshna subarctica* WLK.) (Odonata: Aeshnidae). Sonderdruck aus „Natur und Heimat", 44 (2), Münster.

Goffart P., 2006. De Rode Lijst van de libellen in Wallonië. IN: De Knijf G.. Anselin A., Goffart P.& M. Tailly (eds). De Libellen (Odonata) van België: verspreiding, evolutie, habitats. Libellenwerkgroep Gomphus. Instituut voor Natuur- en Bosonderzoek, Brussel.

Heidemann, H. & R. Seidenbusch, 1993. Die Libellenlarven Deutschlands und Frankreichs. Verlag Erna Bauer, Keltern.

Hill, M. O., 1979. TWINSPAN-A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Section of Ecology and Systematics, Cornell University, Ithaca, New York.

Kamp C., 1962. Das Hohe Venn – Gesicht einer Landschaft. Eifelverein.

LÖBF (Landesanstalt für Ökologie, Bodenordnung und Forsten//Landesamt für Agrarordnung NRW, 1999): Rote Liste der gefährdeten Pflanzen und Tiere in Nordrhein-Westfalen, 3. Fassung. LÖBF-Schriftenreihe 17.

Meier K.-D., 1987. Studien zur periglaziären Landschaftsformung in Finnmark (Nordnorwegen). In: Jahrbuch der geographischen Gesellschaft zu Hannover. Edit.: Buchholz H.J., Hahn-Hannover.

Mullenders W. & Gullentops F., 1969. The age of the Pingos of Belgium. In: The periglacial environment. Edit.: Péwé T.L., McGill-Queen's University Press, Montreal.

Paulissen, M., 1997. A comparison of water chemistry, algal flora and macrophyta vegetation of restored and intact mineral palsas in the Brackvenn area (Hautes-Fagnes, Belgium/germany). – 130 S.; Diplomarbeit, Universiteit Nijmegen.

Pissart A. & Juvigné E., 1983. Struktur und Alter von Resten periglazialer Hügel im Hohen Venn (Belgien). Polarforschung 53 (2); 75-78.

Schmidt Eb., 1983. Zur Odonatenfauna des Wollerscheider Venns bei Lammersdorf. Libellula 2 (1/2): 49-70.

Schwickerath M., 1944. Das Hohe Venn und seine Randgebiete. Band 6, Verlag Gustav Fischer, Jena.

Summary

Aletsee, M., 2010. Classification of dystrophic ponds by means of the TWINSPAN algorithm for an ecological characterisation of the Odonata habitats in the Hohe Venn /Hautes Fagnes (Germany/Belgium). Brachytron 12 (1/2): 50-59.

Abstract

The Hohe Venn contains a large number of mired palsa. Regarding the Odonata, there are two types of reproduction habitats, the ones with a central, open water body (shallow pool, Kolk) and the ones with at most times a shallow, temporary water body (shallow, Schlenke). Huge parts of the fens in this area were destroyed by afforestation and intensive draining (Kamp, 1962). At the beginning of the 1990s, some palsa were restored by filling up the drains with clay (Paulissen, 1997). This paper compares a descriptive morphologic-genetic classification of the habitats of Odonata with a classification using the TWINSPAN algorithm. We discuss in particular the potential of recolonisation of the restored palsa. Some characteristic and very rare species like Aeshna subarctica and *Somatochlora arctica* could not be found in the recently developed habitats, while others such as *Coenagrion hastulatum* and more euryoecious species, i.e. that those that tolerate very different environmental conditions, have successfully established themselves.

Zusammenfassung

Das Hohe Venn birgt eine große Anzahl von Palsenvermoorungen. Bezüglich der Odonatenfauna lassen sich grob zwei Biotoptypen unterscheiden: Solche mit einem zentralen offenen Wasserkörper (Kolk) und solche mit einem temporären meist kleinflächigen Wasserkörper (Schlenke). Einige im Rahmen von Aufforstungsmaßnahmen entwässerte Palsen wurden Anfang der neunziger Jahre restauriert und zeichnen sich durch eine randliche Wasserzone aus. Die vorliegende Arbeit vergleicht eine deskriptive morphologisch-genetische Einteilung der Gewässertypen mit einer Klassifikation der Libellenhabitate beruhend auf einer Twin-Span-Analyse. Hier wird insbesondere das Ansiedlungspotential der renaturierten Palsen für gefährdete Libellenarten diskutiert. So sind die hochspezialisierten Moorarten Aeshna subarctica und *Somatochlora arctica* ausschließlich in den ursprünglichen Palsenvermoorungen anzutreffen, wogegen sich in renaturierten Palsen neben unterschiedlichen euryöken Arten auch *Coenagrion hastulatum* erfolgreich reproduziert.

Samenvatting

In de Hoge Venen zijn een groot aantal veenwateren (palsen, een soort pingo´s) te vinden. Met betrekking tot de libellenfauna zijn er grofweg twee biotooptypen te onderscheiden. Enerzijds die met een centraal open water (de kolken) en anderzijds kleine en ondiepe waterpartijen (de slenken) die vaak een tijdelijk karakter hebben. Na het bebossen en ontwateren van grote delen van de Hoge Venen werden in het begin van de jaren negentig van de twintigste eeuw enkele ontwaterde palsa venen gerestaureerd door het aanbrengen van een kleilaag. In dit artikel wordt geprobeerd een beschrijvende, morfologisch-genetische indeling van de verschillende soorten water te vergelijken met een classificatie van de habitats van de libellen welke berust op een TWINSPAN-analyse. Met name worden de kolonisatiemogelijkheden van de gerestaureerde minerale palsen voor bedreigde libellensoorten besproken. Zo zijn de zeer gespecialiseerde hoogveensoorten zoals de Noordse glazenmaker (*Aeshna subarctica*) en Hoogveenglanslibel (*Somatochlora arctica*) uitsluitend in de oorspronkelijke, met hoogveen volgroeide, wateren te vinden, terwijl in de gerestaureerde wateren zich naast verschillende opportunistische soorten ook de Speerwaterjuffer (*Coenagrion hastulatum*) zich succesvol voortplant.

Keywords: Odonata, palsa mires, species communities, Hohes Venn, Hautes Fagnes, Belgium, Germany, *Somatochlora arctica*, *Coenagrion hastulatum*, *Aeshna subarctica*, habitat preference