INVESTIGATION OF THE EUROPEAN POND TURTLE (*EMYS ORBICULARIS* LINNAEUS, 1758) POPULATION LIVING IN A BACKWATER NEAR THE RIVER TISZA, SOUTHERN HUNGARY

E. Balázs and Gy. Györffy

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Abstract. A European pond turtle population living in a polluted backwater has been investigated since 2002. Turtles were collected with steel cage-traps and then this marked and measured. The average population size estimated by the Frequency of Capture method was 1,187 and by the Petersen-Schnabel method 740, and the density of the population was 142-228 turtles/hectare or 569-913 turtles/km respectively. The sex ratio was near 1:1. The differences between sexes and the distributions of size classes of the following morphological traits were investigated: tail length, shell height, plastron length and width, carapace length and width, and body mass. The turtle population was in good condition based on the correspondence of its body mass to its carapace length. Out of the 458 specimens captured in 2002, 29 males and 54 females were injured, and 65 (33 males and 32 females) had shell abnormalities.

Key words:, capture-recapture, Frequency of Capture method, Petersen-Schnabel method, population size, morphology, sex ratio, body size, condition, Gyálai Holt-Tisza, Hungary.

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Introduction

The European pond turtle (*Emys orbicularis* L. 1758) is the only European species from the subfamily Emydinae and the only native turtle in Hungary. Its distribution area is large, but the sizes of local populations are rather variable and mostly decreasing. We can also see this tendency in European Russia (Bozhansky and Orlova 1998), in the Middle Volga river region, (Bakiev 2004), in the South Urals (Khabibullin 2004), in the Ukraine (Szczerbak 1998), in the Crimea, the Ukraine (Kotenko 2004), in Italy (Ferri *et al.* 1998, Fattizzo 2004), in Catalonia (Mascort 1998), in central Poland (Mitrus and Zemanek 1998), in the Czech Republic (Široký *et al.* 2004), in Slovakia (Novotny *et al.* 2004), and in Northwest Spain (Cordero Rivera and Ayres Fernández 2004).

According to an intensive herpetofaunal mapping project, European pond turtle populations were recorded from 156, 10x10 km UTM squares in Hungary, where this species has the fourth largest known distribution area (Puky *et al.* 2004). It lives in many different water types, even in forest ponds at high elevations, albeit the populations in Pilis, Bakony and Mátra mountains, and in part near lake Balaton may be introduced (Farkas 2000). We can find mostly faunistical data in the Hungarian herpetological literature. Detailed investigations of populations have begun only recently (Kovács *et al.* 2004).

Our main goals were to: i) determine population size and structure, ii) get data about the frequency distribution of different body size values, sex ratio and condition of a turtle population living in a very polluted backwater pool in an urban area.

Study site

The backwater "Gyálai Holt-Tisza" was created between 1855-1887 as part of the regulation work of the river Tisza. It runs along the right side of the river, beyond the dam in an area protected from floods and extends from the Serbian-Hungarian border to the town of Szeged. Its length is 18,7 km, its average width is 86 m, its area is 160 hectares, and its average depth is 3 m. It is divided into three sections by dams and sluices. The utilization of the pools is different. The lower pool is a fishing area while the middle pool is an angler water. The upper one existed as storage of sewage and excess surface waters earlier. Nowadays the water pollution is decreasing, but the water quality is very bad, due to the run-off of thermal waters (Pálfai 2003). As a result of these nearly all-year running waters, the water-level periodically changes, however, a pumping station restores it shortly afterwards (Figs 1. and 2.).

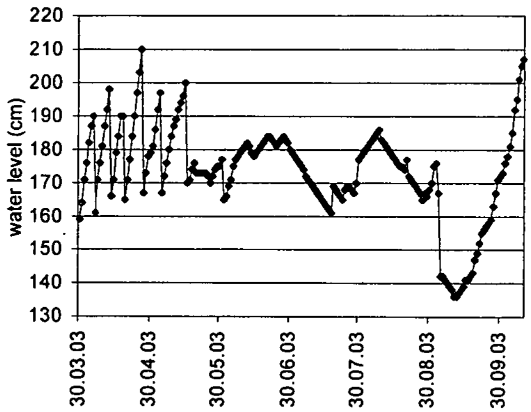

Fig. 1. Changes of the water level in 2003 (daily data).

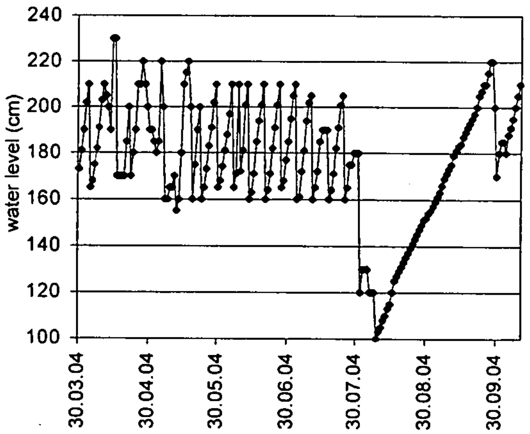

Fig. 2. Changes of the water level in 2004 (daily data)

Our investigations were carried out at the upper pool. This section is between the 15+630 riverkm and 18+660 riverkm, named "Feketevíz" (Blackwater). Samples were taken from the 15+630 riverkm to the 16+952 riverkm.

The southern bank slope is steep while the northern one is flat. The bed of the pool is rather sedimented. The thickness of sediment is 173,50±56,05 cm near the flat slope, 126,73±27,29 cm near the steep slope, and 179,08±67,01 cm in the middle of bed, according to 35 samples from October, 2002. Residential areas, consisting of village-like areas and suburbs of family houses, have been built along the sampled pool. On the shores narrow reed edge is the only plant in the water. As a result of organic and inorganic pollution, thick sediment, and intensive changes of water level, the food web is poor. The seasonality of animal groups depend on the thermal water and rare runoffs from the middle pool (angler water). Long term settlement and reproduction of species is impossible here because of the continuous oxygen depletion. We cannot find benthic invertebrates living in the sediment, neither molluscs, nor fishes. Due to the ecological circumstances, the animal community consists of taxa breathing from the air (Györffy 2005). Primary production is rendered by the toxicity of the water.

Sampling method

Turtles were collected with steel cage-traps (60 × 60 × 100 cm) with two entrances (10 × 20 cm). To prevent the traps from getting under the water, we used empty plastic bottles that were attached to the upper part of the traps. It was important because of the quick changes of water level. Ten traps were used (Table 1.), setting in both banks of the pool. The trapping periods were from 14 June to 4 December 2002, from 28 March to 15 October 2003 and from 31 March to 4 November 2004. The traps were not used in May and June 2004. Samples were taken every 2-4 days.

Each captured turtle was marked with unique combinations of marginal scute notches (Cagle 1939). The following parameters were recorded: straight length and width of carapace and plastron (mm), shell height (mm), length of the base of tail from the end of plastron to the cloacal vent (mm), body mass (to the nearest 0.5 gram), sex, colour of iris, damage and abnormalities. The width of the plastron was measured between the abdominal and femoral scutes. The with of the carapace was measured between the 2nd and 3rd pleural scutes.

We used the EXCEL, STATISTICA and SPSS

computer programs for data analysis. Data normalities were tested with the Shapiro-Wilks method. Pearson correlations were calculated between different body measurements. The significances of differences were tested with the Mann-Whitney U-test. SIMPLY TAGGING was used to estimate the population size with the mark-recapture method.

Table 1: Geographical latitudes and longitudes of the traps.

Trap number	Trap localities	
	North latitude	East longitude
1	46°13'36,7"	20°06'37,7"
2	46°13'38,6"	20°06'34,5"
3	46°13'39,7"	20°06'23,6"
4	46°13'40,6"	20°06'24,1"
5	46°13'40,6"	20°06'16,4"
6	46°13'41,4"	20°06'16,5"
7	46°13'40,6"	20°06'10,4"
8	46°13'41,4"	20°06'03,1"
9	46°13'40,3"	20°06'01,5"
10	46°13'39,8"	20°05'53,6"

Results and discussion

Estimation of population size

We tried to estimate the population size from mark-recapture data. Before choosing the appropriate method, we had to decide if the population is open, or closed. The trapping method is not suitable to collect small turtle individuals, among which the mortality may be rather high. The long lifetime and the relative short sampling periods permit only a little openness regarding the mortality of the older age classes. We consider the population rather closed because of the age-selectivity of traps, the life history of turtles and the extreme sedentary character of individuals (Cheylan and Poitevin 1998, Devaux and Bley 1998, Cadi and Miquet 2004, Kovács *et al.* 2004).

Frequency of Capture Method

Regarding the large amount of data (nearly one thousand marked individuals at the end of 2004), we tried to use the Frequency of Capture Method. This method is reliable, because problems do not arise from unequal catchability, it takes into account the repeated recaptures, and it is useful for not strictly closed populations too (Southwood and Henderson 2000). On the other hand, the different frequency distributions may fit similarly in a given section, but can be very different outside, causing differences in estimations (Demeter and Kovács 1991). Nevertheless, we can reveal the „trapfan" individuals by this method.

If we take into consideration the frequency of capture data, including maximum recapture values, the estimation can be false because of the last values. We can see this from the relationship between the maximum number of captures considered and the estimated number of never trapped turtles (Fig. 3); this means that the maximum number of captures decreases (removing the trapfan individuals), the number of never trapped individuals gets increase until its stagnation. In our opinion these last values are close to reality. We found the exponential function best fitting to our data (e.g. Fig. 4) and this function was used further on.

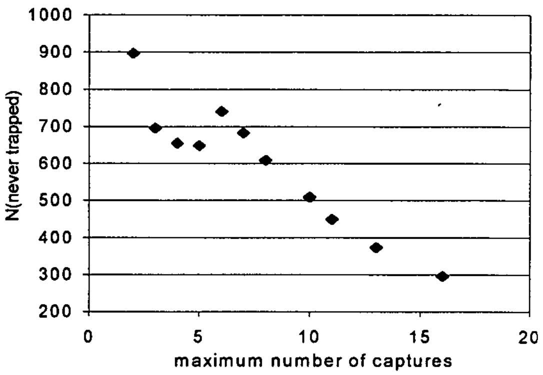

Fig. 3. Relationship between the maximum number of captures considered and the estimated number of never trapped turtles (2002-2004)

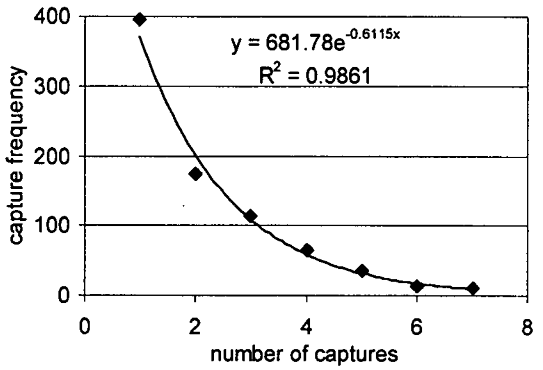

Fig. 4. Capture frequency distribution to 7 captures (2002-2004). N (estimated)= 682+826=1508.

As the number of samples decreases, the maximum number of captures decreases as well, and the section of real estimations gets narrower. On the basis of data from years 2002-2004, the estimations can be good from 3 to 7 maximum number of captures and the population size resulted was

1510±37 individuals (Fig. 3). If data from only one year are investigated, the section of real estimation is between 4-5 maximum number of captures (Figs 5. and 6.).

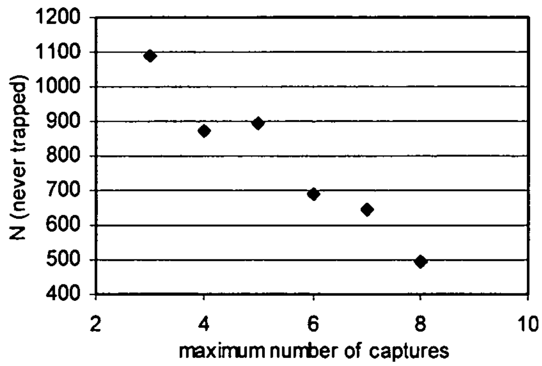

Fig. 5. Relationship between the maximum number of captures considered and the estimated number of never trapped turtles (2003)

According to the above mentioned facts, the population consists of 1369±101 individuals (in 2002, from 4-6 maximum number of captures), 1365±10 individuals (in 2003, from 4-5 maximum number of captures), and 827±12 (in 2004, from 4-5 maximum number of captures) respectively.

Petersen-Schnabel estimation

The Petersen-Schnabel estimation is the most commonly used model as experience has shown that the probability of capture varies between samples, most commonly because of changes in the weather. When only two samples are collected the maximum likelihood estimator is close to Petersen-Lincoln estimator and this method will give the Chapman modification of the Petersen-Lincoln index. This model assumes that all animals in the population have an equal probability of capture at any one time. For our closed population the zero-truncated Poisson test was undertaken for equal catchability in the case of different sample sizes (Table 2). According to the accepted equal catchabilities, we made the Petersen-Schnabel estimations for the different sample groups (Table 3.).

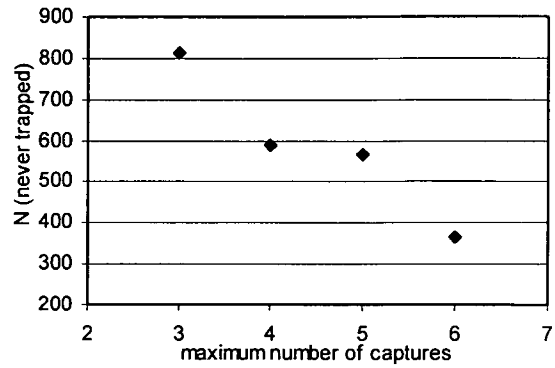

Fig. 6. Relationship between the maximum number of captures considered and the estimated number of never trapped turtles (2004)

By the end of the year 2005 already 978 turtles were marked. We consider this the minimum size of the population. Estimations by the Frequency of Capture Method are above this minimum size, except in 2004. Even though estimations by the

Table 2. Zero-truncated Poisson tests for equal catchability. Abbreviations: Sum(f(i)): total individuals; Sum(i*f(i)): total captures; Mci: mean captures per individual; m: Poisson parameter; Chi-sq.: Chi-squared; Df: degrees of freedom; P: probability; E.c.: equal catchability.

Sample	Sum(f(i))	Sum(i*f(i))	Mci	m	Chi-sq.	Df	P	E.c.
2002 all	466	634	1.36051	0.650255	3.53853	2	0.170458	Accept
2003 all	488	678	1.38934	0.697557	1.68723	3	0.639778	Accept
2004 all	253	299	1,18182	0.343556	1.20568	1	0.272189	Accept
2003 April, July	269	302	1.12268	0.235983	0.232557	1	0.629634	Accept
2004 April, July	179	195	1.08939	0.173423	0.229567	1	0.631845	Accept

Table 3. Estimation of population size by Petersen-Schnabel method.

Sample	Year	N (estimated)	Std. error	Upper conf. limit	Lower conf. limit
All	2002	772	40,26	862	704
	2003	812	40,49	901	743
	2004	637	75,4	815	516
April, July	2003	687	92,6	910	541
	2004	519	103,9	790	369

Petersen-Schnabel method are lower, the tendency is similar.

The surface of the backwater section investigated is about 5,2 hectares. As the average population size estimated by Frequency of Capture Method was 1187, and by Petersen-Schnabel Method was 740, the density of the turtles was 142-228 ind./ha or 569-913 ind./km. These values are rather high compared to data collected from the literature by Fritz (2003). This is the largest turtle population investigated in Hungary until now; nevertheless, based on our other projects there may be other similar populations in backwaters in the Great Hungarian Plain, as believed by Péchy and Haraszthy (1997) earlier. Fortunately, we have found and removed from the backwater only five specimens of *Trachemys scripta elegans* up to the present (three of these in spring of 2006). The ratio of this alien species was lower than in other habitat in Hungary (Kovács *et al.* 2004), and we hope that this North American native species will not endanger the European pond turtle population which has been living here for a long time.

Sex ratio

We identified the sex on the basis of characters mentioned in the literature (Table 4). The sex ratio is near 1:1, a little in favor of females except in 2004 and 2002, when the sampling periods were shorter.

Table 4. Number of identified males and females and the sex ratios in the different years.

Year	2002	2003	2004	2005	2002-2005
Male	232	229	127	124	436
Female	220	242	96	139	465
F/M	0.948	1.057	0.756	1.040	1.066

It is not easy to estimate the sex ratio from samples taken from the traps. Misleading values may be derived from small sample size or from the partial collecting period (Mosiman and Cadi 2004). If the sample size is large enough, we can calculate the number of males and females and from that we can estimate the real sex ratio. In spite of the difficulties there are a lot of sex ratio values in the literature. These female/male (F/M) values are between 0,5 and 4,71 (Fritz 2003). Taking only the examples above 100 individuals; however, the ratios drop to between 0,5 and 2,4.The large sample size is not always appropriate (Devaux and Bley 1998). Although Devaux and Bley counted the 1,7 F/M ratio from a sample consisting of 312 turtles, this number might vary depending on the observation period; for example, June and July is the nesting period for females which may lead to artificially high number of females in a study which takes place during these months. That is why we have to be careful comparing different data.

Morphology

The differences of the characteristics between sexes were investigated using data from the years 2002-2003 (Tables 5-6).

In the literature the length of tail commonly means the length from the anus to the end of tail. We measured the length of tail according to this in 2002 (Table 5, Fig. 7). Males have shorter tails than females.

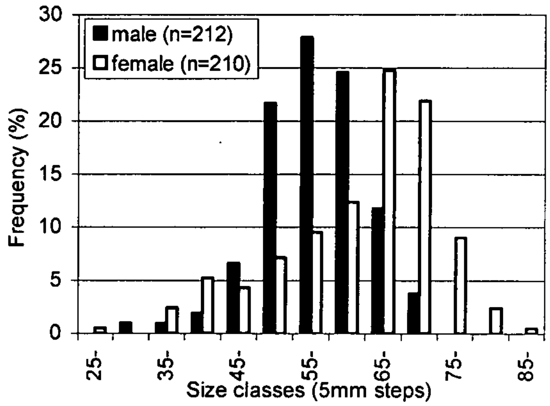

Fig 7. Distribution of size classes of tail length from the anus (2002)

In 2003 we measured both the length of tail base from the end of the plastron to the cloacal vent (Snieshkus 1998) and the width of the tail base (Table 6).

The base of the tail is shorter than the width of it, or these two values are similar in the case of females. The male's tail base is always longer than its width.

The colour of the iris was recorded in 2003. We distinguished two colour categories: lemon-coloured and dark-coloured (including orange, red, red-brown and brown). 226 of 230 females (98%) had lemon-coloured iris, while 186 of 223 males (83%) had dark-coloured iris.

Distributions of size classes of the different morphological data can be seen separately according to sexes in histograms (Figs. 8-12). The left sides of histograms from female data are longer. This may refer to the uncertainty of sex determination among

Table 5. Morphological data of turtles (PL: length of plastron, PW: width of plastron, CL: length of carapace, CW: width of carapace, SH: shell height, TL: length of tail from the cloacal vent, SD: standard deviation)

	PL		PW		CL		CW		SH		TL	
sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Mean (mm)	115	150	70	91	130	155	102	117	46	62	57	65,5
SD	9,8	25	5,91	15,2	12,2	25,6	9,01	16,5	4,22	10,6	7,08	10,9

Table 6. Morphological data of the tail base of the different sexes. (LTB: lengh of tail base, WTB: width of the tail base, SD: standard deviation)

Sex	Males (n=224)			Females (n=236)		
Character	LTB	WTB	LTB/WTB	LTB	WTB	LTB/WTB
Mean (mm)	25,50	20,38	1,25	12,86	16,59	0,78
SD	4,66	2,77	0,16	3,25	2,54	0,16

younger individuals, more exactly to the determination of more individuals as female than male.

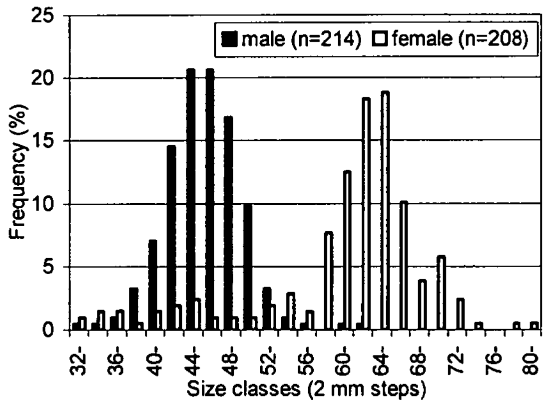

Fig. 8. Distribution of size classes of shell height (2002)

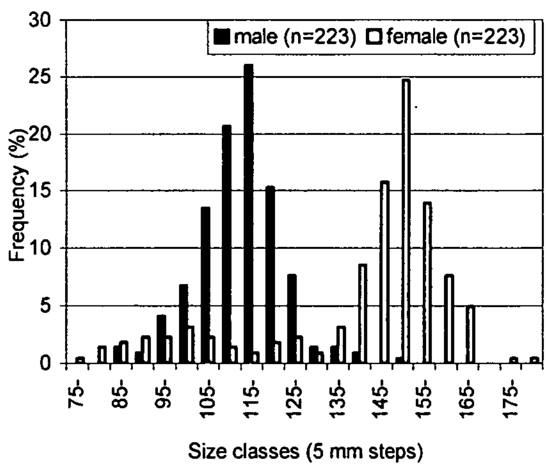

Fig. 9. Distribution of size classes of plastron length (2000).

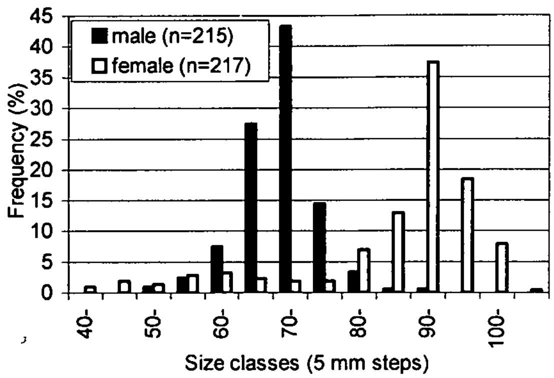

Fig. 10. Distribution of size classes of plastron width (2000).

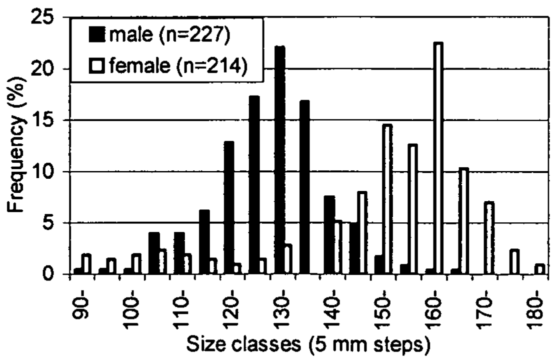

Fig. 11. Distribution of size classes of carapace length (2002).

Significances of differences of morphological parameters between sexes were calculated with Mann-Whitney U-test (Table 7).

We can conclude from the U-values that the tail length and carapace width indicate the smallest differences between males and females. This was one of the reasons not to measure the tail length (from the cloacal vent to the apex) from 2003 on. The carapace width may not be a good parameter to separate the sexes because of the larger variety of male carapaces shapes than that of the females.

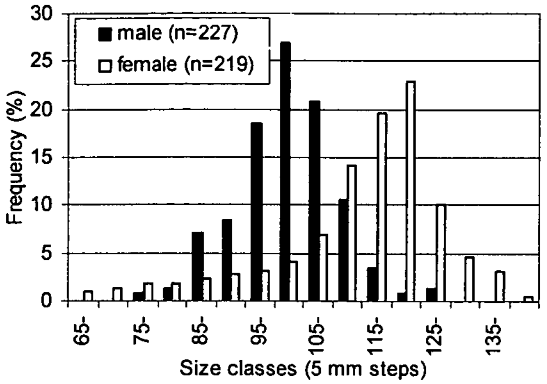

Fig. 12. Distribution of size classes of carapace width (2002).

Table 7. Results of the Mann-Whitney-U-test (2002).

	U	Z	p<	n♂	n♀
Plastron length	9010,000	-12,025	0,001	224	231
Plastron width	9213,000	-11,923	0,001	225	231
Carapace length	11129,000	-10,561	0,001	225	231
Carapace width	12157,000	-9,830	0,001	225	231
Shell height	7602,500	-12,722	0,001	223	224
Tail length	12740,500	-7,599	0,001	212	210
Body mass	9314,000	-10,473	0,001	216	209

Stronger correlations were found between the plastral length and width, the carapace length and carapace width, as well as between the shell height and other parameters in the case of females than males (Table 8.).

Table 8. Results of the Pearson-correlations (PL: length of plastron, PW: width of plastron, CL: length of carapace, CW: width of carapace, SH: shell height)

	males			females		
	r	p<	n	r	p<	n
PL & PW	0,903	0,001	230	0,968	0,001	241
CL & CW	0,928	0,001	230	0,974	0,001	241
PL & SH	0,829	0,001	229	0,856	0,001	240
PW & SH	0,791	0,001	229	0,868	0,001	240
CL & SH	0,819	0,001	230	0,863	0,001	240
CW & SH	0,827	0,001	229	0,848	0,001	240

The straight carapace length (CL) is the most comparable morphological trait, because we can find this in most papers (Fritz 2003). The largest male from Hungary measured 190 mm (Kovács *et al.* 2004) CL, while the CL of the largest available female was 183,0 mm (Farkas 2000). Our largest male had a 167,4 mm long carapace, while the CL of the largest female was 190,0 mm. Compared the average CL values (male: 131,05±11,19mm; female: 153,61±19,92mm) to data from previous studies (Fritz 2003, Auer and Taskavak 2004, Mitrus and Zemanek 2004), males from this study were medium-sized, while the females belonged to larger size classes.

Body mass and condition

The mean body mass was 395g for males and 764g for females in 2002. The high ratio of female/male body mass (1,93) might originate from the fact, that the trapping period began at the end of June. If we take into consideration all data till now, the mean values get lower and the F/M body mass ratio is 1,77. Average body mass is 381,13±84,5g for males (n=500, min. value: 82g, max. value: 809,17g) and 676,3±215,1g for females (n=508, min. value: 95g, max. value: 1121g). The distributions of value classes according sex separated from each other well (Fig. 13).

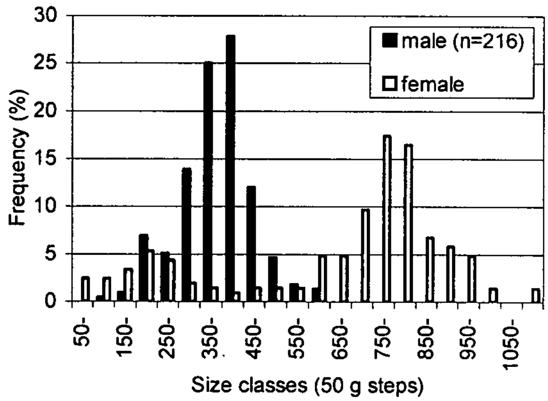

Fig. 13. Distribution of size classes of body mass (2002)

The simplest measure of condition is the body mass condition that compares mass with size (Willemsen *et al.* 2002). The most useful size-parameter was chosen by Pearson correlation between body mass and certain morphological data (Table 9). It is hard to predict the mass from length, that is why we looked at a turtle population from another backwater of better quality as a control group. There was a rich food web in the latter backwater (Tiszakécskei Holt-Tisza) and the water quality was satisfactory (angling water). We have

Table 9. Pearson correlation values between body mass and different morphological data (Gy: backwater "Gyálai Holt-Tisza", Tk: backwater "Tiszakécskei Holt-Tisza", M: male, F: female, BM: body mass, PL: length of plastron, PW: width of plastron, CL: length of carapace, CW: width of carapace).

area	sex	BM-PL			BM-PW			BM-CL			BM-CW		
		r	p	n	r	p	n	r	p	n	r	p	n
Gy	M	.930	***	231	.900	***	230	.938	***	231	.916	***	230
	F	.954	***	241	.951	***	241	.965	***	241	.947	***	241
Tk	M	.934	***	235	.764	***	235	.953	***	235	.908	***	235
	F	.904	***	187	.909	***	188	.904	***	188	.852	***	188

data about the turtle population living there (Balázs *et al.* 2004).

The best correlation was between body mass and carapace length, or plastron length for both populations and both sexes.

Comparison of the two populations was made with paired t-test of body mass values belonging to given carapace length (Tables 10-11). We see from the descriptive statistics that the "Gy" mean scores are higher.

Table 10. Paired Samples Statistics. (Gy: backwater "Gyálai Holt-Tisza", Tk: backwater "Tiszakécskei Holt-Tisza")

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1 (Males)	Gy	357,7667	60	66,7509	8,6175
	Tk	333,2639	60	65,9424	8,5131
Pair 2 (Females)	Gy	640,2222	27	189,4409	36,4579
	Tk	571,8519	27	176,7667	34,0188

There are significant differences in condition between the two populations. Despite the poorer food web in the backwater "Gyálai Holt-Tisza", the condition of turtle population living there is better. The cause of this might be the less anthropogenic disturbation (lack of angling).

Injuries and abnormalities

We found only sporadic data about the types and ratio of injuries in turtle populations (Szczerbak 1998, Kovács *et al.* 2004).

The ratio of injured individuals is rather high in the investigated population. From the 458 specimens captured in 2002, 83 were injured, which is more than 18%. There was significant difference between the sexes, out of the 83 injured individuals 29 were male and 54 were female. The difference may be the consequence of the different behaviour, because the females spend more time outside the water in the nesting periods, when they are at the mercy of predators.

We sorted the injuries into four categories (Table 12): serious shell damages, which are fractures of the carapace or plastron and lack of a large piece of shell; slight shell damages, which are the injuries of more than five marginal scutes and bites on the carapace or plastron; serious soft body wounds, which are the maimed limbs; and, finally, slight soft body wounds, which means maimed toes, claws or tailtips. We did not take into consideration the injuries of fewer than five marginal scutes (28 individuals). Of course, one individual could have more than one type of injury.

Table 11. Results of paired samples t-test. (Gy: backwater "Gyálai Holt-Tisza", Tk: backwater "Tiszakécskei Holt-Tisza")

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Gy-Tk (Males)	24,5028	39,2368	5,0654	14,3668	34,6387	4,837	59	,000
Pair 2 Gy-Tk (Females)	68,3704	54,6641	10,5201	46,7460	89,9948	6,499	26	,000

Table 12. Number of serious and slight shell and soft body wounds according to sex.

Serious shell damage		Slight shell damage		Serious soft body wound		Slight soft body wound	
♂	♀	♂	♀	♂	♀	♂	♀
11	19	18	40	3	8	13	21

There were shell abnormalities in the case of 14,2 % of the population (65 of 458 individuals). The ratio of the injured specimen was 33 males to 32 females. Because the sex ratio in the population is nearly 1:1, there is no significant difference between abnormally developed sexes. These anomalies could be due rather to the high pollution levels than to the inbreeding depression, outbreeding depression or suboptimal temperature or humidity during incubation (Ayres Fernández and Cordero Rivera 2004).

We found only one plastral anomaly when an accessory scute was in the middle of the plastron. The most frequent type of carapace anomalies (nearly 50 p.c.) was accessory scutes between vertebral and pleural scutes in the posterior part of the carapace. Only two specimens had accessory scutes in the anterior part. The number of marginal scutes are normally 12 in both sides, but there were 13 and occasionally 11 scutes in one side. The ratio of this type of anomaly was 23 p.c. There were accessory scutes not causing asymmetries (6 vertebral, 5-5 pleural or 13-13 marginal scutes).

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