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PUMPKINSEED (*LEPOMIS GIBBOSUS*) DISTRIBUTION AND ABUNDANCE IN LITORAL ZONES OF SAND - PIT LAKES

E. UZUNOVA[1], M. GEORGIEVA[1], M. NIKOLOVA[2], S. STUDENKOV[1] and I. TRAYKOV[1]
[1]*Sofia University, Biological Faculty, 8 Dragan Tsankov Blvd., BG – 1164 Sofia, Bulgaria*
[2] *BAS, Central Laboratory of Common Ecology, BG -1113 Sofia, Bulgaria*

Abstract

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The distribution and abundance of invasive fish species *Lepomis gibbosus* L. inhabiting littoral zones of sand-pit lakes was investigated. The study was carried out during May and June – in active breeding period for pumpkinseeds. The investigated water bodies are located along the Lesnovska River, tributary of Iskar River, Danube drainage basin. The pumpkinseed was observed in all water bodies except Chepintci Lake. The mean abundance of pumpkinseed varied between 0.2 and 24.5 (CPUE). The highest abundance was recorded in Negovan Lake. The mean total length of pumpkinseed was relatively low for all investigated sites and varied between 4.9 and 7.4 cm, corresponding to an average age of 0.7 and 2.09 years respectively. The character of a bottom and density of water vegetation significantly correlated with pumpkinseed abundance.

Key words: Lepomis gibbosus, sand-pit lakes, abundance, age, length, environmental factors

Introduction

Pumpkinseed, *Lepomis gibbosus* L., is a native fish species to the eastern North America (Scott and Crossman, 1973). Introduced to Europe freshwaters during the late nineteenth century the pumpkinseed is now wide spread in at least 28 European countries (Copp and Fox, 2007). In recent years, the species spread rapidly into the Bulgarian inland water bodies (Uzunova and Zlatanova, 2007, Uzunova et al., 2008).

In general the ecological effect of pumpkinseed on native species and habitats is determined as adverse (Casal, 2006). It has been reported to be responsible for the decline of other fish species (Welcome, 1988; Zapata and Granado-Lorencio, 1993; Godinho, 2004), gastropods (Osenberg et al., 1988) and other invertebrates (van Kleef et al. 2008). It is considered that the presence, increase in abundance or the area of occupation of invasive species may be indicative of environmental degradation (Kennard et al., 2005). Therefore, monitoring invasive species is a good tool both for detecting other drivers of environmental degradation and for understanding their direct impacts on biodiversity and ecosystem processes. On the other hand the level of impact of an invader is strongly correlated with its abundance (Parker et al., 1999; Ricciardi, 2003).

One of the most seriously infested with pumpkinseed water bodies are small, shallow, man - made lakes (Gutierrez–Estrada et al., 2000; van Kleef et al., 2008; Uzunova et al., 2008). In Bulgaria the majority of these water bodies were formed as a result of sand and gravel extraction. These lakes are characterized by sandy and/ or muddy bottoms, lush macrophytes in the littoral zone, and high level of eutrophication. After finishing excavation work these lakes are suitable places for sport fishery activities and in some cases for the conservation of native aquatic species. As potential pumpkinseed dispersal mechanisms in Bulgaria freshwaters were supposed the transports of larvae or adult fish for restocking from already infested water bodies or by anglers as bait fish.

With aim to reveal the role of environmental and anthropogenic factors in process of invasion of exotic pumpkinseed fish we focused our investigation on the distribution, abundance, size and age structure of this fish, inhabiting former and present sand – pit lakes.

Materials and Methods

Study design

Samples were taken from 5 lakes and 16 stations located at accessible sites, representative for the particular water body. Sampling was conducted during the breeding season (May and June, 2009) when territorial males guard their nest, situated mainly in the littoral zone.

Lakes chosen for this study were all human made for extraction of inert materials (Table 1).

Sampling protocol

Each lake was sampled with minnow traps to identify species composition and estimate the relative abundance of small-bodied fish in the littoral zone fish assemblage. Minnow traps were chosen because they could be set in almost any lake or habitat type. A total of 10 baited minnow traps were set per site. These were commercially available Gee minnow traps with an opening diameter of 6 - 7 cm and a mesh size of 0.8 cm. Traps were baited with a dry, trout feed and were set near the shoreline at depths ranging from 0.3 to 2.0 m. Traps were set for 1 hour during the sunny days. The collected fishes were counted and identified to species. Only pumpkinseeds were preserved in 70% alcohol. Native fishes were counted at site and released.

Habitat assessment

Habitat quality was assessed after fish sampling. We measured or scored the following biological and physical habitat variables at transects 20m apart for the length of each site: dissolved oxygen (mg l^{-1}), pH, and water temperature (^{o} C) were measured with WTW Oxi 330i and WTW pH 330i, respectively. Electro conductivity (µS/cm) was measured with portable conductometer. Substrate composition (in % of section area) – mud< 0.06 cm; sand: 0.06-0.2 cm; gravel: 0.2-2 cm; boulders: 2-20.0 cm) was visually estimated in a 1-m-wide band centred across each transect. Emergent and submerged aquatic vegetation (% of section area) was classified in four categories: (1) missing, (2) sparse, (3) intermediate and (4) dense. Costal vegetation was classified as: 1 - reed-belt; 2 - mixed broad-leaved; 3 - grass. With aim to describe lake use two classes were determined: 1 - active pit-sand; 2- former pit-sand. All lakes were exploited for recreational fisheries. Presence of predator fish species was described in two categories: 1- present and 2- absent (Table 2).

Fish analyses

Size measurements included total (TL) and standard (SL) length. The fish were weighted (W,g) to the nearest 0.1 g. The age of the fish was determined from scales removed 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 magnifications. Two investigators independently determined the age of fish. Age was confirmed if the percentage of disagreement was below 10 percent, for the scales with higher discrepancies additional measurements were made until agreement was reached.

Data analyses

Relative abundance estimates of minnow traps were

Table 1
Names and codes for lakes and lake information, data of fish collecting and sample site length

N	Pond name	Site code	Data	Site length, m
1	Dolni Bogrov	DB1	10. May	50
2	Dolni Bogrov	DB2	10. May	55
3	Dolni Bogrov	DB3	11. May	20
4	Dolni Bogrov	BD4	12. May	25
5	Negovan	NEG1	16. May	21.5
6	Negovan	NEG2	16. May	22
7	Svetovrachene	SV1	31. May	25
8	Svetovrachene	SV2	31. May	35
9	Svetovrachene	SV3	01. June	30
10	Svetovrachene	SV4	02. June	50
11	Chepintzi	CHP1	17. May	35.3
12	Chepintzi	CHP2	17. May	20
13	Chepintzi	CHP3	18. May	12
14	Chepintzi	CHP4	18. May	19.7
15	Chelopechene	CHL1	15. June	30
16	Chelopechene	CHL2	15. June	30

derived from mean catch per unit effort (CPUE) for each species in each lake sampled. The relationship between fish abundance (i.e. the number of species present in each site) and several environmental parameters was studied by bivariate linear regression. These analyses were evaluated using the STATISTICA software pack.

Results and Discussion

Species distribution and composition

A total of 1230 fishes belonging to 7 species from 4 families were obtained from the survey. The most widespread species was the sunfish pumpkinseed. It occurred in four of the five studied water bodies. Pumpkinseed was not found only in the Lake Chepintci. One factor which may limit the distribution of pumpkinseed in this lake is the permanent water currents resulting from active dredging. Usually, pumpkinseeds prefer still waters (e. g. Balon, 1959; Crivelli and Mestre, 1988; Copp et al., 2002). The other fish species were either scarce or had much more restricted distributions (Figure 1). Harlequin (*Pseudorasbora parva),* bleak (*Alburnus alburnus)* and pike *(Esox lucius)* were recorded only once. The rest of the fish species were with wider distribution.

In general, fishes which could spread widely are those highly adaptable to adverse environmental factors mainly in result of water pollution and habitat degradation. In many cases such so called 'tolerant' species are exotic invasive fishes (Vila and Garcia-Berthou, 2009). Harlequin is also non-indigenous species but obviously not well presented in littoral zones in this type of lakes. Eurasian perch *Perca fluviatilis* was also wide spread in the littoral zone of the investigated water bodies, found in small numbers in 7 sites. No significant correlation was found between the co-existence of pumpkinseed and its predator (*P. fluviatilis)* (P = 0.32). *Rhodeus sericeus* was found in 5 sites (2 lakes). This fish species is listed in Annex II of the EC Habitats Directive 92/43/EEC.

In general, the fish assemblages' structure of the

Table 2

Mean values for environmental variables measured at 16 sites (May - June 2009): surface area (in square kilometres); maximum depth (m); mean depth of the sampling area (m); shore type (1=steep; 2 = slant); bottom substrate in % (mud; sand: 0.06-0.2 cm; gravel: 0.2-2 cm; boulders: 2- 20.0 cm); oxygen saturation (ppm); dissolve oxygen content (mg dm3); temperature (Co); electro conductivity (µS/cm); current lake use (1 = active pit-sand; 2 = ex-sand-pit)

N	Site code	Surface area, km^2	Maximum depth, m	Altitude, m	Mean sampling depth, m	Shore type	Mud, %	Sand, %	Gravel,%	Boulders, %	Dissolved oxygen, mg/dm^3	Oxygen saturation, ppm	pH	T^oC	Electroconductivity, µS/cm	Water body use	Coastal vegetation	Aquatic vegetation	Type of co-existence fishes
1	DB1	0.37	4.5	550	0.6	1	50	50	0	0	7.8	87	8.5	19.3	478	2	1	4	2
2	DB2	0.37	4.5	550	0.4	2	40	40	20	0	7.8	87	8.5	19.3	480	2	1	3	1
3	DB3	0.37	4.5	550	0.4	2	20	70	0	0	7.8	87	8.5	19.3	475	2	3	1	2
4	BD4	0.37	4.5	550	0.5	1	60	40	0	0	7.8	87	8.5	19.3	480	2	1	3	2
5	NEG1	0.1	2.8	550	0.45	2	30	30	30	10	10	133	8.3	30	675	2	1	4	1
6	NEG2	0.1	2.8	550	0.8	2	60	20	10	10	10	133	8.3	30	675	2	3	3	1
7	SV1	0.04	2.2	550	0.55	2	60	40	0	0	8	88	8.5	20.4	322	2	3	2	2
8	SV2	0.04	2.2	550	0.4	1	60	40	0	0	8	88	8.5	20.4	322	2	2	3	2
9	SV3	0.04	2.2	550	0.35	2	70	30	0	0	8	88	8.5	20.4	322	2	3	4	1
10	SV4	0.04	2.2	550	0.7	2	70	30	0	0	8	88	8.5	20.4	322	2	1	3	2
11	CHP1	0.24	19	560	1.4	1	0	80	10	10	7.8	89	8.6	21	382	1	3	2	1
12	CHP2	0.24	19	560	1.2	1	0	90	10	0	7.8	89	8.6	21	382	1	3	2	1
13	CHP3	0.24	19	560	1	1	0	90	10	0	7.8	89	8.6	21	382	1	1	2	1
14	CHP4	0.24	19	560	1.4	1	20	80	0	0	7.8	89	8.6	21	382	1	1	2	1
15	CHL1	0.82	15	550	0.3	2	0	90	10	0	9.7	129	8.63	26	385	1	1	3	2
16	CHL2	0.82	15	550	0.9	2	0	90	10	0	9.7	129	8.63	26	420	1	1	3	1

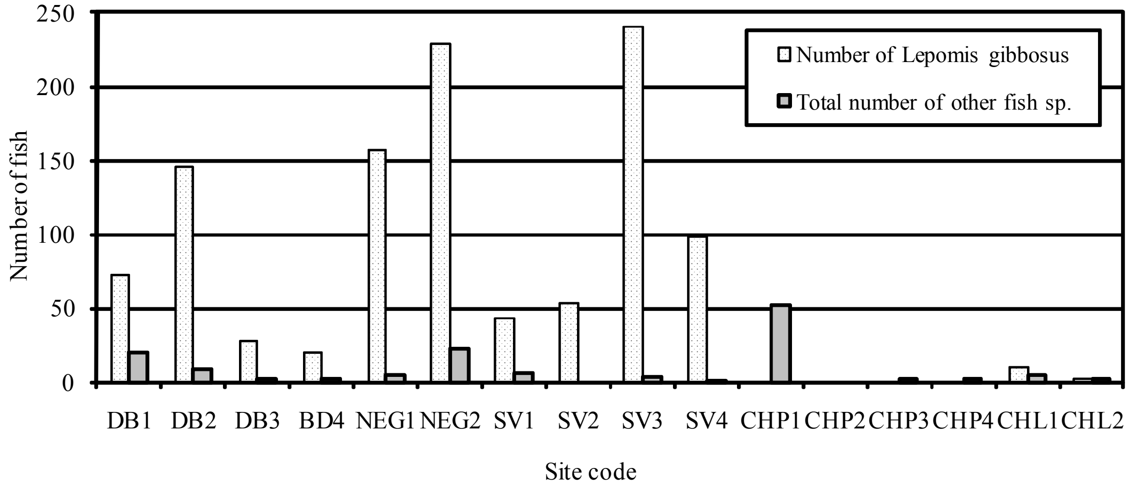

Fig. 1. Distribution of pumpkinseed and the other fish species in 16 investigated sites

littoral zone of pit sand likes/lakes is typical for small lowland lakes and reservoirs in Bulgaria during early summer mounts (E. Uzunova, unpubl. data).

With regard to fish abundance, our results showed high variability even among the sites in the same water body (Figure 3). Total fish abundance varied between 0 and 27.8 sp. h^{-1} with a mean value of 7.7 sp. h^{-1} (SD =7.7). Pumpkinseeds dominated with 9.18 mean CPUE followed by *P. fluviatilis* with mean CPUE 1.26 (Figure 2). The abundance of the other fish species reached values around 0.5 sp. h^{-1}. The maximum CPUE for pumpkinseed was found out in site NEG2. Regression analyses showed significant correlation between pumpkinseed abundance and their body length size (r^2=0.255, P = 0.045) (Figure 4). The site with lowest body length of pumpkinseeds was DB2, where fish do not reach more than 5.0 cm TL. The mean length for all sites was 6.4 cm (SD = 0.92). The most probable reason for low body length is increased fish density and competition for space and food (Copp et al., 2004; Klaar et al., 2004). The domination of small individuals within the population is normal to the shallower depths.

Mean weighted pumpkinseeds age was 1.48 and varied between 0.72 and 2.09 (SD = 0.51) (Figure 5). Maximum recorded age was 4+ years. Not sig-

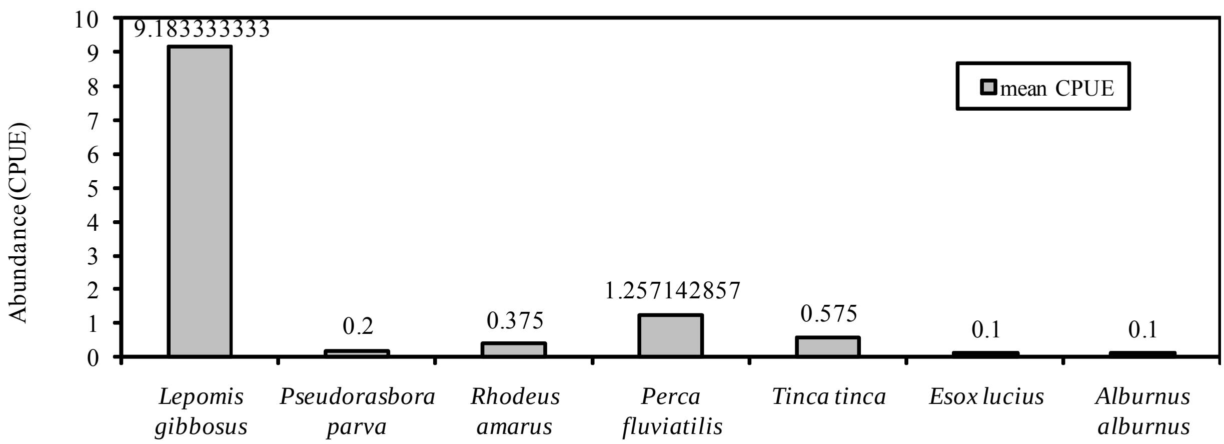

Fig. 2. CPUE for different fish species captured in May-June 2009 in littoral zone of the sand – pit lakes

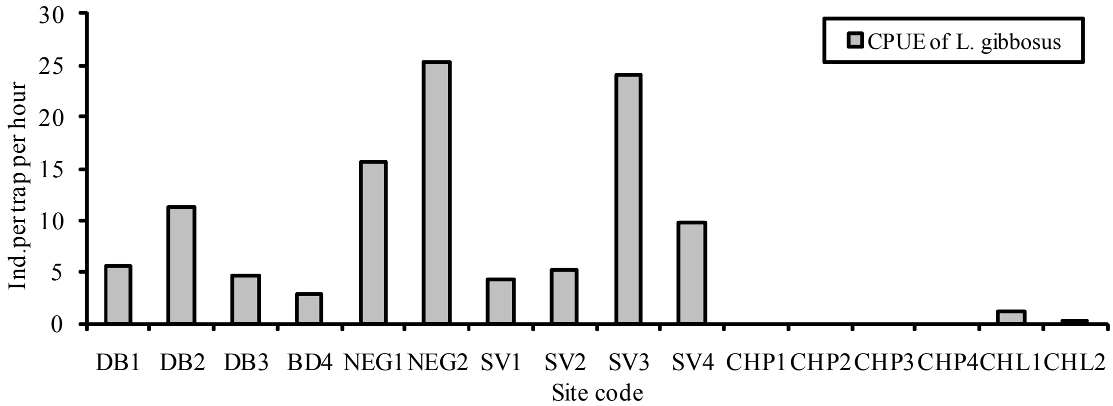

Fig. 3. Pumpkinseed abundance (expressed by CPUE) in investigated sites

nificant correlation was found between abundance and age (r^2= 0.222, P = 0.065). The similar age structure was reported for several other pumpkinseed populations from a different type of water bodies and geographical latitudes (Constantinescu, 1981; Gutierrez-Estrada et al., 2000, Villeneuve et al., 2005; Bobori et al., 2006; Uzunova, 2008). Domination of juvenile pumpkinseed in some of the sites indicated that the littoral zone of lakes was not only a nesting place for mature fish but also a preferable place for young fish.

Influence of abiotic and biotic factors

Many abiotic and biotic factors, ranging from water quality to habitat conditions, could be suspected as influential factors in defining population parameters of pumpkinseed. The littoral zone of the sand pit lakes is characterized with several types of microhabitats depending on environmental conditions. The character of the substrate was one of the most important factors influencing abundance of *L. gibbosus* in the littoral zone of sand pit lakes. We observed that pumpkinseed abundance was correlated significantly with a muddy bottom (r^2=0.55, P=0.045), whereas gravel and rocky substrate was avoided. Therefore, the possible reasons for the lack of pumpkinseed in the Chepintci Lake can be, on the one hand, the prevalence of coarse substrates in littoral zones, and on the other hand, the intensive excavation work carried out. On the contrary, Danylchuk and Fox (1996) observed a preference of female fish for nesting on firm substrates as opposed to soft. This demonstrates high adaptation ability of pumpkinseed and explains their invasion success. Significant correlation was observed between aquatic vegetation and sunfish abundances

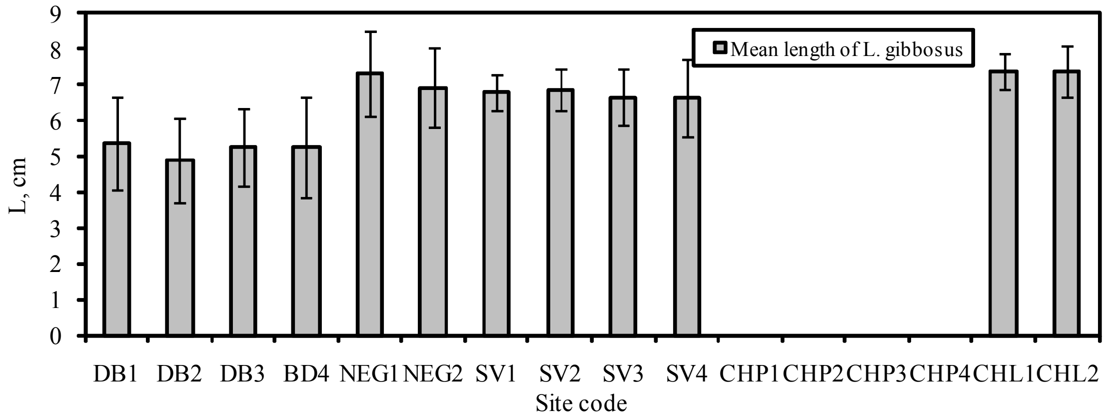

Fig. 4. Mean total length (in cm) of pumpkinseed in each sampling site

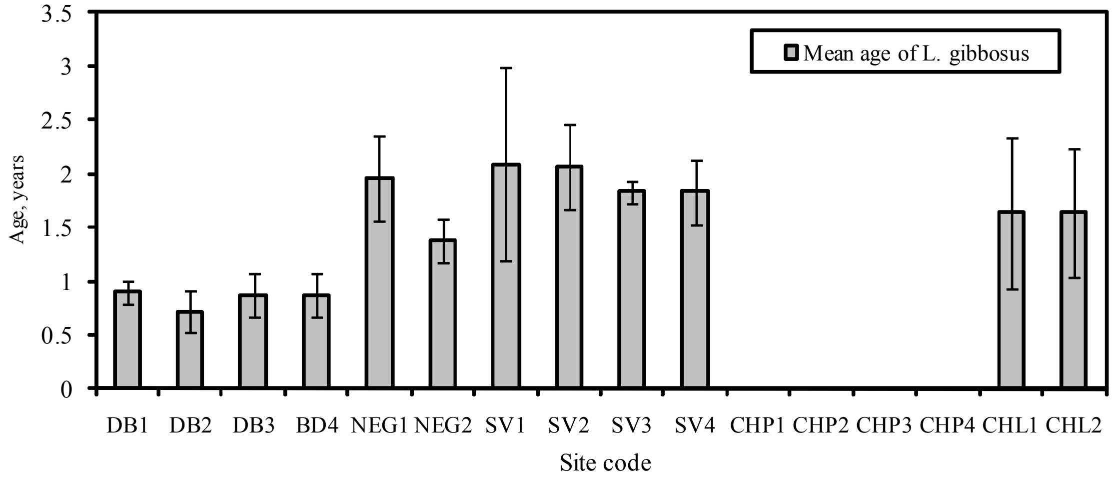

Fig. 5. Mean values of age of pumpkinseed in each sampling site

(r^2=0.475, P = 0.03). Mean daily temperatures recorded during the period of sampling in 2009 were similar among sites and all reached 20°C (Table 2). The mean water temperature observed in all 16 sites was 22.2°C (SD = 3.68). We hypothesized that high pumpkinseed abundance in some sites was a result from favourable temperature conditions in the shallow sun-exposed littoral zones but not found a significant correlation was not found between these parameters.

The abundance was also associated with human activities. In Lakes with active sand extraction, a lack or low abundance of the pumpkinseed was recorded. Van Kleef et al. (2008) reported that higher pumpkinseed abundance often coincided with specific management practices (the removal of organic mater and macrophytes, dredging), or which have been artificially created. According to van Kleef et al. (2008) these activities are a result of significant enhancement of the suitable breeding habitats. The authors found out that most infested water bodies are situated close to villages and roads.

In general, littoral zones in the investigated sand pit lakes can be divided in several groups according to the aquatic vegetation and substrate: muddy with dense vegetation, and zones with sandy or muddy substrates without any or scares aquatic vegetation. In the second type pumpkinseed was more abundant.

Other factors that were not investigated, such as food availability in different sites, may have a significant effect on abundance, age and size structure of pumpkinseeds (e. g. Garcia-Berthou and Moreno-Amich, 2000). Further studies have to include more different water bodies with aim to verify obtained correlations between pumpkinseed abundance and microhabitat factors as muddy bottom substrate, density of water vegetation and human activities.

The long term strategies for rehabilitation of these small lowland lakes have to include pumpkinseed removal, nest destroying and restocking with native predators and competitors. Restoration of native fish population can produce great benefits to local fishermen.

Conclusions

Dominant fish species in littoral zone of the sand-pit situated along the Lesnovska River in late spring and early summer months was pumpkinseed. The most abundant pumpkinseeds were in the sites with muddy bottom substrate, dense aquatic vegetation and no active excavation work. In the littoral zone of the pit-sand lakes predominated pumpkinseeds from 1+ and 2+ age groups with mean body length 6.4 cm?

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