

## Aquatic Invasions Records

## *Katamysis warpachowskyi* Sars, 1877 (Crustacea, Mysida) invaded Lake Constance

Almut J. Hanselmann

*Limnological Institute, University of Konstanz, Mainaustraße 252, 78467 Konstanz, Germany*  
E-mail: [almut.hanselmann@uni-konstanz.de](mailto:almut.hanselmann@uni-konstanz.de)

Received: 12 April 2010 / Accepted: 29 May 2010 / Published online: 10 June 2010

### Abstract

The mysid *Katamysis warpachowskyi* Sars, 1877 originated in the Ponto-Caspian region and the associated river systems. The first evidence of its transgression of the limits of the watersheds of its natural Ponto-Caspian origin was found when three individuals were recorded in October 2009 in eastern Lake Constance (Austria). In March 2010, *K. warpachowskyi* comprised 10% of the mysid assemblage and was mainly found in rocky habitats. On both sampling dates, breeding females were present. Before this invasion, *Limnomysis benedeni* Czerniavsky, 1882, was the only mysid in Lake Constance and is also distributed in the Rhine river system. Since the two mysids coexist in Lake Constance, *K. warpachowskyi* will likely become established in the lake and further expand into the main part of the Rhine. *K. warpachowskyi* is known as a benthic organism and feeds on detritus and small algae; therefore, the impact on the lake ecosystem should be weaker than that of pelagic mysids.

**Key words:** invasive species, littoral zone, *Limnomysis benedeni*, neozoan, Ponto-Caspian

### Introduction

The number of invasions by alien species in freshwater ecosystems has increased over the last decades with increasing connection of water systems by humans to transport goods (Kinzelbach 1995; Bij de Vaate et al. 2002; Chandra and Gerhardt 2008). Several new species also invaded the littoral zone of Lake Constance. Recently, three species were recorded for the first time in the eastern part of the lake (Vorarlberg/Austria): the bivalve *Corbicula fluminea* Muller 1774 in 2003 (Werner and Mörtl 2004), the mysid *Limnomysis benedeni* Czerniavsky, 1882 in 2006 (Fritz et al. 2006), and the amphipod *Crangonyx pseudogracilis* Bousfield, 1958 in 2008 (Hanselmann and Gergs 2008). All these species are common invaders and are distributed in the Rhine below Lake Constance (Bernauer and Jansen 2006, Leuven et al. 2009). The invasions are most probably due to human impact, e.g., via boat transports or ballast waters, because Lake Constance is separated from the main part of the Rhine by a natural barrier, a waterfall (Kinzelbach 1995; Rheinhold and Tittizer 1998; Martens and Grabow 2008).

In Central and Western European freshwaters systems, the invasive mysids are *Hemimysis anomala* Sars, 1907 and *L. benedeni* (Kelleher et

al. 1999; Ketelaars et al. 1999; Wittmann and Ariani 2008). These mysids have been distributed in parts of the Rhine-Main-Danube system for more than 25 years (Schleuter et al. 1998; Bij de Vaate et al. 2002; Wittmann 2007). The mysid *Katamysis warpachowskyi* Sars, 1877 originated in the Ponto-Caspian region, i.e., mainly in the Caspian Sea and the euryhalin regions of the Danube and Dnjestr (Wittmann 2002, and older Russian literature cited therein). The species was first recorded in the Don in 2000 (Daneliya 2001) and in the upper parts of the Danube (km 1769) in 2001 (Wittmann 2002). In 2008, it reached the winter harbor of Passau/Germany (km 2228) (Wittmann 2008). The mysid, however, had not transgressed the limits of the watersheds belonging to its exclusively Ponto-Caspian range (European Watershed) and therefore was not considered as a neozoan invader for a long time (Wittmann 2007). Here I report the first recordings of this mysid outside of its Ponto-Caspian range, i.e. its jump over the European Watershed.

### Materials and methods

The study site is located on the eastern part of Lake Constance, near the confluences of the rivers Alpen-Rhine and Dornbirner Ach, on the shoreline of a dam of anthropogenic origin

(Hard, near Bregenz, 47°29'53.8"N, 9°40'50"E). The substrate on the sampling site consisted of areas with stones of different sizes (gravel, stones from 2 to 25 cm, rocks). During continuous studies on *Limnomysis benedeni* (e.g. Gergs et al. 2008), quantitative samples (three replicates each) were taken on July 29, 2009, October 12, 2009, and March 12, 2010. These samples were taken in the stony habitat with an underwater surber sampler (area of 625 cm<sup>2</sup>, height of 40 cm, mesh wide 200 µm, Baumgärtner 2004; Mörtl 2004) at a water depth of 0.5 m. In the laboratory, the number of all mysids was counted. Additional samples were taken by kick-sampling between the rocks and directly fixed in 96% ethanol to measure the population structure. Photographs were taken with a fire-wire camera (Imaging Source) a stereomicroscope and a computer. Body length was measured from the top of the rostrum to the end of the telson (e.g., Schleuter et al. 1998). As mysids carry their brood in a brood pouch, the marsupium (Mauchline 1980), larval stages could be identified according to Wittmann (1981). The species *L. benedeni* and *K. warpachowskyi* were identified by their characteristic telson (Figure 1). Males and females were differentiated by the marsupium of the females or the enlarged 4th pleopod of the males (Bacescu 1954). Temperature, pH, conductivity, and oxygen concentration (mg l<sup>-1</sup> and % saturation) were measured in the field (WTW MultiLine F/Set-3).

## Results

In mysid samples from Lake Constance in July 2009, only *Limnomysis benedeni* was present. On October 12, 2009, I found the first specimens of *Katamysis warpachowskyi* in Lake Constance (Figure 1). Most of the mysids were found in shallow areas (about 0.5 m depth) with larger stones, especially between the rocks. The composition of the mysid assemblage changed with the habitat. 254 individuals of *L. benedeni* and 3 individuals of *K. warpachowskyi* (~ 1 % of the mysid assemblage) were recorded in October between the rocks. The 3 *K. warpachowskyi* mysids consisted of 1 juvenile and 2 females; the marsupium of the larger female was filled with nauplioids (Table 1). The abundance of *L. benedeni* in October 2009 on the stones was  $75 \pm 56$  individuals m<sup>-2</sup>, and of *K. warpachowskyi*, one single animal was found in one of the three replicates ( $5 \pm 9$  individuals m<sup>-2</sup>).



**Figure 1.** *Katamysis warpachowskyi* from Lake Constance. a: female; b: male; c: telson.

**Table 1.** Body length and brood size of *Katamysis warpachowskyi* in Lake Constance given as mean  $\pm$  standard deviation if  $n > 3$  or single measurements if  $n \leq 3$ .

	October 12, 2009		March 12, 2010	
	[mm] or egg/♀	n	[mm] or egg/♀	n
Juveniles	2.6	1	-	
Males	-		$6.31 \pm 0.67$	10
Females	4.1; 4.7	2	$7.39 \pm 0.91$	6
Brood size	7	1	14; 19; 27	3

**Table 2.** Abiotic factors at the sampling site in Lake Constance.

Abiotic factor	October 12, 2009	March 12, 2010
Depth [m]	0.5	0.5
Temperature [°C]	16.6	4.1
Conductivity [ $\mu\text{S cm}^{-1}$ ]	299	343
Oxygen [%]	102	115
Oxygen [mg l <sup>-1</sup> ]	9.37	14.33
pH	8.14	8.24

On March 12, 2010, the proportion of *K. warpachowskyi* within the mysid sample from the rocks increased to more than 10 %. The mean body length of *K. warpachowskyi* females was higher than that of males (Table 1). No juveniles were found on that date, but every female ( $n = 6$ ) had a marsupium, which was not always filled. All recorded broods were characterized as embryos. The abundance of *L. benedeni* on the stones on March 3, 2010 was  $171 \pm 74$  individuals  $m^{-2}$ , and that of *K. warpachowskyi* again  $5 \pm 9$  individuals  $m^{-2}$ . None of the *L. benedeni* females carried a brood in March.

The abiotic factors in October 2009 and March 2010 were similar (Table 2), except that the temperature was higher in October 2009. On both dates, the oxygen content exceeded 100 %.

## Discussion

The recording of *Katamysis warpachowskyi* on October 12, 2009 in Lake Constance is the first outside the Ponto-Caspian drainage system. After *Limnomysis benedeni*, *K. warpachowskyi* is the second mysid found in Lake Constance. The immigration of *K. warpachowskyi* must have been enabled by human impact, probably by moving boats from one water body to another (Martens and Grabow 2008), because the nearest incidence of the mysid is in the Danube near Passau (Wittmann 2008), around 300 km in linear distance away. This supports the hypothesis of Wittmann (2008) that human impact is responsible for the range expansion of *K. warpachowskyi* in the Danube.

The low proportion of *K. warpachowskyi* in Lake Constance in October 2009 and the low abundances suggest that the mysid invaded Lake Constance recently. The higher proportion on the mysid assemblage in the rocks in March 2010 indicates that the mysids reproduced in the lake. It is surprising that *K. warpachowskyi* carried broods in March since *L. benedeni* does not reproduce at this temperature (unpublished data), but there are no detailed reports on the reproduction period of *K. warpachowskyi*. Daneliya (2001) only one reported from the Don a smaller brood size in summer than in spring.

The dispersion of the mysids differed between the habitats. *K. warpachowskyi* was mainly found between the rocks, whereas *L. benedeni* was found everywhere. Both mysids are necto-benthic, but *K. warpachowskyi* seems to be adapted to higher water velocity. Their body is

much more depressed, and they were not found in drift (Wittmann 2002). The abiotic factors at the sampling site (Table 2) were similar to those measured at other locations where *K. warpachowskyi* has been found (Wittmann 2002, 2007). *K. warpachowskyi* often coexists with *L. benedeni* (Wittmann 2007). In Lake Constance, the two mysids were found together, but *L. benedeni* dominated the mysid community. The environmental demands of the two mysids are comparable, except for oxygen. *K. warpachowskyi* requires at least  $6 \text{ mg l}^{-1}$ , whereas *L. benedeni* requires only  $4 \text{ mg l}^{-1}$  (Bacescu 1954; Wittmann et al. 1999).

The mean body length of adult *K. warpachowskyi* in March 2010 in Lake Constance was longer than that recorded in May 1995 in the Danube by Wittmann (2002), but the range of body length is within these previous published data. In Lake Constance, the females were longer in body length than the males, which is typical for the species (Bacescu 1954; Wittmann 2002). The maximal brood size in Lake Constance was higher than expected by Wittmann (2002) and recorded by Bacescu (1954) and comparable to the data from Daneliya (2001).

The feeding behavior of *K. warpachowskyi* has not been studied well, and only a few observations and stomach analyses are available. The mysid feeds on detritus and small algae and is not a predator (Wittmann 2002); it likely feed the same way as *L. benedeni* (Gergs et al. 2008). Therefore, the impact of *K. warpachowskyi* should be comparable to that of *L. benedeni*, in keeping with the hypothesis of Wittmann (2002). *K. warpachowskyi* will probably not have such a high impact as, e.g., the pelagic predator *Hemimysis anomala*, introduced in the Netherlands (Ketelaars et al. 1999). Nevertheless, it is probable that *K. warpachowskyi* will establish in Lake Constance, colonize the lower parts of the Rhine easily, and then spread up through the associated water systems, if enough oxygen is available. Therefore, the monitoring of the macrozoobenthos community of this water system should be continued.

## Acknowledgements

I thank René Gergs for his help in general; Monika Friedel, Timo Basen, and Cornelia Welte for their support in the field; Karen A. Brune for editing the English language; Andreas Martens, and two anonymous reviewers for helpful comments on an earlier version of the manuscript; and Philipp Menzel for editing the picture. Special thanks are given to Karl-Otto Rothhaupt for his support and motivating encouragement.

## References

- Bacescu M (1954) Crustacea: Mysidacea. *Fauna Republicii Populare Romine* 4: 1-126
- Baumgärtner D (2004) Principles of macroinvertebrate community structure in the littoral zone of Lake Constance. PHD Thesis, University of Konstanz, Konstanz, Germany, 197 pp
- Bernauer D & Jansen W (2006) Recent invasions of alien macroinvertebrates and loss of native species in the upper Rhine River, Germany. *Aquatic Invasions* 1: 55-71, doi:10.3391/ai.2006.1.2.2
- Bij de Vaate A, Jazdzewski K, Ketelaars HAM, Gollasch S, van der Velde G (2002) Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe. *Canadian Journal of Fisheries and Aquatic Sciences* 59: 1159-1174, doi:10.1139/f02-098
- Chandra S, Gerhardt A (2008) Invasive species in aquatic ecosystems: issue of global concern. *Aquatic Invasions* 3: 1-2, doi:10.3391/ai.2008.3.1.1
- Daneliya ME (2001) O rasprostraneni Katamysis warpachowskyi G.O. Sars (Crustacea, Mysidacea) v basseini Reki Don. *Izvestija vuzov Severo-Kavkazskij region. Estestvennie nauki* 2: 49-50
- Fritz B, Nisch A, Wittkugel C, Mörtl M (2006) First record of *Limnomysis benedeni* Czerniavsky in Lake Constance (Crustacea: Mysidacea). *Lauterbornia* 58: 157-160
- Gergs R, Hanselmann A J, Eisele I, Rothhaupt K O (2008) Autecology of *Limnomysis benedeni* Czerniavsky, 1882 (Crustacea: Mysida) in Lake Constance, southwestern Germany. *Limnologia* 38: 139-146, doi:10.1016/j.limno.2007.12.002
- Hanselmann AJ, Gergs R (2008) First record of *Crangonyx pseudogracilis* Bousfield 1958 (Amphipoda, Crustacea) in Lake Constance. *Lauterbornia* 62: 21-25
- Kelleher B, van der Velde G, Wittmann K J, Faasse MA, Bij de Vaate A (1999) Current status of the freshwater Mysidae in the Netherlands: with records of *Limnomysis benedeni* (Czerniavsky 1882), a pontocaspian species in Dutch Rhine branches. *Bulletin Zoölogisch Museum Universiteit van Amsterdam* 16: 89-94
- Ketelaars HAM, Lambregts-van de Clundert FE, Carpentier CJ, Wagenvoort AJ, Hoogenboezem W (1999) Ecological effects of the mass occurrence of the Ponto-Caspian invader, *Hemimysis anomala* G.O. Sars, 1907 (Crustacea: Mysidacea), in a freshwater storage reservoir in the Netherlands, with notes on its autecology and new records. *Hydrobiologia* 394: 233-248, doi:10.1023/A:1003619631920
- Kinzelbach R (1995) Neozoans in European waters - Exemplifying the worldwide process of invasion and species mixing. *Experientia* 51: 526-538, doi:10.1007/BF02143203
- Leuven RSEW, van der Velde G, Baijens I, Snijders J, van der Zwart C, Lenders HJR, bij de Vaate A (2009) The river Rhine: a global highway for dispersal of aquatic invasive species. *Biological Invasions* 11: 1989-2008, doi:10.1007/s10530-009-9491-7
- Martens A, Grabow K (2008) Risk of spreading of non-indigenous Amphipoda due to overland transport of recreation boats. *Lauterbornia* 62: 41-44
- Mauchline J (1980) The biology of mysids and euphausiids. *Advances in Marine Biology* 18: 1-681
- Mörtl M (2004) Biotic interactions in the infralittoral of Lake Constance. PHD Thesis, University of Konstanz, Konstanz, Germany, 159 pp
- Rheinhold M, Tittizer T (1998) *Limnomysis benedeni* Czerniavsky 1882 (Crustacea: Mysidacea): a further alien species of pontocaspian origin in the Main-Danube-Canal. *Lauterbornia* 33: 37-40
- Schleuter A, Geissen H-P, Wittmann KJ (1998) *Hemimysis anomala* G. O. Sars 1907 (Crustacea: Mysidacea), an euryhaline Pontocaspian mysid in the rivers Rhine and Neckar. First report for Germany. *Lauterbornia* 32: 67-71
- Werner S, Mörtl M (2004) First record of the Asian clam *Corbicula fluminea* in Lake Constance. *Lauterbornia* 49: 93-97
- Wittmann KJ (1981) Comparative biology and morphology of marsupial development in *Leptomysis* and other Mediterranean Mysidacea (Crustacea). *Journal of Experimental Marine Biology and Ecology* 52: 243-270, doi:10.1016/0022-0981(81)90040-X
- Wittmann KJ (2002) Further expansion of Pontocaspian Mysidacea (Crustacea) into the middle and upper Danube: first records of *Katamysis warpachowskyi* for Hungary, Slovakia and Austria with notes on the biology and ecological risk potential. *Lauterbornia* 44: 49-63
- Wittmann KJ (2007) Continued massive invasion of Mysidae in the Rhine and Danube river systems, with first records of the order Mysidacea (Crustacea: Malacostraca: Peracarida) for Switzerland. *Revue Suisse de Zoologie* 114: 65-86
- Wittmann KJ (2008) Further expansion of the Pontocaspian mysid shrimp (Crustacea: Mysida: Mysidae) *Katamysis warpachowskyi* in the upper Danube: first record for Germany. *Lauterbornia* 63: 83-86
- Wittmann KJ, Ariani AP (2008) Reappraisal and range extension of non-indigenous Mysidae (Crustacea, Mysida) in continental and coastal waters of eastern France. *Biological Invasions* 11: 401-407, doi:10.1007/s10530-008-9257-7
- Wittmann KJ, Theiss J, Banning M (1999) The drift of Mysidacea and Decapoda and its significance for the dispersion in the Main-Danube system. *Lauterbornia* 35: 53-66