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The composition of the dragonfly community (Insecta: Odonata) of a small artificial pond in Mödling (Lower Austria): seasonal variations and aspects of bioindication

With 2 tables

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An artificial pond was subjected to a comprehensive evaluation of the dragonfly fauna. In 1996, 26 field trips were conducted to set up a complete species inventory and to investigate seasonal variations in the composition of the community. 26 species were recorded, of which 10 are listed in the Red List of endangered species. The dragonfly community is dominated by species preferring standing waters rich in aquatic plants. The present species inventory has been compared to a "target list" established on the basis of historical data.

An einem künstlichen Weiher wurden im Jahr 1996 umfangreiche Untersuchungen der Libellenfauna durchgeführt (26 Begehungen). 26 Arten wurden nachgewiesen, 10 davon sind in der Roten Liste der gefährdeten Tierarten aufgelistet. Die Libellenzönose ist als typische "Verlandungsgesellschaft" zu bezeichnen. Schwerpunkte der Arbeit sind die Analyse der jahreszeitlichen Unterschiede in der Zusammensetzung des Artenspektrums sowie ein Vergleich des nachgewiesenen Arteninventars mit einem faunistischen Leitbild, das auf der Basis historischer Daten ermittelt wurde.

1 Introduction

Surveys of dragonfly communities have become a more and more important tool for the ecological assessment of aquatic systems (e.g. VOSHELL & SIMMONS 1978; MOORE 1984, 1991; WARINGER 1989; CHWALA & WARINGER 1996; HOLZINGER 1996; CHOVANEC & RAAB 1997). Particularly the ecological quality of the aquatic vegetation, littoral zones, habitat heterogeneity and the land-water-interface of water bodies can be evaluated (e.g. SCHMIDT 1985; WILDERMUTH 1994). The additional use of other adequate indicators e.g. amphibians (WARINGER-LÖSCHENKOHL & WARINGER 1990; CHOVANEC 1994) or fish - and abiotic descriptions (e.g. physico-chemical parameters, hydro-morphological features) allow the assessment of the ecological integrity of whole aquatic ecosystems (CHOVANEC & al. 1997a,b).

Dragonfly species are used as "target species" in nature protection and water management, because a high portion of the species is endangered and results ob-

tained from dragonfly records are representative for large parts of the aquatic fauna. This is also the reason why dragonflies play an important role as key indicators; comprehensive action plans for dragonflies may also be favourable for a number of other (endangered) species (MÜHLENBERG 1989; RECK 1993; REICH 1994).

Because of their worldwide decline, wetlands are one of the most threatened wildlife habitats of the natural resource base. In the course of the last few decades, the number of wetlands in Austria sank drastically on account of human influences. It is estimated that since 1945 more than 200,000 ha were drained and converted into arable land (LIEBEL 1991). In the U.S.A., about 87 million ha of wetlands existed before colonisation, but only half of them remained; each year, 100,000 to 200,000 ha of wetlands still are lost (HAMMER 1992).

Thus, the construction of ponds or other types of standing waters may represent a sound compensation measure for ecologically degraded regions formerly rich in wetland areas (BURMEISTER 1988, KÜRY & DURRER 1991, MOORE 1991, WILDERMUTH 1991, CHOVANEC & RAAB 1997). Efficiency control programmes have to be part of those wetland creation projects providing information on the success of planning, constructing and managing the wetland and on the ecological requirements of the indicators used and recorded. Last but not least they will give a new impulse to the integration of wildlife conservation into environmentally sound landscape planning.

About five visits per year are necessary to evaluate the representative spectrum of odonate species ("RSO"; SCHMIDT 1985). In the case of a higher number of excursions more detailed information is available:
- It is possible to build up an (almost) complete species inventory (including accidental records).
- Counts of irregularly or temporarily appearing and not breeding species can be easier distinguished from the autochthonous dragonfly association of the water body investigated. Especially in regions where information on the dragonfly fauna is lacking, information on these records of guests is essential. They may indicate the presence of a population in the environs of the water body; compare also the discussion of meta-populations by STERNBERG (1995).
- Phenological aspects can be evaluated (e.g. WISSINGER 1988).

The study presented in this paper summarises the results of a survey made of the dragonfly community of an artificial pond (Priessnitz pond). The high number of 26 visits does not only allow the characterisation of the water body and the assessment of its ecological quality by a detailed faunistic analysis but also of seasonal variations in the composition of the community. Last but not least the study provides data on a region of Lower Austria where knowledge of the current status of the dragonfly fauna has been missing (RAAB & CHWALA 1997).

2 Study area

The study was conducted at a man-made pond located in the western part of Mödling (altitude 228m), a small town (20,000 inhabitants) about 15 km south of Vienna. The study area is situated in the eastern outskirts of the Anninger mountain (674 m), which is one of the major summits of the north-eastern limestone Alps.

The water body with a size of about 200 m^2 was constructed in 1989. It is sealed with a plastic foil; a surface layer of fine gravel, sand, plant debris and detritus overlays the foil. Maximum and average depths of the water body are about 1.2 and 0.5 m, respectively. After construction, initial plantings on the shoreline were made. Now, most of the littoral areas are lined by rushes, reed and sedges, which create a habitat of high structural diversity. The dominant emergent plants are: *Alisma plantago-aquatica, Bidens tripartitus, Bolboschoenus maritimus, Carex acutiformis, Carex gracilis, Glyceria plicata, Iris pseudacorus, Juncus inflexus, Lycopus europaeus, Lythrum salicaria, Mentha aquatica, Polygonum sp., Scirpus sylvaticus, Schoenoplectus lacustris, Sparganium erectum, Typha angustifloia, T. latifolia and T. shuttleworthii*. Submergent vegetation is rich and dominated by *Myriophyllum spicatum* and *Utricularia sp.*; half of the water surface is covered by *Nymphoides peltata* and *Nymphaea alba*. One small alder-tree with a height of about one metre is situated at the shore of the pond.

A small belt of ruderal vegetation between 1 and 5 m consisting of *Arctia lappa* and *Artemisia vulgaris* separates the water body from a spruce afforestation with a size of about 0.3 ha. At one point a small platform of a size of about 3 m^2 allows visitors to look at the pond but access is prohibited by a fence. A foot path from which the platform can be reached passes the pond in the north. This area, consisting of the afforestation zone, the clearing with the pond and the small area with ruderal vegetation, and the foot path represent the bottom of a small valley (Priessnitz Tal) and are bordered by slopes of the Anninger mountain. In the east a meadow (size 0.3 ha) separates the afforestation from the settlement area.

During the summer months the pond is totally exposed to the sun during 9:00 am and 5:00 pm. In 1995, some goldfish could be found in the pond, in 1996, the year of the investigation, the water body was free of fish. The pond has been colonised by a herpetofauna rich in species: *Bufo bufo, Rana dalmatina* and *Natrix natrix*. Large populations of the "Green Water Frog" *Rana sp.* and newts *(Triturus vulgaris)* probably have developed on the basis of individuals introduced by visitors. The creation of a breeding water for amphibians (especially toads and "Brown Frogs") was one of the major reasons for the construction of the pond.

Other standing water bodies are situated already in the flat areas of the Vienna basin in Lower Austria about 3 km east of the study area. Most of them are

large ponds with reed stands constructed in the course of former brick-making in the 19th and in the first half of the 20th century.

3 Climatic situation

The transition area from the eastern Alpine areas into the flat Vienna basin is of high biogeographical interest because of its climatic situation. In this region, the climatic transition belt between Central European and continental conditions is strongly influenced by pannonian and submediterranean, but also by alpine conditions, which favour the occurrence of a highly diversified flora and fauna.

The slopes of the Anninger massif situated near the investigation area are covered by deciduous forests, especially consisting of *Fagus sylvatica* and *Quercus sp.*, mixed woodlands and by the *Pinus niger* woods, which are typical for these regions of the eastern Alps.

The climatic situation is described by 1996 data of the Central Institute for Meteorology, taken from the monitoring station Gumpoldskirchen, which is situated about 3 km away from the study area: In this year, air temperatures ranged from -19.4 °C (Dec. 28th) to 31 °C (June 10th); monthly mean temperatures ranged from -2.7 °C (Jan.) to 19.2 °C (Aug.). In 1996, still in the beginning of April air temperatures below 0 °C could be measured, in December the water surface of the pond was already frozen. The total monthly precipitation ranged from 9 mm (Dec.) to 137 mm (Sept.).

4 Data collection in the field

26 field trips were conducted between May 4th and November 9th, 1996. Only sunny days were chosen for the excursions. Each visit lasted about 2.5 hours and was made between 11:00 am and 2:00 pm. Field working was done by slowly walking round the pond and through the surrounding ruderal vegetation (about 5 times per visit) and by identifying resting individuals by sight or by taking photographs. Additionally, individuals were caught with an handnet (diameter 30 cm, handle length 1.5 m), identified and then released. Adults involved in reproductive behaviour were also counted. At each field trip exuviae were also collected from the vegetation and identified in the laboratory. For species determination the keys of FRANKE (1979), BELLMANN (1987), ASKEW (1988), JURZITZA (1988), LAISTER (1991) and HEIDEMANN & SEIDENBUSCH (1993) were used. The evaluations were carried out according to the methodological working scheme of CHOVANEC (1998).

5 Evaluation of a reference state

The assessment of the ecological quality of a water body is based on a comparison between the status quo of the habitat and a natural or potentially natural situation (ÖNORM M 6231; ÖNORM M 6232 1995). This reference state can be

deducted from comparable water bodies of high ecological quality in the same region or from historical data and zoogeographical knowledge. One of the key elements of this assessment is the comparison of a target list of indicator species with the current species inventory of the water body.

In the region where the Priessnitz pond is situated, there neither is a comparable water body nor comprehensive and recent data on the dragonfly fauna. Thus the target list was set up on the basis of the historical observations of BRAUER (1851, 1856, 1857), JAUS (1935) and FRANZ (1961). These publications do not contain results of systematic dragonfly surveys but give just an overview on species appearing in the region without detailed information on the locations of observation. According to the data about Mödling and the neighbouring regions the following list of standing water dragonflies was established:

ZYGOPTERA

Lestes barbarus, Lestes dryas, Lestes macrostigma, Lestes virens, Lestes viridis, Sympecma fusca, Platycnemis pennipes, Coenagrion puella, Coenagrion pulchellum, Enallagma cyathigerum, Ischnura elegans, Ischnura pumilio

ANISOPTERA

Aeshna affinis, Aeshna cyanea, Aeshna grandis, Aeshna isosceles, Aeshna mixta, Anax imperator, Anax parthenope, Gomphus vulgatissimus, Somatochlora flavomaculata, Somatochlora metallica, Libellula quadrimaculata, Orthetrum caerulescens, Orthetrum cancellatum, Sympetrum danae, Sympetrum meridionale, Sympetrum striolatum, Sympetrum vulgatum.

Old maps show only one large pond situated at a small distance from the former municipal area of Mödling (GIANNONI 1905; STADTGEMEINDE MÖDLING 1975). A painting of Ferdinand Olivier from 1818 (depicted in STADTGEMEINDE MÖDLING 1975) shows people cutting reed, the exact location of the wetland can not be reconstructed. The location where the Priessnitz pond is situated was then free of permanent standing water bodies although some springs can still be found in this area. The villages in the vicinity of Mödling (Brunn, Wiener Neudorf) were formerly rich in ponds and wetland areas.

6 Results and discussion

Species inventory

At the study site, 26 of the 78 Austrian species were recorded (33 %; Zygoptera: 14 species belonging to 4 families, Anisoptera: 12 species belonging to 3 families); for Lower Austria 67 species are recorded. The species inventory of the Priessnitz pond is listed in Tab. 1 and includes 10 Red List-species (RAAB & CHWALA 1997). 9 of the 26 species can be regarded as autochthonous (records of adults, collected exuviae): *Lestes viridis, Coenagrion puella, Aeshna cyanea, A. mixta, Anax imperator, Cordulia aenea, Libellula quadrimaculata, Sympetrum sanguineum and S. striolatum*; probably autochthonous (records of adults, obser-

Taxon	distribution	ab.	rep.	ex.	R.L.
ZYGOPTERA					
Calopteryx splendens (Harris 1782)	pontomediterranean	2			IV
Lestes barbarus (Fabricius 1798)	holomediterranean	3			II
Lestes dryas Kirby 1893	siberian	2			I
Lestes sponsa (Hansemann 1823)	siberian	3			
Lestes virens Charpentier 1825	pontomediterranean	3			II
Lestes viridis (Vander Linden 1825)	atlantomediterranean	4		2	
Sympecma fusca (Vander Linden 1820)	holomediterranean	2			III
Piatycnemis pennipes (Pallas 1771)	pontocaspian	1			
Coenagrion puella (Linnaeus 1758)	pontocaspian	5		4	
Coenagrion pulchellum (Vander Linden 1825)	pontomediterranean	1			II
Enallagma cyathigerum (Charpentier 1840)	siberian	3			
Ischnura elegans (Vander Linden 1820)	adriatomediterranean	1			
Ischnura pumilio (Charpentier 1825)	pontomediterranean	1			II
Pyrrhosoma nymphula (Sulzer 1776)	atlantomediterranean	2			
ANISOPTERA					
Aeshna cyanea (Müller 1764)	holomediterranean	2		2	
Aeshna isosceles (Müller 1767)	atlantomediterranean	1			I
Aeshna mixta Latreille 1805	holomediterranean	4		1	
Anax imperator Leach 1815	holomediterranean	2		1	
Cordulia aenea (Linnaeus 1758)	westsiberian	3		3	
Libellula depressa Linnaeus 1758	holomediterranean	2			
Libellula quadrimaculata Linnaeus 1758	siberian	3		2	III
Orthetrum albistylum (Selys 1848)	caspian	1			V
Orthetrum cancellatum (Linnaeus 1758)	holomediterranean	1			
Sympetrum sanguineum (Müller 1764)	holomediterranean	4		2	
Sympetrum striolatum (Charpentier 1840)	holomediterranean	3		2	
Sympetrum vulgatum (Linnaeus 1758)	westsiberian	2			

Tab. 1: Dragonfly species at the Priessnitz pond in Mödling (Lower Austria); order according to JANECEK & al. (1995). distribution: according to LEHMANN (1990); ab. (maximum abundance): visit with the largest number. 1: single record, 2: 2-5, 3: 6-30, 4: 31-100, 5: >100 individuals (according to CHOVANEC 1994); rep. (reproduction): observed tandems, copulae or egg deposition; ex. (exuviae): abundance class of collected exuviae (like above); R.L. (Red List): classification according to RAAB & CHWALA (1997). I: threatened with extinction; II: highly endangered; III: endangered; IV: potentially endangered; V: status indeterminate

vations of reproduction / breeding behaviour) are *Lestes barbarus, L. sponsa, L.virens, Enallagma cyathigerum, Pyrrhosoma nymphula, Libellula depressa* and *S. vulgatum*; two species (*Lestes dryas, Sympecma fusca*) are possibly autochthonous (adults in intermediate abundances).

Dominant species

The total number of adults was estimated at about 600 individuals; the four most common species, indicated by the abundance classes 4 and 5 in Tab. 1, *L. viridis, C. puella, A. mixta* and *S. sanguineum*, numerically counted for about two thirds of this number. Taking into account the size of the water body, the maximum population densities which are possible at a small water body and the territory size of the individual species, *C. aenea, L. quadrimaculata, A.cyanea, A. imperator* and *S. striolatum* also have to be classified as dominant elements within the dragonfly community.

Seasonal variations

Abundance classes and observed reproduction behaviour for all detected species at all visits within the investigation period are illustrated in Tab. 2. Considering the populations' development and the periods when species were at peak numbers the following phenological groups can be distinguished:
spring (-early summer) species: *P. nymphula, C. aenea, L. quadrimaculata*;
(spring-) summer species*: C. puella, A. imperator, L. depressa;*
midsummer species*: E. cathigerum, L. barbarus, L. dryas, L. sponsa, S. sanguineum, S. vulgatum;*
midsummer-autumn species: *L. virens, A. cyanea, A. mixta;*
(midsummer-) autumn species: *L. viridis, S. striolatum.*
These observations are to a large extent in line with the data of SCHMIDT (1985), MOORE (1991), LAISTER (1994/95) and CHWALA & WARINGER (1996).

The seasonal overlap of many species was responsible for interspecific competitive interactions between adults: Similar habitat requirements and spatial overlap - e.g. concerning the selection of perching sites or the size of territories - caused frequent interactions especially between individuals of *C. aenea, L. depressa* and *L. quadrimaculata; A. imperator* and *S. sanguineum* were also involved. In times of the common appearance of *Aeshna*- and *Anax*-species the inter-

actions were not so intensive because of different spatial patterns of habitat use of these species (niche partitioning): Two *A. cyanea* males often patrolled between 0.5 and 1.5 m above the water surface and also passed the littoral areas and even the ruderal vegetation and the beginning of the forest; their territories mostly were clearly delimited. One or two *A. imperator* males generally flew in higher altitudes than *A.cyanea* (between 1.5 and 4 m), their territories comprised the whole clearing consisting of the pond and the small area covered with ruderal vegetation. *A. mixta* individuals preferably hunted over the meadow in the east of the pond and the afforestation zone; appearing at the pond they flew in altitudes of about 5 m or higher. July and the first half of August was the period with the highest number of simultaneously appearing species (Tab. 2).

Dragonfly associations

Although the composition of single species and the discussion of their habitat requirements has to be the key element of the assessment of a water body by using dragonfly data, JACOB's (1969) concept of dragonfly associations is a tool often applied for the description and evaluation of the dragonfly fauna and for habitat characterisation. It has been adopted by STARK (1976), WARINGER (1989) and CHWALA & WARINGER (1996). It is necessary to stress that dragonfly associations occur in different compartments of the same habitat and, therefore, different associations or members of different associations probably appear at the same water body. Because of zoogeographic variations the rigid application of just one concept is not useful, modifications are necessary (see also CHOVANEC 1998).

The occurrence of *L. barbarus, L. dryas, L. sponsa, L. virens, L. viridis, S. fusca* (these species represent the major part of those species belonging to the family Lestidae and appearing in Austria), *C. puella, E. cyathigerum, A. mixta, L. quadrimaculata, S. sanguineum* and *S.vulgatum* represents an assemblage preferring water bodies with well-developed terrestrification areas and dense littoral vegetation. This group of species nearly totally corresponds to the „*Lestes-Sympetrum-(A. mixta)*-association" described by STARK (1976), WARINGER (1989) and CHWALA & WARINGER (1996).

Habitat characterisation and assessment

The Priessnitz pond is characterised by a high structural diversity of both the pond with its littoral areas and its surrounding, which is illustrated by some examples. The dense macrophyte community builds up a heterogenous mosaic of vertical structures of different heights and densities and of horizontal structures. Many conponents of the dragonfly assemblage need vertical macrophytes as structural prerequisite for oviposition: the high number of species of the family Lestidae which show characteristic ovipositing in vertical aerial stems clearly indicates that the Priessnitz pond is a suitable habitat from this point of

Tab. 2: Comparative phenology and abundance of the dragonfly species recorded at the Priessnitz pond in Mödling (Lower Austria). Abundance class 1: single record, 2: 2-5, 3: 6-30, 4: 31-100, 5: >100 individuals; underlining: observation of tandems, copulae or egg deposition; order according to the temporal appearance

	May					June					July				August					September			October		November	
	4	12	18	19	25	1	6	8	16	29	4	20	23	28	2	9	20	23	24	8	15	30	13	20	4	9
C. aenea	2	2	2	2	3	3	2	2	2	2	2		2													
L. quad.			2	2	3	3	3	3	1	2	2		2													
P. nymph.				2	2	2	2	2	2																	
L. depr.				1	2	2	2	2	2	2	2	2	2		2											
C. puella				2	4	5	5	5	4	5	5	4	4	4	5	4	3	2	2							
A. imp.						1	2	2	2	2	2	2	2	1	1											
E. cyath.							2		1	2	3	2	2		1	3										
S. sang.							1	1	1	3	3	3	3	3	4	3	4	3	4	1						
A. isosc.							1																			
C. spl.								1	2							1										
P. penn.								1		1																
L. barb.									1	2	2		2	2	3	3	2									
L. dryas										2			2		2	2										
L.sponsa											2	2	2	1	2	3	3	3	3	2						
L. virens											1		1	1	2	3	3	3	3	2	2	2				
A. cyanea											1	2	2	2	2	2	2	2	2	2		1	1			
S. striol.											2	2	2	2	3	3	3	3	3	3		3	3	2	3	2
L. viridis											1					3	4	3	4	2	2	3		2		1
O. albist.											1															
O. canc.												1														
I. elegans												1														
A. mixta														3	4	3	2	3	3	3	1	3	2	1		
C. pulch.														1												
S. fusca															1	2	2			1			1			
I. pumilio															1			1								
S. vulg.																		2								

view (see also LENZ 1991). These plant structures are not only required as ovipositing sites, for many dragonfly species they also serve as emergence and perching site and as place for mating behaviour. An interesting behaviour of *L. viridis* was observed: eggs were inserted into old and dry stems of *Typha* and *Schoenoplectus* as well as into stems of the terrestric *Artemisia vulgaris* and *Arctia lappa*.

Structures created by the floating leaves of *N. peltata* are essential e.g. for the egg-laying *of C. puella*. This species oviposits in submerged stems while sitting on the horizontal structure of the floating leaves, which is typical for coenagrionids. But also for *A. imperator* submerged or floating vegetation is essential for oviposition; females of this species were observed inserting their eggs also into floating reed debris. *A. cyanea* females placed eggs into half-decomposed tissues mostly at the edges of the pond.

Open water areas are another important structural element, which can be found at the water body. In these areas the e.g. libellulid females dipped their eggs into the water. Bare banks with gravel and sand are suitable perching sites for *Sympetrum* species; they were also found perching on large stones which radiated heat when the air temperature was already low.

Not only the pond itself but also its surrounding as part of the dragonfly habitat has to be subject of the characterisation and evaluation of the pond. The wooded surrounding seems to play an essential role for the odonate community: it provides resting places, also for the night, and shelter from storm and rain. The meadow situated near the pond was used as hawking area by congregations of *A. mixta*. *C. splendens*, an abundant species in many parts of the Vienna basin in Lower Austria (personal observations) has to be classified as guest coming from running water sections situated in this regions. As STETTMER (1995) showed, *Calopteryx* species are able to migrate over a distance of up to 4 km within a day. In 1995, a *Calopteryx virgo* male could be detected in the garden of the author in Mödling.

Comparison with a reference community

The reference community listed above comprises to a large extent dragonfly species preferring standing water bodies with dense macrophyte stands. The zygopteran species nearly totally correspond to the target species evaluated on the basis of historical data, anisopteran species do this to a large extent. As far as running water species are concerned, *C. splendens* would also have to be included in the target list of this region (FRANZ 1961).

7 Conclusions

The mosaic of different vegetation structures and of other microhabitat types at the Priessnitz pond form a suitable biotope for a dragonfly fauna rich in species. The appearance of Red List species also signalises the high importance of the

water body within the area. A comparison with the target list suggests that the water body provides ecological prerequisites supporting the occurrence of elements of a dragonfly community corresponding to historically derivable reference conditions. Not only the species inventory of the dragonflies but also the colonisation of the pond by amphibians show the need for constructing new water bodies and their importance for the integrity and health of this area situated in the interface between wooded mountainous areas and the flat plains of the Vienna basin.

The reduced accessibility of the pond facilitated by the fence allowed a nearly undisturbed development of the cenosis. Nevertheless, the construction of new ponds of the same type would be useful to support and strengthen the small populations of some dragonfly species occurring at the Priessnitz pond and to make possible the connection and population exchange between this water body and others located some kilometers away in the plains of the Vienna basin; in this connection the faunistic investigation of the brickworks ponds would be essential.

As already pointed out by CHOVANEC (1994) the construction of ponds must never be used as justification for destroying precious primary biotopes; in nature conservation, top priority has to be given to the protection and restructuring of remaining wetland areas. But man-made ponds may represent a compensation measure for ecologically degraded areas suffering a loss of wetland areas. The results presented in this study indicate that the evaluation of the odonate fauna in combination with the description of habitat features and other indicator organisms is well suited for indicating the type and the quality of aquatic habitats (see also CORBET 1993). Especially in regions where comprehensive faunistic data on odonates are lacking, intensive data collection procedures provide useful information: An almost complete species inventory at the study site does not only allow an evaluation of the study site but also provides the basis for an assessment of the faunistic potential of the region. Furthermore seasonal variations in the composition of the dragonfly community could be studied. This may provide an impetus to carry out further investigations, e.g. with regard to comparative population ecology, competition processes or strategies of niche specialisation (e.g. WILDERMUTH 1991; RAAB & al. 1996).

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