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Feeding ecology of the invasive Amur sleeper (*Perccottus glenii* Dybowski, 1877) in Central Europe

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Abstract

In the last two decades, the invasion of the Amur sleeper (*Perccottus glenii* Dybowski, 1877) originating from the Far East can be observed in Eastern and Central Europe. Since the Amur sleeper is a non-game fish species, few detailed studies exist on its feeding ecology both in its native and invaded habitats. We examined the seasonal feeding ecology of Amur sleeper in a lentic and in a lotic habitat. Chironomid larvae, zygpoteran larvae, crustaceans and ephemeropteran larvae dominated the diet. No clear differences between the two habitats were found. The diet composition was mainly regulated by the body size that had stronger effect than the habitat and the season. Although fish consumption was uncommon, we anticipate this finding to the structure of the examined populations, in which large bodied individuals were rare. Our study shows that the Amur sleeper may influence several levels (compartments) of the aquatic food web, although the species proved to be an especially important predator of the invertebrate assemblage.

1. Introduction

Besides habitat degradation, the spread of non-native invasive species is the main concern for the decline of biodiversity (Clavero & Garcia-Berthou 2005, Casal 2006, Khan & Panikkar 2009). For example, invading plant and animal species have caused drastic changes in the receiving biota both in terrestrial ecosystems like in New Zealand, Hawaii, Australia (Lövei 1997) and in aquatic ecosystems like in Lake Victoria (Gurevitch & Padilla 2004). In the past centuries the rates of invasion by non-native species have been increasing worldwide, especially in aquatic environments, with wide ranging consequences for the invaded ecosystems (Puntila et al. 2013). Therefore, the investigation of the ecology of invasive species has become an important topic of the scientific community to aid management plans for biodiversity conservation (Gozlan 2008).

One of the most important ecological questions about new invaders is how they can affect the trophic relationships in the recipient communities. Previous studies emphasized that their ecological impacts on the native community are cannot be assessed (Vitule et al. 2009, Lenhardt et al. 2010). Invasion of alien fish species may have important economic and ecological consequences, as they can substantially affect the structure and functioning of native communities. Predation and competition exerted by non-native species may lead to changes in the relative abundance of indigenous prey species or competitors and may ultimately results in their local extinction (Zaret & Paine 1973, Lodge 1993, Khan & Panikkar 2009).

Amur sleeper is one of the most invasive fish species in Eurasia in the last few decades (Copp et al. 2005, Reshetnikov & Ficetola 2011, Reshetnikov 2013). The original distribution of the Amur sleeper is the Russian Far East, North-East China, and the northern part of the Korean Peninsula (Berg 1949, Nikolsky 1956, Jurajda et al. 2006). The expansion from its native range started in 1916 when the species was introduced to a garden pond in St Petersburg, eastern Russia (Reshetnikov 2004). The species accommodated to the environment in its non-native habitat soon, and it has been spreading extremely fast in Eastern and Central European river systems (Reshetnikov 2004, Reshetnikov & Ficetola 2011). The first occurrence of Amur sleeper in Hungary was recorded in 1997 in a reservoir of the River Tisza (Harka 1998). The species spread along the Tisza catchment within a decade. Today one of the westernmost documented distribution of the species in Europe is the Balaton catchment, Hungary (Reshetnikov 2010), where the species was presumably arrived via game fish transport from the Tisza Catchment (Erős et al. 2008). Interestingly, the species was also recently discovered in fish ponds in Germany, more than 500 km away from the hitherto known westernmost records in the canals of Lake Balaton, Hungary (Reshetnikov & Schliewen 2013).

Due to their extreme fast invasion and numerical dominance in many locations in the invaded range it can be assumed that the Amur sleeper soon become an integrated element of the aquatic food web in both lotic (lowland streams and rivers) and lentic (ponds and lakes) habitats in Europe. Detailed knowledge about the role in the food web would be essential for a variety of aquatic habitats and ecoregions to base any management actions. The few studies on its non-native range confirms previous knowledge and suggest that the Amur sleeper is a versatile predator of a variety of macroinvertebrate taxa, but also consumes fish, and can be dangerous even to the larvae of amphibians (Szító & Harka 2000, Bogutskaya &Naseka 2002, Reshetnikov 2003, Orlova et al. 2006, Koščo et al. 2008, Grabowska et al. 2009). Although these studies give some insight into the feeding ecology of the species, several aspects of the feeding ecology of Amur sleeper still need more information to estimate the impact of this species in the newly invaded areas including the detailed elaboration of habitat, time or ontogenetic changes in diet, or the examination of prey preference. Consequently, the goals of this study were to investigate the feeding ecology of the Amur sleeper in a lotic and in a lentic habitat in one of the westernmost part of the species' distribution, Hungary. Specifically, we (i) examine the seasonal composition of the potential food resource macroinvertebrate assemblage, (ii) provide detailed data on the diet composition of the species including seasonal, ontogenetic and habitat dependent comparisons, and (iii) contrast diet data with the composition of the macroinvertebrate assemblage.

2. Materials and methods

Study area

Fish and macroinvertebrate samples were taken in a lentic (Rakamaz-Tiszanagyfalui-Nagy-morotva hereafter: RNM; N48°05'45.2", E21°27'45.8") and a lotic (Lónyay-főcsatorna hereafter: LOF; N48°08'38.6", E21°37'47.1") habitat. The RNM is an oxbow lake of the Tisza

River, which is the second largest tributary of the Danube River. The RNM oxbow has a length of 4.4 km, a mean width of 200 m, and a mean depth of 1.8 m. The LOF is a lowland canal, which is connected to the Tisza River. The length of LOF is 91 km. Its mean width is 6-7 m, mean depth is 1-2 m, and its velocity is 40-60 cm s^{-1} at average discharge. Both habitats are densely vegetated with macrophytes (mainly *Stratoides aloides, Hydrocharis morsus-ranae, Ceratophyllum demersum, Phragmites australis, Potamogeton* sp*.*, *Ceratophyllum demersum, Lemna* sp.).

Sampling protocol and laboratory analyses

Samples were taken in spring (07.04.), summer (02.07.), and autumn (10.10.) in 2011. Macroinvertebrates were collected according to the AQEM protocol with a standard net (aperture: 25 cm, mesh size: 250µm) (Hering et al. 2004) and preserved in 5% formaldehyde solution at the study area. Nine samples were taken from a variety of meso/microhabitats at both sites and in all seasons in areas where fish sampling was performed. Fish samples were taken in the littoral zone by electrofishing (Hans-Grassl IG200/2B, PDC, 75-100 Hz, 350-650 V, max. 10 kW; Hans Grassl GmbH, Germany). Collected specimens were euthanized with overdose of clove oil and preserved in 5% formaldehyde. We collected at least 50 individuals at both sampling sites and every season, so altogether 330 individuals were captured and used for the laboratory analysis.

In the laboratory macroinvertebrate samples were identified to the lowest reasonable taxonomic level, depending on the difficulty of the identification (e.g. Chironomidae). To assess the relative biomass of the groups their wet weight was measured. Fish were measured for standard and total length (mm) and wet weight of fish were recorded. Based on the standard lengths four size groups were distinguished (0: 0-20mm, I: 20-40mm, II: 40-60, III: 60<) (Table 1.). Individuals were dissected to remove the first 1/3rd of the gut which is the stomach. Diet components were identified corresponding to the macroinvertebrate samples. The percentage occurrence of every single food category from the total stomach content was estimated (Hyslop 1980).

Data analysis

Only fish with non-empty stomachs were included in the analyses. Wet weight of the food items from the Amur sleepers' stomach were measured directly to the nearest 0.0001g. We calculated the gut fullness coefficient as follows

$$GFC = [Wgc / (W\text{-}Wgc)] \times 1000$$

where Wgc is the weight of the stomach content and W is eviscerated fish weight (Grabowska & Grabowski 2005).

The diet of Amur sleeper was characterised by calculating percentage occurrence and the percentage prey specific abundance (average weight percentage of the prey taxon considering fish only in which it occurred) of each prey type (Amundsen et al. 1996). We also compared weight percentage of each prey taxa in the macroinvertebrate community with their weight percentage in diet by plotting the data on the *x* and *y* axes, respectively (Borza et al. 2009). Points above the 1:1 regression line may indicate positive selection for the taxon, whereas points below it show rejection, which may give a rough picture on prey preferences.

We examined the effects of habitats (lotic vs lentic), seasons (spring, summer, autumn) and size groups (0, I, II, III) on diet contents (volume %) using cluster analysis. We used the Euclidean distance and the Unweighted Pair Group Means algorithm (UPGMA) for classification (Podani 1997, Czeglédi & Erős 2013).

We tested the homogeneity of variances with Bartlett test and since the result was only marginally insignificant (p=0.0.65) we used three way analysis of variance (ANOVA) to test whether stomach fullness differed between sampling sites, size and season. Outliers, and extreme values were omitted from the statistical analysis (see Fig 5.). We did not use the 0 group for the ANOVA (and consequently for the analyses about gut fullness) because it did not appear in all treatments or treatment combinations. We used the program STATISTICA for all analyses.

3. Results

Composition of the macroinvertebrate assemblage (% biomass) showed high variations between seasons and habitats (Fig. 1.). The most abundant groups were molluscs (81%), platyhelminthes and annelids (4%), crustaceans (4%), heteropteras (2%). Other important groups were zygopteran larvae (>1%). In the oxbow lake trichoptera larvae (2%) reached notably high proportion. In every season molluscs represented the highest bulk of the biomass, mainly *Bithynia tentaculata*, *Radix balthica, Segmentina nitida* (Table 2.). The biomass of platyhelminthes and annelids decreased from spring to autumn, whereas odonata larvae number and biomass increased. Chironomid larvae had low share on the total biomass, although they were very abundant in both habitats in every season.

Chironomid larvae, zygopteran larvae, crustaceans and ephemeropteran larvae were the most abundant groups in the diet of Amur sleeper (Table 3.). Chironomid larvae dominated in the diet in both habitat types in all seasons (Fig. 2.). In the spring asellids (*Asellus aquaticus*) was the dominant food content in the RNM. Zygopteran larvae were frequent prey in the LOF and chironomid larvae were the other important food category in both site. In the summer the abundance of ephemeropteran larvae, chironomid larvae and planktonic crustaceans increased in the diet in the RNM. In the LOF the importance of zygopteran larvae decreased. Chironomid larvae were the most important prey category besides fish larvae which were also frequently eaten. In the autumn the most important food categories were Chaoboridae and chironomid larvae in the RNM. In the LOF the number of chironomid larvae decreased in the stomach content; gastropods and zygopteran larvae were the firstly and secondly most often preyed food categories, respectively.

The Amur sleeper showed a rather opposite food choice between the two habitats in the spring (Fig. 3.). In the RNM the species preferred asellids and rejected zygopterans and chironomids. In the LOF it relied on zygopterans and avoided asellids. In the RNM the species preferred ephemeropterans in summer and Chaoboridae larvae in autumn. In LOF it still relied on zygopteran larvae in summer, and hirudineas in autumn, but it preferred zygopteran larvae in all seasons.

The diet composition was mainly determined by body size that had stronger effect than habitat and season (Fig. 4.). The diet of 0 size group contained mainly planktonic crustaceans, while I-II size groups contained mainly chironomid larvae, and other small macroinvertebrates. The diet of II-II. size groups were diverse. The importance of chironomid larvae was lower, although fish and gastropods importance were higher than for smaller (younger) individuals. In both habitats, II-III size groups (LOF_T_3, RNM_T_3, RNM_T_2) preyed mainly on asellids in spring.

Gut fullness varied between 0.00 and 48.95 with a mean value of 3.61 (Fig. 5.). The three-way ANOVA did not reveal significant differences between gut fullness coefficient data between sampling sites or size classes or seasons (Table 4.). Significant differences were found only in the interaction between sampling site and season ($p<0.001$), and between season and size ($p<0.001$). .

4. Discussion

The diet of Amur sleeper included a variety of animal taxa, but mainly macroinvertebrates in both habitats. In all investigated seasons chironomid larvae, ephemeropteran larvae, zygopteran larvae and amphipods dominated in the diet. There was not a single most important food category. Most of the prey taxa were on the left side of the Amundsen diagrams, which means that these prey categories occurred rarely but in high density in the stomach content samples. Such a pattern may indicate, but cannot prove unambiguously, that individuals in the population divide the potential food sources to reduce intraspecific competition (Amundsen et al. 1996).

The two habitats (RNM and LOF) maintained diverse and relatively similar macroinvertebrate assemblages, where Molluscs were the most dominant assemblage constituting group in terms of biomass besides Crustaceans (Asellus), Oligochaeta, Platyhelminthes, Odonata, Heteroptera and Trichoptera taxa. No consistent seasonal changes in assemblage composition could be observed. It is thus not surprising that the food of the Amur sleeper showed a diversity of food categories, and we did not find clear differences between seasons and habitats in diet composition. In fact, diet composition was mainly determined by body size (i.e. fish length) that had stronger effect than habitat and season. Therefore, ontogenetic changes in diet preferences seem to be more important than habitat and seasonality for the diet of the Amur sleeper. Size dependent differences in diet support the results of previous studies (Koščo et al. 2008, Grabowska et al. 2009).

The diet of small sized juvenile (0+) individuals contained mainly one type of prey category with high volume. Planktonic crustaceans were dominant in the diet of 0 individuals, but this category was also found in relatively high abundance in the diet of II and III individuals, too. Large individuals of Ostracoda, Cladocera and Copepoda have been reported to often occur in the diet of matured Amur sleeper (Koščo et al. 2008). With growing body size the diet composition widened out, and consisted mainly of macroinvertebrate taxa (Koščo et al. 2008, Grabowska et al. 2009). Fish and gastropod consumption was observed at bigger individuals, but chironomid larvae consumption was more frequent at smaller ones.

Fish have been frequently found in the diet of large Amur sleeper, mainly from a size of 60 mm (Sinelnikov 1976, Koščo et al. 2008, Grabowska et al. 2009). In fact, this invasive species has been considered as a harmful predator of small bodied fishes of lowland ponds and streams including the endangered and endemic European mudminnow (*Umbra krameri*) (Erős et al. 2008, Ambrus & Sallai 2014), which also occupies lowland waterbodies with dense aquatic vegetation (Pekárik et al. 2014). Although fish was not common in the stomach in our study, we anticipate this finding to the structure of the populations. Amur sleeper showed dense populations in both habitats, and as a consequence the populations consisted mainly of small bodied individuals. The relatively low ratio of large bodied individuals in these populations can be caused by colonization effects of recently invaded habitats (Gutowsky & Fox 2001). It is also true that preying on macroinvertebrates can be more profitable for small predatory fish than catching fish which is more energy-consuming (Polačik el al. 2009). Nevertheless fish was observed in the diet all year round in LOF, but in spring and autumn occurred with low frequency, while in summer we found fish in every fifth individuals. In summer the increasing abundance of fish in the diet was due to preying on fish larvae (i.e. young of the year individuals). In the literature the most prevalent preys were cyprinids, mostly bitterling (*Rhodeus amarus*) (Grabowska el al. 2009). Interestingly, bitterling was an abundant species in LOF, but it was lacking from the diet. The most important fish prey was tubenose goby (*Proterorhinus semilunaris*). Both species prefer almost the same habitat, and it is likely that the young, slow moving tubenose gobies were a relatively easily available prey for the Amur sleeper. Cannibalism was found to be frequent at some populations (Koščo et al. 2008), but we found Amur sleeper larvae only in few individuals.

Gastropods and zygopteran larvae were important part in the diet in autumn. Considering the data from both sites 70% biomass of the consumed individuals were molluscs in autumn. In the literature Amur sleeper was found to eat gastropods, but mostly the bigger individuals, and generally in autumn (Koščo et al. 2008, Grabowska et al. 2009). In LOF small gastropod species were abundant in all year, which can be optimal prey item for Amur sleeper. Their importance in the diet in autumn cannot be explained by the occurrence of the new gastropod generation. In case of other mollusc-consuming fish species this food content occurs just as a secondary group (Borza et al. 2009, Polačik et al. 2009). In our opinion these food resources were secondary for Amur sleeper too; although in the oxbow-lake they were in high abundance, but they were relatively rare in the stomach content. Our results suggest that Amur sleeper eat gastropods if other food resources are getting depleted, like in the LOF, where the gastropods and zygopteran larvae were the most abundant prey items (60% of all). Interestingly, stomach fullness did not depend on fish size, season and habitat. However, gut fullness was rather low in each group which suggest intraspecific competition for diet in both habitats in these invasive populations.

In conclusion, most of the food categories identified in the diet of Amur sleeper in both habitats are also common preys of this species in its natural range of distribution as well as in the areas already colonised (Spanovskaya et al. 1964, Sinelnikov 1976, Litvinov & O'Gorman 1996, Reshetnikov 2003, Miller & Vasil'eva 2003, Grabowska et al. 2009). Generally, the populations in the oxbow lake and the lowland canal fed rather on macroinvertebrates, tending to shift to piscivorous behaviour with the growing body size. The large number of food categories found in the stomach of Amur sleeper confirms previous findings that this fish species is a non-selective predator with a broad diet spectrum.

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Figure legends

Fig. 1. Percentage of biomass (without molluscs) of macroinvertebrate taxa in the lentic (RNM) and lotic (LOF) sites. The percentage values of molluscs are shown above the columns

Abbreviations: PAN - Platyhelminthes+Annelida, CRU - Crustacea, CLA - Coleoptera larvae, CIM - Coleoptera imago, HET - Heteroptera, ODO - Odonata, TRI - Trichoptera, MEG - Megaloptera, LEP - Lepidoptera, EPH- Ephemeroptera, ODI - Other Diptera, CHI - Chironomidae

Fig. 2. Seasonal diet composition of Amur sleeper according to the method of Amundsen et al. (1996) (SL - Mean standard length (mm), SD - Standard deviation)

Abbreviations: Ase - Asellus aquaticus, Ani - Anizoptera, Zyg - Zygoptera, Gas - Gastropoda, Chi - Chironomidae, Ann - Annelida, Pis - Pisces, Oth - Other, Lep - Lepidoptera, Het - Heteroptera, Mph - Macrophyta, Cim - Coleoptea imago, Eph - Ephemeroptera, Cha - Chaoboridae, Pcr - Zooplankton, Cla - Coleoptera larvae, Tri - Trichoptera, Cer - Ceratopogonidae, Oli - Oligochaeta, Pla - Platyhelminthes, Odi - Other Diptera, Hir - Hirudinea, Ost - Ostracoda

Fig. 3. Graphical representation of food preference of Amur sleeper in the lentic (RNM) and lotic (LOF) sites (SL - Mean standard length (mm), SD - Standard deviation)

Abbreviations: Ase - Asellus aquaticus, Zyg - Zygoptera, Gas - Gastropoda, Chi - Chironomidae, Ann - Annelida, Lep - Lepidoptera, Eph - Ephemeroptera, Cha - Chaoboridae, Cla - Coleoptera larvae, Tri - Trichoptera, Hir - Hirudinea

Fig. 4. Dendrogram of diet composition data

Abbreviations indicate habitat (RNM, LOF), season (spring, SP; summer, SU; autumn AU) and categories of standard length

Fig. 5. Box plots of the gut fullness coefficient values. The box represents the 25 and 75 % quartiles, and the band in the box is the median. The whiskers represent the highest and lowest values that are not outliers or extreme values. Open circles and asterisks denote outliers and extreme values, respectively.

Abbreviations indicate habitat (RNM, LOF), season (spring, SP; summer, SU; autumn AU) and categories of standard length

Table 1. Number of individuals in each size group (above) and number of individuals with non-empty stomahc which were used in further analyses (below)

Abbreviations: SP - Spring, SU - Summer, AU - Autumn, RNM - Rakamaz-Tiszanagyfalui-Nagy-morotva, LOF - Lónyay-főcsatorna, 0, I, II, III - Size groups (standard length)

Number of individuals in each size groups

	Spring	Summer	Autumn	Mean size (mm)	SD	Total		Spring	Summer	Autumn	Mean size (mm)	SD	Total
RNM 0.	0	4	0	18.3	1.1	4	**LOF 0.**	0	5	0	18.5	0.7	5
RNM I.	23	5	9	31.6	5.2	37	**LOF I.**	34	10	0	30.2	5.6	44
RNM II.	18	46	36	48.0	5.2	100	**LOF II.**	11	38	43	49.7	5.3	92
RNM III.	14	4	12	79.9	18.3	30	**LOF III.**	5	6	7	73.4	12.6	18
Total	55	59	57				**Total**	50	59	50			330

Number of individuals which used in further analyses (Individuals with non-empty stomach)

	Spring	Summer	Autumn	Mean size (mm)	SD	Total		Spring	Summer	Autumn	Mean size (mm)	SD	Total
RNM 0.	0	4	0	18.3	1.1	4	**LOF 0.**	0	5	0	18.5	0.7	5
RNM I.	21	5	5	31.1	5.3	31	**LOF I.**	26	10	0	30.2	6.0	36
RNM II.	17	41	23	47.9	5.2	81	**LOF II.**	10	26	20	49.7	5.2	56
RNM III.	14	3	7	76.0	15.3	24	**LOF III.**	3	4	6	71.9	11.6	13
Total	52	53	35				**Total**	39	45	26			250

Table 2. Food categories in the benthos of Rakamaz-Tiszanagyfalui Nagy-morotva (RNM) and Lónyay-főcsatorna (LOF)(%N, relative numeric abundance of macrozoobenthos, W% weight of macrozoobenthos)

				RNM								**LOF**							
				Spring		**Summer**		**Autumn**		**Together**		**Spring**		**Summer**		**Autumn**		**Together**	
Subphylum/Classis	**Ordo**	**Subordo/Familia**	**Species**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**
Hexapoda/Insecta	Coleoptera	Haliplidae		0.24		0.15		0.56	0.11	0.31	0.01	2.26	0.08	11.68	0.25	0.50	0.07	4.89	0.17
		Noteridae										0.79	0.10	0.07				0.34	0.04
		Dytiscidae		0.24	0.02			1.37	0.28	0.52	0.02	0.73	0.17	1.37	0.13			0.75	0.14
		Hydrophilidae		0.16		0.07				0.08		0.06		0.48	0.02			0.18	0.01
		Helophordiae												0.27	0.02			0.09	0.01
		Gyrinidae						0.08	0.16	0.03	0.01								
	Heteroptera	Pleidae	*Plea minutissima*	8.81	0.10	1.19	0.03	0.56	0.09	3.50	0.07	1.86	0.05	2.41	0.05	0.08	0.01	1.56	0.05
		Nepidae	*Ranatra linearis*	0.16	0.22	0.07	0.10	0.08	1.12	0.10	0.22			0.14	0.05	0.08	1.40	0.07	0.10
			Nepa cinerea			0.07	0.09			0.03	0.03			0.34	0.23			0.11	0.12
		Naucoridae	*Ilyocoris cimicoides*	2.12	2.06	0.22	0.05	0.24	2.52	0.86	1.43	0.51	1.07	1.58	0.36			0.72	0.64
		Corixidae	*Sigara sp.*									1.52	0.29	0.21	0.03			0.68	0.14
			Cymatia coleoptrata	0.94	0.01					0.31	0.01	0.17	0.01					0.07	
			sp.	0.08	0.01					0.03	0.01					0.17	0.19	0.05	0.01
			Micronecta					0.08		0.03									
		Gerridae	*Gerris argentatus*									0.06						0.02	
			sp.			0.07	0.01			0.03				0.14				0.05	
			Aquarius paludum											0.21	0.09			0.07	0.05
		Notonectidae	*Notonecta sp.*					0.08	0.84	0.03	0.04	0.11	0.29					0.05	0.12
	Diptera	Chironomidae		16.82	0.16	48.92	0.35	13.63	1.56	26.97	0.29	33.99	0.68	27.90	0.09	9.55	0.48	25.38	0.36
		Ceratopogonidae		2.44	0.02	2.09	0.06	0.81	0.08	1.79	0.04	6.66	0.25	5.09	0.15	0.67	0.09	4.52	0.19
		Simulidae										0.06		0.27				0.11	
		Stratiomyidae		0.94	0.28	0.07				0.34	0.18			0.07	0.04			0.02	0.02
		Chaoboridae		0.24						0.08									
		Tabanidae							0.09					0.07	0.05			0.02	0.03
		Sciomyzidae			0.01			0.08		0.03									
	Lepidoptera			0.47	0.03			0.56	0.71	0.34	0.05					0.25	0.21	0.07	0.01
		Nymphulinae				0.15	0.05			0.05	0.02			0.07				0.02	
			Cataclista lemnata			0.07	0.03			0.03	0.01			0.07	0.03			0.02	0.01
			Paraponyx stratiotata			0.07	0.05			0.03	0.02								
	Odonata	Anisoptera		0.71	2.76			1.13	4.68	0.60	1.95	0.06	0.24	0.62	0.37			0.23	0.29
		Zygoptera		2.44	0.45	4.33	0.77	16.61	12.62	7.66	1.09	4.35	1.70	3.44	0.61	19.68	14.81	8.19	1.77
	Ephemeroptera	Baetidae		5.66	0.13	0.30	0.01	3.23	0.27	3.01	0.10	1.47	0.16	0.76	0.02			0.84	0.08
		Caenidae		1.18	0.00	4.55	0.16	3.39	0.19	3.06	0.06	0.51	0.01	0.21		0.50	0.04	0.41	0.01

				RNM								LOF							
				Spring		Summer		Autumn		Together		Spring		Summer		Autumn		Together	
Subphylum/Classis	**Ordo**	**Subordo/Familia**	**Species**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**	**N%**	**W%**
	Trichoptera	Polycentropodidae										0.06	0.01			0.08	0.02	0.05	
		Limnephilidae										0.17	0.16					0.07	0.07
		Phryganeidae		0.08	0.22					0.03	0.14								
		Beraeidae		0.55						0.18									
		Sericostomatidae												0.14				0.05	
		Leptoceridae				0.75	0.03	2.26	0.29	0.99	0.02								
		Polycentropodidae				2.91	0.23	12.34	5.80	4.98	0.33								
		Other														0.08	0.21	0.02	0.01
Clitellata	Hirudinea			5.90	2.42	5.67	0.44	4.19	0.64	5.27	1.70	0.23	0.26	3.92	0.33	0.08	0.41	1.40	0.30
	Oligochaeta			7.15	0.56	12.01	1.08	19.68	5.94	12.87	0.96	29.25	6.86	21.79	1.10	14.15	1.15	22.71	3.54
Turbellaria	Tricladida	Platyhelminthes						1.94	0.28	0.62	0.01	0.06	0.01			15.41	2.46	4.19	0.12
	Megaloptera	Sialidae				0.52	0.14	0.32	1.15	0.29	0.10								
Crustacea/Malacostraca	Isopoda	Asellidae		12.89	2.26	7.31	0.13	0.81	0.27	7.06	1.48	0.56	0.17	0.21	0.01			0.29	0.07
	Amphipoda	Gammaridae		0.79	0.07					0.26	0.04	0.06						0.02	
	Mysida	Mysidae						1.05	0.22	0.34	0.01								
Gastropoda				29.01	88.21	7.01	93.99	14.11	49.00	16.56	88.35	14.40	84.73	16.15	92.16	38.69	78.45	21.54	88.34
Bivalvia						1.42	2.18	0.81	11.13	0.75	1.20	0.06	2.69	0.34	3.81			0.14	3.15

Table 3. Relative numeric abundance (%N) and relative percentage of volume (V%) of food items in gut of Amur sleeper (P. glenii) from 2 sites in Rakamaz-Tiszanagyfalui Nagy-morotva (RNM) and Lónyay-főcsatorna (LOF)

				RNM								**LOF**							
				Spring		**Summer**		**Autumn**		**Together**		**Spring**		**Summer**		**Autumn**		**Together**	
Subphylum/Classis	**Ordo**	**Subordo/Familia**	**Species**	**N%**	**V%**	**N%**	**V%**	**N%**	**V%**	**N%**	**V%**	**N%**	**V%**	**N%**	**V%**	**N%**	**V%**	**N%**	**V%**
	Coleoptera							0.47	2.03	0.12	0.68			0.81	0.09	13.01	8.59	4.96	2.89
Hexapoda/Insecta		Dytiscidae		0.40	0.29					0.12	0.10								
		Hydrophilidae												0.81	2.10			0.29	0.70
		Hydrochidae												0.81	2.21			0.29	0.74
	Heteroptera															0.81	1.96	0.29	0.65
		Pleidae	*Plea minutissima*			0.28	0.19			0.12	0.06								
	Diptera	Chironomidae		45.24	23.22	32.12	19.94	10.80	21.32	30.62	21.50	52.58	35.56	48.78	24.48	1.63	2.28	32.94	20.78
		Ceratopogonidae		0.40	0.39	0.56	1.02			0.36	0.47			0.81	0.02			0.29	0.01
		Chaoboridae		6.35	6.96	0.56	0.19	69.95	39.49	20.29	15.55								
		Tabanidae												0.81	2.19			0.29	0.73
	Lepidoptera			0.40	0.98	0.56	2.45			0.36	1.14					1.63	0.54	0.58	0.18
	Odonata	Anisoptera										1.03	0.13	0.81	0.77			0.58	0.30
		Zygoptera		3.17	9.12	2.51	4.28	1.88	9.41	2.55	7.60	24.74	35.87	4.07	6.62	21.95	18.15	16.33	20.22
	Ephemeroptera			0.79	0.43	23.46	42.51	2.82	5.38	11.18	16.11	4.12	6.79	3.25	4.19	0.81	0.65	2.62	3.88
		Baetidae		3.97	10.87					1.22	3.62	3.09	4.23					0.87	1.41
	Trichoptera			0.40	1.67	7.26	9.19	4.69	10.27	4.50	7.04			3.25	2.54			1.17	0.85
Annelida																4.88	8.91	1.75	2.97
Clitellata	Hirudinea			0.79	1.94					0.24	0.65								
	Oligochaeta					0.84	1.25			0.36	0.42	3.09	5.10					0.87	1.70
Turbellaria	Tricladida	Platyhelminthes				0.28	0.85			0.12	0.28								
Crustacea/Malacostraca	Isopoda	Asellidae		32.94	36.13	6.42	9.60			12.88	15.25	3.09	3.85					0.87	1.28
	Cladocera			3.17	4.16	21.51	1.02	5.16	0.89	11.66	2.02	2.06	2.59					0.58	0.86
	Copepoda					0.56	2.26			0.24	0.75	5.15	3.36	11.38	2.76			5.54	2.04
	Ostracoda			0.79	1.96	1.40	0.13			0.85	0.70								
Mollusca						1.12	2.55			0.49	0.85								
	Gastropoda							4.23	11.22	1.09	3.74			6.50	15.28	52.03	52.07	20.99	22.45
Terrestrial Arthropods				0.40	0.59					0.12	0.20			0.81	2.21			0.29	0.74
Piesces		Odontobutidae	*Perccottus glenii*									1.03	2.51					0.29	0.84
		Gobiidae	*Proterorhinus semilunaris*			0.28	1.70			0.12	0.57			9.76	20.31	1.63	4.35	4.08	8.22
Plant														3.25	5.63	0.81	0.43	1.46	2.02
Other				0.79	1.28	0.28	0.85			0.36	0.71			4.07	8.61	0.81	2.07	1.75	3.56

Table 4. Three-way ANOVA results of gut fullness coefficient data

	SS	d.f.	MS	*F*	*P*
Sampling Site	0.02	1	0.02	0.16	0.69
Season	0.21	2	0.10	0.86	0.43
Size	0.16	2	0.08	0.66	0.52
Sampling site : Season	1.65	2	0.82	6.62	<0.001
Sampling site : Size	0.13	2	0.07	0.53	0.59
Season : Size	2.81	4	0.70	5.65	<0.001
Sampling site : Season : Size	0.46	4	0.12	0.93	0.44
Error	38.50	315	0.12		