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Growth and Diet of *Alburnoides tzanevi* Chichkoff, 1933 (Teleostei: Cyprinidae) in the Istranca Stream, Istanbul, Turkey

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Abstract: The aim of the present study is to provide initial data on the growth and feeding characteristics of *Alburnoides tzanevi* Chichkoff, 1933. Monthly sampling surveys were carried out at six sampling sites in the Istranca Stream from March 2012 to June 2013. A total of 155 specimens was collected by electrofishing. The total length and body weight of samples varied between 2.8–11.0 cm and 0.17–15.83 g, respectively. The age composition of the population ranged from 0+ to 5+. The length-weight relationship, condition factor and von Bertalanffy growth equation were calculated for all specimens as $\ln W$=-5.100+3.241 $\ln TL$, K=0.94 and $L_t=22.93(1-e^{-0.092(t+1.196)})$, respectively. To present the feeding habits of the species, the indices of relative importance (MI% and IRI%) of each uncountable (major groups such as plant, detritus, etc.) and countable (insect groups) food items were estimated. The diet spectrum of *A. tzanevi* contained a total of four major groups as food type: insect (Diptera, Ephemeroptera, Plecoptera, Odonata, Trichoptera, Coleoptera and Hymenoptera), plant (terrestrial plants and algae), arachnid (Araneae and Acari) and detritus. Insects (73.8%) was the most prevalent food type in terms of frequency of occurrence (F%).

Key Words: Length-weight relationship, condition, age, diet, niche breadth

Introduction

The members of the genus *Alburnoides* Jeitteles, 1861 are widely distributed in the freshwaters of Europe, the Caucasus, Asia Minor and Central Asia, where *Alburnoides* is represented by several species (Berg 1949, Kottelat 1997, Ruchin et al. 2007). Until recently, the members of the genus living in Turkish inland waters were called as *Alburnoides bipunctatus*. However, five species of the genus *Alburnoides* were identified on the basis of their morphological variations associated with their geographical distribution: *Alburnoides manyasensis* from the Lake Manyas, *A. fasciatus* from the rivers of the western coasts of the Black Sea, *A.* cf. *smyrnae* from Büyük Menderes River basin, *A. eichwaldii* from the Kura-Aras River basin and *A. tzanevi* from the Rezve Stream (Bulgarian name: Rezovska) and Lake Durusu basin (Turan et al. 2013).

Alburnoides spp. are small-sized fish, which inhabit fast flowing waters (especially the upper and middle parts of streams) with gravely bottoms and well-oxygenated clear water and surface zones of lakes (Kottelat & Freyhof 2007, Patimar et al. 2012, Seifali et al. 2012, Abbasi et al. 2013). The members of the genus are considered a good biological indicator of environmental quality due to their low tolerance to water pollution (Abbasi et al. 2013). Because *Alburnoides* spp. have no commercial value in the Turkish fisheries, the number of studies about the biological characteristics of the genus is limited; in the available studies, the members of the genus are described as "*Alburnoides bipunctatus*" (see Yildirim et al. 1999, Sari et al. 2012). Growth and feeding studies are necessary in order to understand the life history traits of fishes and predator-prey in-

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teractions. The present study aimed, therefore, to provide initial data on some growth and feeding characteristics of *A. tzanevi*, including length-weight relationship, age, condition, length growth, prey importance in the diet and niche breadth in the Istranca Stream in the European part of Turkey.

Materials and Methods

Fish collection

The study was carried out at six sampling sites in the Istranca Stream, which runs from a low altitude, through the Istranca (Yıldız) Mountains to the Lake Durusu in Istanbul. The following sampling sites were visited: Danamandıra (two points: 41.32975ºN, 28.26322ºE and 41.31415ºN, 28.24893ºE), Büyükdere (41.41175ºN, 28.17310ºE), Şeytan (41.41750ºN, 28.13845ºE), Karamandere (41.37920ºN, 28.29610ºE) and Karacaköy Streams (41.39946ºN, 28.38352ºE). Totally, 155 specimens were collected by electrofishing at the sampling sites from March 2012 to June 2013 with monthly sampling surveys. The electrofishing was performed at sampling sections with length of 50 m without stop nets, for approximately 20 minutes at each station.

Fish aging and growth parameters

The specimens were measured to the nearest 0.1 cm: total length (TL), fork length (FL) and standard length (SL). They were weighed to the nearest 0.01 g: total body weight (W). For length-length relationships, the linear regressions were calculated: (a) FL versus TL; (b) FL versus SL; (c) SL versus TL. Scales were used for age determination. For this purpose, scales were taken from the region of the fish between the dorsal and the lateral line; after cleaning, they were put into small envelopes and preserved dry. Scales were then placed on microscope slides and were read using a Microfish Reader (Lagler 1969). Age was estimated by reading annuli on scales. In order to confirm the age, two independent operators cross-checked the determinations. In case of non-compliance of the two operators in age readings, those ages were not evaluated. Fish were sexed as female and male by macroscopic or microscopic observations of the gonads. Sex ratio was tested with the Chi-square test (Zar 1999).

Length–weight relationship was calculated using the equation: $W=aL^b$, where W is the total weight (g), L is the total length (cm), a and b are the equation parameters (Le Cren 1951, Froese 2006). The relationship ($W=aL^b$) was converted into the logarithmic form ($\ln W=a+b\ln L$) in order to bring the regression to a straight line. Confidence limit of parameters a and b was estimated by the equation, $95\%Cl=x\pm(t_{0.05(n-2)}\times SE)$ (x: a and b; t:table value of t (t-test at 95% confidence); SE: standard error value of a and b; see King 2007). The null hypothesis of the isometric growth was tested with a t-test using the equation, $t_s=(b-3)/SE_b$ (SE_b is the standard error of the slope; see Sangun et al. 2007). Fish condition was estimated by Fulton's Condition Factor $K=(W/L^3)100$ (Ricker 1975). Growth in length was expressed by the von Bertalanffy equation; $L_t=L_\infty[1-e^{-k(t-to)}]$, where L_t is length at time t, L_∞ is asymptotic length, t is age, t_o is age when the length equals to 0 and k is the coefficient of development (Cailliet et al. 1986). Overall growth performance was estimated by the index Φ' (phi-prime test), $\Phi'=\ln k+2\ln L_\infty$ (Pauly & Munro 1984).

Diet analyses

For the diet analysis, digestive tracts were removed and fixed in 4% formaldehyde solution. To determine the seasonal differences in feeding intensity, vacuity index (VI) was estimated as percentage of empty digestive tracts (Sarkhanizadeh et al. 2014). A quantitative and qualitative analyses of the food contents in the digestive tracts were made. Food items were identified and categorised to the lowest possible taxonomic level. The identification and the counting were done with binocular microscope and weighed thereafter (dry weight, nearest 0.0001 g). To present the feeding habits of the species, the indices of relative importance of each uncountable major groups such as plant, detritus, etc. (MI%; Castriota et al. 2005) and countable food items i.e. insects (IRI%; Hyslop 1980) were estimated as follows: $MI\%=[(F\%\times W\%)/\Sigma(F\%\times W\%)]100$ and $IRI\%=[((N\%+W\%)F\%)/\Sigma((N\%+W\%)F\%)]100$, where F% is the percentage of frequency of occurrence [(number of digestive tracts containing a food item/total number of digestive tracks with food)×100], N% is numerical percentage and W% is the percentage of gravimetric composition. The overlap in the diet among ages and seasons was estimated using Schoener's Index α (Schoener 1970) as follows; $\alpha=1-0.5(\sum(P_{xi}-P_{yi}))$, where P_{xi} and P_{yi} are the points proportions of food category i, in the diets group x and group y. The index ranges from 0 (no overlap) to 1 (total overlap); overlap values of α=0.6 or greater are considered to be biologically significant in terms of prey items consumed by groups x and y (Macpherson et al. 2010).

To interpret the prey importance in digestive tract contents data, the modified Costello's (1990) method was used as graphical analysis (Amundsen et al. 1996). In this method, the prey-specific abundance (P_i) was plotted against the frequency of occurrence

(F_i%). The calculation of the prey-specific abundance; $P_i=(\sum S_i/\sum S_{ti})\times 100$; where P_i is the prey-specific abundance of prey i, S_i is the digestive tract content (volume, weight or number) comprised of prey *i*, and S_{ti} is the total digestive tract content in only those predators with prey *i* in their digestive tract.

Seasonal population dietary niche breadth was calculated for the species using Levins' (1968) and Levins' standardised (Hurlbert 1978) indices: $B=1/\sum(P_j)^2$ and $B_A=(B-1)/(n-1)$, where *B* is Levins's measure of niche breadth, P_j is proportion of individuals found using resource *j*, B_A is Levins' standardised niche breadth and *n* is the number of possible resource states. Levins' *B* and standardised B_A are minimal when all individuals occur in only one resource state (minimum niche breadth, maximum specialisation). The range of *B* is from 1 to *n*, where *n* is the total number of resource states and B_A varies between 0 and 1.0 (Krebs 1998).

Results

The total length and body weight of 155 samples varied between 2.8–11.0 cm and 0.17–15.83 g, respectively (Table 1). The sex ratio of female to male was found to be 1:2.14 with significant difference from the ratio of 1:1 ($X^2=15.21$; $p<0.05$). The length–weight relationship of *A. tzanevi* was calculated for female, male and all specimens. The slopes of the relationships (*b* values) indicated a positive allometric growth ($p<0.05$) for the population (Table 1).

Results of length-length relationships are $FL=0.920\times TL-0.045$ ($r^2=0.989$), $SL=0.785\times TL-0.008$ ($r^2=0.990$) and $SL=0.846\times FL-0.003$ ($r^2=0.986$), respectively. The age composition of 136 specimens ranged from 0+ to 5+ (Table 2).

Von Bertalanffy growth equation of *A. tzanevi* was estimated for females, males and all individuals as $L_t=19.67(1-e^{-0.011(t+2.481)})$, $L_t=24.79(1-e^{-0.080(t+2.458)})$ and $L_t=22.93(1-e^{-0.092(t+1.196)})$, respectively. The growth performance index (Φ') for females was 3.76, for males 3.90 and for all individuals 3.88. The mean (±SD) condition factor was calculated as 0.94±0.12 for females, 0.95±0.11 for males and 0.94±0.13 for all individuals. Monthly changes of the condition factor (for all individuals) is shown in Fig. 1.

Among 155 examined individuals only 61 fish had full alimentary tract. It was determined that 43% of 155 individuals had a full digestive tract. Vacuity index varied with seasons: it was estimated as the

Table 1. Length (*TL*, cm) and weight (*W*, g) distribution and estimated parameters of length-weight relationships of *Alburnoides tzanevi* in Istranca Stream, Istanbul, Turkey (n: number of individuals, TL: total length, W: body weight, a: intercept, b: slope, Cl: confidence limits, r^2: coefficient correlation)

Sexes	n	TL, cm (min.-max.)	W, g (min.-max.)	Regression parameters		95% *Cl*		r^2
				a±SE	*b*±SE	*a*	*b*	
Female	37	3.7 – 9.9	0.38 – 10.56	-5.224±0.090	3.310±0.051 (+)	0.183	0.102	0.991
Male	79	3.5 – 10.2	0.37 – 12.15	-5.114±0.078	3.244±0.042 (+)	0.154	0.083	0.987
All specimens	155	2.8 – 11.0	0.17 – 15.83	-5.100±0.060	3.241±0.034 (+)	0.118	0.067	0.983

"+" means positive allometric growth ($p<0.05$).

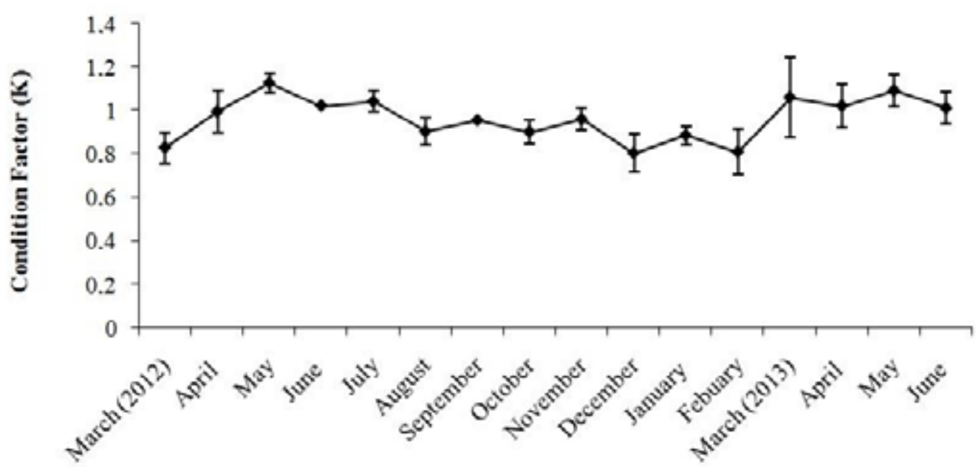

Fig. 1. Mean monthly values of the condition factor (K) of all *Alburnoides tzanevi* individuals in Istranca Stream, Istanbul, Turkey

Table 2. The range of length (*TL*, cm) and weight (*W*, g) in different ages of *Alburnoides tzanevi* in Istranca Stream, Istanbul, Turkey (n: number of individuals, TL: total length, W: body weight, SD: standard deviation)

Ages	n	TL±SD (min. – max.)	W±SD (min. – max.)
0+	1	2.8	0.17
1+	52	4.2±0.5 (2.9– 5.8)	0.68±0.32 (0.23 – 1.99)
2+	37	5.8±0.7 (4.7 – 6.8)	1.95±0.74 (0.83 – 3.24)
3+	21	7.5±0.4 (6.6 – 8.4)	4.04±0.81 (2.40 – 6.05)
4+	21	8.6±0.5 (8.0 – 9.5)	6.58±1.25 (4.80 – 9.21)
5+	4	10.0±0.2 (9.7 – 10.2)	10.76±1.26 (9.15 – 12.15)

Table 3. Seasonal vacuity index (VI, %), Levins' (B) and Levins' standardised (B_A) niche breadth indices for *Alburnoides tzanevi* population living in Istranca Stream (n: number of individuals)

	Spring (n=27)	Summer (n=12)	Autumn (n=18)	Winter (n=4)
Vacuity index **(VI, %)**	47.5	35.0	32.1	88.6
Levins' niche breadth **(B)**	2.11	2.51	2.73	1.92
Levins' standardised niche breadth **(B_A)**	0.37	0.76	0.87	0.92

Table 4. Seasonal changes of relative importance (*MI*% and *IRI*%) values of food types in *Alburnoides tzanevi* diet in Istranca Stream, Istanbul, Turkey (n: number of individuals)

MI (%)				
	Spring (n=27)	Summer (n=12)	Autumn (n=18)	Winter (n=4)
Insecta	73.8	66.9	6.7	42.9
Plant	18.4	30.5	12.2	-
Detritus	3.2	2.6	81.1	57.1
Arachnida	<0.1	-	-	-
IRI (%)				
Diptera	60.4	-	8.8	76.0
Coleoptera	0.9	14.2	-	-
Ephemeroptera	7.7	7.2	50.1	-
Trichoptera	1.7	64.7	35.2	-
Plecoptera	27.6	-	5.9	24.0
Odonata	1.8	-	-	-
Hymenoptera	-	13.8	-	-

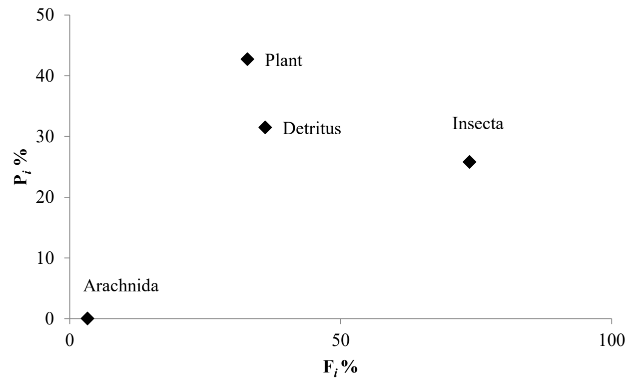

Fig. 2. Modified Costello feeding strategy diagram for the individuals of *Alburnoides tzanevi*. Prey-specific abundance (P_i) plotted against frequency of occurrence (F_i%) of food items in the diet of the species.

highest in winter (88.6%) and the lowest in autumn (32.1%; Table 3). Seasonal niche breadth indices (B and B_A) of the diet are shown in Table 3. Levins' niche breadth (B) values varied from 1.92 (in winter) to 2.73 (in autumn), while standardised niche breadth (B_A) values ranged from 0.37 (in spring) to 0.92 (in winter). According to analyses, the diet spectrum of *A. tzanevi* contained a total of four major groups as food type: Insecta (Diptera, Ephemeroptera, Plecoptera, Odonata, Trichoptera, Coleoptera and Hymenoptera), plant (terrestrial plants and algae), arachnids (Araneae and Acari) and detritus. Insecta (73.8%) was the most prevalent food type in terms of frequency of occurrence (F%), followed by detritus (36.1%), plant (32.8%) and arachnid (3.3%). Diptera (24.6%) was the most prevalent insect group in terms of frequency of occurrence (F%), followed by Plecoptera (23.0%), Trichoptera (18.0%), Ephemeroptera (14.8%), Coleoptera (6.6%), Odonata (4.9%) and Hemiptera (1.6%).

According to relative importance (MI%) values of food types, insects predominated in spring and summer, while detritus dominated in autumn and winter. The relative importance value (IRI%) of countable insect groups showed that Diptera constituted the major value in spring (60.4%) and winter (76.0%), though Trichoptera and Ephemeroptera were important diet during summer and autumn (Table 4).

For different ages, insects (mainly Diptera) were the most prevalent food group in terms of relative importance indices (MI% and IRI%) of early ages, though plant were the most important group for age 3+ and 5+ (Table 5). Feeding overlap values of major groups are given in Table 6 and also insect groups in Table 7.

The diagram of modified Costello graphical method is shown in Fig. 2. In terms of prey impor-

Table 5. Relative importance (MI% and IRI%) values of food types at the different ages of *Alburnoides tzanevi* in Istranca Stream, Istanbul, Turkey (n: number of individuals)

MI (%)					
	1+ (n=21)	2+ (n=15)	3+ (n=11)	4+ (n=9)	**5+ (n=1)**
Insecta	91.0	46.9	15.0	59.6	-
Plants	<0.1	15.2	45.2	34.7	100.0
Detritus	8.9	35.2	39.8	5.7	-
Arachnida	0.1	-	-	-	-
IRI (%)					
Diptera	61.2	38.1	22.4	33.5	-
Coleoptera	2.4	6.6	-	-	-
Ephemeroptera	11.3	1.4	62.2	14.1	-
Trichoptera	8.9	26.8	-	6.5	-
Plecoptera	15.8	27.0	15.3	33.8	-
Odonata	0.5	-	-	7.3	-
Hymenoptera	-	-	-	4.7	-

Table 6. Dietary overlap values between the seasons. The overlap was estimated with Schoener's Index. Values equal or greater than 0.6 are considered significant (* means overlap is significantly important).

	MI (%)			IRI (%)		
	Summer	Autumn	Winter	Summer	Autumn	Winter
Spring	0.88*	0.22	0.46	0.10	0.24	0.84*
Summer	-	0.22	0.45	-	0.42	0
Autumn	-	-	0.64*	-	-	0.15

Table 7. Dietary overlap values between the ages. The overlap was estimated with Schoener's Index. Values equal or greater than 0.6 are considered significant (* means overlap is significantly important).

	MI (%)				**IRI (%)**		
Ages	***2+***	***3+***	***4+***	***5+***	***2+***	***3+***	***4+***
1+	0.59	0.24	0.65*	0	0.67*	0.49	0.68*
2+	-	0.65*	0.71*	0.15	-	0.39	0.68*
3+	-	-	0.55	0.45	-	-	0.52
4+	-	-		0.35			

tance, Arachnida, plant and detritus presented low values in axis (P_i and F_i%), displaying evidence of a rare feeding. However, Insecta have been eaten by more than half of the individuals (F_i%=73%) indicating a generalist feeding strategy.

Discussion

The study presents initial data on some biological characteristics of *A. tzanevi* from the Thrace Region of Turkey. As an important parameter in fisheries studies, the exponents of length-weight relationship of *A. tzanevi* showed that the population had positive allometric growth (*b* values were significantly different from 3; $p<0.05$) for females, males and all individuals (Table 1). Length-weight relationships are used to calculate the weight corresponding to length and *b* values depend primarily on the shape and fatness of fish. According to the results of the growth type, the species grew in height or weight more than in length, and the results indicated that the population had good health.

Due to the presence of a single sample for age 0+, the other five ages (between 1+ and 5+) were used in the calculation of the von Bertalanffy growth equation. In the present study, theoretical asymptotic length (L_∞) was calculated as 22.93 cm (for all individuals) and it appeared realistic, since the largest specimen observed in the data set was smaller than the calculated length value for the population. The biggest fish was determined at age 5+ (max.15.83 cm, TL). The members of the genus are small-sized and short-lived fishes and the number of 5+ years old specimens was determined as limited numbers. This may be related to the survival of a few individuals of the maximum age, or different factors such as natural death, competition, predation and hunting causing a decrease in the number of fish at older ages, as it is typical for most fish species (Matthews 1998, Alkan Uçkun & Gökçe 2015).

There is literature information regarding some growth parameters (*b* value and asymptotic length) of *Alburnoides* species from different habitats. According to Treer et al. (2000) the *b* value of *A. bipunctatus* populations from Croatian rivers ranged from 2.797 to 3.557, while L_∞ was between 11.5 cm and 20.5 cm. The *b* value and L_∞ of *A. eichwaldii* were 2.94 and 10.08 cm for Shirud River (Iran) and 3.221 and 12.91 cm for Aras River (Turkey) (Monajjemi et al. 2014, Çiçek et al. 2016). Tabatabaei et al. (2014) reported that the *b* value and the asymptotic length of *A. namaki* in Kavir and Namak basins (Iran) ranged from 2.90 to 3.22 and from 11.27 cm to 12.24 cm, respectively. The values of *b* and L_∞ calculated in the present study (*b*=3.241 and L_∞=22.93 cm) are similar to the values given for the other species of the same genus. The *b* value and the asymptotic length may vary mainly depending on the different species of a genus studied. Furthermore, the differences in these values can be attributed to a combination of one or more factors such as sex, maturity, season, availability of food, geographical location, environmental conditions, number of examined species, health and differences in the observed length ranges of the specimens caught (Jamali et al. 2014, Radkhah & Eagderi 2015, Çiçek et al. 2016, Saç & Okgerman 2016).

In the present study, the condition factor of *A. tzanevi* showed some variations in different months, it was determined that the K was higher (K=1.13, May 2012) during the spring months due to growth of the gonads when fish entered into the spawning activity (Fig. 1). In addition to this, the condition factor was also estimated as high in summer in relation to the feeding activity, food abundance and metabolic rate which increased with water temperature.

Studies on feeding ecology of fishes are useful tools to understand the predator-prey relationship in aquatic systems (Lopez-Peralta & Arcila 2002). The members of the genus feed on terrestrial and drifting invertebrates (Kottelat & Freyhof 2007, Abbasi et al. 2013). The results of the present study indicated that the primary diet of *A. tzanevi* was insects and that Diptera was the most important prey item of the species. Examinations on the feeding habits of the species depending on the values of MI% for the seasons showed that it mainly preferred the insect groups in spring and summer. With decreasing of water temperature, the importance value of insect also decreased and they were replaced by detritus. This may be related to decrease of the feeding rate of the species throughout the day in winter. While the importance value of plant was maximum in summer, it started to decrease in autumn and plants were not consumed during the winter. This result might be related to differences in presence of plant in environment during the year. Feeding overlap values for different seasons also proved that there was an overlap in warm (between spring and summer) and cold seasons (between autumn and winter), separately (Table 6). Feeding habits during different age were also explored and it was observed that the relative importance value of Insecta (mainly Diptera) was higher in early ages. However, with increasing of age some differences in the food groups were determined and the importance value of plant in the digestive tract increased.

Variation of feeding intensity throughout the year is negatively related to the percentage of empty stomachs (Figueiredo et al. 2005, Altin et al. 2015). The feeding rates of *A. tzanevi* decreased when the water temperature decreased in winter (Table 3). However, the diet of the species was relatively diverse in every season except for winter when the number of digestive tract was not sufficient to describe it. The value niche breadth (B) was found as higher in autumn, whereas the standardised niche breadth (B_A) value was the highest in winter. Niche breadth or standardised niche breadth are important parameters for the evaluation of the level of dietary specialisation (Krebs 1998, Sá-Oliveria et al. 2014). The low values of standardised niche breadth (B_A=0.35 in spring) was related to the maximum specialisation in spring when insects constituted the primary diet during.

A central aspect of feeding strategy, the generalist-specialist dichotomy, is of major importance to niche theory (Pianka 1988). According to Amundsen et al. (1996), the lower left corner in Costello's diagram provides a measure of prey importance as rare or unimportant, whereas prey positioned in the lower part have been eaten more occasionally (generalization). In the present study, *A. tzanevi* appeared to be a generalist as all prey points were located in the lower part of the diagram (Fig. 2). Besides, arachnids were consumed rarely during the year and their point was positioned lower in the left corner.

In conclusion, the present study might be a key about exploring the growth and feeding characteristics of *A. tzanevi* and, it is hoped that the results will contribute to understanding the function of this species in nature.

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