CHANGES IN THE EPHEMEROPTERA AND PLECOPTERA POPULATIONS OF A SWISS JURA STREAM (RÖSERENBACH) BETWEEN 1935 AND 1990

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The investigation of macrozoobenthos in the Röserenbach (Basel, Switzerland) performed by GEIJSKES (1935) was repeated in 1990. The number of Ephemeroptera species was eleven, both in 1935 and 1990. Two species which were present in 1935 have disappeared and two new species were found in 1990. The number of Plecoptera species decreased from 19 in 1935 to five only in 1990. Six of the 14 Plecoptera species which have disappeared in the Röserenbach seem to be regionally extinct. The change and status of each species are discussed. The causes responsible for the decline of species in the Röserenbach may be intensified agriculture and forestry leading to changes in microhabitat structure, hotel sewage and a decrease in the amount of water due to a higher production of drinking-water. Macrozoobenthos and especially Plecoptera proved to be very sensitive indicators of changes in the landscape.

INTRODUCTION

To estimate the consequences of environmental changes in order to ensure the conservation and protection of running waters, the study of the development of macroinvertebrate populations over a long period is of great interest. However, only a few results exist on this subject. These mainly originate from investigations on large rivers (KINZELBACH, 1978; CASPERS, 1980; FITTKAU & REISS, 1983; SCHRÖDER & REY, 1991). In different works, authors have noticed historical changes in the taxonomic invertebrate groups in wider geographic regions (e.g. STÖCKEL, 1984). To evaluate endangered and declined species of larger areas like countries, Red Data Books have been elaborated. A few of them provide data on Ephemeroptera and Plecoptera species (PUTHZ, 1984; ZWICK, 1984; REUSCH & BLANKE, 1993; SARTORI *et al.*, 1994).

The basic objectives and scientific questions relating to faunistic investigations have changed considerably (RITTER, 1992) since the 19th century. To compare data over a historical period we must also consider the objectives of past investigations. Only very few streams which were formerly investigated provide adequate faunistic information to allow a comparison with the present macroinvertebrate fauna. In his Ph. D. thesis, GEIJSKES (1935) presents faunistic data from the Röserenbach which were carefully collected and analysed. His scientific questions and methods are «modern» in the sense that he precisely indicates localities and even the absolute abundances on several stream sections.

By comparing former and actual macroinvertebrate communities, it is possible to measure the consequences of environmental changes which took place on a local scale. To develop strategies for the conservation and the control of the water quality of the Röserenbach, a historical analysis should show the way in which the local populations have changed. This change will also measure to what degree the populations are endangered in the surroundings of Basel (Switzerland).

The investigation of the biological communities in the Röserenbach was ordered by the Environmental Protection Board of the canton Basel-Landschaft. It was possible to adapt the investigation programme according to historical data.

MATERIAL AND METHODS

In 1990, the macroinvertebrates of the Röserenbach were investigated using two different methods. Four representative stream sections were sampled semiquantitatively using a modified «Surber»-sampler (area of 0.20 m x 0.20 m). Sampling took place in April and June. In addition, a qualitative sampling was performed on other stream sections and 14 springs spread along the valley. All the localities investigated by Geijskes were visited at least once. Field work was carried out between March and October. Furthermore, the riparian vegetation was characterized and discharge was measured in different seasons.

To compare the landscape situations of 1935 and 1990, maps of 1936 and 1986 (representative fraction of 1:25000) were used. The Röserenbach is situated 10 km south-east of Basel in the Swiss «Tafeljura". The stream is 5 km long (Fig. 1). The upper sections are situated in a wooded area while the lower sections are surrounded by agricultural zones, house-gardens and streets. The Röserenbach valley is very rich in springs, mostly situated near the stream. In

the densely populated area of the town Liestal, the riparian zones are affected by embankments, while the banks of the upper sections have remained quite natural. The water of the upper section is of rather high quality while in the lower part sewage from the small water purification plant of a hotel is diverted into the Röserenbach.

RESULTS

In 1990, eleven Ephemeroptera species were found in the Röserenbach. Their numbers had not changed compared to the 1935 study although the composition of the fauna is distinctly different.

Four species which GEIJSKES identified in 1935 are no longer found: *Centroptilum luteolum, Baetis fuscatus, B. gemellus* and *Habrophlebia fusca*. On the contrary, four other species are new in the Röserenbach: *Baetis lutheri, B. rhodani, Epeorus sylvicola* and *Electrogena lateralis* (Table 1). Two of the species which have disappeared (*Centroptilum luteolum* and *Baetis fuscatus*) are known in other streams and rivers in the surroundings of Basel (KÜRY, 1994) but *Baetis gemellus* and *Habrophlebia fusca* never seem to have belonged to the Swiss fauna, according to STUDEMANN *et al.* (1992). *Baetis gemellus* was probably confused with *B. rhodani* because it is lacking from GEIJSKES 1935 list. Futhermore, he estimated *Baetis spp.* as «very abundant» but according to the actual population size of the genus *Baetis*, only *B. rhodani* could have been abundant in 1935. Because *Baetis lutheri* and *Alainites muticus (Baetis muticus)* do not at present attain high population densities in the Swiss Jura region

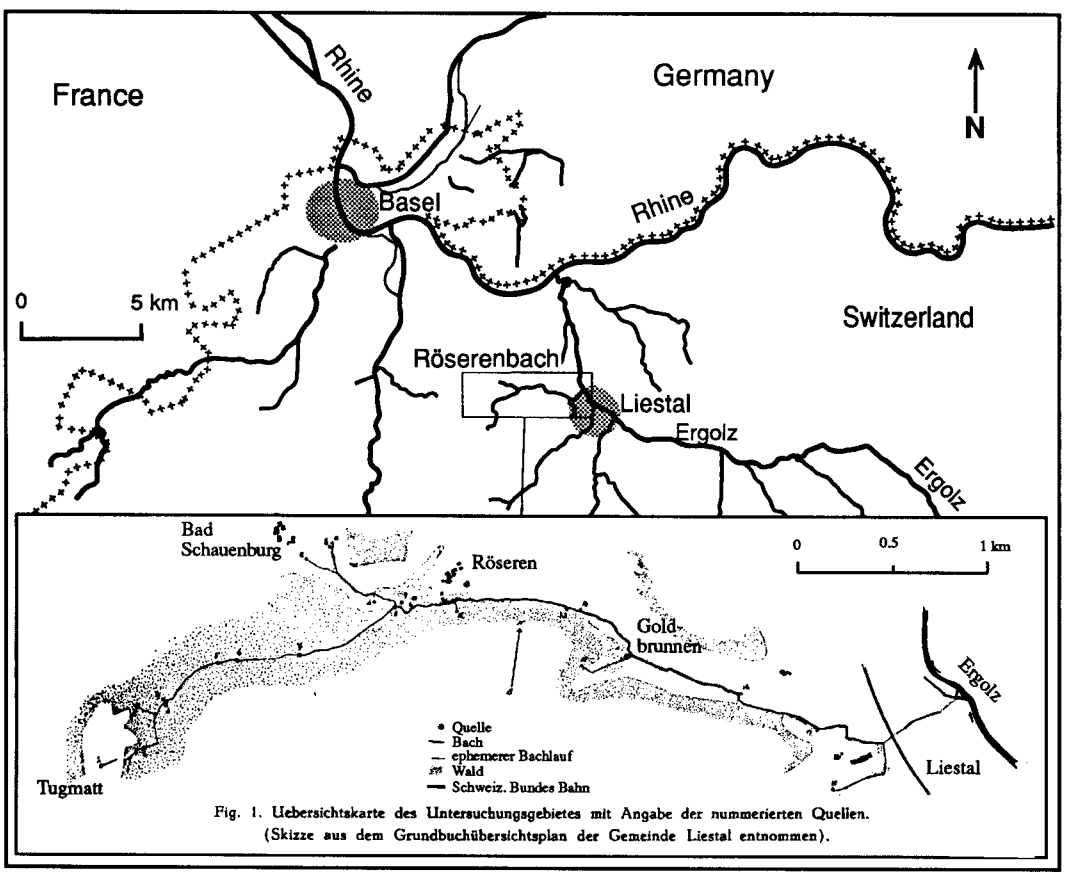

Fig. 1. Situation of the Röserenbach. The lower part shows the original map (slightly modified) from GEIJSKES (1935).

Table 1. Ephemeroptera species in the Röserenbach 1935 and 1990. Abundances are indicated as follows: +++: very abundant, ++: abundant, +: rare. «Surr.»: «x» indicates the presence of a species in the surroundings of Basel.

Taxon	1935	1990	surr.	status of change
Alainites muticus (L.)	+	+	x	unchanged
Baetis fuscatus (L.)	+	–	x	disappeared
Baetis gemellus Eat.	+++	–	–	confused with rhodani?
Baetis lutheri M.-L.	–	+	x	described in 1967
Baetis rhodani (Pict.)	–	+++	x	confused with gemellus?
Centroptilum luteolum (Müll.)	+	–	x	strong decrease
Rhithrogena semicolorata (Curt.)	+++	+++	x	unchanged
Ecdyonurus venosus (F.)	+	+	x	unchanged
Electrogena lateralis (Curt.)	–	+	x	new
Epeorus sylvicola (Pict.)	–	+	x	new
Habroleptoides confusa Sart.&Jac.	+++	+	x	decline
Habrophlebia fusca (Curt.)	+	–	–	confused with lauta?
Habrophlebia lauta Eat.	+	+	x	unchanged
Ephemerella ignita (Poda)	++	++	x	unchanged
Ephemera danica (Müll.)	++	+	x	decline
Total number of species	11	11	13	

(STUDEMANN *et al.*, 1992; KÜRY, 1994), it seems quite unlikely that they would have been abundant in 1935. *Habrophlebia fusca* might have been confused with *H. lauta* because in 1935 both species were found only as single individuals (one *H. fusca* larva).

In addition, the fauna shows changes according to the dominance of the species: In 1935, Ephemeroptera were dominated by *Rhithrogena semicolorata*, *Baetis spp.* and *Habroleptoides confusa*. *Ephemerella ignita* and *Ephemera danica* were described by Geijskes as abundant (subdominant) and only a few individuals of all the other species were found (Table 1). Among the 1990 fauna *Rhithrogena semicolorata* and *Baetis rhodani* were the dominant species. *Ephemerella ignita* appeared as abundant and all other species were rare. This means that only five species show an unchanged status and additionally *Habroleptoides confusa* decreased from «very abundant» to «rare» and *Ephemera danica* from «abundant» to «rare». Two species found in 1990 were not listed by Geijskes: *Electrogena lateralis* and *Epeorus sylvicola*. At present both have to be characterized as «rare».

From 19 species in 1935 the Plecopteran fauna had decreased to only five species in 1990. This is a reduction of 74%. A total of 14 Plecoptera species had disappeared in 1990 (Table 2), eight decreased in the Röserenbach but were still present in other streams in the surroundings of Basel between 1989 and 1994 (KÜRY, 1994). To this group belong: *Brachyptera risi, Nemoura cinerea, N. intricata, Nemurella pictetii, Leuctra albida, L. prima, Isoperla rivulorum* and *Perla marginata*. Another group consisting of six species have not been found in the streams surrounding Basel in the past ten years: *Protonemura lateralis, P. nitida, P. praecox, Amphinemura sulcicollis, Leuctra major* and *Chloroperla tripunctata*.

In 1935, GEIJSKES recognized five species as very abundant (*N. marginata, P. intricata, A. sulcicollis, L. prima* and *I. rivulorum*) but in 1990 only *Nemoura marginata* could be recorded in great numbers. Eight species were considered «abundant» in 1935 and only one in 1990 (Table 2).

DISCUSSION

Over several successive years of faunistic investigations the abundance of a particular

Table 2. Plecoptera species in the Röserenbach 1935 and 1990. Abundances are indicated as follows: +++: very abundant, ++: abundant, +: rare. «Surr.»: «x» indicates the presence of a species in the surroundings of Basel.

Taxon	1935	1990	surr.	status
Brachyptera risi (Mort.)	++	–	x	strong decline
Nemoura cambrica (Steph.)	+	+	x	unchanged
Nemoura cinerea (Retz.)	+	–	x	strong decline
Nemoura marginata (Pict.)	+++	+++	x	unchanged
Protonemura intricata Ris	+++	–	x	strong decline
Protonemura lateralis (Pict.)	++	–	–	locally extinct
Protonemura nitida (Pict.)	++	–	–	locally extinct
Protonemura praecox (Mort.)	++	–	–	locally extinct
Protonemura risi Jac. & Bian.	++	++	x	unchanged
Amphinemura sulcicollis (Steph.)	+++	–	–	locally extinct
Nemurella pictetii Klap.	++	–	x	strong decline
Leuctra albida Kemp.	++	–	x	strong decline
Leuctra braueri Kemp.	+	+	x	unchanged
Leuctra major Brinck	+	–	–	locally extinct
Leuctra prima Kemp.	+++	–	x	strong decline
Perlodes jurassicus Aubert	+	+	x	unchanged
Isoperla rivulorum (Pict.)	+++	–	x	strong decline
Perla marginata (Panz.)	+	–	x	strong decline
Chloroperla tripunctata (Scop.)	++	–	–	locally extinct
Total number of species	19	5	13	

species can considerably vary. At times it may even be missing for a few years without becoming locally extinct (HYNES, 1970; BRAUKMANN, 1987). In this paper two inventories, both of them on a rather short time scale, are compared. To avoid wrong estimations of the species status Geijskes' data are not only compared to the present data of the Röserenbach but also to the faunistic data of all running waters in the cantons Basel-Landschaft and Basel-Stadt (KÜRY, 1994).

The Ephemeroptera fauna which shows quite a remarkable change between 1935 and 1990 can be characterized as a «faunistic shift». According to their preference for habitats with a relatively low current, the decline of *B. fuscatus* and *C. luteolum* may be linked to the destruction of lentic microhabitats. The newly occurring *E. sylvicola* prefers rhithral sections and *E. lateralis* lentic zones. *Habroleptoides confusa* which decreased from «very abundant» (1935) to «rare» in 1990 can be found in many running waters in the surroundings of Basel. It seems to colonize lotic habitats of varying temperature regimes (PLESKOT, 1953). The larvae of *Ephemera danica* prefer sandy zones. Its decline is probably due to the reduction of the proportion of sandy sediments. *Baetis lutheri* was described in 1967. It colonizes the upper zones of streams but because of its description after 1935 it is impossible to estimate a change in density.

The change in the number of Plecoptera species shows a stronger decline compared to Ephemeroptera. This corresponds largely to the observations made by ZWICK (1984) in Germany. According to EIDEL (1955), ILLIES (1955) and AUBERT (1959) the regional extinction of the mentioned Plecoptera comprises high-mountain species (*Leuctra major, Chloroperla tripunctata*) and species of montane streams (*Protonemura nitida, P. praecox, P. lateralis* and *Amphinemura sulicollis*). All species which have disappeared (with the exception of *L. major*) were abundant

in 1935. AUBERT (1959) cites similar abundances of the mentioned species for other regions of Switzerland. In addition, other authors in Central Europe refer to these species as locally abundant (EIDEL, 1955; BRAUKMANN, 1987). Compared to these results, the decline of the Plecoptera populations in the Röserenbach is very important and some which have disappeared are still present in the Regio Basiliensis, seem to show a strong decline in comparison to 1935. Of these, *L. prima, P. intricata* and *I. rivulorum* colonize streams. *L. albida, P. marginata* and *B. risi* prefer streams and rivers and *N. pictetii* is a species of various crenal habitats. The loss of microhabitats is probably the main factor. At the same time, the increasing immission of diffuse charges like nitrogen plays an important role. Four Plecoptera species which have stayed unchanged are known to colonize mountain streams. This group includes the most commun species *Nemoura marginata.*

The fact that many species are presently not found in the surroundings of Basel shows that their decline or extinction might be a regional phenomenon more than a local one. But more recent data of Plecoptera distribution on a regional or national scale are lacking. Work in progress on the Swiss Atlas of Ephemeroptera, Plecoptera and Trichoptera as well as the inventories being taken in the surroundings of Basel will later allow a more detailed interpretation of this phenomenon. At first, the Röserenbach seems to be only slightly influenced by human activities. The interpretation of the changes according to the flow velocity in the Röserenbach is rather contradictory: not only do the species which prefer lotic zones of streams disappear or decline but so do the species of lentic zones. To explain this, we can presume that in the upper zones of the Röserenbach lotic zones have disappeared since the building of small water falls made to minimize erosion. This prevents the upstream movement of the hololimnic species. Stream regulation can provoke the decline or regional extinction of fish species (BLESS, 1990) but also of macroinvertebrates (KOTHÉ & KNÖPP 1965; ZWICK, 1992; HÜTTE *et al.*, 1994). In the lower course, lentic zones have disappeared and lotic zones have increased because of the reinforcement of the banks.

Another factor outlined by FOECKLER & BOHLE (1993) seems to correspond widely to changes which must have taken place on the Röserenbach. Compared to 1935, the composition of tree species in the forest has been altered. In several riparian zones, deciduous tree species were replaced by the monoculture of gymnosperms (*Thuja sp.*, spruce and Douglas fir). Small springs situated in the riparian zone especially are strongly influenced by the altered vegetation. The changes of the composition of forest trees species are known to have caused the extinction of animal species in streams (DITTMAR, 1955).

The diversion of water from streams that took place in different sections of the Röserenbach since 1935 is known to create new hydraulic, thermal and chemical situations on the surface of the substratum (WARD & STANFORD, 1979; WARD, 1984; STATZNER *et al.*, 1990).

The purified waste water diverted into a small tributary of the Röserenbach might have caused the decrease of water quality indices and the diversity of species observed in the stream system below that point (KÜRY *et al.*, 1991; FOECKLER & BOHLE, 1993).

To conclude, the massive decline of Plecoptera in the Röserenbach corresponds very well with the changes found on a national scale in Germany (ZWICK, 1984). Macroinvertebrates and especially Plecoptera turn out to be very sensitive indicators of various changes of environmental factors like current, riparian structures, water quality or monocultures of conifers on a local scale.

In addition, the results show the great need to analyse the factors influencing the macroinvertebrate populations in order to develop objectives and methods for the restauration of streams and rivers. This includes the following steps: 1) compilation of specific autoecological preferences (e.g. substrate structure, oviposition site, hatching, larval development, life cycle), 2) list of the characteristic species on a regional level (see e.g. KÜRY, 1994), 3) objectives concerning the faunistic composition for every stream and river based on historical data, 4) restauration steps for every running water, 5) monitoring of the effects.

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REFERENCES

AUBERT, J. 1959. Plecoptera. Insecta Helvetica, Fauna 1: 1-140, Imprimerie La Concorde, Lausanne.

BLESS, R. 1990. Die Bedeutung von gewässerbaulichen Hindernissen im Raum-Zeit-System der Groppe (*Cottus gobio*). Natur u. Landschaft 65: 581-585.

BRAUKMANN, U. 1987. Zoozönologische und saprobiologische Beiträge zu einer allgemeinen regionalen Bachtypologie. Arch. Hydrobiol. Beih. (Ergebn. Limnol.) 26: 1-355.

CASPERS, N. 1980. Die Makrozooobenthos-Gesellschaften des Hochrheins bei Bad Säckingen. Beitr. naturk. Forsch. Südw. Dts. 39: 115-142.

DITTMAR, H. 1955. Ein Sauerlandbach. Arch. Hydrobiol. 50: 305-552.

EIDEL, K. 1955. Die Plecopteren des Schwarzwaldes. Arch. Hydrobiol./Suppl. 22(1/2): 65-89.

FITTKAU, E. J. & REISS, F. 1983. Versuch einer Rekonstruktion der Fauna europäischer Ströme und ihrer Auen. Arch. Hydrobiol. 97(1): 1-6.

FOECKLER, F. & BOHLE, H. W. 1993. Fliessgewässer und ihre Auen - prädestinierte Standorte ökologischer und naturschutzfachlicher Grundlagenforschung. *In*: HENLE K. & G. KAULE (Eds) Arten und Biotopschutz in Deutschland, pp. 236-266, Forschungszentrum Jülich (Berichte aus der Ökologischen Forschung, Vol. 4/1993), Jülich.

GEIJSKES, D. C. 1935. Faunistisch-ökologische Untersuchungen am Röserenbach bei Liestal im Basler Tafeljura. Beiträge zur Ökologie der Mittelgebirgsbäche. (Diss. Univ. Basel) Tijdschrift voor Entomologie 78(3/4): 249-382.

HÜTTE, M., BUNDI, U. & PETER, A. 1994. Konzept für die Bewertung und Entwicklung von Bächen und Bachsystemen im Kanton Zürich. EAWAG AND KANTON ZÜRICH (Eds), Zürich, 133 p.

HYNES, H. B. N. 1970. The ecology of running waters. Univ. Press, Liverpool, 555 p.

KINZELBACH, R. 1978. Veränderungen der Fauna des Oberrheins. Beih. Veröff. Naturschutz Landschaftspfl. Bad.-Württ. 11: 291-301.

KOTHÉ, P. & KNÖPP, H. (1965): Die Bedeutung des biologischen Wasserbaus für Gewässerbiologie und Fischerei. *In*: BUNDESANSTALT FÜR GEWÄSSERKUNDE KOBLENZ (Ed.) Der biologische Wasserbau an den Bundeswasserstrassen, pp. 268-285, Ulmer Verlag, Stuttgart.

KÜRY, D. 1994. Die Wirbellosenfauna der Fliessgewässer in der Region Basel. Verh. Naturf. Ges. Basel 104: 19-44.

KÜRY, D., RITTER, M., DI PIETRO, J. & BAERLOCHER, T. 1991. Ökologische Bestandsaufnahme zum Schutz des Röserenbachs. Unpublished manuscript, 71 p.

PLESKOT, G. 1953. Zur Ökologie der Leptophlebiidae (Insecta, Ephemeroptera). Öst. zool. Z. 4: 45-107.

PUTHZ, V. 1984. Rote Liste der Eintagsfliegen (Ephemeroptera). *In*: BLAB, J., NOWAK, E., TRAUTMANN, W. & SUKOPP, H. (Eds) Rote Liste der gefährdeten Tiere und Pflanzen in der Bundesrepublik Deutschland, pp. 118-120, Kilda-Verlag, Greven.

REUSCH, H. & BLANKE, D. 1993. Rote Liste der in Niedersachsen und Bremen gefährdeten Eintags-, Stein- und Köcherfliegenarten. Informs. d. Naturschutz Niedersachs. 13(4):129-148.

RITTER, M. 1992. Aspekte einer Geschichtsschreibung der Tierwelt Basels. Verh. Naturf. Ges. Basel 102(1): 211-276.

SARTORI, M., LANDOLT, P. & ZURWERRA, A. 1994: Rote Liste der gefährdeten Eintagsfliegenarten der Schweiz. *In*: DUELLI, P. (Ed.) Rote Liste der gefährdeten Tierarten in der Schweiz, pp. 72-74, BUWAL – Serie Rote Listen, Bern.

SCHRÖDER, P. & REY, P. 1991. Fliessgewässernetz Rhein und Einzugsgebiet, Milieu, Verbreitung und Austauschprozesse der Wirbellosenfauna zwischen Bodensee und Taubergiessen. IFAH-Scientific Publications, Konstanz, 236 p. + appendix.

STATZNER, B., KOHMANN, F. & SCHMEDTJE, U. 1990. Eine Methode zur ökologischen Bewertung von Restabflüssen in Ausleitungsstrecken. Wasserwirtschaft 80: 248-254.

STÖCKEL, G. 1984. Zur Häufigkeit der Libellenarten im Kreis Neustrelitz einst und jetzt. Naturschutzarbeit in Mecklenburg 27(2): 83-89.

STUDEMANN, D., LANDOLT, P., SARTORI, M., HEFTI, D. & TOMKA, I. 1992. Ephemeroptera. Insecta Helvetica, Fauna 9. Imprimerie Mauron+Tinguely & Lachat SA, Fribourg, 175 p.

WARD, J. V. 1984. Ecological perspectives in the management of aquatic insect habitats. *In*: RESH, V. H. & ROSENBERG, D. M. (Eds) The ecology of aquatic insects, pp. 558-577, Praeger Publishers, New York.

WARD, J. V. & STANFORD, J. A. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. *In*: WARD, J. V. & STANFORD, J. A. (Eds) The ecology of regulated rivers, pp. 35-55, Plenum Press, New York.

ZWICK, P. 1984. Rote Liste der Steinfliegen (Plecoptera). *In*: BLAB, J., NOWAK, E., TRAUTMANN, W. & SUKOPP, H. (Eds) Rote Liste der gefährdeten Tiere und Pflanzen in der Bundesrepublik Deutschland, pp. 115-116, Kilda-Verlag, Greven.

ZWICK, P. 1992. Stream habitat fragmentation – a threat to biodiversity. Biodiversity & Conservation 1: 80-97.