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Rapid Communication

First records of the invasive Amur sleeper, *Perccottus glenii* Dybowski, 1877 in German freshwaters: a need for realization of effective management measures to stop the invasion

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Abstract

Since 2013, more than 60 specimens of the Amur sleeper, *Perccottus glenii* Dybowski, 1877 have been captured in four minor watercourses of the Upper Danube, in Bavaria, Germany. Its occurrence in the wild is probably due to unintentional release incidences from nearby enclosed fishponds. An ecological risk assessment showed that this species is a threat to freshwater faunal biodiversity in Germany and has been assigned to the German Action list of invasive alien species. In accordance with nature conservation efforts, effective management policies should urgently be developed and implemented by the appropriate authorities to prevent further dispersal of the Amur sleeper in Germany. The establishment and uncontrolled spread of this invasive alien species in the Upper Danube watercourse and other habitats in Europe can be expected, if preventative measures are not immediately put in place.

Key words: Pisces, alien species, risk assessment, Union list

Introduction

The Amur sleeper, *Perccottus glenii* Dybowski, 1877, known also as rotan or Chinese sleeper, is a hardy freshwater fish and a generalist feeder that has a preference for stagnant waters with dense vegetation and a silty substrate (Nikolskii 1956). It is known to severely affect aquatic ecosystems, especially by damaging amphibian and fish populations (Reshetnikov 2003). The native range of this fish species is located in the Pacific basin of East Asia (Reshetnikov 2010).

Its first introduction to Europe dates from 1912 when several individuals were brought to St. Petersburg, Russia, kept in aquaria for four years and then released to garden ponds where they bred, and spread to adjoining water bodies (Reshetnikov 2004). Since then, the Amur sleeper has colonised various parts of Asia and Europe. In most cases, introductions were related to the release of fish by aquarists, or by its use as live bait or by translocation with commercial fish stock mainly Asian carp species (Reshetnikov 2004).

With its first appearance in enclosed fishponds in the aquaculture industry in Germany in early 2000 (Reshetnikov and Schliewen 2013), it was only a matter of time before this invasive alien species spread into the wild. Multiple captures in open waterways interconnecting and adjacent to the fishponds confirm their presence.

First records in Germany

Germany in general, has had little interest in *P. glenii*, due to its low economic and recreational value (Riehl and Baensch 1991; Reshetnikov 2013). Between 1962 and 1965, *P. glenii* was imported (i.e. "first introduction in Germany" according to the GABLIS protocol, Essl et al. 2011, Table 3) and used for scientific breeding experiments by Potsdam College. Later, it was also used by aquarists

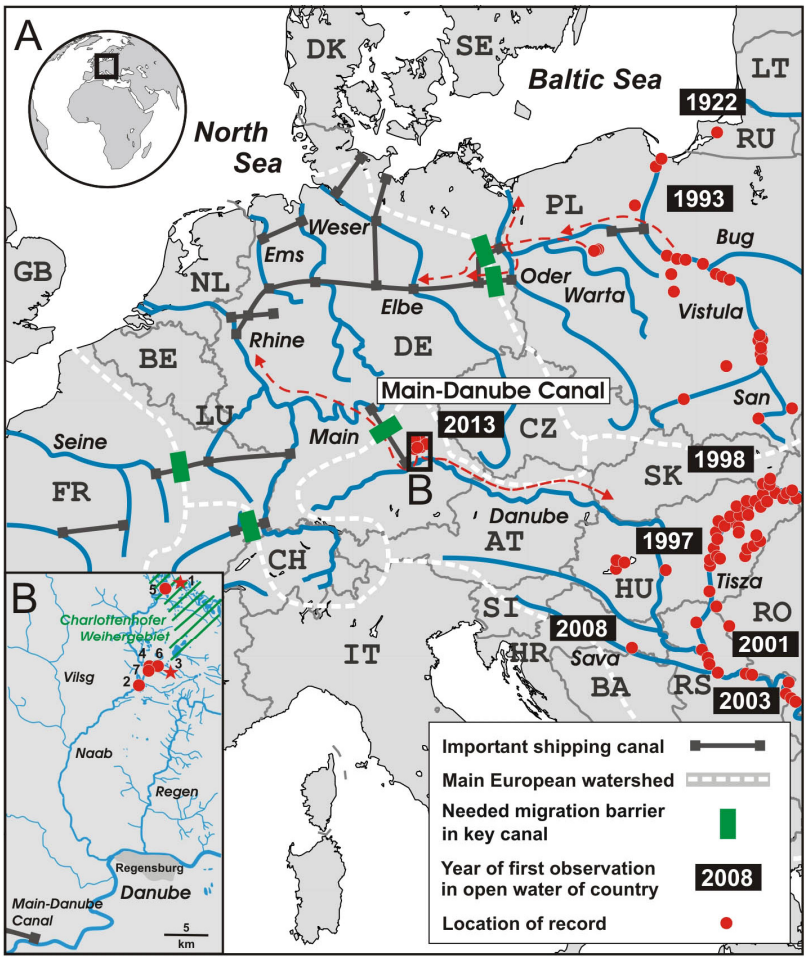

Figure 1. A) West European range of invasive Amur sleeper, *Perccottus glenii* (Records: modified after Reshetnikov and Schliewen 2013). B) Fishponds (red star) with known occurrence of Amur sleeper and records of specimens outside fishponds, Upper Danube watercourse, Bavaria, Germany (coordinates outlined in Table 1).

of the former German Democratic Republic (Schenke and Grabow 1965). However, it took almost 50 years before the Amur sleeper became of any significant interest in Germany. In 2013, populations of *P. glenii* in enclosed fishponds in an aquaculture industry in the South East of Germany near Regensburg, Bavaria, were noted by Reshetnikov and Schliewen (2013). The fishponds are located in "Charlottenhofer Weihergebiet", a Natura 2000 site, protecting 28 species and 8 habitat types of the Habitats Directive (EEA 2013). The site is comprised of both artificial and natural waterbodies (No. 1, Figure 1B). For decades the fishponds have been managed extensively for the production of zander (*Sander lucioperca*), common carp (*Cyprinus carpio*) and northern pike (*Esox lucius*) (Reshetnikov and Schliewen 2013). It was assumed by Reshetnikov and Schliewen (2013) that *P. glenii* was probably accidentally introduced into these fishponds with commercial fish transportations. *P. glenii* had been known in these fishponds since 2003. However, specimens were collected, identified and deposited in the Bavarian Natural History collection from one of the fishponds in November 2009 (Reshetnikov and Schliewen 2013, Table 1).

On 18 August 2014, the fishpond with a known population of Amur sleeper was re-visited; 35 specimens (young-of-the-year individuals with total length, TL = 22–38 mm and older individuals up to 110 mm) were captured (Table 1) (Reshetnikov, Schliewen and Karyagina, unpubl.). Size distribution represented the full reproductive cycle. The potential spread of the Amur sleeper outside of the enclosed fishponds was also investigated, by sampling a small stream (Siegenbach) into which fishpond water is regularly discharged.

The Siegenbach is a left tributary of the River Naab and part of the Upper Danube drainage system. One specimen (TL 110 mm) was caught

Table 1. Verified records of *Perccottus glenii* from the Charlottenhofer Weihergebiet, Upper Danube watercourse (Bavaria, Germany). The number in the first column refers to site number outlined in Figure 1B.

	Location	Coordinates of the Sampling Site		Collected individuals	Record date	Reference
		Latitude, N	Longitude, E			
1	Fishpond (CW)	49° 22′ 00″	12° 10′ 12″	>3	2009	Reshetnikov and Schliewen 2013
2	Grünwinkelgraben	49° 14′ 18″	12° 05′ 11″	1	06/2013	This study
3	Fishpond (SW)	49° 15′ 09″	12° 08′ 12″	>3	Autumn 2013	This study
4	Bücherlgraben	49° 15′ 28″	12° 06′ 17″	1	07/2014	This study
1	Fishpond (CW)	49° 22′ 00″	12° 10′ 12″	35	18/08/2014	Reshetnikov, Schliewen and Karyagina, unpubl. data
5	Siegenbach	49° 21′ 57″	12° 08′ 19″	1	18/08/2014	Reshetnikov, Schliewen and Karyagina, unpubl. data
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	1	09/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	3	23/11/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	5	25/11/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	5	29/11/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	7	7/12/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	1	7/12/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	10	13/12/2014	This study
6	Bücherlgraben	49° 15′ 43″	12° 06′ 53″	25	20/01/2015	BO-FfF 2015
7	Neuweihergraben	49° 15′ 13″	12° 06′ 06″	1	20/01/2015	BO-FfF 2015

(No. 5, Figure 1B, Table 1) (Reshetnikov, Schliewen and Karyagina, unpubl.). Almost three months later, on November 23, a sport fisherman incidentally caught three adult specimens of *P. glenii* (TL 65–72 mm) in another small stream (Bücherlgraben) on the southern end of the "Charlottenhofer Weihergebiet" reserve (No. 6, Figure 1B and 2, Table 1). This stream is also a left tributary of the River Naab, but located approx. 13 kilometres upstream of the described fishpond and the Siegenbach stream (Figure 1B).

To estimate the expanse of this species in German open waters, a minor survey was conducted in the area where the Amur sleeper had recently been found. During the period November 25 to December 13, 2014, a total of 28 specimens of *P. glenii* (juveniles and adults of the both sexes, TL range 30–145 mm) were caught in the Bücherlgraben stream. Multiple age classes in the samples suggest that *P. glenii* is becoming established and is on its way to developing a permanent population in this section of the Danube watercourse.

In accordance with nature conservation efforts to minimise the invasion of alien species, no individuals were returned. Several specimens were stored in a freezer, while others were sent to the Senckenberg Institute Frankfurt for genetic studies. Three specimens were kept alive in an aquarium, where an individual (TL 98 mm) was observed to prey on topmouth gudgeon (*Pseudorasbora parva*) up to 45 mm in total length.

Since the first catch in Bücherlgraben, surveys were conducted in local fishing clubs, German Internet forums for sport fishermen, among scientists and in local, regional or federal authorities. Results showed that in July and September 2014, two specimens were caught by anglers in the Bücherlgraben (No. 4 and 6, Figure 1B, Table 1). However, the first official record of *P. glenii* in German open freshwater dates back to June 2013. A sport fisherman caught (by angling) one specimen at the mouth of a small stream (Grünwinkelgraben), where it meets the river Naab (No. 2 Figure 1B, Table 1), approximately 5 kilometres south of the known population in Bücherlgraben.

It was suggested that the Amur sleeper may occur in other aquaculture fishponds on the River Naab, since many of them support favourable habitat conditions. This assumption was supported by the capture of several specimens in 2013 during the autumnal harvesting of a fishpond in "Siegenhöfer Weihergebiet", located approx. 4 kilometres east of the Bücherlgraben stream. No specimens however, were recorded in 2014 (No. 3 Figure 1B, Table 1).

This study believes that the presence of *P. glenii* in the small streams is casually linked to the water management of fishponds in "Charlottenhofer Weihergebiet". These fishponds are drained every year or every third year (Reshetnikov and Schliewen 2013), discharging the water into open into open water bodies of the upper Danube. Thus, it is very likely that this management has unintentionally and repeatedly released the Amur sleeper into the wild.

Figure 2. The invasive Amur sleeper, *Perccottus glenii*, in a small stream (Bücherlgraben) in the Upper Danube drainage system, Germany, 23 November 2014. A) The habitat in which most specimens were collected. B) Specimen of Amur sleeper, 72 mm in total length. C) Head of specimen. Photographs by Jürgen Steinhof.

Table 2. Results of ecological risk assessment of *Perccottus glenii* in European countries.

Country	Naturalisation	Protocol	Result	Reference
Austria	absent	GABLIS	Invasive (warn list)	Nehring et al. 2010
Belarus	established	FISK	High risk	Mastitsky et al. 2010
Belgium	absent	ISEIA vers. 2.6	High risk (alert list)	Branquart and Verreycken 2013
Bulgaria	established	FISK vers. 2	Moderately high risk	Simonović et al. 2013
Croatia	casual		Invasive	Ćaleta et al. 2010
Czechia	absent	GABLIS	Invasive (warn list)	Pergl et al. 2014
Estonia	established		Potentially invasive	NOBANIS 2007
Finland	absent	FISK vers. 2	High risk	Puntila et al. 2013
Germany	absent (up to 2013)	GABLIS	Invasive (warn list)	Nehring et al. 2010; Rabitsch et al. 2013a
Germany	casual (since 2013)	GABLIS	Invasive (action list)	This study
Great Britain	absent	FISK	High risk	Copp et al. 2009
Hungary	established	FISK vers. 2	High risk	Ferincz 2014
Latvia	established		Invasive	Pupiņa and Pupiņš 2012
Lithuania	established		Invasive	Bukantis et al. 2014
Moldova	established	FISK	High risk	Bulat et al. 2013
Netherlands	absent	PRA	High risk	Spikmans et al. 2010
Poland	established		Invasive	NOBANIS 2011
Romania	established		Potentially invasive	Telcean and Cupşa 2012
Russia (European part)	established		Invasive	NOBANIS 2006
Serbia	established	FISK vers. 2	Moderately high risk	Simonović et al. 2013
Slovakia	established		Invasive	Koščo et al. 2010
Sweden	absent		Invasive (Alert list)	AsiSs 2013

Ecological risk assessments

P. glenii is a typical limnophilic species and thrives in low quality waters. Ćaleta et al. (2010) noted that its tolerance, opportunism and aggressive behaviour make the Amur sleeper a 'perfect conqueror'. Within a few decades the Amur sleeper has successfully invaded many localities in Europe, due to accidental introductions and natural migrations. First records in open freshwaters of particular interest in chronological order are as follows: European part of Russia (1922), Belarus (1970s), Ukraine (1980s), Lithuania (1985), Poland (1993), Latvia (1996), Hungary (1997), Slovakia (1998), Romania (2001), Serbia (2003), Bulgaria (2005), Estonia (2005), Moldova

(2005), Croatia (2008) and Germany (2013) (Reshetnikov 2010, this study, Figure 1A). It is expected that the rapid expansion of this fish in Central European waters will cause a serious threat to local aquatic communities and may lead to adverse economic impacts upon aquaculture farms and fishery. Thus, the recent discovery of several specimens in German waters is of significant concern.

P. glenii is known as a high risk invasive species and ecological risk assessments have been performed in several European countries (Table 2). In 2008, a newly developed and tested risk assessment tool for invasive alien species, the "German-Austrian Black List Information System" (GABLIS), was implemented by competent authorities in both countries (Essl et al. 2011, Nehring et al. 2013). It has been developed as a trans-national and taxonomically universal risk assessment system. In GABLIS, alien species causing a threat for native species and ecosystems are assigned to the list of invasive species, which is further separated into three specific sub-lists ('warn', 'action' and 'management' lists), according to the current distribution of the alien species and emergency measures available. In 2010, in accordance with the GABLIS guidelines, *P. glenii* was considered a threat to German biodiversity and has been assigned to the German 'Warn' list of not-yet-present invasive alien species (Nehring et al. 2010, Table 2) because no specimens were known from German open waters at that time. In 2013, *P. glenii* was assessed and pronounced as one of the most likely candidates for future invasion into German open waters (Rabitsch et al. 2013a,b). However, our record of specimens outside of fishponds areas in Germany in 2013, has now upgraded and assigned *P. glenii* to the German 'Action' list of invasive alien species, where management measures are available (Table 3).

Management measures

These German records are the most westerly findings of *P. glenii* in freshwater ecosystems in Europe. Prior to this, the nearest Amur sleeper records were located approx. 500 km east, in the Kis-Balaton watershed, Hungary (Erós et al. 2008; Antal et al. 2009), and in the Glówna River, the right tributary of the Warta River, Poland (Andrzejewski et al. 2011) (Figure 1). Given the experiences in Eastern Europe (e.g. Hungary: Harka et al. 2002; Slovakia: Koščo et al. 2003) and neighbouring country Poland (Nowak et al. 2008), the results of species distribution models show 'high risk of invasion' in not-yet-invaded Western Europe (Reshetnikov and Ficetola 2011). Confirmed reproduction of *P. glenii* in water bodies of the "Charlottenhofer Weihergebiet", suggests that the long term naturalisation of this invasive alien species in German open waters is highly likely.

Although the presence of invasive *P. glenii* in enclosed fishponds, located in the "Charlottenhofer Weihergebiet", has beenknown since the beginning of 2000, confirmed in 2009 and published in 2013 (Reshetnikov and Schliewen 2013), apparently no sufficient management measures were taken to avoid invasion of open waters. The intentional or unintentional release of alien animal species into the wild is not permitted by German law. The Federal Nature Conservation Act (BNatSchG 2009), Article 40, paragraph 3 instructs that the competent Federal and Länder authorities should immediately implement suitable measures aimed at eliminating, or preventing the spread of, newly appearing invasive alien species. Article 40, paragraph 6 further prescribes that the competent authority may order the elimination of animals that have been placed or escaped into natural surroundings (without relevant permits by the polluter), in order to ward off threats to ecosystems, biotopes or species.

The invasion of *P. glenii* in Germany may have been detected at an early stage. Data confirms that present-day expansion of this fish within the Naab drainage system may be categorised as *Stage II to III of colonisation* according to Reshetnikov's (2013) classification. Stage II is outlined as the latent period of development of an initial population (increase in population density) while Stage III is the movement downstream during a flooding event and consequent rapid colonization of flood-plain water bodies, located downstream of the initial population. It is now essential, in accordance with nature conservation efforts, to develop and implement effective management policies by the appropriate authority to stop the dispersal of the invasive Amur sleeper in German waters.

Emergency measures should include the tutoring of fishpond owners, sport fishermen, fishing clubs and societies, aquarists, scientists, authorities and local population regarding potential spread, impacts and biosecurity issues associated with Amur sleeper. Post discovery of specimens in Bücherlgraben, a species alert was published in cooperation with the European Network on Invasive Alien Species (NOBANIS)

Table 3. Ecological risk assessment of *Perccottus glenii* in Germany (Assessment protocol: "German-Austrian Black List Information System" (GABLIS); for further information, see Essl et al. 2011 and Nehring et al. 2013).

A) GENERAL INFORMATION	
Systematics and nomenclature	*Perccottus glenii* Dybowski, 1877 Pisces, Odontobutidae Amur sleeper (EN), Amurgrundel (DE)
Important synonyms	Percottus glehni (misspellings); Rotan, Chinese sleeper (EN), Schläfergrundel (DE)
Habitat	Freshwater
Status	Casual
Native region	Russian Far East, Eastern Asia
Introduction	Deliberate and non-deliberate
Import vectors	Science, Aquaculture, Canals
First introduction	1962
In 1962 scientific breeding experiments were conducted by the Zoological Institute of the College Potsdam in the former German Democratic Republic (Schenke and Grabow 1965). Species known from managed fishponds located in the integral nature reserve "Charlottenhofer Weihergebiet" in the upper Danube watercourse (Bavaria, Germany) for at least 12 years (Reshetnikov and Schliewen 2013). Probably accidentally introduced into adjacent enclosed artificial water bodies with commercial fish transportations (Reshetnikov and Schliewen 2013).	
First record	2013
First record in German open waters in 2013 adjacent to the fishponds in the "Charlottenhofer Weihergebiet" reserve (this study).	
B) THE MAIN CRITERIA - RISKS TO BIODIVERSITY	
1 Inter-specific competition	unknown
Inter-specific competition with native fish species is possible but not proven (Litvinov and O'Gorman 1986; Reshetnikov 2003).	
2 Predation and Herbivory	Yes
In small water bodies, known to extirpate other fish species, amphibian larvae and macroinvertebrates (Koščo et al. 2003; Reshetnikov 2003).	
3 Hybridization	No
Currently unknown	
4 Transfer of pathogens or parasites	evidence-based assumption
Transfer of parasites to other fish, reptiles, birds, and mammals (Sokolov et al. 2014). Four species were introduced to new regions by P. glenii as their vector (Sokolov et al. 2014).	
5 Negative effects on ecosystems	Evidence-based assumption
Strong changes of trophic relations and succession processes are assumed (Reshetnikov 2003).	
C) ADDITIONAL CRITERIA	
1 Current distribution	small-scale
Occurrence in four small streams of the upper Danube watercourse are known (this study).	
2 Emergency measures	Available
Mechanical measures (eradication or control may be possible in small water bodies, Zaloznykh 1984, Reshetnikov and Ficetola 2011), prevention of intentional and unintentional release, public relations. The installation of migration barriers (electrical deterrent systems, air bubble curtains, chloride or pH-altered locks, facilities for ship hulls cleaning and ballast water exchange etc.) in key canals (such as the Main-Danube Canal) should be undertaken.	
D) BIOLOGICAL-ECOLOGICAL CRITERIA	
1 Occurrence in natural, semi-natural or other high nature value habitats	Yes
Usually inhabits still or slow-flowing waters and sometimes swamps (Nikolskii 1956; Harka and Farkas 1998; Koščo et al. 2003; this study).	
2 Reproductive capacity	high
Spawns for the first time at 1-3 years, fecundity depends on female size, it can range from 230eggs to more than 17,000 per year, males guard eggs (Zaloznykh 1984; Kottelat and Freyhof 2007).	
3 Spread capacity	high
Accidentally introduced with commercial fish transports for stocking (Reshetnikov and Schliewen 2013), kept in aquaria and used as live bait (Reshetnikov 2004; Kottelat and Freyhof 2007), active and passive dispersal downstream along rivers (Koščo et al. 2003; Reshetnikov 2013).	
4 Current spread history	expansive
In the recent past strong expansion in Eastern Europe, e.g., Vistula, Tisza, Danube, (Harka et al. 2002; Grabowska et al. 2010; Jarić et al. 2012; Zorić et al. 2014; see also Reshetnikov 2013 for a review). Species distribution models show high risk of invasion in not-yet-invaded Western Europe, Western Siberia, China, and North America (Reshetnikov and Ficetola 2011).	
5 Monopolization of resources	yes
Forms numerous dense populations in shallow lentic water bodies and consumes a wide range of animal species of all trophic levels (Reshetnikov 2003, 2013).	
6 Facilitation by climate change	yes
Tolerates low oxygen concentrations and able to survive in dried out or completely frozen water bodies by digging itself into mud where it hibernates (Kirpichnikov 1945). Benefits from climate change are expected (Wiesner et al. 2010).	

Table 3 (continued).

D) ADDITIONAL INFORMATION	
1 Negative economic effects	yes
Aquaculture, Fisheries (predation on small-sized individuals of commercial fish species, Zaloznykh 1984; Harka and Farkas 1998).	
2 Positive economic effects	no
3 Negative effects on human health	unknown
Host of the mammal parasite Isthmiophora melis, a fluke, which is potentially dangerous (Sokolow et al. 2014).	
4 Knowledge gaps and research needs	no

E) ASSESSMENT RESULT [a)]
Invasive alien species – Action list
[a)] **Classification methodology**
Step 1: Scaling results in section B
At least one "yes" in B1-5 -> ***Invasive alien species***
Step 2: Classification result of Step 1 and scaling results in section C
"Invasive alien species" in Step 1 and "small scale" in C1 and "available" in C2 -> ***Invasive alien species – Action list***

(Nehring and Steinhof 2014). A minor control survey was carried out by a competent fishery authority (BO-FfF 2015); on 20 January 2015, twenty-five specimens of Amur sleeper were caught at the main distribution area in Bücherlgraben using landing nets and electrofishing equipment (No. 6 Figure 1B, Table 1). A further specimen was caught 50 m from the river mouth of a stream (Neuweihergraben) where it meets the Bücherlgraben (No. 7 Figure 1B, Table 1).

This research has investigated for the first time the occurrence of the Amur sleeper in German open waters and compiled unpublished data from various sources. The picture however is incomplete. All capture datasheets by fishpond owners and fishermen in the Upper Danube watercourse should be collated. A species-specific targeted survey for the Amur sleeper should be carried out in all aquaculture fishponds and streams in the River Naab watercourse. Other areas which could potentially provide suitable habitat conditions in the Upper Danube area should also be examined.

To avoid the unintentional release of *P. glenii* into the wild, there is an immediate need to strictly regulate the discharge of fishpond water (with the presence of Amur sleeper) into open water bodies. Technical solutions (e.g. exposure to ultrasonic waves or heating) need to be developed to avoid the contamination of receiving waters. Action plans should include effective measures and regulation of stocking material for the German fishtrade, thereby preventing the initial introduction of *P. glenii* to new fishponds and watercourses. Regional and supra-regional transportations are common means of unintentional introduction of this species (Reshetnikov 2004; Reshetnikov and Schliewen 2013). Currently there is no market for the sale of this fish species in Germany. However, in future it could be used as an aquarium fish species or as live bait (and illegally released) (cf. Riehl and Baensch 1991; Verreycken 2013). Therefore, as a precautionary measure, it is suggested that the keeping, breeding as well as the marketing of *P. glenii* should be prohibited in Germany. Up until now, *P. glenii* only occurs in fishponds and a few adjacent small open water bodies in Germany. Rapid, intense and sustained management measures could be hugely successful in eliminating all individuals and avoid any future spread of this species, thereby preventing the loss of biodiversity and native fisheries.

Monitoring the effectiveness of measures should be included in the management plan. Reshetnikov and Ficetola (2011) summarized that eradication or control of *P. glenii* populations may be possible in small isolated systems (like ponds and oxbows) if action is taken soon after detection of the species. It seems that a combination of different measures will be necessary because the Amur sleeper is able to survive in dried out or completely frozen water bodies, by digging itself into mud where it hibernates (Kirpichnikov 1945). A cost efficient manner to eradicate *P. glenii* from a fish farm is to initially dry out the fishponds and subsequently dredge up the bottom substrate and store it on land for a period of time. After the death of the Amur sleeper, the substrate can be returned into the fishpond if required. Especially in the case of the small open water Bücherlgraben, a competent authority should prove, if dewatering of this system is a possible eradication method, as this would increase chances of success for complete removal of this German population of *P. glenii*.

Where management measures are not taken or fail, the establishment and spread of this invasive

alien species to new watercourses can be expected in the forthcoming years in German rivers. The small streams with confirmed Amur sleeper occurrence are directly connected to the River Naab which flows into the Danube near Regensburg (Bavaria, Germany). Since this species is not a successful swimmer (Koščo et al. 2003), it might be expected that its dispersal within the Danube river system would be mainly downstream and thereby threatening not-yet-invaded habitats along the upper and middle Danube in Germany, Austria, the western part of Slovakia and central Hungary (cf. Reshetnikov and Schliewen 2013). However, due to the short distance between the mouth of River Naab (Danube, river kilometre 2385.3) and the upstream mouth of Main-Danube Canal (Danube, river kilometre 2411.6) an active migration of Amur sleeper or passive dispersal with ships (e.g. dense rows of eggs deposited on underwater surfaces, cf. Kottelat and Freyhof 2007) into the canal cannot be excluded.

The Main-Danube Canal crosses the primary European watersheds and connects the Danube and Rhine river basins (Figure 1). In 2009 *P. glenii* was recorded in Poland from the Oder river basin (Andrzejewski et al. 2011) which is connected by two shipping canals (Oder-Spree and Oder-Havel Canal) with German inland waters (Figure 1).

To prevent the crossing of *P. glenii* and other aquatic invasive alien species, the installation of migration barriers (electrical deterrent systems, air bubble curtains, chloride or pH-altered locks, facilities for ship hulls cleaning and ballast water exchange etc.) in the Main-Danube Canal and other key canals (Figure 1) should be realized (Nehring 2005). Successful spreading via one of these canals, and consequent dispersal along German inland waters will threaten native aquatic fauna of yet uncolonised waters in north-western Europe, i.e. initially probable colonisation of western or northern Germany and the Netherlands.

Conclusion

The prevention of the (re)introduction of invasive alien species is a key issue in alien management. In Europe, *P. glenii* has a high risk invasive potential. Its occurrence is related to diverse pathways of intentional and unintentional introduction and dispersal. Thus, it should be examined whether concerted action at European Union level is required to prevent its introduction, establishment or spread. Available scientific data and knowledge indicate, that *P. glenii* could be a real candidate for listing on the "List of invasive alien species of Union concern (Union list)" within the scope of the new Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species (European Community 2014).

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