Journal of Fish Biology (2006) **69,** 1575–1580
doi:10.1111/j.1095-8649.2006.01218.x, available online at http://www.blackwell-synergy.com

On the occurrence of the Asiatic cyprinid *Pseudorasbora parva* in the Netherlands

B. J. A. Pollux*†‡ and A. Korosi§

**Department of Aquatic Ecology and Environmental Biology, Institute for Water and Wetland Research, Radboud University Nijmegen, Toernooiveld 1, NL-6525 ED Nijmegen, The Netherlands, †Department of Plant-Animal Interaction, Centre for Limnology, Netherlands Institute of Ecology (NIOO-KNAW), Maarssen, The Netherlands and §Department of Cellular Animal Physiology, Radboud University Nijmegen, Toernooiveld 1, NL-6525 ED Nijmegen, The Netherlands*

(Received 29 August 2005, Accepted 16 June 2006)

A large scale inventory along the Meuse River (the Netherlands), showed that floodplain lakes function as spawning, nursery and adult habitats, while the main river channel merely serves as a dispersal corridor for adult *Pseudorasbora parva*, one of the most successful invasive fish species that have colonized Europe.

Key words: dispersal; distribution; habitat preference; invasive; reproduction.

The topmouth gudgeon *Pseudorasbora parva* (Temminck & Schlegel 1846) is native to East Asia, *e.g.* northern China, Korea, Japan and Taiwan (Bănărescu, 1999). It was first recorded in Europe in 1960, after its inadvertent introduction into fishponds along the River Danube in Romania (Bănărescu, 1964). From the Lower Danube region, this species has exhibited a rapid spread in all directions. It has dispersed north-west through the Danube and Rhine river systems, successively invading Hungary in 1970 (Biro, 1972), Czechoslovakia in 1974 (Zitman & Holčik, 1976), Austria in 1982 (Weber, 1984), East Germany in 1984 (Arnold, 1985), West Germany in 1987 (Lelek & Köhler, 1989), Poland in the early 1990s (Kotusz & Witkowski, 1998), the Netherlands in 1992 (Lenders, 1993), Flanders (Belgium) in 1992 (Vandelannoote *et al.*, 1998) and Denmark in 2002 (Olesen *et al.*, 2003). Around the late 1970s it was intentionally introduced into Lake Skadar (Albania), as a food source for predatory fishes reared in hatcheries (Wildekamp *et al.*, 1997). From here, *P. parva* subsequently spread to Serbian, Montenegrin, Macedonian and Greek waters, due to unintentional introductions (Bianco, 1988; Cakic *et al.*, 2004). *Pseudorasbora parva* has

‡Author to whom correspondence should be addressed. Tel.: +31 24 3653047; fax: +31 24 3652134; email: b.pollux@science.ru.nl

also been recorded in Italy (*c.* 1988; Sala & Spampanato, 1991), France (1980s; Allardi & De Chancerel, 1988), England (1990s; Gozlan *et al.*, 2002) and Spain (in 2001; Caiola & De Sostoa, 2002); its presence here has been attributed to human-mediated introductions, because natural spread to these countries is impeded by the presence of geographic barriers (*e.g.* the Alps, the Pyrenees and the North Sea). The species' presence has further been reported from countries south-east of the Lower Danube region, *e.g.* the Republic of Moldova (Blanc *et al.*, 1971), Ukraine (Movchan & Smirnov, 1981), the Russian Federation (Bogutskaya & Naseka, 1996), Azerbaijan (Reshetnikov *et al.*, 1997), Kazakhstan (Blanc *et al.*, 1971), Uzbekistan (Kamilov & Urchinov, 1995), Turkmenistan (Coad, 1995), Turkey (Wildekamp *et al.*, 1997), Iran (Coad & Abdoli, 1993), Afghanistan (Coad, 1981) and Algeria (Perdices & Doadrio, 1992).

Pseudorasbora parva is one of the most successful invasive fish species that have recently colonized Europe, reaching an almost pan-Eurasian distribution within a period of <40 years (Gozlan *et al.*, 2002). Its success can be explained by its opportunistic life-history characteristics (*e.g.* omnivore, short generation time, polyphilic spawner, high reproductive effort and parental care; Rosecchi *et al.*, 2001) and by its wide physiological tolerance, which enables it to withstand extreme environmental conditions (*e.g.* low water levels, elevated temperatures, low oxygen concentrations and algal blooms; Bănărescu, 1999; Pollux & Pollux, 2004). Although little information is available on the interaction of *P. parva* with native European fish species, negative impacts have been reported, including predation on the eggs and larvae of native species (Stein & Herl, 1986), interspecific competition for food (Declerck *et al.*, 2002) and introduction of exotic parasites (Gozlan *et al.*, 2005). Knowledge of the species' dispersal capability, habitat preference and the existing scale of invasion is therefore essential for predicting where, and which, fish communities may be potentially threatened by future invasions of *P. parva.*

Pseudorasbora parva was first discovered in the Netherlands in 1992, at the confluence of the Aalsbeek River with the Meuse River, near the city of Tegelen [one specimen, 25 mm total length, L_T, 11 April 1992; Lenders, 1993; Fig. 1(a)]. A few months later *P. parva* was caught in the Swalm River (Meuse catchment), near the city of Swalmen (five specimens, 20–40 mm L_T, 17 October 1992; Lenders, 1993). Although the exact method and route of invasion is unknown, *P. parva* is thought to have reached the Netherlands from Germany, *via* the Rhine drainage (Lenders, 1993). Although *P. parva* has gradually spread to other locations in the Netherlands since 1992, its centre of distribution still appears to lie in the south-eastern part of the country, along the Meuse River, in the Province of Limburg [De Nie, 1997; Lenders, 2000; Anon., 2005; Fig. 1(a)]. Unfortunately, most reported observations concern accidental catches of single specimens, predominantly at the confluences of the Meuse River and its tributaries. A systematic inventory assessing the full scale of the invasion, in terms of total numbers of specimens and geographic distribution, is, to date, largely lacking.

To assess population densities and potential habitat preference in Dutch waters, 35 locations were selected in the Meuse River (at the confluences of the Meuse River and its tributaries) and 10 floodplain lakes along the Meuse River [Fig. 1(b)]. These sites were sampled between May 2004 and August

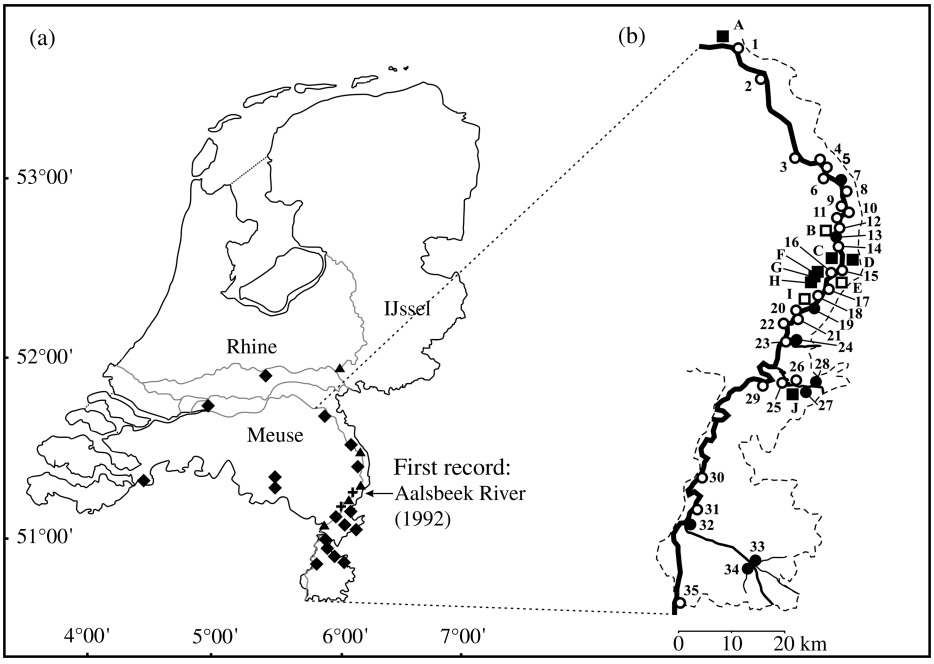

FIG. 1. (a) Geographic locations of recorded catches of *Pseudorasbora parva* in the Netherlands (✚, 1992; ▲, 1993–1997; ◆, 1998–2005, catches from this study not included). (b) Study area showing the sampled river locations 1–35 (○) and floodplain lakes A–J (□). River locations (●) and floodplain lakes (■) where *P. parva* were caught are indicated.

2005 (river locations: $n = 152$ times and floodplain lakes: $n = 24$ times), by means of hand-nets (mouth size 70 × 50 cm; mesh-size 3·0 × 3·0 mm) (Pollux *et al.*, 2006). The results showed a highly significant difference in mean *P. parva* densities between river locations (mean ± S.D.: 0·11 ± 0·61 individuals 100 m^{-2}) and floodplain lakes (141·29 ± 175·23 individuals 100 m^{-2}) (Mann–Whitney *U*-test, $n = 176$; $P < 0{\cdot}001$).

The river locations were characterized by shallow, relatively clear waters (compared to the floodplain lakes), a heterogeneous bed morphology with a variety of substrata (*e.g.* silt, mud, sand, gravel and pebbles), and the absence of aquatic and riparian vegetation. Here, a total of 26 fish species were caught (Table I), dominated by eurytopic and rheophilic species. *Pseudorasbora parva* were rarely caught ($n = 16$ individuals, caught in nine of the 35 locations, from 152 sample sessions) and all catches consisted of adult specimens (≥24 mm fork length, L_F). The floodplain lakes were characterized by shallow (<1 m), relatively turbid waters, with little aquatic vegetation (<0·1% cover), but with an abundant shoreline vegetation (*e.g. Phragmites australis*, *Mentha aquatica, Myosotis scorpioides* and *Scirpus* sp.). Here, a total of 15 fish species were caught (Table I), dominated by eurytopic and limnophilic species. *Pseudorasbora parva* were frequently caught ($n = 3058$ individuals, caught in seven of the 10 floodplain lakes, from 24 sample sessions), and catches consisted of both adults (≥24 mm L_F) and 0+ year larvae and juveniles (<24 mm L_F). Since the floodplain lakes had not

TABLE I. Mean per cent composition of the fish fauna observed in the 35 river locations ($n = 7690$ fishes) and the 10 floodplain lakes ($n = 8774$ fishes), grouped according to flow preference (after Schiemer & Waidbacher, 1992)

Species	River locations	Floodplain lakes
Rheophilic A		
Brook lamprey *Lampetra planeri*	0·01	0
Nase *Chondrostoma nasus*	0·04	0
Dace *Leuciscus leuciscus*	0·04	0
Brown trout *Salmo trutta fario*	0·14	0
Barbel *Barbus barbus*	0·29	0
Minnow *Phoxinus phoxinus*	2·03	0
Bullhead *Cottus gobio*	6·11	0
Chub *Leuciscus cephalus*	9·36	0
Rheophilic B		
Ide *Leuciscus idus*	0·05	0
Spined loach *Cobitis taenia*	1·38	0·10
Gudgeon *Gobio gobio*	8·69	0
Stone loach *Barbatula barbatula*	13·97	0·05
Eurytopic		
Eel *Anguilla anguilla*	0·22	0
Pikeperch *Sander lucioperca*	0·01	0
Ruffe *Gymnocephalus cernuus*	0·05	0
Silver bream *Blicca bjoerkna*	0·25	0
Pike *Esox lucius*	0·20	0·05
Bleak *Alburnus alburnus*	0·25	0·13
Bream *Abramis brama*	1·81	0·07
Roach *Rutilus rutilus*	21·42	0·07
Perch *Perca fluviatilis*	6·55	1·38
Carp *Cyprinus carpio*	0·05	10·86
Three-spined stickleback *Gasterosteus aculeatus*	25·97	49·75
Limnophilic		
Bitterling *Rhodeus sericeus*	0	0·06
Rudd *Scardinius erythrophthalmus*	0·07	0·11
Nine-spined stickleback *Pungitius pungitius*	0·83	0·84
Tench *Tinca tinca*	0	1·61
Topmouth gudgeon *Pseudorasbora parva*	0·21	34·85
Sunbleak *Leucaspius delineatus*	0	0·07

been flooded for at least 1 year, the presence of 0+ year fish indicated reproduction of *P. parva* in the floodplain lakes (Pollux & Korosi, 2002).

The results show that *P. parva* reached its highest densities in floodplain lakes, which acted as suitable spawning, nursery and adult habitats for this species. The low observed densities of predominantly adult individuals in the river locations furthermore suggest that the river merely serves as a dispersal corridor for adult specimens. Therefore, native species that use the floodplain lakes, at least during one of their life stages, are the most likely species to be affected by the presence of *P. parva*. These include limnophilic species, that reside

mainly in the floodplain lakes [*e.g.* bitterling *Rhodeus sericeus* (Pallas), rudd *Scardinius erythrophthalmus* (L.), tench *Tinca tinca* (L.), sunbleak *Leucaspius delineatus* (Heckel) and nine-spined stickleback *Pungitius pungitius* (L.)], as well as eurytopic species that use these floodplain lakes temporarily, for example, as a spawning and nursery habitat, and move to and from the floodplain lakes during periodic floods [*e.g.* roach *Rutilus rutilus* (L.), bream *Abramis brama* (L.), carp *Cyprinus carpio* L., perch *Perca fluviatilis* L., pike *Esox lucius* L. and three-spined stickleback *Gasterosteus aculeatus* L.]. Thus, although the impacts seem greatest in the floodplain lakes that are peripheral to the main channel, *P. parva* may also affect species in the main river channel.

We wish to thank P. Pollux, W. Verberk, M. Dorenbosch, J. Aben, M. van Riel and S. Gómez for their assistance in the field and P. Walker for his helpful comments on an earlier draft. This is publication 3880 of the Netherlands Institute of Ecology (NIOO-KNAW).

References

Allardi, J. & De Chancerel, F. (1988). Sur la présence en France de *Pseudorasbora parva* (Schlegel, 1842). *Bulletin Français de Pêche et Pisciculture* **306,** 35–37.

Anon. (2005). Waarnemingenoverzicht 2003–2004. *RAVON* **7,** 46–64.

Arnold, A. (1985). *Pseudorasbora parva* nun auch in der DDR. *Zeitschrift fuer die Binnenfischerei* **32,** 182–183.

Bănărescu, P. M. (1964). *Pisces, Osteichthyes*, Vol. 13. Bucharest: Fauna Republikii Populare Romine.

Bănărescu, P. M. (1999). *Pseudorasbora parva* (Temminck & Schlegel 1846). In *The Freshwater Fishes of Europe*, Vol. 5/I Cyprinidae 2/I (Bănărescu, P. M., ed.), pp. 207–224. Wiebelsheim: AULA-Verlag.

Bianco, P. G. (1988). Occurrence of the Asiatic gobionid *Pseudorasbora parva* (Temminck & Schlegel) in south-eastern Europe. *Journal of Fish Biology* **32,** 973–974.

Biro, P. (1972). *Pseudorasbora parva* a Balatonban. *Halazat* **18,** 37.

Blanc, M., Gaudet, J. L., Bănărescu, P. M. & Hureau, J. C. (1971). *European Inland Water Fish: a Multilingual Catalogue*. London: Fishing News Books.

Bogutskaya, N. G. & Naseka, A. M. (1996). Cyclostomata and fishes of Khanka Lake drainage area (Amur river basin). An annotated check-list with comments on taxonomy and zoogeography of the region. *Zoological Institute of the Russian Academy of Sciences* **3,** 1–89.

Caiola, N. & De Sostoa, A. (2002). First record of the Asiatic cyprinid *Pseudorasbora parva* in the Iberian Peninsula. *Journal of Fish Biology* **61,** 1058–1060. doi: 10.1006/jfbi.2002.2103

Cakic, P., Lenhardt, M., Kolarevic, J., Mickovic, B. & Hegedis, A. (2004). Distribution of the Asiatic cyprinid *Pseudorasbora parva* in Serbia and Montenegro. *Journal of Fish Biology* **65,** 1431–1434. doi: 10.1111/j.1095-8649.2004.00525.x

Coad, B. W. (1981). Fishes of Afghanistan, an annotated checklist. *Publications in Zoology, National Museums of Canada* **14,** 1–26.

Coad, B. W. (1995). Freshwater fishes of Iran. *Acta Scientiarum Naturalium Academiae Scientiarum Bohemicae Brno* **29,** 1–64.

Coad, B. W. & Abdoli, A. (1993). Exotic fish species in the freshwaters of Iran. *Zoology in the Middle East* **9,** 65–80.

Declerck, S., Louette, G., De Bie, T. & De Meester, L. (2002). Patterns of diet overlap between populations of non-indigenous and native fishes in shallow ponds. *Journal of Fish Biology* **61,** 1182–1197. doi: 10.1006/jfbi.2002.2133

De Nie, H. W. (1997). Blauwband. In *Atlas van de Nederlandse Zoetwatervissen* (De Nie, N. W., ed.), pp. 66–67. Doetinchem: Media Publishing International.

Gozlan, R. E., Pinder, A. C. & Shelley, J. (2002). Occurrence of the Asiatic cyprinid *Pseudorasbora parva* in England. *Journal of Fish Biology* **61,** 298–300. doi: 10.1006/jfbi.2002.2042

Gozlan, R. E., St-Hilaire, S., Feist, S. W., Martin, P. & Kent, M. L. (2005). Disease threat to European fish. *Nature* **435,** 1046. doi: 10.1038/4351046a

Kamilov, G. & Urchinov, Z. U. (1995). Fish and fisheries in Uzbekistan under the impact of irrigated agriculture. In *Inland Fisheries Under the Impact of Irrigated Agriculture: Central Asia* (Petr, T., ed.), pp. 10–41. *FAO Fisheries Circular* **894**.

Kotusz, J. & Witkowski, A. (1998). Morphometrics of *Pseudorasbora parva* (Schlegel, 1842) (Cyprynidae, Gobioninae), a species introduced into the Polish waters. *Acta Ichthyologica et Piscatoria* **28,** 3–14.

Lelek, A. & Köhler, C. (1989). Zustandanalyse der Fischartengemeinschaften im Rhein (1987–1988). *Fischökologie* **1,** 47–64.

Lenders, A. J. W. (1993). De Blauwbandgrondel, een nieuwe vissoort voor de Nederlandse wateren. *Natuurhistorisch Maandblad* **82,** 201–205.

Lenders, T. (2000). Blauwband. In *Vissen in Limburgse beken – De verspreiding en Ecologie van vissen in stromende wateren in Limburg* (Crombaghs, B. H. J. M., Akkermans, R. W., Gubbels, R. E. M. B. & Hoogerwerf, G., eds), pp. 206–213. Maastricht: Stichting Natuurpublicaties Limburg.

Movchan, Y. V. & Smirnov, A. I. (1981). *Fauna of Ukraine. Fishes. Cyprinid Fishes* (Part 1). Kiev: Naukova Dumka Publishing House.

Olesen, T. M., Nielsen, J. G. & Møller, P. R. (2003). Båndgrundling *Pseudorasbora parva* (Temminck og Schlegel, 1864) ny ynglefisk i Danmark. *Flora og Fauna* **109,** 1–5.

Perdices, A. & Doadrio, I. (1992). Presence of the Asiatic cyprinid *Pseudorasbora parva* (Schlegel, 1842) in North Africa. *Miscellania Zoologica (Barcelona)* **16,** 236–239.

Pollux, B. J. A. & Korosi, A. (2002). De Romeinenweerd als voortplantingsgebied voor de Blauwband *Pseudorasbora parva*. *Natuurhistorisch Maandblad* **91,** 234–236.

Pollux, B. J. A. & Pollux, P. M. J. (2004). Vis- en vogelsterfte door blauwalgen in de Romeinenweerd. *Natuurhistorisch Maandblad* **93,** 207–209.

Pollux, B. J. A., Korosi, A., Verberk, W. C. E. P., Pollux, P. M. J. & van der Velde, G. (2006). Reproduction, growth, and migration of fishes in a regulated lowland tributary: potential recruitment to the River Meuse. *Hydrobiologia* **565,** 105–120.

Reshetnikov, Y. S., Bogutskaya, N. G., Vasil'eva, E. D., Dorofeeva, E. A., Naseka, A. M., Popova, O. A., Savvaitova, K. A., Sideleva, V. G. & Sokolov, L. I. (1997). An annotated check-list of the freshwater fishes of Russia. *Journal of Ichthyology* **37,** 687–736.

Rosecchi, E., Thomas, F. & Crivelli, A. J. (2001). Can life-history traits predict the fate of introduced species? A case study on two cyprinid fish in southern France. *Freshwater Biology* **46,** 845–853.

Sala, L. & Spampanato, A. (1991). Prima segnalazione de *Pseudorasbora parva* (Schlegel 1842) in acque interne Italiane. *Rivista di Idrobiologia* **29,** 461–467.

Schiemer, F. & Waidbacher, H. (1992). Strategies for conservation of a Danubian fish fauna. In *River Conservation and Management* (Boon, P. J., Calow, P. & Petts, G. E., eds), pp. 363–382. Chichester: John Wiley & Sons Ltd.

Stein, H. & Herl, O. (1986). *Pseudorasbora parva* – eine neue Art der mitteleuropaeischen Fishfauna. *Zeitschrift fuer die Binnenfischerei* **36,** 1–2.

Vandelannoote, A., Yseboodt, R., Bruylants, B., Verheyen, R., Coeck, J., Belpaire, C., Van Thuyne, G., Denayer, B., Beyens, J., De Charleroy, D., Maes, J. & Vandenabeele, P. (1998). *Atlas van de Vlaamse Beek- en Riviervissen*. Wijnegem: Water-Energik-vLario (WEL).

Weber, E. (1984). Die Ausbreitung der Pseudokeilfleckbarden im Donauraum. *Österreichs Fisherei* **37,** 63–65.

Wildekamp, R. H., Van Neer, W., Küçük, F. & Ünlüsayin, M. (1997). First record of the eastern Asiatic gobionid fish *Pseudorasbora parva* from the Asiatic part of Turkey. *Journal of Fish Biology* **51,** 858–861.

Zitman, R. & Holčik, J. (1976). On the first find of *Pseudorasbora parva* in Czechoslovakia. *Zoologicke Listy* **25,** 91–95.