Bulgarian Journal of Agricultural Science, 26 (No 1) 2020, 213–222

Morphological characteristics, growth and age structure of allochthonous fish pumpkinseed, *Lepomis gibbosus* in Bara Lake, Croatia

Momotaz Khanom[1,2*], Muhammad Abdur Rouf[1], Nazmul Ahsan[1], Noman Siddiqui[1] and Tea Tomljanović[2]

[1]*Khulna University, Fisheries and Marine Resource Technology Discipline, School of Life Science, Khulna 9208, Bangladesh*
[2]*University of Zagreb, Department for Fisheries, Beekeeping, Game management and Special Zoology, Faculty of Agriculture, 10000 Zagreb, Croatia*
[*]*Corresponding author:* momotaz_khanom@yahoo.com

Abstract

Khanom, M., Abdur Rouf, M., Ahsan, N., Siddiqui, N. & Tomljanovic, T. (2020). Morphological characteristics, growth and age structure of allochthonous fish pumpkinseed, *Lepomis gibbosus* in Bara Lake, Croatia. *Bulg. J. Agric. Sci.*, 26 (1), 213–222

The allochthonous pumpkin seed, (*Lepomis gibbosus*, L.1758) is the most abundant species (about half of the total fish abundance) in Bara Lake, Croatia. Pumpkin seeds caught by electro fishing were subjected to the determination of length-weight relationship, length-length relationship, morphometric and meristic characters, age structure and growth performance. The length-weight relationship showed a significant linear relationship (P = 0.00). Similarly, the total and standard length also showed a highly significant linear relationship ($P < 0.05$).The growth model for the individuals based on length-weight relationship was determined as $W = 0.013L^{3.14}$. Three age groups were observed (1 + to 3 +) in the age structure among which more than 60% of the fish belonged to the 2 + groups. The asymptotic length (L_∞) found in the present study was smaller (8.45cm) than those reported from other European countries. The estimated value of growth coefficient was 0.723 and overall growth performance, ǿ was 1.71derived using Von Bertalanffy growth parameters. The pumpkinseed population in the present study was characterized by higher growth and smaller age structure compared with other European pumpkinseed populations suggesting the recent invasion of pumpkinseed population in Bara Lake.

Keywords: pumpkinseed; age structure; growth coefficient; Bara Lake; Croatia
Abbreviations: TL – Total length; SL – Standard length; HL – Head length; PDL – Post dorsal length; PrDL – Pre-dorsal length; PrPL – Pre-pectoral length; PrPlL – Pre-pelvic length; PrAL – Pre-anal length; DHL – Dorsal head length; HW – Head width; HH – Head height; ED – Eye diameter; SnL – Snout length; POL – Post-orbital length; IOW – Inter orbital width; VMO – Vertical mouth; opening; HMO – Horizontal mouth opening; MA – Mouth area; S- Scale radius; L1 – Length at age 1 + ; L2 – Length at age 2 + ; L3 – Length at age 3 +

Introduction

The pumpkinseed (*Lepomis gibbosus*, L. 1758) was introduced in Europe from its native North America as a potential sport and garden fish in 19th century and today found in West and Central Europe (De Groot, 1985; Welcomme, 1992). It was transferred to the European part of Russia in 1948, where it was quickly adapted and spread to eastern and central waters of Europe (Holopainen et al., 1997). The first written source about its appearance in former Yugoslavia was recorded by Plančić (1967) describing the fish fauna in Ečka ponds in 1962. The spreading of this species was recorded in delta of Danube River in 1949 at the rate of distribution of 30 km/year (Kozlov, 1993; Fedonenko & Marenkov, 2013). It is one of the most abundant fishes in shallow water bodies and considered alone of the most successful introduced species in Europe, probably due to its predatory behavior and reproductive strategy (Uzunova & Zlatanova, 2007). The pumpkinseed has been studied in its natural geographic range (Werner & Hall, 1979; Collins, 1989), but little is known about its biology outside its natural distribution (Uzunova et al., 2008).It is more highly adapted to complex maneuvering in lentic environments than to swimming in a current (Webb, 1998). Age, growth and morphology of the pumpkinseed have been studied in the lower Danube, Hungary (Papadopol & Ignat, 1967), Italy (Tandon, 1977) and Camargue (Crivelli & Mestre, 1988). Recent studies on the biology of invasive fishes has now addressed the adaptations in life history traits of non-native fishes in their new environments (Fausch et al., 2001; Copp et al., 2004; Vila-Gispert et al., 2005; Copp & Fox 2007; Ribeiro et al., 2008). However, a progressive elimination of indigenous species can be occurred with an enhancement of pumpkinseed population in Europe causing the adverse changes in biocenoses (Almeida et al., 2014, Godinho, 2004). The adverse ecological impacts of invading species of pumpkinseed has also been reported in several countries as these species may feed on small fish, fish eggs and other vertebrates (Berg, 1965; Scott and Crossman, 1973; Billard, 1997). In addition, it is important to mention that the presence of pumpkinseed negatively affects native fish populations of the River Sava (Bakota et al., 2003). Considering the stable tendency of increasing the distribution and abundance of other populations of pumpkinseed in Europe, expansion of this species in different shallow water bodies in Croatia is likely.

Morphometric parameters of a fish species has major role to ensure whether there is any disparity between the same species of different geographic regions (Naeem et al., 2012). Length-weight relationship, as a tool for fish conservation, provides information on the condition, growth pattern, ontogenic changes in fish population dynamics (Oscozet al., 2005; Simon et al., 2009). This relationship is also useful to estimate stock biomass from limited sample sizes (Binohlan & Pauly, 1998; Valle et al., 2003; Ecoutin et al., 2005; Simon et al., 2009). The relationships between mouth and body size quantify prey-size based feeding patterns (Karachle & Stergiou, 2012), definethe ecological position of organism within food web and are used for fisheries management to select bait size (Erzini et al., 1997; Karpouzi & Stergiou, 2003). A very little attention has been paid to the growth, age structure and morphological characters of newly introduced pumpkinseed in Croatia. The biology of invasive species are more imperative in order to pathway their performance in anew ecosystems. Therefore, the aim of the present study for the first time is to provide morphometric and meristic measures, age-structure and growth performance of the pumpkinseed, *L. gibbosus* population in Bara Lake located in the continental part of Croatia in the Sava River basin. This information may serve as useful biological data for future management of this fishery resource.

Materials and Methods

Study area and sample collection

Specimens were collected during October, 2015by electrofishing from the Bara Lake having eutrophic character, muddy bottom and surrounded by low aquatic vegetation. The Bara Lake is located within the administrative boundaries of the town of Kutina (Sisak-Moslavina County) in the fishing area of Sava River. Total area of Bara Lake is about 0.75 ha with depth varying from 0.5 to 5 m. The bottom of this lake is muddy except few sandy parts in the left side with gentle slope and low depth. The physico-chemical parameters of Bara Lake are shown in Table 1.

A total of nine species were recorded in this lake among which 55% are non-native species and 45% native species. The most abundant species was pumpkinseed in this lake constituting 50.7% of the total fish abundance. Pumkinseed coexisted with five autochthonous species: European perch (*Perca fluvialitis*), Freshwater bream (*Abrami brama*), Roach (*Rutilus rutilus*), Ray-finned fish (*Alburnus arborella*), Ide (*Leucis cusidus*) and Northern pike (*Esox lucius*) and two allochthonous (introduced) species: Pikeperch (*Sander Lucioperca*) and Stone moroko (*Pseudorasbora perva*).

Table 1. Physico-chemical parameters of Bara Lake

Parameters	Values	Parameters	Values
Temperature (°C)	13.80	NO_3^- (mg/l)	0.00
O_2 (mg/L)	9.00	$CaCO_3$ (mg/l)	0.00
Conductivity (µS/cm)	35.20	Ammonia MR (mg/l)	
pH	7.80	NH_3-N	0.00
Free chlorine (mg/l)	0.12	NH_3	0.00
Nitrite LR (NO_2^-) (mg/l)	0.08	Phosphate LR (mg/l)	
Nitrite LR (NO_2^- – N) (mg/l)	0.02	PO_4^{3-}	0.27
Nitrate (NO_3^- – N) (mg/l)	0.00	P	0.09

Data collection and analysis

Morphometric and meristic characteristics

The collected specimens were immediately transported to the laboratory of Department for Fisheries, Beekeeping, Game management and Special Zoology, Faculty of Agriculture, University of Zagreb, Croatia with ice and kept in frozen condition after measuring length and weight. All the specimens were defrosted before further laboratory analyses. The length of different body parts of all specimens were measured to the nearest 0.01 mm using measuring board and digital slide caliper (absolute digimatic digital calipers, Mitutoyo, Japan) and weighed to 0.01 g accuracy (wet weight) with RADWAG Wagi electronic balance (Model-PS 750. R1). All meristic characters (fin rays and scales and gill rackers) were counted using a stereo microscope (Stemi DV4/DR, Zeiss, Oberkochen, Germany). Several morphometric measures such as total length (*TL),*standard length (*SL*),and fork length (*FL*) were estimated for determining the growth of different body parts of the fish and compared with the head length and total length of the body as percentage (Hile, 1948). Fork length (*FL*) was calculated from standard length using conversion factor (Carlander, 1977):

$$SL = 1.04FL/1.25.$$

For all individuals the vertical (*VMO*) and horizontal (*HMO*) mouth openings were measured to the nearest 0.01 mm to determine mouth area (*MA*) using the following formula (Erzinietal, 1997; Karpouzi & Stergiou, 2003):

$$MA = 0.25\pi \times (VMO \times HMO).$$

Length-weight and length-length relationship

The relationships between lengths of different body parts of the fish were derived using linear regression. The data were subjected to statistical analysis by fitting length-weight relationship following Le Cren (1951) and the growth model was expressed as

$$W = aLb,$$

where W = weight in gm, L = length in cm, a = a constant being the initial growth index, and b = growth coefficient.

Age determination and growth performance

Five to six well-developed scales were removed from the body portion in between the lateral line and dorsal fin of each specimen. The scales were then cleaned and compressed with two glass slide s for age determination. The number of completely developed annual rings (annuli) was counted and both the scale radius (*S*) from the focus to the end of the scale and annual increments (from the focus to the annuli) were measured from photographs taken by Dino-Lite Digital Microscope PR0 with magnification- 10x~50x, 200x (AM413T). The relationship between total length (*TL*) and scale radius (*S*) was calculated by the linear regression:

$$TL = a + bS.$$

Back-calculated lengths at each year with growth marks were estimated using the Fraser-Lee equation (Francis, 1990):

$$Li = a + (TL-a) \times (Si/S),$$

where Li is the total length of the individual at growth mark i, TL is the total length at time of capture, Si is the length between scale focus to growth mark i, S is scale radius and a is the intercept on length axis of the linear regression between TL and S.

Overall growth performance index (ǿ) was interpreted by the growth index (Munro & Pauly, 1983):

$$ǿ = \log(K) + 2\log(L_\infty),$$

which is derived using von Bertalanffy parameters where K is the rate at which ultimate length, L_∞ is approached.

Statistical analysis

Regression coefficient, coefficient of determination, power curve relation and significance test(at 5% significance level) was estimated following MS Excel program.

Result

Morphometric and meristic measures

The pumpkinseed is a deep-bodied species with a very small mouth. The head is large occupying about one fourth of the total body length. The dorsal fin is long, unbranched and fused with 10 spiny and 10-12 soft rays elongated from the operculum to the frontal caudal peduncle. The pelvic fin is comprised of one spine and five soft rays and anal fin has three spine and 9-12 soft rays. The long pectoral and caudal fin comprised of 10-14 and 18-20 fin rays respectively. The length and depth of caudal peduncle are 4-9.5 mm and 6.5-16 mm respectively. There are 31-39 scales in a lateral line with 5 scales above- and 10-12 scales below lateral line. The length of first gill arch (left side, out part) was found as 7-12 mm with 7-10 gill rakers (Table 4).

The mean length and weight of the pumpkinseeds were found as6.61±1.14cm and5.23±2.51 gm respectively in Bara Lake. The standard length, head length, post dorsal length, pre-dorsal length, pre-pectoral length, pre-pelvic length, pre-anal length were found as 76.95%, 28.39%, 17.80%, 31.83%, 26.36%, 31.80% and 60.15% of the total length of the fish respectively (Figure 1a). Moreover, dorsal head length, head width, head height, eye diameter, snout length, post-orbital length, and inter orbital width were found as 51.79%, 42.22%,

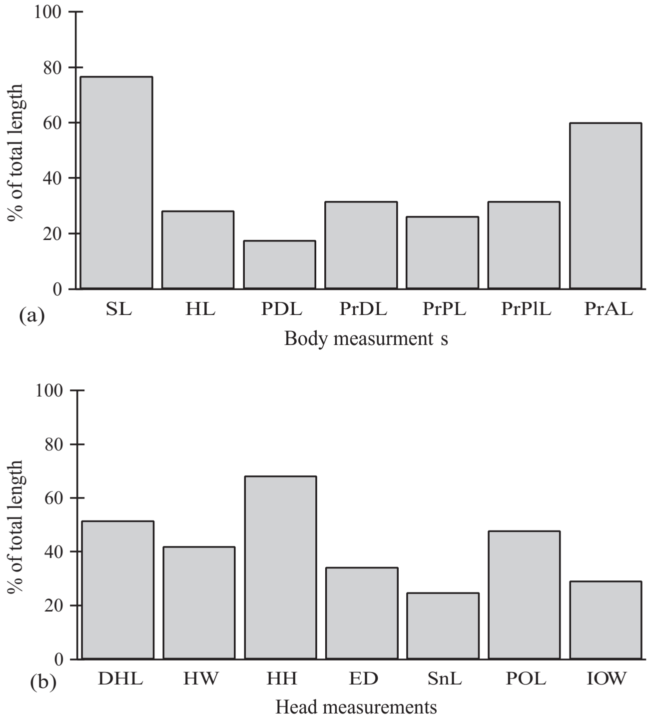

Figure 1. Morphometric measures of pumpkinseed in relation to the *a*) total length and *b*) head length of the fish in percentage

68.36%, 34.48%, 25.00%, 47.97% and 29.33% in relation to the head length of the fish respectively (Figure 1b).

Relationship between length-weight and different body parts

Relationship between mouth area and total length

The mouth area was ranged from 0.18 to 0.77 cm^2 with the mean of 0.46 cm^2 and were exponentially related to the total length ($MA = 0.040e^{0.356TL}$; $r^2 = 0.855$) for pumpkinseed (Figure 2).

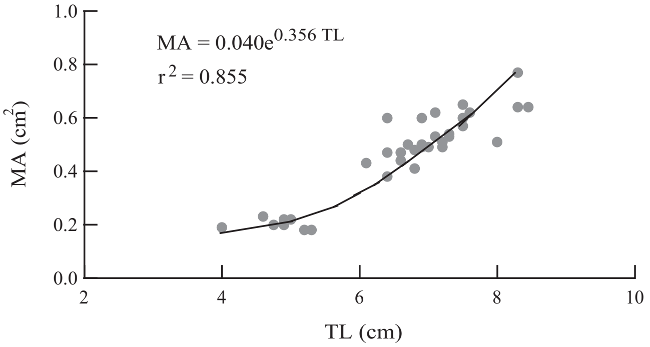

Figure 2. Relationship between the total length (*TL*) and mouth area (*MA*)

Length-weight and length-length relationship

The regression equation of length-weight relationship was estimated as Log $W = 3.138$ Log $TL - 4.366$ and $r^2 = 0.991$ (Figure 3). The obtained linear relationship between length and weight was highly significant ($P = 0.00$). However, the growth model for this species based on length-weight relationship was determined as $W = 0.013L^{3.14}$ with $r^2 = 0.991$ (Figure 4) following hypothetical lengths.

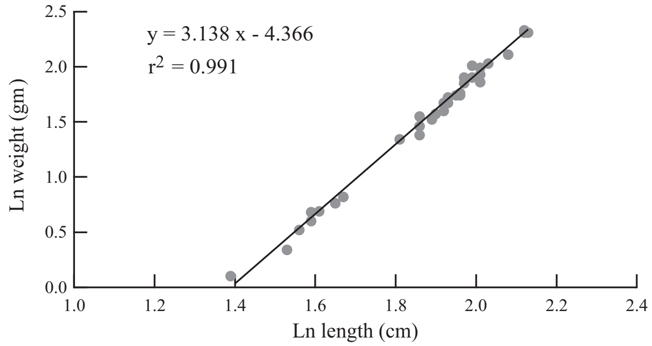

Figure 3. Logarithmic relationship between the length and weight

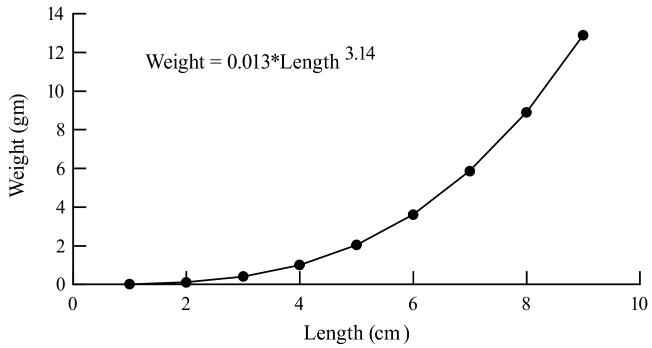

Figure 4. Power curve relationship between the length and weight

Regression equation of length-length relationship between the total length and standard length, the total length and fork length, the standard length and fork length as well as the total length and head length was found as $SL = 0.772TL + 0.010$; $r^2 = 0.991$ (P = 0.03), $FL = 0.928TL + 0.012$; $r^2 = 0.991$(P = 0.00), $SL = 0.832FL + 9E\text{-}14$; $r^2 = 1$(P = 0.00) and $HL = 0.292TL\text{-}0.053$; $r^2 = 0.926$ (P = 0.00), respectively. Highly significant linear relationships ($P < 0.05$) between the above mentioned measurements were observed in this study. Determination coefficients (r^2) of the length-length relationships of pumpkinseed in the present study were ranged between 0.991 and 1, which indicate a good match between the data points (Figures 5 – 8).

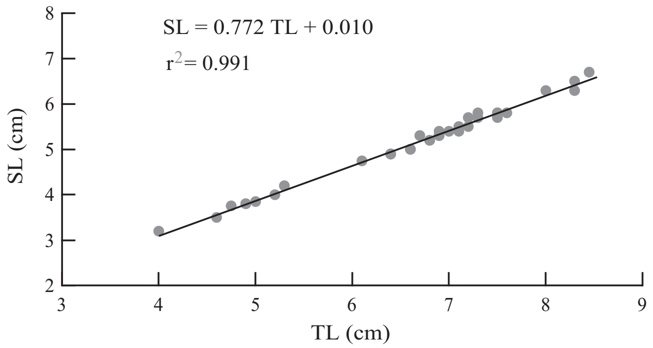

Figure 5. Relationship between total length (*TL*) and standard length (*SL*)

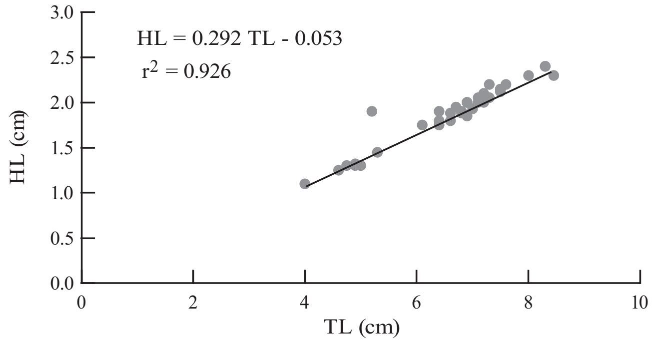

Figure 8. Relationship between total length (*TL*) and head length (*HL*)

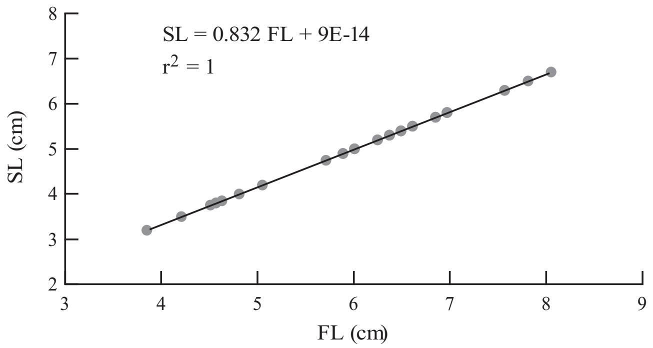

Figure 6. Relationship between fork length (*FL*) and standard length (*SL*)

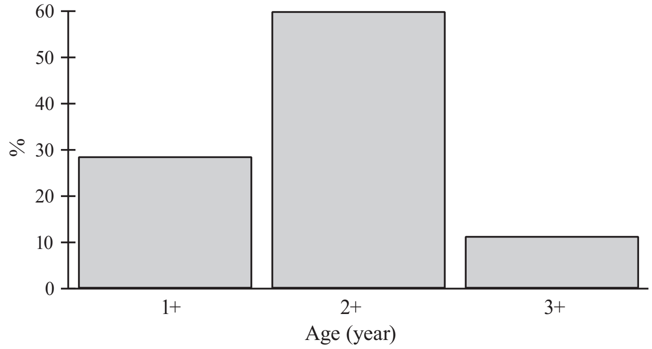

Figure 9. Age distribution of pumpkinseed in Bara Lake

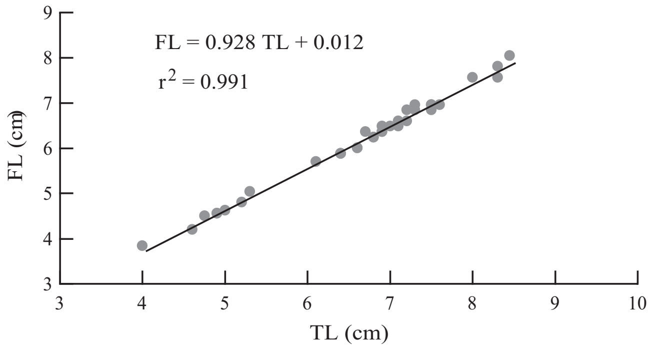

Figure 7. Relationship between total length (*TL*) and fork length (*FL*)

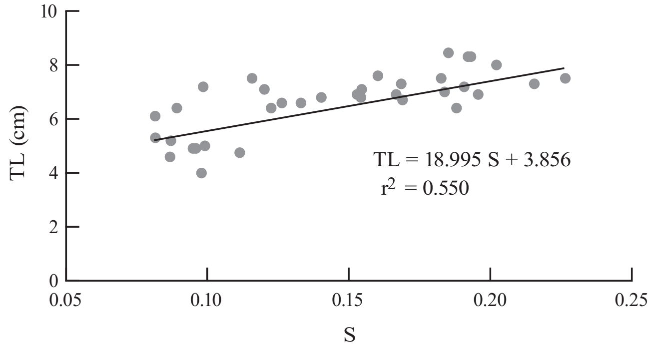

Figure 10. Relationship between total length (*TL*) and scale radius (*S*)

Table 2. Length and weight at age of pumpkinseed in Bara Lake

Age Group	$Length_{Mean}$ (cm)	$Length_{max}$ (cm)	$Length_{min}$ (cm)	$Weight_{mean}$ (g)	$Weight_{max}$ (g)	$Weight_{min}$ (g)
1 +	5.35±0.91	7.20	4.0	2.74±1.72	6.70	1.10
2 +	7.01±0.74	8.45	4.9	5. 90±1.92	10.25	1.83
3 +	7.73±0.39	8.30	7.5	7.98±1.46	10.12	6.90

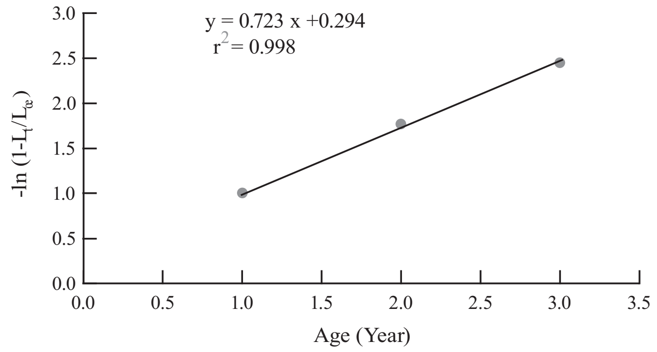

Figure 11. Relationship between –ln(1-L_t/ L_∞) against the age

Table 3. Mean back-calculated total length (cm) at each year

Mean back-calculated total length (cm) at each year:			
Age at capture	L1	L2	L3
1 +	4.79		
2 +	5.18	5.93	
3 +	5.51	6.13	6.74
Mean	5.16	6.03	6.74
Annual growth increments	5.16	0.87	0.71
Observed length (cm) at age (year)	1 +	2 +	3 +
Mean	5.35	7.01	7.73
Annual growth increments	5.35	1.66	0.72

Age structure and growth

The collected individuals were grouped into three age groups: 1 +, 2 + and 3 +. The dominant age group was two years' old (2 +) fish in the catches accounting for 60%whereas the least in number at the oldest age group 3 + in the investigated lake (Figure 9). The maximum length and weight of the individual were estimated as8.45cm and 10.25 g respectively at age group 2 + though the highest mean length and mean weight was found at the age group 3 + (Table2).

The scale radius (S) was linearly related to total length for pumpkinseed and the regression equation was $TL = 18.995S + 3.856$ ($r^2 = 0.55$) and are shown in Figure 10.

The intercept of the regression was used to back calculation of length at age of each year (Table 3). The highest growth rate in length (5.16 cm) was obtained in the first year of life and decreased in the subsequent years. The oldest age group of the individuals were revealed 3 + in the investigated lake with lowest growth rate (mean back-calculated value = 0.71 cm and observed value = 0.72 cm) (Table 3).

There were no significant differences between the mean back-calculated and observed length at any group (P = 0.3619). The value of growth coefficient, K is 0.723 and the theoretical age at length, t_0(-0.407yr) were derived from the Von Bertalanffy plot (Figure 11).

Discussion

The total length of the pumpkinseed found in the Sava River was recorded as 5.95±24.44 cm (Sumer et al., 2005). According to McAllister and Coad (1974), the dorsal fin of pumpkinseed has 9 or 10 spines and 11-13 soft rays and the anal fin has 3 spines and 10-12 soft rays that support the present study. Erk'akan (1983) depicted specimens of the pumpkinseed fish from the Ipsala drainage canals in Edirne with 10 spines and 11-12 soft rays in dorsal fin and 33-36 scales on a lateral line (Table 4).

Jakovlic & Treer (2001) estimated morphometric traits of pumpkinseed populations from gravel–pit Vukovina in Croatia with standard length 81%, fork length 95%, head length 26% of total length and eye diameter 33% of head length which is consistent with those of the present investigation. While stream pumpkinseed pectoral fins were longer than those of Lake Pumpkinseed, in most other cases the length and width of the fins was greater in the lake fish. Anal and dorsal fin heights were greater in lake fishes of both species, and all fin sizes (pectoral, pelvic, anal and dorsal) were larger in the lake dwelling rock bass (Brinsmead & Fox, 2002). Mouth areas were highly exponentially significant related to total length that agrees the findings on this species of Bobori et al. (2006). Mouth morphology plays an important role in foraging ability, resource exploitation and consequently on fish diet (Stergiou & Fourtouni, 1991; Labropoulou & Markakis, 1998; Karpouzi & Stergiou, 2003).

Fish are said to be isometric growth when length increases in equal proportions with body weight for constant specific gravity. Regression co-efficient for isometric growth is '3' and the values greater or lesser than '3' indicate allometric growth. The growth co-efficient (3.14) of the present study derived from regression equation of length-weight relationship is higher than the theoretical value of 3 which indicates that pumpkinseed of Bara Lake tends to become relatively fatter or have more girth as it grows longer and shows allometric growth. Therefore, it can be said that the surrounding environment is suitable for better growth of this species. Similar positive allometric growth obtained by Domagala & Kondratowicz (2006); Uzunova et al. (2008); Giapis (2003) supports that of the present study. However, a variation in slope(b) may occur due to species variation, difference in environmental factors, sex variation etc (Joadder, 2009).The asymptotic length (8.45cm) obtained in the present study was less compared to the mean value of this parameter established in other European populations and native ranges of North America (Copp et al., 2002; Tandon, 1977)most probably due to short lived pumpkinseed observed in Bara lake. Indeed, the rate at which L_∞ is reached is slower for long lived species and higher for short lived species (Wootton, 1998). However, the estimated K value was higher most likely as a consequence of establishing the juvenile stage, age 2 + and short samples of the population in Bara lakethan that reported for other introduced populations for pumpkinseed

Table 4. Some morphometric and meristic measures of pumpkinseed in Bara Lake

Measure or count	Value of present study Mean ± SD	Ranges	Reference value	References
Total length (cm)	6.61±1.14	4.0–8.45	11.70; 5.95	Sasi & Balik, 2003 Sava river (Sumer et al., 2005)
Standard length (cm)	5.11±0.88	3.2–6.7	9.60; 5.09–13.77	Sasi & Balik, 2003; Brinsmead & Fox, 2002
Length of dorsal fin (mm)	10.77±1.81	7–14	–	–
Dorsal fin base length (mm)	22.43±4.78	13.5–31	38·9–40	Brinsmead & Fox, 2002
Pectoral fin length (mm)	16.39±3.21	9–21.5	23.2–27·19	Brinsmead & Fox, 2002
Length of pelvic fin (mm)	12.32±2.24	7–15.5	15·60–17·78	Brinsmead & Fox, 2002
Length of anal fin (mm)	12.50±2.32	8–16.5	13·16–15·85	Brinsmead & Fox, 2002
Anal fin base length(mm)	10.41±2.15	7–14.7	17·71	Brinsmead & Fox, 2002
Caudal fin length (mm)	14.77±2.74	8–20	–	
Depth of caudal peduncle (mm)	6.99±1.45	4–9.5	10·53	Brinsmead & Fox, 2002
Length of caudal peduncle (mm)	11.97±2.28	6.5–16	–	
Dorsal fin rays*	X 11	X 10–12	X 11 X 12	Sasi & Balik, 2003; McAllister & Coad, 1974
Anal fin rays*	III 10	III 9–12	III 10 III 11	Sasi & Balik, 2003; McAllister & Coad, 1974
Pectoral fin rays	12±0.94	10–14	–	–
Caudal fin rays	19±0.40	18–20	–	–
Pelvic fin rays	I 5	I 5	–	–
Scales on Lateral Line	35.34±1.79	31–39	49 35–44	Sasi & Balik, 2003 McAllister & Coad,1974
Scales above Lateral Line	4.09±0.31	4–5	–	–
Scales below Lateral Line	11.34±0.62	10–12	–	–
MA (cm^2)	0.46	0.18–0.77	0.24–0.92	Bobori et al., 2006
Length of the first gill arch (mm)	10.5±1.45	7–12	–	–
Number of gill rakers (left side, outpart)	7.9±0.89	7–10	–	–

*Roman numbers and numerals indicate numbers of spiny and soft fin rays respectively

Table 5. Growth parameter (L_∞: asymptotic length, cm; K: growth coefficient, yr-1; t_0: hypothetical age at zero length, yr; t_{max}: maximum recorded age, yr; ǿ: overall growth index) estimates for pumpkinseed from Bara lake and other European and North American Lake/reservoirs

Lake/reservoirs	Sex **	L_∞(cm)	K(yr^{-1})	t_0(yr)	t_{max}(yr)	ǿ	Reference
Kerkini reservoir*	C	19.4	0.152	-0.52	8	1.76	Giapis (2003)
Kerkini reservoir*	M	26.7	0.088	-1.04	7	1.80	Giapis (2003)
Kerkini reservoir*	F	19.9	0.133	-0.76	8	1.72	Giapis (2003)
Tavropos reservoir*	C	11.9	0.506	-1.67	3	1.85	Bobori, et al. (2006)
European populations	C	12.8(SL)	0.265	-	8	3.64	Copp et al. (2004)
North American Populations (Native)	C	16.86 (SL)	0.232	-	10	3.82	Copp et al. (2004)
Bara lake	C	8.45	0.723	-0.41	3	1.71	Present study

* Located in Greece

** M – Male; F – Female and C – Combined sex in Europe and native North America (Copp et al., 2004) although overall growth performance, ǿ was approximately similar to that of individuals of some reservoirs in Greece and lower than native populations (Table 5).

The pumpkinseed found in Bara lake is short-lived species with a typical high growth rate in the first years of life that agrees the findings of Carlander (1977) and Copp et al. (2002) (Table 3). Adult growth rates and asymptotic length (L_∞) of introduced European populations, relative to native North American populations, may be lower due to the result of higher reproductive effort associated with the colonization of new ecosystems (MacArthur & Wilson, 1967).

Copp et al. (2004) reviewed some information on growth of pumpkinseed in its native North American and introduced European ranges to compare somatic growth. He found the lowest (3.7 cm) SL at age 2 in Cottesmore Pond (England) in introduced European ranges and highest (10.4cm) in water bodies of Delware, USA of its Native American ranges for juvenile growth rate. He reported that the growth rate among distant populations may significantly differ and found that the adult growth rate was faster in North American (native) populations than that of European ones (introduced).

The maximum reported age (10 yr) for the species was observed from the native water bodies such as Pennsylvania, USA (Carlander, 1977) and8 yr of age in introduced regions such as Kerkini reservoir in Greece (Giapis, 2003) and Divor reservoir in Portugal (Brabrand & Saltveit, 1989). In contrast, short lifespan was reported for several pumpkinseed populations from different type of water bodies and geographical latitudes to reach3yr in Western Greece (Bobori et al., 2006) as similar to that of the present study;4yrin Bulgaria (Uzunova et al., 2008) and 5yr in Poland (Domagala et al., 2016). In the findings of Bobori et al. (2006) the three age classes of the pumpkinseed found from Tavropos reservoir and other areas of their Greek distribution had almost equal number of individual which corroborates the present study. The back-calculated lengths of pumpkinseed reported as 8.7 cm, 10.0 cm and 10.7cm for first, second and third year for Tavropos reservoir (western Greece) by Bobori et al. (2006) was higher than those of the present study. Similar higher back-calculated lengths were reported by Neophitou & Giapis (1994) for Odra River (Poland) and Kerkini Reservoir (Greece). Opposite scenario ie.,lower back calculated lengths were reported for Tapada Pequena Reservoir (Portugal) by Godinho & Ferreira (1996) compared to the results of the present study. However, annual growth pumpkinseed populations in Bara Lake were approximately similar to the findings obtained by Gutikrrez-Estrada et al. (2000).

Individuals of younger age groups (1 + and 2 +) prevailed among caught fishreported for the waters of Spain(-Gutierrez-Estrada et al., 2000), England (Villeneuve et al., 2005), Bulgaria (Uzunova et al., 2008), and Czech Republic (Konečná et al., 2015) that agreed with prevalence of age group 2 + in the investigated lake of the present study.

Conclusion

The small number of age groups attendant with small size of pumpkinseed indicates that these are recently invaded population in Bara Lake considering the early stages (2 + age group) of population establishment. Relatively higher growth coefficient as well as positive allometric growth of pumpkinseed in this lake compared to other introduced and native regions indicates expressive abilities of adaptation, resistance and reproduction of the species in the new environment. However, data on allochthonous pumpkinseed is limited to few populations in water bodies of Croatia, so further study and monitoring is frequently required to investigate their distribution, growth, reproduction and ultimately impact assessment on aboriginal species in ecosystems.

Acknowledgements
The financial support provided by EXPERTS SUSTAIN Consortium-Erasmus Mundus Action 2 for this study is greatly acknowledged. We thanks also Marina Piria and Daniel Matulićfor their invaluable field and laboratory assistance.

References

Almeida, D., Vilizzi, L. and Copp, G. H. (2014). Interspecific aggressive behavior of invasive pumpkinseed *Lepomis gibbosus* in Iberian fresh waters. *PLoSONE, 9(2)*: e88038, doi:10.1371/journal.pone.0088038.

Bakota, R., Treer, T., Odak, T., Mrakovčić, M. & Ćaleta**, M.** (2003). Structure and condition of ichthyofauna in Lonjsko polje. *Ribarstvo*, *61(1)*, 17-26.

Berg, L. S. (1965). Freshwater Fishes of the USSR and Adjacent Countries. *3,* 4th Edition, Israel Program for Scientific Translations Ltd., Jerusalem.

Billard, R. (1997). Les Poissons d'eau Dauce des Rivieres de France, Identification, Invertaire et Repartition des 83 Especes. Laboratoired'Ichthyologie Generale et Appliquee et le Service du Patrimoine Naturel de l'Institute d'Ecologie et de Gestion de la Biodiversite, Museum National d'Histoire Naturelle.

Binohlan, C. & Pauly, D. (1998). The length-weight table. In: Froese R., Pauly D.(eds) *Concepts, design and data sources*, Fishbase. ICLARM, Manila, Philippines, 293.

Bobori, D. C., Athanassios, C., Nikolaos, T. & Economidis, I. (2006). Some morphological and biological characteristics of fishes from Tavropos reservoir (Western Greece). *Folia Zool.*, *55(2*): 199–210.

Brabrand, Å. & Saltveit, S. J. (1989). Ecological aspects of the fish fauna in three Portuguese reservoirs. *Arch. Hydrobiol.*, *114,* 575–589.

Brinsmead, J. & Fox, M. G. (2002). Morphological variation between lake- and stream-dwelling rock bass and pumpkinseed populations. *J. Fish Biol.*, *61,* 1619–1638.

Carlander, K. D. (1977). Handbook of freshwater biology. *The Iowa State Press, Ames., 2*, 5–63.

Collins, N. C. (1989). Daytime exposure to fish predation for littoral benthic organisms in unproductive lake. *Can. J. Fish. Aquat. Sci., 46(1),* 11-15.

Copp G. H. & Fox, **M. G.** (2007). Growth and life history traits of introduced pumpkinseed (*Lepomis gibbosus*) in Europe, and the relevance to invasiveness potential. In: Gherardi, F. (ed) *Freshwater bioinvaders: profiles, distribution, and threats.* Springer, Berlin, 289–306.

Copp, G. H., Fox, M. G. & Kováč, V. (2002). Growth, morphology and life history traits of a cool water European population of pumpkinseed. *Lepomis gibbosus*. *Archiv fur Hydrobiol., 155*, 585-614.

Copp G. H., Fox, M. G., Przybylski, M., Godinho, F. N. & Vila-Gispert, A. (2004). Life-time growth patterns of pumpkinseed *Lepomis gibbosus* introduced to Europe, relative to native North American populations. *Folia Zool.*, *53,* 237–254.

Crivelli, A. J. & Mestre, D. (1988). Life history traits of pumpkinseed, *Lepomis gibbosus,* introduced into the Camargue, a Mediterranean wetland. *Arch. Hydrobiol., 111(3),* 449-466.

De Groot, S. J. (1985). Introductions of non-indigenous fish species for release and culture in the Netherlands. *Aquaculture, 46*, 237 – 257

Domagała, J. & Kondratowicz, A. (2006). Environmental conditions of waters of cold and warm canals of "Dolna Odra" Power Station in the second half of the nineties*. Rocznik Ochrona Środowiska, 22*: 355-360.

Domagała, J., Czerniejewski, P. & Pilecka-Rapacz, M. (2016). Growth rate, age and size structure of the alien pumpkinseed, *Lepomisgibbosus* (L., 1758) population from a heated-water discharge canal of a power plant in the lower stretch of the Oder River, Poland. *Ann. Set The Environ. Protect., 18,* 273-290.

Ecoutin, J. M., Albaret, J. J. & Trape, S. (2005). Length-weight relationships for fish populations of a relatively undisturbed tropical estuary: The Gambia. *Fish. Res.*, *72,* 347–351.

Erk'akan, F. (1983). The fishes of Thrace Region. *Hacettepe Bulletin of Natur. Sci. and Engi., 12,* 39-48.

Erzini, K., Gonçalves, J. M. S., Bentes, L. & Lino, P. G. (1997). Fish mouth dimensions and size selectivity in a Portuguese longline fishery. *Journal of Applied Ichthyology*, *13,* 41-44.

Fausch, K. D., Taniguchi, Y. & Nakano, S. (2001). Flood disturbance regimes influence rainbow trout invasion success among five Holarctic regions. *Ecol Appl.*, *11,* 1438–1455.

Fedonenko, E. V. & Marenkov, **O. N.** (2013). Spreading, spatial distribution, and morphometric characteristics of the pumpkinseed sunfish *Lepomis gibbosus* (Centrarchidae, Perciformes) in the Zaporozhye Reservoir. *Russian Journal of Biological Invasions*, *4(3),* 194–199.

Francis, R. I. C. C. (1990). Back-calculation of fish length: a critical review. *J. Fish Biol., 36: 883–902*.

Giapis, A. J. (2003). Ecology of the *Lepomis gibbosus* L. in Kerkini lake. Doctoral dissertation|, School of Forestry and Natural Environment, Aristotle University of Thessaloniki.

Godinho, F. N. (2004). The ecology of largemouth bass *Micropterus salmoides*, and pumpkinseed sunfish *Lepomis gibbosus*, in the lower Guadiana basi: the environmental mediation of biotic interactions. Universidad Téchnica de Lisboa, Portugal. *Journal of Fish Biol., 57, 29–40.*

Godinho, F. N. & Ferreira, M. T. (1996). The application of size-structure indices to *Micropterus salmoides* (Lacépède, 1802) and *Lepomis gibbosus* L., 1758 populations as a management tool for southern Iberian reservoirs. *Publ. Espec. Inst. Esp. Oceanogr. 21: 275–281.*

Gutierrez-Estrada, J. C., Pulido-Calvo, I. & Fernandez-Delgado, C. (2000). Age-structure, growth and reproduction of the introduced pumpkinseed *(Lepomis gibbossus* L., 1758*)* in a tributary of the Guadalquivir River (Southern Spain). *Limnetica, 19,* 21-29.

Hile, R. (1948). Standardization of methods of expressing lengths and weights of fish. *Transactions of the American Fisheries Society*, *75(1),* 157-164.

Holopainen, I. J., Tonn, W. M. & Paszkowski, C. A. (1997). Tales of two fish: the dichotomus biology of crucian carp (*Carassius carasius*) in northern Europe. *Annales Zoologica Fennici, 34,* 1-22.

Jakovlić, I. & Treer, T. (2001). Structure, growth and morphology of fish populations from gravel-pit Vukovina. *Ribarstvo*, 59 (4), 142-149.

Joadder, A. R. (2009). Length-weight relationship and condition factor (Kn) of Gobi, *Glossogobius giuris* (Hamilton) from "Atrai River" in the northern part of Bangladesh. *J. Fish. Int*., *4(1),* 1-4.

Karachle, P. K. & Stergiou, K. I. (2012). Morphometrics and Allometry in Fishes, Morphometrics. In: Christina Wahl (ed.), ISBN: 978-953-51-0172-7, InTech, 65-86.

Karpouzi, V. S. & Stergiou, K. I. (2003). The relationships between mouth size and shape and body length for 18 species of marine fishes and their trophic implications. *J. Fish Biol., 62,* 1353–1365.

Konečná, M., Janáč, M., Roche, K. & Jurajda, P. (2015). Variation in life-history traits between a newly established and long-established population of non-native pumpkinseed, *Lepomis gibbosus* (*Actinopterygii: Perciformes: Centrarchidae*). *Acta Ichthyologica et Piscatoria, 4,* 385-392.

Kozlov, V. I. (1993). Ecological forecasting of freshwater ichthyofauna in Ponto Caspian Region, Moscow: Vseross. Nauchno Issled. Inst. Ryb. Ozer. Khoz.

Labropoulou, M. & Markakis, G. (1998). Morphological-dietary relationships within two assemblages of marine demersal fishes. *Envir. Biol. Fish., 51*, 309–319.

Le Cren E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol., 20,* 201–219.

Macarthur, R. H. & Wilson, E. O. (1967). Theory of island biogeography. Princeton University Press, Princeton, 203.

McAllister, D. E. & Coad, B. W. (1974). Fishes of Canada's National Capital Region, Fisheries Research Board, Ottawa. *Spe-*

cial Publication, 24, 144-145.

Munro, J. L. & Pauly, D. (1983). A simple method for comparing the growth of fishes and invertebrates. *Fishbyte, 1(1),* 5-6.

Naeem, S., Duffy, J.E. & Zavaleta, E. (2012). The functions of biological diversity in an age of extinction. *Science*, *336(6087).* 1401-6. doi: 10.1126/science.1215855

Ndome, C. B., Eteng, A. O. & Ekanem, A. P. (2012). Length-weight relationship and condition factor of the smooth mouth marine catfish (*Carlarius heudelotii*) in the gulf of Guinea, Niger delta, Nigeria. *AACL Bioflux*., *5(3),*163-167.

Neophitou, C. & Giapis, A. J. (1994). A study of the biology of pumpkinseed (*Lepomis gibbosus* L.) in lake Kerkini (Greece). *Jour. Appl. Ichthyol., 10,* 123-133.

Oscoz, J., Campos, F. & Escala, M. C. (2005). Weight–length relationships of some fish species of the Iberian Peninsula. *J. Appl. Ichthyol*., 21: 73-74.

Özaydin**, O. and E. Taskavak,** 2007. Length-weight relationships for 47 fish species from Izmir Bay (Eastern Agean Sea, Turkey). *Acta Adriat., 47(2),* 211-216.

Papadopol, M. & Ignat, G. H. (1967). Contribution to the study of reproductive biology and growth of the American sunfish *(Lepomis gibbosus* in the Lower Danube). *Bul. Inst. Cerc. Project. Pisc.*, *26,* 55-68.

Plančić, J. (1967). Prussian carp – *Carassius auratus gibelio* a new species of our ichthyofauna. *Ribarstvo Jugoslavije,* 22.

Ribeiro, F., Elvira, B. & Collares-Pereira, M. J. (2008). Lifehistory traits of non-native fishes in Iberian watersheds across several invasion stages: a first approach. *Biol. Invasions*., *10,* 89–102.

Sasi, H. & Balik, S. (2003). The distribution of three exotic fishes in Anatolia. *Turk J. Zool., 27,* 319-322.

Scott, W. B. & Crossman, E. J. (1973). Freshwater Fishes of Canada, Bull. Fish Research Board, 184.

Simon, K. D. & Mazlan, A. G. (2008). Length-weight and length-length relationships of archer and puffer fish species. *The Open Fish Sci. J.*, *1,* 19-22.

Simon, K. D., Bakar, Y., Samat, A., Zaidi, C. C., Aziz, A. & Mazlan, A. G. (2009). Population growth, trophic level, and reproductive biology of two congeneric archer fishes (*Toxotes chatareus*, Hamilton, 1822 and *Toxotes jaculatrix*, Pallas, 1767) inhabiting Malaysian coastal waters. *J. Zhejiang Univ-Sci. B (Biomed and Biotechnol). 10(12),* 902-911.

Stergiou, K. I. & Fourtouni, H. (1991). Food habits, ontogenetic diet shift and selectivity in *Zeus faber* Linnaeus, 1758. *J. Fish Biol.*, *39,* 589–603.

Sumer, S., Kovac, V., Povz, M. & Slatner, M. (2005). Externalmorphology of a Slovenian population of pumpkinseed *Lepomis gibbosus* (L.) from a habitat with extreme thermal conditions. *J. Appl. Ichthyol*., *21,* 306–311.

Tandon, K. K. (1977). Age and growth of pumpkinseed (*Lepomis gibbosus* (*Perciforms, Centrarhidae*)) from Hungary. *Vestn. Ceskosl. Spolect. Zool*., *16,* 74-79.

Uzunova, E. & Zlatanova, S. (2007). A review of the fish introductions in Bulgarian freshwaters. *Acta Ichthyologica et Piscatoria*., *37,* 55-61.

Uzunova, E., Velkov, B., Studenkov, S., Georgieva, M., Nikolova, M., Pehlivanov, L. & Parvanov, D. (2008). Growth, age and size structure of the introduced pumpkinseed (*Lepomis gibbosus*) population from small ponds along the Vit river (Bulgaria). *Bulg. J. Agric. Sci., 14 (2),* 227-234.

Valle, C., Bayle, J. T. & Ramos, **A. A.** (2003). Weight–length relationships for selected fish species of the western Mediterranean Sea. *J. Appl. Ichthyol*., *19,* 261-262.

Vila-Gispert, A., Alcaraz, C. & Garcı´a-Berthou, E. (2005). Life-history of invasive fish in small Mediterranean streams. *Biol. Invasions, 7,* 107–116.

Villeneuve, F., Copp, G. H. & Fox, M. G. (2005). Interpopulation variation in growth and life history traits of the introduced sunfish, pumpkinseed *Lepomis gibbosus*, in Southern England. *J Appl. Ichthyol*., *21,* 275–281.

Webb, P. W. (1998). Swimming, In: Evans, D. H. (ed.), *The Physiology of Fishes*, 2nd edn, FL, CRC Press, Boca Raton, 3–24.

Welcomme, R. L. (1992). A history of international introductions of inland aquatic species. *ICES Marine Sci. Symposium*., *194,* 3-14.

Werner, E. E. & Hall, D. J. (1979). Competition and habitat shift in two sunfishes (Centrarchidae). *Ecol., 58,* 869-876.

Wootton, R. J. (1998). Ecology of Teleost Fishes. Kluwer Academic Publishers, The Netherlands.

Received: March, 18, 2019; *Accepted:* November, 26, 2019; *Published:* February, 29, 2020