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The round goby *Neogobius melanostomus* (PALLAS, 1814) (Perciformes: Gobiidae), an invasive species in the Albert Canal (Belgium)

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Over the last two decades several exotic invertebrate species of different origins have appeared (or reappeared) in the Albert Canal: crustaceans such as the Chinese mitten crab - *Eriocheir sinensis* (MILNE-EDWARDS, 1854) -, the spiny-cheek crayfish - *Orconectes limosus* (RAFINESQUE, 1817) -, the Iberian dwarf shrimp - *Atyaephyra desmaresti* (MILLET, 1831) -, the killer shrimp - *Dikerogammarus villosus* (SOWINSKY, 1874) - and bivalves such as the Asiatic clam - *Corbicula fluminea* (MÜLLER, 1774) -, and the quagga mussel - *Dreissena rostriformis bugensis* (ANDRUSOV, 1897). Some of those species became invasive. Recently, two exotic fish species have also appeared in the canal: the round goby *Neogobius melanostomus* (PALLAS, 1814) since 2010 (1) and the bighead goby *Neogobius kessleri* (GÜNTHER, 1861), the latter first recorded in Belgium on June 13th, 2012 (2).

The round goby is native to the Ponto-Caspian area, where it is a euryhaline benthic species of some economic importance (3). *Neogobius melanostomus* was transported with ballast water of cargo ships to the region of the Great Lakes in North America and to different countries in Central, East, North and West Europe (4, 5, 6). In the Netherlands the round goby was found for the first time in 2004 in the River Lek (7). It was reported for the first time in Belgium on April 8th, 2010 from the River Scheldt near the Liefkenshoektunnel (1). The round goby probably reached the River Scheldt in the ballast water of cargo ships. The species is also known from different places in the Albert Canal, which is connected to the river Scheldt at Antwerp. Since the canal is far too deep for electric fishery

Fig. 1. – Male specimen of *Neogobius melanostomus* from the Albert Canal at Grobbendonk (TL = 137 mm), exhibiting the characteristic black spot on the first dorsal fin. Specimen not preserved.

TABLE 1

Morphometric data of *Neogobius melanostomus* of the Albert Canal at Merksem and Grobbendonk. Abbreviations: TL = total length; SL = standard length; mm = millimeter; OL = otolith length; OH = otolith height. All measurements are in millimeters.

	TL	SL	Sex	Weight in grams	Locality	OL	OH
N. melanostomus	160	137	female	57	Merksem	4,65	2,94
	157	134	male	53	Grobbendonk	4,94	3,24
	146	122	male	49	Grobbendonk	4,59	3,35
	143	123	male	47	Grobbendonk	4,65	2,88
	140	120	male	38	Grobbendonk	4,06	2,71
	138	118	male	40	Grobbendonk	4,53	2,76
	138	116	male	32	Grobbendonk	4,18	2,88
	137	115	male	38	Grobbendonk	4,24	2,76
	132	110	male	31	Grobbendonk	4,41	2,82
	131	112	male	32	Grobbendonk	3,94	2,76
	120	102	male	23	Grobbendonk	4,06	2,59
	120	102	female	21	Grobbendonk	3,76	2,53
	110	95	female	18	Grobbendonk	3,18	2,29
	110	90	male	16	Grobbendonk	3,76	2,82
	105	91	female	12	Grobbendonk	3,56	2,65
	105	85	male	12	Merksem	3,41	2,59
	85	70	male	6	Grobbendonk	2,65	1,94
	83	67	male	6	Grobbendonk	2,41	2,06
N. kessleri	110	92	unknown	unknown	Danube, Vienna	3,94	2,76
	91	77	unknown	unknown	Danube, Vienna	3,12	1,95

and since, according to INBO (the Belgian Research Institute for Nature and Forests), round goby catches in fyke nets are very poor, most data come from anglers (VERREYCKEN, 2012, personal information); indeed at Grobbendonk in locations where round goby catches with fishing-rods were plentiful, the catches with fyke nets placed by INBO were nil.

Fig. 2. – Map showing the Albert Canal in Belgium and sampling sites (Merksem and Grobbendonk).

N. melanostomus has a fairly round head, and rather large eyes, which are slightly protruding from the top of the head. The pelvic fins are fused and form a single pelvic suction disc. A good diagnostic characteristic is the posterior dark spot of the first dorsal fin (Fig. 1), which is absent in the other species of Ponto-Caspian gobies in West Europe. There are 49-55 scales on the lateral line (1). Adult round gobies are mottled with olive green, brown and black irregular spots, whereas juvenile specimens are grey in colour.

Males and females of the round goby can be distinguished by their urogenital papilla: it is white to grey, long and pointed in males and brown, short and blunt tipped in females (4). During the spawning season they exhibit sexual

dimorphism; the males turn black and their cheeks become swollen. They are territorial and display male parental care (guarding the nests with eggs and hatchlings). Spawning can take place in fresh water as well as in salt water (8). The females can spawn up to six times during the spawning season. This results in a fairly high reproduction rate and enhances rapid distribution of this invasive species.

In August 2012 we found two new locations colonized by the round goby in the Albert Canal (Belgium): at Grobbendonk (51° 10' 47.2" N – 04° 45' 17.4" E) and at Merksem (51° 14' 06.6" N – 04° 26' 36.4" E) (Fig. 2). At both sites the species was already fairly abundant: 16 specimens at Merksem and 52 specimens at Grobbendonk were caught on a bank section of 5 m each. Of these, five are preserved at the RBINS (IG 32254 reg. 24951-24954 (Grobbendonk) and IG 32254 reg. 24955 (Merksem)), and 18 were used to collect biometric data (Table 1) and to extract otoliths (see below). The length of the measured specimens varied between 85 mm and 160 mm, whereas the maximum reported length is 220 mm (8).

The distribution of the round goby in the Albert Canal seems to be discontinuous. Apart from the sampling areas, where they are abundant, there are large parts in the canal where they are absent: *e.g.* at Grobbendonk not one single round goby was caught outside the section mentioned above in the first year. The fact that both new locations lay near regularly used mooring places of barges, pleads for the distribution of the round goby by disposal of ballast water by those barges in the Albert Canal. The construction of underwater bank protection with stone debris in that canal (2) probably also facilitates the sustainability of the round goby, because that kind of bank protection forms a suitable habitat for *Dreissena* sp., a regular prey for round gobies. Follow up in future years will determine whether the round goby is able to fill the gaps in its distribution by natural dispersal. In the second year, wider dispersal has already been confirmed by catches at five new locations at Grobbendonk of which only one location was a mooring place.

The round goby has recently been reported from two locations in the River Meuse in Belgium: one near the Dutch border and one near Liège (Verreycken 2013, personal information). This means, that the species is now present in both the rivers Scheldt and Meuse in Belgium, which are connected by the Albert Canal. It had already been reported from the Dutch part of the river Meuse earlier (RAVON, http://www.ravon.nl/Soorten/Vissen).

Round gobies can feed all day long (4), but at Grobbendonk and at Merksem round goby catches with fishing-rods decreased almost to nil after dark. In freshwater the diet of the round goby consists of worms, small crustaceans, insect larvae, molluscs, fish eggs, fish larvae and small fish (8, 9, 10, 11). That diet puts them in competition for food with the native bullhead species - *Cottus perifretum* Freyhof, Kottelat & Nolte, 2005 and *Cottus rhenanus* Freyhof, Kottelat & Nolte, 2005 - resulting in a possible decline of the latter species (11). In the Albert Canal juvenile quagga mussels and juvenile zebra mussels - *Dreissena polymorpha* (Pallas, 1771) - form important prey of the round goby: the smallest shells are swallowed whole, whereas the larger ones are crushed with the laryngeal teeth. In fact, each time that we put some freshly caught round gobies in a clean aquarium, we found a few hours later some small bivalve shells and shell debris of larger specimens of dreissenids on the bottom. So far three juvenile doublets of the Asiatic clam have also been found. Since some pieces of that shell debris are far too large - larger than 1 cm - and too sharp to pass through the intestines or the anus, we presume that at least the large pieces were vomited out by the round gobies after the digestion of the soft parts. In nature, juveniles of those two exotic invasive species of *Dreissena* thus constitute an important part of the food of round gobies, which is probably the only positive aspect of the presence of the latter species in West European waters.

TABLE 2

List of distinguishing features in the otoliths between *Neogobius kessleri* and *Neogobius melanostomus*.

Feature	*N. melanostomus*	*N. kessleri*
(1) dorsal rim	crenelated only in large specimens, more convex with deep notch	crenelated, hardly convex, no notch
(2) postdorsal process	well below highest point of the sagitta	at the same level as the highest point of the sagitta
(3) ventral rim	concave posteriorly	straight
(4) anterior rim	high	not high
(5) sulcus (ostium)	ostium: crista superior convex, crista inferior concave	crista superior and inferior not convex

Potential predators of the round goby in the Albert Canal are pike - *Esox lucius* LINNAEUS, 1758 -, perch - *Perca fluviatilis* LINNAEUS, 1758 -, zander - *Sander lucioperca* (LINNAEUS, 1758) -, European catfish - *Silurus glanis* LINNAEUS, 1758 -, big eel - *Anguilla anguilla* (Linnaeus, 1758) -, big flounder - *Platichthys flesus* (LINNAEUS, 1758) -, big plaice - *Pleuronectes platessa* LINNAEUS, 1758, the great cormorant - *Phalacrocorax carbo* (LINNAEUS, 1758) -, commonly observed at the Albert Canal, and the great crested grebe - *Podiceps cristatus* (LINNAEUS, 1758) (12). But pike, flounder and plaice are far too rare in the canal to be of great influence. Among the birds, the depth of the canal eliminates the grey heron - *Ardea cinerea* LINNAEUS, 1758 - as a predator. As the round goby has only very recently been recognized as an invasive species in the Albert Canal, no research on its predation has been confirmed yet. We observed, however, that round gobies were successfully used as bait by anglers to catch zander.

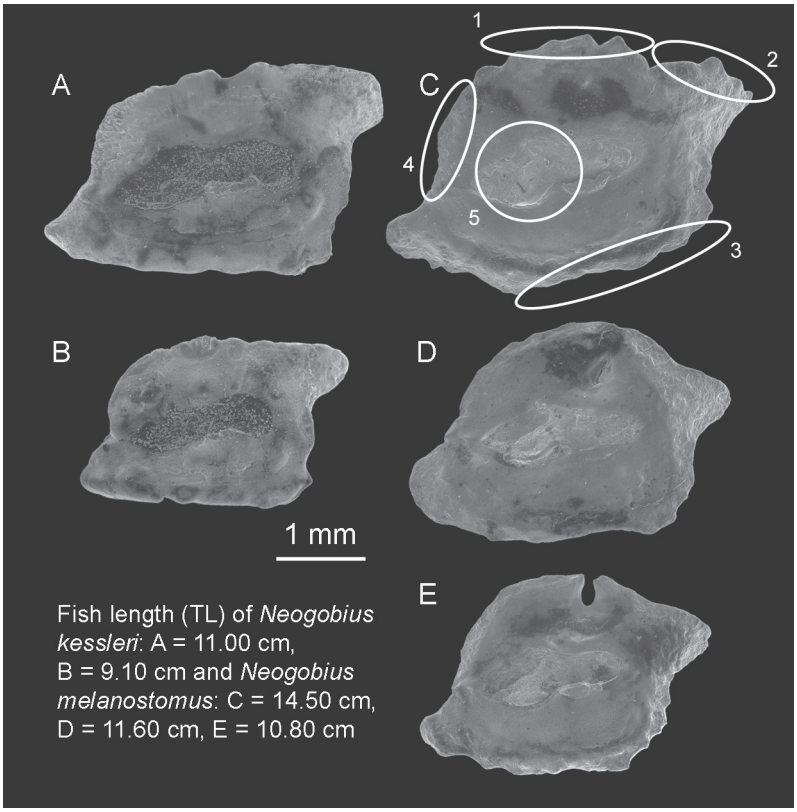

Fig. 3. – Right sagittae of *Neogobius kessleri* (A, B) and *Neogobius melanostomus* (C, D, E). (1) = dorsal rim; (2) = postdorsal process; (3) = ventral rim; (4) = anterior rim; (5) = ostium.

The potentially rapid distribution of the two aforementioned invasive fish species (*N. melanostomus* and *N. kessleri*) can be followed up by direct sampling of river or canal stretches susceptible to yield catches, in particular the mooring places of river barges, where ballast tanks are drained. Another method is the inspection of bird pellets or droppings for fish otoliths along waterways. Predator birds feed on fish, but do not digest their hard parts (such as bones and otoliths), which are subsequently vomited out or ejected in droppings (e.g., 13, 14).

Otoliths (sagittae) provide a useful tool in identifying fishes to species level and they are widely used to that effect in ichthyology, ornithology, cetology and palaeontology (15). For this reason we present here a list of distinctive features (Table 2), and illustrations of the sagittae of *N. melanostomus* and *N. kessleri* (specimens from the RBINS collection, unnumbered, Fig. 3) to enhance identification of otolith finds in pellets of birds. Moreover, using the OL and OH information from Table 2, the length and weight of the consumed fish can be reasonably well estimated. As no specimens of *N. kessleri* from Belgium were available for dissection, we figure otoliths from two specimens caught on the Danube, near Vienna in Austria.

Otoliths of *N. kessleri* and *N. melanostomus* are quite thin in ventral view and have an overall rectangular to parallelogram outline. Those of *N. melanostomus* are characterized by a convex, sometimes notched dorsal rim (feature 1), with the postdorsal process (feature 2) well below the highest point of the dorsal rim. Only the sagittae extracted from a fish of 16 cm TL had a very concave dorsal rim. The otoliths show little marginal ornamentation, except for specimens from larger fish. The posterior part of the ventral rim (feature 3) is bent, whereas the ventral rim in otoliths of *N. kessleri* is more or less straight. The anterior rim (feature 4) is higher in *N. melanostomus* than in *N. kessleri*, due to the convexity of the dorsal rim of the former. The ostium (feature 5, anterior part of the sulcus) is wider in *N. melanostomus* than in *N. kessleri*.

In our small sample, there appears to be a clear relationship, for the larger sizes, between body weight and OL, but less so between TL and OL (Table 1). Two male specimens of 138 mm and two of 140 mm and 143 mm TL resp. have a different OL depending rather on the body weight than on the TL. This contrasts, however, to an earlier study concerning a large sample of the same species from the Baltic Sea, which showed a clear correlation between fish length and body weight (16). Moreover, our sample contains specimens of 105, 110 and 120 mm, represented each by one male and one female. In two cases (TL 110 and 120 mm) the otoliths of the males are larger than those of the females, but in one case (TL 105 mm) the opposite is true. The two largest specimens (one female of 160 mm TL and one male of 157 mm TL) are comparable in size, but the otoliths of the male are much larger than those of the female. Possibly, such differences can be attributed to sexual dimorphism. It must be noted, however, that sexual dimorphism in otoliths is a rarely observed phenomenon and when observed otoliths of male fish are not necessarily larger than those of female fish. It will, however, require much more additional material than presently available to verify our assumptions.

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