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GROWTH, AGE AND SIZE STRUCTURE OF THE INTRODUCED PUMPKINSEED (*LEPOMIS GIBBOSUS* L.) POPULATION FROM SMALL PONDS ALONG THE VIT RIVER (BULGARIA)

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Abstract

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The age and size structure, length and weight growth of the introduced fish species *Lepomis gibbosus* L. was studied. The study area included four small artificial lakes, part of lake's system ("adaptive ponds") that serve as a buffer zone between the oil refinery "Plama"(city Pleven) and the River Vit (North Bulgaria). Four age groups were observed (1+ to 4+). Small-sized fish dominated, standard size of 46 to 55 mm comprised 38% of the entire stock. The relationship between standard length (SL) and scale radius (R) was: SL = 0.1253R+1.124; TL = 0.1522R+2.3048 for total length respectively. The maximum-sized fish (SL) that was observed was 92mm. Von Bertalanffy length grow curve is presented by the follow equation: $SL_t = 95 [1-e^{-0.32(t-0.05)}]$. Weight-length relationship for pumpkinseed population is expressed by the equation: $W = 0.0245SL^{3.187}$. Compared with other European pumpkinseed populations, the current stock was characterized by lower annual weight and length growth, simple age structure and domination of fish with relatively low sizes.

Key words: Lepomis gibbosus, age-structure, growth rate, small ponds

Introduction

The pumpkinseed sunfish (*Lepomis gibbosus*) was introduced in Europe as a potential sport and garden fish (Kunstler, 1908; Vooren, 1972; Holcic, 1991; Welcomme, 1992) and it's one of the 26 alien fish species occurring in Bulgarian waters (Uzunova and Zlatanova, 2007). The native distribution of the pumpkinseed was restricted to eastern North America (Skott and Grossman, 1973). Today it is found in West and Central Europe (De Groot, 1985; Welcomme, 1988) as well as in Iberian Peninsula (Elvira and Almodovar, 2001), and the Black sea region (Economidis et al., 2000). Negative impacts on the native fishes were first reported in Spain and Portugal (Zapata and Granado-Lorencio, 1993; Godinho, 2004).

Investigations of the pumpkinseed are focused on

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its age, growth and morphology in different geographical ranges, and different type water bodies in Europe (Papadopol and Ignat, 1967; Tandon, 1977ab; Crivelli and Mestre, 1988; Neophitou and Giapis, 1994; Gutierrez–Estrada et al., 2000; Fox and Crivelli, 2001; Coop et al., 2004; Villeneuve et al., 2005).

Despite of the wide distribution of south-eastern European populations studies are particularly scarce. At the same time, the investigations of pumpkinseed's growth and population structure are extremely important, because they are closely related to its life strategies, mechanisms and intensity of the spread and establishment.

The aim of this study is to provide information on the age-structure and growth performance of a population of *L. gibbosus* inhabiting small artificial lakes in northeastern part of the Balkan Peninsula (the Vit River watershed).

Material and Methods

Study area

Study area includes over 30 shallow polimictic lakes formed as a result of inert materials excavation. These water bodies are part of lake's system ("adaptive ponds") that serve as a buffer zone between the oil refinery "Plama" (city Pleven) and the River Vit**.** The pools are connected by ditches and furthermore they are even closer connected during high water levels. Pumpkinseeds were collected from four water bodies. These sites were selected because they encapsulate the known pumpkinseed requirements and are known not to run dry in the summer. That's why we assumed all collected fish to constitute a single population. Moreover differences and structure of stocks collected in different pools were not significant. No wastewater was released in studied ponds. The age of the water bodies is about 15 to 20 years. The surface area varies from 300 m^2 to 22000 m^2. The average depth is 1.5 m (0.3-3.5 m). Changes in water temperature and hydrochemical parameters are shown in Table 1 (Asenova et al., 2003 a,b).

The bottom substrate is presented by mud (dominate), gravel and sand. Within the investigated water bodies the pumpkinseed sunfish dominated the fish community. The other fish species presented were false harlequin *Pseudorasbora parva*, Eurasian perch (*Perca fluviatilis*), pike (*Esox lucius),* carp (*Ciprinus carpio*), crucian carp *Carasius auratus*, tench (*Tinca tinca),* mosquitofish (*Gambusia affinis*, rudd (*Scardinius erythrophthalmus*). Besides the pumpkinseed other numerous species were perch, false harlequin and rudd. The mosquitofish formed numerous populations within only one of the basins. The remaining species were presented in low quantities. The arrival and spread of the pumpkinseed in these water bodies most probably were caused by anglers due to its use as baitfish.

Table 1
Hydrochemical parameters of the investigated lakes (Asenova et al., 2003a,b)

Month	Oxygen, $mg.l^{-1}$	Temperature, ^0C	pH	NO_3	NO_2	NH_4	PO_4
May	6.6	13.0	6	0.01	0.01	0.5	0.01
July	6.0	26.0	7.5	0.06	0.01	0.02	0.02
November	5.6	12.0	6.8	0.04	0.01	0.1	0.03

Significant part (30-80%) of the water surface was covered by macrophytes (*Typha latipholia, Phragmites australis, Potamogeton natans* and *Elodea canadensis*).

Sampling methods

Fish from selected water bodies was collected seasonally (May, July and November) by electro-fishing and net (funnel) traps. Standardized fishing effort was applied, two hours of trapping and angling per location. Four traps and two rods were used. The total of 268 individuals was investigated.

Size measurements included total (TL) and standard (SL) length. Fish were weighted (total, Wt and gutted weight, Wg) to the nearest 0.1 g. Gonads were inspected to determine the sex and also were weighted.

Age of the fish was determined from scales re-

moved below the anterior part of the dorsal fin. Measurements were made on the oral radius. Ageing study was made using microfilm reader in 17.5 magnification. Two readers independently determined the age of fish. The percentage of agreement was above 90 percent. The remaining scales were additionally discussed until agreement was reached.

Data analyses

The linear growth was estimated by back-calculation of standard length from oral radius of scales. Male and female fish were investigated separately. SL at age 2 was used as an indicator of "juvenile growth rate".

Growth curves were modeled by the von Bertalanffy growth function (VBGF) (Bertalanffy, 1938): $SL_t = Linf\,[1-e^{-k(t-t0)}]$, where SL_∞ is the standard body length at age t [mm], SL_∞ is the asymptotic (potential) length, k is a constant expressing the rate of growth at which SL_∞ is approached and t_0 represents the theoretical age at which the predicted standard mean length is zero.

The weight growth was estimated according to the equation $W=aSL^b$, where W is a total individual weight at time of capture [g], ***a*** and ***b*** are parameters of W-SL relation. The linear and weight growth and increment per year were calculated ($t=L_{t+1}-L_t$; $t=W_n-W_{n-1}$). The condition coefficient according to Fulton's equation was calculated as follows: $k=(Wt/SL^b).100$, where *b* is the exponent from length - weight relationship.

These parameters were calculated by the programme FiSAT (Gayanilo et al., 1994).

Results and Discussion

Age and size structure

Four age groups constituted the pumpkinseed populations from investigated lakes. The 1+, 2+ and 3+ age groups were presented relatively equal and dominated the catch. The oldest age group, 4+ was poorly represented (Figure 1).

The lenght strudture of the population is presented at Figure 2.

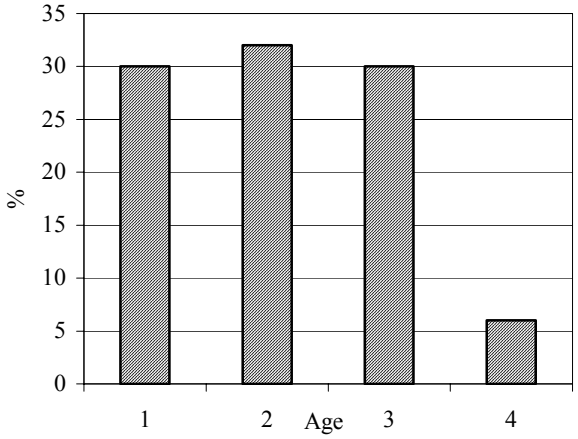

Fig. 1. Age distribution of pumpkinseed from small ponds along the Vit River

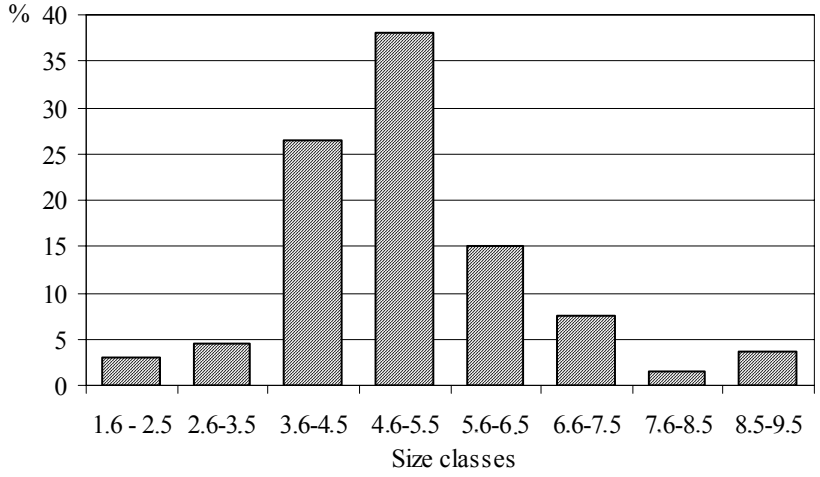

Fig. 2. Size distribution of the pumpkinseed from small ponds along the Vit River

Small pumpkinseeds, which size varied between 46 and 55 mm dominated (38%), followed by fish with size between 36 to 45 mm (26%). No significant differences were observed between individual maximum standard body length of male and female fish. The largest fish caught during the period of investigation was male, which size (SL) was 92mm.

Length growth

The relationships between SL (TL) (Figure 3 a,b) and scale oral radius follow the next equations:

SL= 0.1253R+1.7124

TL= 0.1522R+2.3048

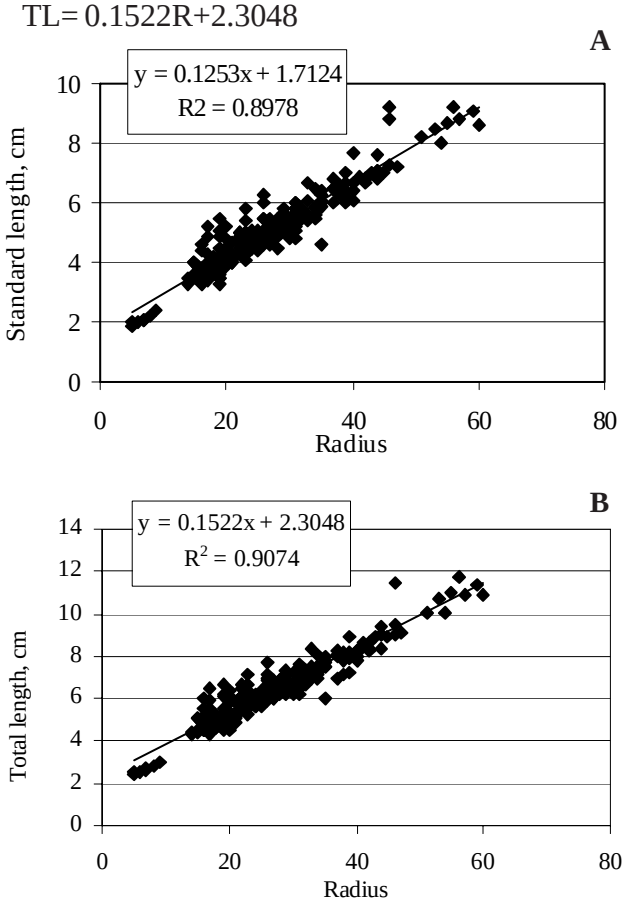

Fig. 3. Standard length (A) and total length (B) - radius relationship for pumpkinseed from small ponds along the Vit River

As no significant differences between the male and female pumpkinseed was found, the back calculation of length for both sexes are combined.

The back calculated standard length and at particular age and the standard length at time of captured was presented in Table 2.

Differences between back-calculated lengths of both sexes were found only for 4+ age groups ($p<0.05$). Standard length increment was greatest for age 1+ and significantly decreased in the next ages (Figure 4). Mean length at age 2 was relatively low.

Two groups of fish were discriminated, based on size of the first scale annual circle. One of them included fish, which radius had the mean of 0.46 mm and the other, which possessed larger scale radius. First group reached 31 mm length in their first year of growth and the second one - only 25 mm ($p<0.05$). We suggest that these two groups correspond to two batches of eggs that female fish released during the summer. No significant differences were found between the sizes of scale radii, which were formed at older age. Mean length at age 2 was relatively low. The following parameters of mathematical growth model according von Bertalanffy were determined on the base of back calculated lengths: $SL_t = 95\ [1-e^{-0.32(t-0.05)}]$.

Wight growth

The length-weight relationships for both sexes are presented on Figure 5.

The respective equation is: $W=0.0245SL^{3.187}$. Table 3 shows the results of the analysis of weight growth for the pumpkinseed population. Maximum

Table 2

Standard length of pumpkinseedfrom small ponds as determined by back calculation and at time of capture

Year class	Age	n	Back calculated lengths, mm				SL[mm] at capture ±CD	Range, mm
			L1	L2	L3	L4		
2006	1	69	28				39 ± 0.3	33 - 49
2005	2	77	29	44			50 ± 0.4	44 - 69
2004	3	71	3	44	54		60 ± 0.84	48 - 92
2003	4	13	28	45	58	69	77 ± 1.26	55 - 92
Mean			29	44	56	69		

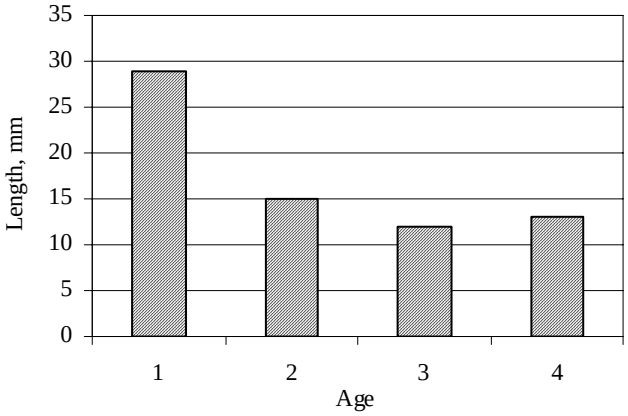

Fig. 4. Standard length increment of pumpkinseed from small ponds along the Vit River

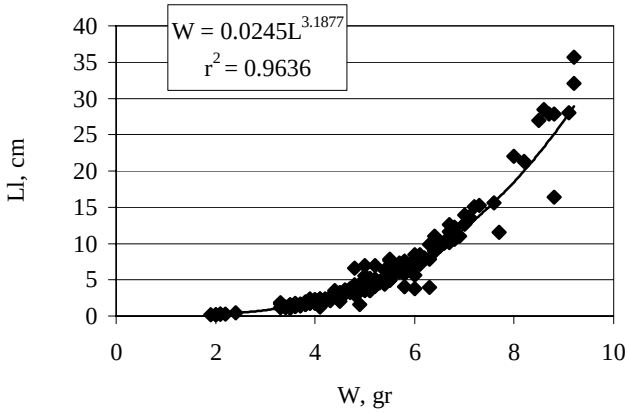

Fig. 5. Relationship between standard length and weight of pumpkinseed, *Lepomis gibbosus* L. from small ponds along the Vit River

Table 3

Growth rate in weight of pumpkinseed from small ponds as determined by back calculation and at time of capture

Year class	Age	n	Back calculated weights, g				W[g] at capture ± CD	Range, g
			W1	W2	W3	W4		
2006	1	69	0.65				1.65 ± 0.4	0.94 - 3.36
2005	2	77	0.73	2.8			3.6 ± 0.9	2.3 - 6.8
2004	3	71	0.82	2.8	5.3		7.26 ± 3.8	3.0 - 27.7
2003	4	13	0.65	3	6.7	11.6	16.2 ± 7.7	5.4 - 30.5
Mean			0.71	2.9	5.0	11.6		

body weight obtained from back calculations was 11.6 g.

The body conditions do not differ significantly between different ages (Figure 6).

Pumpkinseed, as one of the most successful introduced fish species in Europe, may occur in different types of water bodies. Small, eutrophic lakes and marshlands are typical for this species. It is considered that in most cases pumpkinseed was released in water bodies by anglers (Garcia-Berthou et al., 2005).

Small number of age groups in the investigated population is not a unique characteristic. The similar age structure was reported for several other pumpkinseed populations from different type of water bodies and geographical latitudes (Constantinescu, 1981; Gutierrez-Estrada et al., 2000, Villeneuve et al., 2005; Bobori et al., 2006). In Bulgaria the majority populations from small ponds and micro-dams have similar structure, composed by three or four age groups. At the same time larger reservoirs have one or two age groups more. The investigated ponds are situated in the southern part of Europe, which provide better climatic conditions, hence longer growing period in a year. The rate of general development (including younger age and smaller size at maturity) is among the most intense for the species. It is known, that after reaching maturity, body growth become much slower due to the significant energy allocation to breeding and gonad development (Justus and Fox, 1994). The dominance of small individuals within the population can be also attributed to the lower depths, which provide suitable conditions for spawning, dense vegetation, serving as shelter for the young-of-the-year and to lack of predators. These features of the ponds predetermine low mortality among the young fish (Bertschy and Fox, 1999). The remaining large numbers within the smaller cohorts experience higher intraspecific levels of competition, hence one of the lowest growth rates in the country. The lack of large male individu-

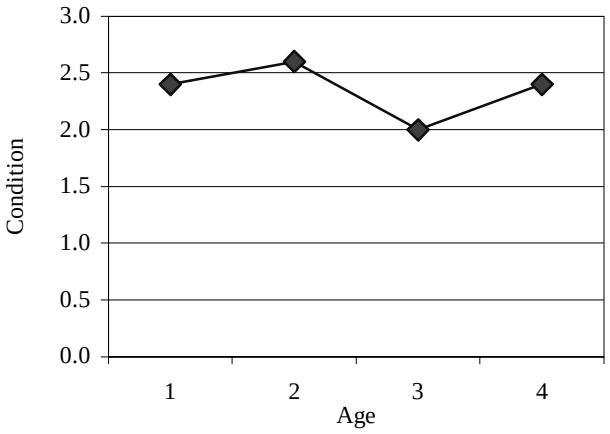

Fig. 6. Age variation of body condition of pumpkinseed from small ponds along the Vit River

Location of the lakes allows relatively long active growth period - approximately 5-6 months. But obviously there are other factors that limit growth. One of most possible reason is increased fish density and competition for space and food (Klaar et al., 2004). It is interesting that the grow parameters of this population were more similar to those from northern parts of Europe (Coop et al., 2002). The asymptotic length, according to the mathematical growth model is 95 mm, among the lowest known. According to the model it is reached at the age of 5-6 years. The K value, which reflects the intensity of reaching the asymptotic length is also low (0.35).

The small number of age groups attendant with small size of fish is particularly characteristic of the early stages of population establishment. At that time the lack of typical structure (mostly social), the presence of empty niches and usually the suitable conditions predetermine the "boom" of numerous small individuals. Most probably the populations exist here for a period between ten and fifteen years, despite this relatively long period their characteristics are similar to recently invaded population. The reason could be the

Table 4

Standard body length of pumpkinseed populations from water bodies situated on adjacent geographical latitudes

Water body	Standard length of pumkin seed from different latitude, mm										
	Latitude	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Tapada Pequena Reservoir, Portugal	38	31	45	60	67	71	74				
Tapada Grande Res. Portugal	38	37	50	59	64	75					
Monte Nove Res. Portugal	39	43	65	81	88	92	96	99			
Kerkini Res. Greece	41	61	73	84	93	101	109				
Pleven ponds, Bulgaria	42	29	44	56	69						
Banyoles lake, Spain	42	40	78	103	116	122	124	130			
Fumemrte channel, France	43	32	58	71	84	93	101	102			
Sollac marsh, France	43	31	58	84	100	109	114	122			
Dabas lake, Hungary	47	32	50	66	76	80					
Danube River	47	39	67	87	103	117	128				
Cottesmore pond, England	51	27	37	49	56	63					
Odra River, Poland	53	65	87	109	124	138	142	145			
Mean for Europe		40	61	77	88	96	108	114	90		
Mean for North America		35	60	82	100	116	13	137	136	144	144

als, which normally is a strong inhibitor of the age at maturity also influence the population structure.

The length-at-age trajectories of this pumpkinseed population show poor growth relative to the other population from southern European water bodies located on the same or adjacent geographical latitude (Neophitou and Giapis 1994; Coop and Fox, 2007) (Table 4).

often presented delaying phase of the invading population. Also the climatic and hydrological features of the region are specific. The temperature variations here are among the largest. The small size of the ponds and their interstitial inflow provide their low "buffer" capacity, they are highly prone to follow the climatic variations. The significant seasonal variations of water level, temperature variations, pollutants accumulation during certain periods, ice cover and winterkills cause the population's return to an earlier stage of development and the equilibrium shift.

Conclusion

Compared with other European pumpkinseed populations, the current stock was characterized by lower annual weight and length growth, simple age structure and domination of fish with relatively low sizes.

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