ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 59 (2), 2007: 153-163

Population Ecology and Biology of *Testudo hermanni* (Reptilia: Testudinidae) at the Eminska Mountain, Bulgaria

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Abstract: A small population of *Testudo hermanni boettgeri* Mojsisovics, 1889, was discovered and studied in detail in the easternmost part of the Balkan Mountain Range – Eminska Mountain. 57 *Testudo hermanni* Gmelin, 1789, with adult sex ratio males/females of 1.52 were marked and described. Only one male specimen of *Testudo graeca ibera* Pallas, 1814, was found and marked. The age structure was skewed, low juvenile/female ratio – 0.19 pointed at an alarming decline of population density. Detailed, continuous observations over the seasonal and daily activity level, territorial and courtship behaviour were conducted in the field and within the enclosed protected 2000 sq. m area. Seven adult females, 3 males and 12 hatchlings were the object of detailed observations in the enclosed protected area. The actual nest excavation and the egg laying process were precisely described, along with some unusual behaviour, the preferred time for nesting was assumedly established. Monitoring of temperatures during incubation period of a natural nest was carried out and the results were compared with the ones measured in an artificial incubator environment. Detailed description of the hatchlings and their development and growth rate during the first 90 days was made.

Key words: *Testudo hermanni*, growth rate, age, structure, behaviour, Bulgaria

Introduction

The systematic study of the distribution and abundance of Mediterranean tortoises in Bulgaria has been underway for the past 20 years (Beshkov 1984). Surveys of local populations exist for a few regions, mostly in the southern part of the country (Lazarkevitch-Stancheva 1997). In general the cumulative data on the present status of Bulgarian tortoise populations are scarce or absent for most regions.

The collection of tortoises for human consumption and for pet trade, the introduction of intensive agriculture causing substantial habitat alteration, the rising number of free-ranging pigs, dogs, jackals and wild boars, the lack of effective conservation measures and actions, and the long recruitment period within tortoise populations, etc., have resulted in considerable negative impacts upon the distribution and the abundance of tortoises and in some areas have led to their disappearance. Detailed studies of various local populations will make a significant contribution to undertaking adequate steps to stop the decline and the disappearance of tortoises in Bulgaria. This paper focuses upon aspects of the population ecology and biology of tortoises of particular relevance to the conservation of those populations inhabiting small, circumscribed regions.

Brief Characteristics of the Area

The study area is situated in the easternmost part of the Balkan Mountain Range – Eminska Mountain,

comprising a territory of approximately 80 sq. km. The borders to the south and to the east are the Black Sea; to the west, the main Burgas – Varna highway, and to the north**,** the Ghin River (Fig. 1). The area lies within the Black Sea coastal climatic zone with an average annual precipitation of 550-600 mm and an average annual temperature of 12^{O} C. The vegetation consists of mixed broadleaved forests featuring cerris oak, elm, ash, oak, hornbeam, etc. The region is very favourable from ecological point of view. There are no mineral resources, nor industry, the human population density is low, and the region remains undisturbed by resort construction.

A small population of *Testudo hermanni boettgeri* Mojsisovics, 1889, was discovered on a south-facing slope, 2 sq. km in area, to the south of Banya village (Fig. 1), approximately 8 km to the west of Cape Emine. The characteristics of the area (microrelief, vegetation, microclimate, etc.) are quite typical of a *T. hermanni* habitat. The major part of the study has been carried out in this area.

Materials and Methods

The studies were conducted during the period of April – November 2003 and may be classified into three broad categories.

A. Field observations using the mark-recapture method and walk-stop-listen pattern (Hailey, 1988) on the following dates:

April – totally 18 h 15 min; May – 2 h 30 min; June – 24 h; July –36 h 30 min; August – 32 h; September – 28 h; October – 20 h. The total duration is 161 h 15 min and it is calculated from the moment of entering the area where tortoises have been found, until leaving it.

Each individual was given a mark with a fine-toothed hacksaw blade over a marginal scute. Table 1 includes data for each marked specimen – sex, dimensions, estimated age, date and hour found, and distinguishing marks. The measured dimension parameters (1 mm precision) are: straight carapace length (SCL), median width (MW), and maximum

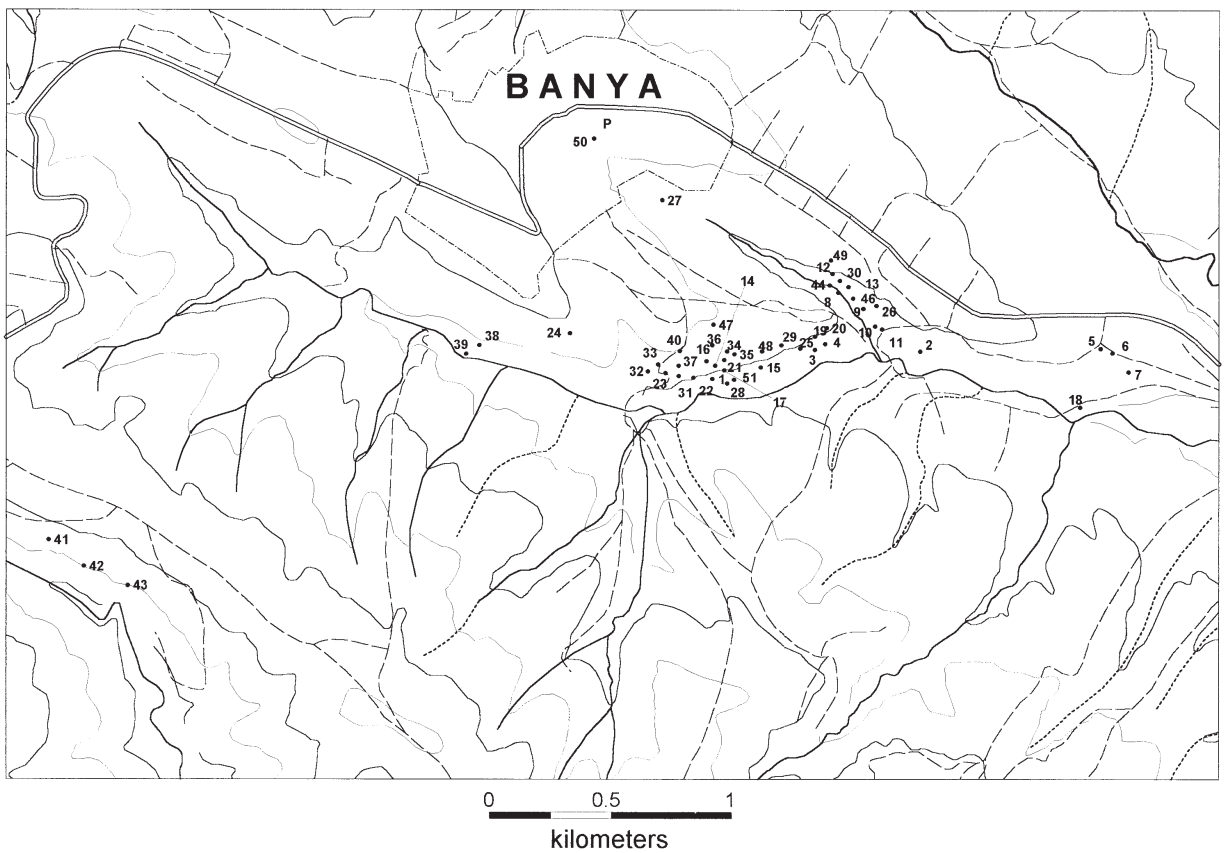

Fig. 1. Schematic map of the area of Banya with indicated spots of first finding of marked specimens from No 1 to No 50. P: Enclosed protected area.

height (MH). In females, MH is measured from the medial plastron to the highest point of the carapace; in male specimens, from the mid-plastral concavity to the same highest point. Approximate ageing was established by counting the growth rings; morphological defects and injuries including an undivided supracaudal scute comprised the distinguishing marks. Tortoises of less than 10 cm SCL were termed juveniles. The field techniques and ageing were based on the methods described by Stubbs *et al*. (1984).

It must be noted that the use of transects was not feasible at this site owing to the low tortoise density, uneven topography, dense brush, and limited number of human observers**.**

B. Detailed, continuous observations of 10 specimens *Testudo hermanni* (3 males and 7 females) enclosed in a protected 2000 sq. m area, situated adjacent to the natural habitat on the south slope (Fig. 1) with very similar characteristics.

Temperature variations were measured on the bottom of a 9 cm deep and 10 cm wide natural nest and on the surface of the ground right above it. The egg-laying female is No 14 in Table 1. The period of measuring is from 17 June – the day of developing the clutch, to 14 September – the day hatching took place. Mercury thermometers with a 50^{O} C column were used.

C. Observations of 12 *Testudo hermanni* hatchlings. After hatching they were maintained in an outdoor enclosure very similar to their natural habitat until the middle of October.

An incubator was constructed following Highfield (1987). Heat was provided by a 15W silicon heating cable. Temperature control was provided with on/of type thermostat maintaining temperatures to +/- 0.15^{O} C. Humidity was provided by placing a tray of water containing sponges and controlled with hygrometer.

All available data are vectorised by means of GIS software – MapInfo.

Results

Results of Tortoise Marking

At the study site, a single male *Testudo graeca ibera* specimen and 57 *Testudo hermanni boettgeri* were found and marked (Table 1).

The marked population consists of 56.2% males, 36.8% females and 7% juveniles, the adult sex ratio being 1.52.

Population Structure

Fig. 2 shows that the age structure of the observed population is deformed, revealing a very low number of specimen over 25 years and below 10 years of age. Local people consider the tortoises to

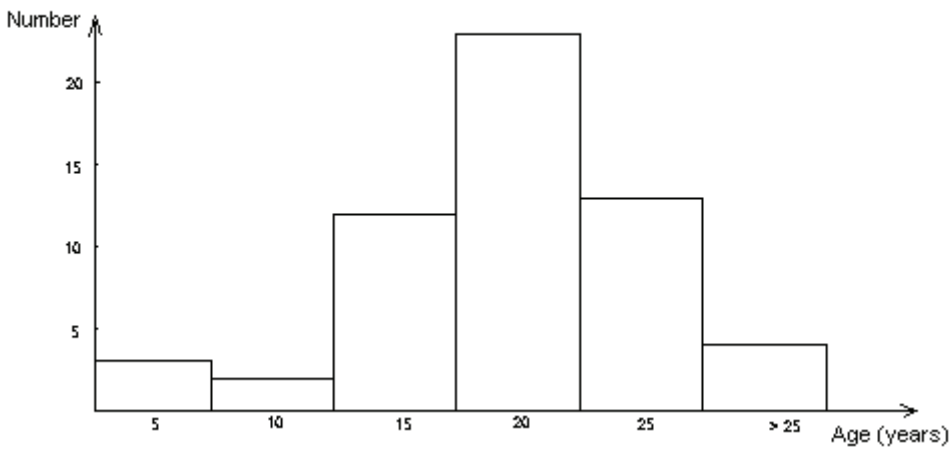

Fig. 2. Age structure of the observed population.

Table 1. General data about marked specimens *T. hermanni* to the date of the first capture (for abbreviations see Material and Methods). Among juveniles (SCL < 100mm) sex was not determined; * – Specimen *T. graeca.*

No	Sex	SCL mm	MW mm	H mm	Age years	Date of capture	Hour of capture
1	male	165	135	83	>20	26/04/2003	10.20
2	male	163	120	71	>20	26/04/2003	11.45
3*	male	165	128	78	>20	29/04/2003	10.50
4	male	153	115	72	>20	29/04/2003	11.10
5	male	163	130	79	17	30/04/2003	11.45
6	male	175	141	86	22	30/04/2003	11.45
7	male	172	135	83	20	30/04/2003	12.25
8	male	181	146	81	>20	01/05/2003	10.30
9	female	174	134	86	14-15	01/05/2003	11.00
10	male	173	136	81	>20	01/05/2003	11.45
11	female	181	137	93	16-17	01/05/2003	11.45
12	male	172	130	84	17	01/05/2003	12.20
13	female	143	111	70	11	01/06/2003	10.20
14	female	186	140	95	17	05/06/2003	17.00
15	female	184	137	87	17	05/06/2003	17.50
16	female	180	140	85	20	05/06/2003	17.30
17	female	190	147	82	>20	06/06/2003	18.25
18	female	210	155	95	very old	07/06/2003	18.35
19	juv.	72	65	40	4-5	09/06/2003	10.30
20	female	175	135	113	>16	10/06/2003	9.00
21	female	190	145	90	very old	13/06/2003	8.10
22	male	150	120	75	13	13/06/2003	8.30
23	female	195	150	100	20	13/06/2003	9.20
24	female	189	146	95	20	25/06/2003	9.25
25	juv.	67	58	35	3	26/06/2003	10.20
26	female	203	155	97	20	13/07/2003	10.20
27	male	150	125	75	very old	14/07/2003	17.15
28	juv.	80	65	40	6	14/07/2003	18.00
29	male	170	140	90	20	14/07/2003	18.45
30	male	157	132	76	>20	15/07/2003	10.20
31	male	152	137	76	20	16/07/2003	9.15
32	male	169	131	85	>20	16/07/2003	9.50
33	male	152	122	84	14	16/07/2003	10.05
34	female	195	146	100	20	18/07/2003	9.20
35	male	145	117	76	15	18/07/2003	9.20
36	female	195	142	90	>20	18/07/2003	9.55
37	male	160	130	82	20	18/07/2003	10.30
38	male	157	125	79	very old	25/07/2003	9.30
39	male	168	132	92	14-15	25/07/2003	10.15
40	male	140	113	77	13	28/07/2003	10.20

Table 1. Continued.

No	Sex	SCL mm	MW mm	H mm	Age years	Date of capture	Hour of capture
41	male	170	1300	84	20	06/08/2003	10.40
42	male	172	0	0	>20	06/08/2003	10.55
43	female	203	153	105	>20	06/08/2003	11.30
44	male	171	135	85	25	13/08/2003	10.15
45	female	123	100	70	9	17/08/2003	12.50
46	male	163	130	84	20	18/08/2003	9.45
47	female	152	119	78	10-11	19/08/2003	9.45
48	male	166	132	85	18	19/08/2003	10.20
49	juv.	34	31	0	hatchling	15/09/2003	13.00
50	female	200	152	100	19-20	16/09/2003	0.00
51	male	154	120	80	15	22/10/2003	10.55
52	female	189	135	89	15	2002	
53	female	163	124	82	15	2002	
54	male	160	133	80	20	2002	
55	male	155	127	85	>15	2002	
56	male	162	133	82	20	2002	
57	male	145	120	79	13-14	2002	
58	male	155	129	81	>15	2002	

be virtually extinct, because of collection for human consumption, whereas over 20 years ago they were abundant.

The low number of juveniles (including a single hatchling) indicates a lack of recruitment and a declining population. During the field study 8 destroyed clutches and 2 dead juveniles were found; most likely wild boars were responsible. Nowadays an increasing number of wild boars and jackals in the area is probably the major limiting factor for the recovery of the tortoise population in this particular area. The low juvenile/female ratio (Hailey, Wright, Steer 1988) – 0.19, points at an alarming decline of the population density.

Activity Level Variations

In 2003 tortoises left their winter refuges between 25 and 29 April. The first signs of activity, observed in the enclosed area, were related mostly to courtship attempts by males. Feeding tortoises were observed right after awakening, but most of them started feeding after 3-5 days. In May the activity level increased significantly due to searching for mates during the mating season. June and July were the months of highest tortoise activity, declining afterwards. Whilst the August decline can be attributed to the rise of ambient temperatures, in September and October it is correlated mostly with their drop. The number of tortoises found per hour is a good presentation of activity level frequency (ALF) per month. It is obtained by dividing the number of tortoises found by the hours of field search per month.

Tortoises could be found throughout day between 8.00-19.00 h. June may be nicknamed the "female" month, the high ALF of the females being related to the peak of the nesting season (Hailey, Willemsen 2000). Most females were found in June (Table 2) around the nesting sites. The (daily) activity of the females increases in the evenings - the preferred time for nesting. Fluctuations in the activity of the sexes in which male activity predominates, excluding the nesting season, are presumably related

Table 2. Characteristics of the activity of tortoises during the season. ALF – (Activity Level Frequency) – number of specimens found per hour field search.

Month / Sex	April Num	%	May Num	%	June Num	%	July Num	%	August Num	%	September Num	%	October Num	%	Total
Male	7	100	3	60	4	23	17	65	8	47	2	33	1	50	42
Female	0	0	2	40	11	65	8	31	9	53	3	50	1	50	34
Juv.	0	0	0	0	2	12	1	4	0	0	1	17	0	0	4
Total	7		5		17		26		17		6		2		80
ALF	0.38		2.00		0.71		0.71		0.53		0.21		0.10		

to the aggressive courtship behaviour attempts of the males throughout the activity season. Except during the mating season the females are obliged to hide not only from their natural enemies, but from male tortoises as well, making them more difficult to find in the field. During the second half of June, as environmental temperatures increase, the unimodal daily activity pattern changes to a bimodal one with an inactive midday period between about 11.00 and 16.00-17.00 h. July and August are characterized with daily activity between 8.30 and 19.30 h with a midday inactive period. The latest hour of recorded activity was on 23 July, when female No 17 was observed laying eggs at 23.00 h.

As the temperatures fall during the second half of September, prolonged periods of low activity may last up to 2 days. Daily activity was observed for only 4-5 hours around midday, and there was a sharp decline in feeding.

On 22 October the last specimen in the field was found. The tortoises in the enclosed area showed a very low level of activity. They would expose themselves to the sun, remaining but one or two meters from their refugia. Feeding tortoises were rarely observed during October. On the early mornings of 27 through 29 October, the temperatures fell to 1-2^{O} C. Light snow fell on 27 October between 19.00 and 20.00 h. None of the tortoises immediately made attempts to hibernate, the first one doing so on 29 October.

Almost all tortoises in the enclosed area entered hibernation during November, the last one doing so on the 26.11.

Territorial Behaviour

The three adult males inside the enclosed area of 2000 sq. m. subdivided it, each of them becoming established within his own territory. Occasional agonistic behaviour ensued, after which one male's dominance was accepted by the others. In subsequent chance encounters, the others sought to avoid conflict by simply running away. Fights can be described as violent banging and biting (often till bleeding), and trying to overturn the rival. Mostly the fight was over when the loser quickly withdrawed. The dominant male was often observed trying to pick a fight upon spotting another male feeding or passing by, without showing interest in the food. It is suspected that the purpose of this behaviour is to prevent further competition. Temporarily introduced adult males were treated in the same way. Although the dominant male appeared to be older and larger in size than the other two, during the field studies smaller males were observed to dominate larger ones. Some individuals definitely show more aggressive behaviour, resulting in field superiority.

Females are not spared the dominant male's aggression. However, such behaviour is combined with attempts to copulate. In general, adult female *Testudo hermanni* show no particular territorial behavior. One female exhibited periods of unusual homosexual behavior during 2 consecutive years, butting and biting another female.

There was no sign of confrontation between the three *Testudo hermanni* and the only *Testudo graeca* male observed in the enclosed area, except once,

when the *T. graeca* was butting from behind a male *T. hermanni* as he attempted to copulate.

Adult male *Testudo hermanni,* unlike females, have well expressed territorial behaviour. Fights among them are frequent, with a peak during the mating season. Dominance is not exclusively correlated with size and age, but with the determination of each male individual to prevail.

Courtship Behaviour

The first signs of courtship behaviour of adult male *Testudo hermanni* appear in the first few days after coming out of hibernation. Some of the males were observed attempting to copulate while still covered with soil, just a couple of meters away from their winter refuge. About two weeks later they were very active in such pursuits. Their courtship behaviour was rather violent, combined with butting and biting, and was observed throughout the active period, at various intervals. Rainfall seemed to stimulate the desire to copulate.

The adult male *Testudo graeca*, among female *Testudo hermanni* between 29 April – 3 August, showed no interest in them. Afterwards he started chasing them, attempting the carapace-butting courtship behaviour, common for this species (Hailey 1990).

The first courtship behaviour observed among hatchlings was 40 days after hatching.

In general, adult male *Testudo hermanni* show a high frequency of courtship behaviour throughout the active season, especially during the periods of concerted mating, and they try to copulate with as many females as they can. Courtship pressure, related to the large spur on the tip of the tail is probably one of the causes for female mortality and could partially explain the uneven sex ratio (Hailey, Willemsen 2000).

Nesting

Seven adult females were the object of detailed, continuous observation. The youngest two, (No 9) and (No 53), whose respective SCL was 174mm and 163mm (Table 1), and whose estimated age was 14 and 15 years, did not oviposit. Two others laid 6 unfertilized eggs each. The first of them – No 17, during the period June 26th – July 23rd laid eggs one or two at a time. Only two of them were laid in a nest, which was not covered, and two other nests were dug, but left empty. The other four eggs were found on the surface of the ground. The second female – No 15, on June 23rd laid 6 unfertilized eggs.

From the other 3 females, 12 hatchlings hatched from 19 eggs. The dates and data of laying eggs are as followed:

– № 52 on 4th of June – 4 eggs – nest depth (ND) 9 cm, nest width (NW) 10 cm – 2 eggs hatched;

– № 52 on 23rd of June – 4 eggs – the same ND and NW – 2 hatched. This is the only female who developed two clutches. It is interesting that the second nest was dug exactly on the same place as the first one, this way two of the eggs of the previous clutch (laid 19 days ago) were pushed away. There was no other chance than to move them to the incubator, but most probably because of overturning they didn't hatch.

– № 14 on the 17th of June – 4 eggs – 9 cm ND and 10 cm NW – 4 hatched.

– № 11 on the 21st of June – 7 eggs – 9 cm ND and 10 cm NW – 4 hatched.

Judging from destroyed clutches found in the field as well as from observed nesting behavior in the enclosed area, adult female *Testudo hermanni* prefer the upper edges of forests on south-facing slopes for nesting sites. Following a suggestion put forth by M. Connor (1993), some artificial slopes in the enclosed territory were made, but they were not preferred, probably because the whole territory was on a slope.

The preferred time of day for laying eggs seems to be between 17 and 20 h. Only one female (No 15) completed a nest at 8 AM on July 23rd. Creating the actual nest in which the eggs are laid is preceded by digging of a couple of other (false) nests which

remain uncovered – up to 5 observed, in a period of 2-3 days. Choosing the spot with the right temperature, humidity and soil density may explain such behaviour. Another possibility is that by excavating false nests, the female to try to keep potential predators' attention away from the real one.

The actual nest excavation and egg laying is a long process proceeding as follows:

– excavation. Using her hind legs alternately, the female digs for 30-40 min depending on the soil density until reaching the desired depth – between 7 and 10 cm – approximately the length of a hind leg;

– shaping. After reaching sufficient depth, digging continues for another 30 or more minutes and entails using one hind leg to enlarge the cavity, and using the other to tamp down the bottom, as the nest depth remains the same;

– laying the eggs. Each egg is repeatedly pushed alternately with both hind legs. Once a female was observed pushing one egg out of the nest while depositing and arranging another;

– completion. Thirty or more minutes are spent covering and stepping over the nest in a semicircle until perfectly concealing the nest.

– retreat. The exhausted female withdraws, with shaking legs, to the nearest refuge.

While laying eggs the female is highly vulnerable, because of the open vegetation of the nesting sites. It is assumed that evenings are the preferred time for nesting, not only due to maternal peak metabolic preparation, but to avoid potential enemies. Around this time, diurnal predators and birds of prey are hiding away, while nocturnal ones have yet to emerge. Encountering a male tortoise and its aggressive courtship behaviour would make nesting impossible, but as evening comes, males retreat to their overnight shelters.

An interesting observation was made while trying to save a clutch laid 19 days previously from being exposed and damaged by the same female, nesting again. Moving the tortoise aside does not seem to bother her - she continues digging at the new spot. The same behaviour occurred when a female was removed while filling in and covering the nest.

Incubation and Hatching

The inside of the incubator was maintained at 30-31^{O} C temperature with 60-80% humidity. From 14 fertilized eggs, 10 neonates emerged after 55, 58, and 63 days. Hatching takes some time - between 4 and 24 hours per egg. The hatchling's position inside the eggshell varies from a normal lengthwise to a transverse orientation; one hatchling began to emerge turned upside down. Eggs from the same clutch usually hatch in 24-72 hours, but in one case the final hatchling emerged eight days after the others had already hatched.

In the natural environment, 2 of 5 fertilized eggs hatched after an incubation period of 89 and 95 days. The observed hatchlings appeared on the surface presumably after 24 hours, a conclusion made by comparing their yolk-sacks (which were nearly absorbed) with those hatched in the incubator.

Fig. 3 shows the temperatures measured at the bottom of the nest and on the surface above it throughout the incubation period (89 days). The internal temperature variation is considerably less than that outside. The reduced fluctuations inside the nest protect the eggs from the outside peak temperatures. The difference between the highest and the lowest average nest temperatures varies between 8 and 12 degrees (Table 3). The relatively low variation of average temperatures in June – August show the "buffer" role of the nest. The constant temperature and humidity in the incubator are probably the reason for the greater hatching success – 71,42% vs. 40% in the natural nests.

Hatchlings

Hatchlings vary in size from 29 mm to 36 mm SCL and 26-34 mm MW (Table 4). One hatched with its width greater than length – 34 MW x 31 SCL, because the embryo had been transversely placed within the egg. After about 6 hours it stretched out to 35mm SCL x

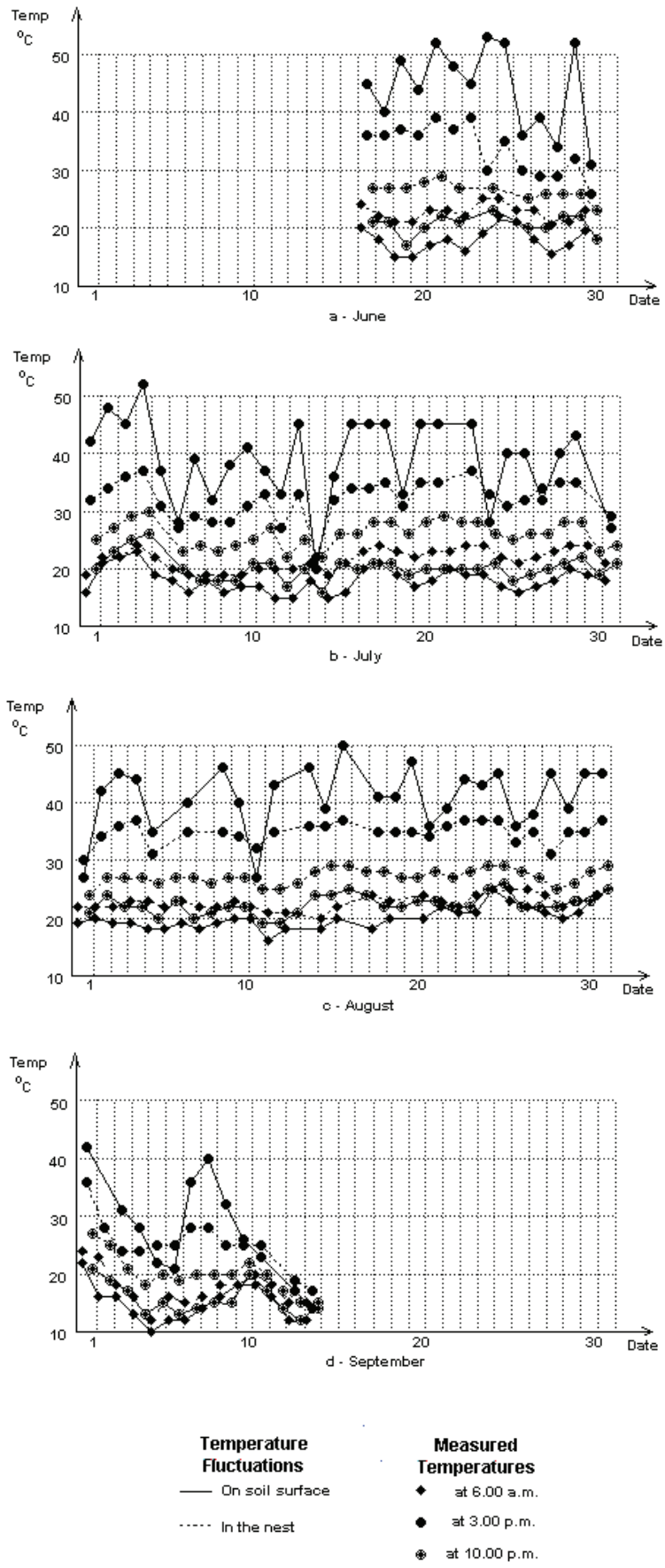

Fig. 3. Temperature fluctuations during the incubation period June 17 – September 14. 2003.

Table 3. Average monthly temperatures measured three times daily in the natural nest during 89 days period of incubation: 17.06-14.09.2003.

Hour	June	July	August	September
6 .00	22.6	21.6	22.9	17.4
15 .00	33.6	32.1	34.8	25.3
22 .00	26.5	26.0	27.1	19.8

Table 4. *T. hermanni* hatchling growth during the first 90 days, where M is the mean value of the measured parameter and SD shows the standard deviation.

Age (days)	N	SCL (mm)		MW (mm)	
		M	SD	M	SD
0	12	32.67	2.425	30.25	2.701
7	12	36.02	2.353	32.17	2.037
30	12	38.50	2.431	33.00	2.374
60	12	39.33	3.114	33.58	2.811
90	10	39.60	3.273	33.90	3.318

34 mm MW. The common morphological features of all hatchlings are the irregular shape of the carapace and the yolk-sack on the plastron, which pulsates with every heartbeat. After 24-48 hours the yolk-sack is nearly closed, essentially reabsorbed. During that time the hatchlings significantly increase in size as they elongate during the reabsorption process. The ensuing monthly growth is about 2-3mm, but pauses are also observed (statement based on continuous observations). Initially the nails are colourless and translucent, then dark pigmentation infiltrates from the base of the nail. Due to falling temperatures in October – November the growth rate slows down and ceases before hibernation. The egg-tooth, which is used to pierce the egg shell, disappears about four months after hatching.

Most likely because of the high temperatures maintained within the incubator, leading to a shorter incubation period, some morphological defects occur. Two of the hatchlings from one clutch have 6 vertebral scutes, the supernumerary being between the fourth and the fifth vertebral. Another one hatched with considerably shorter first claws on the forelimbs.

On the fourth day after hatching, aggressive behaviour by one hatchling towards another was observed, as among adult males, but this case was unique.

Right after hatching, the youngsters' behaviour mirrors that of their adult counterparts, but on a smaller scale. The daily activity is reduced to a couple of hours, a function of the environmental temperatures, their small size, and minimal food requirement (White 2002). This reduced activity probably accounts for the difficulty in finding hatchlings in the field.

Conclusion

The desperate state of the Banya tortoise population in view of its low density and reduced capacity for recovery may be regarded as typical of local populations in Bulgaria. The trend towards the replacement of human consumption by predation as the predominant limiting factor should be reflected in the urgently needed measures for the tortoises' preservation. It is high time to take steps not only to prevent local extinction, but to focus attention on protecting small, endangered populations. The recruitment process has to be subsidized in three main stages: safeguarded incubation; "head starting" in environmentally suitable areas with guaranteed protection from all predictable limiting factors; eventual release into a viable, protected population. For this purpose it is necessary to create specialized centers, which, in line with detailed research, carry out the first two stages of accelerating the recruitment process.

Banya is herpetologically and ornithologically important site. For *Testudo hermanni* and *Testudo graeca* it offers suitable, intact tortoise habitat despite the recent sharp decline in both species. Fortunately, the Banya area is ecologically well preserved, despite the upsurge of certain predatory species. Its long-term conservation should be promoted and safeguarded.

Acknowledgements: I am grateful to Mr. V. Beshkov, Mr. J. Buskirk, Mr. B. Petrov and Mr. A. Stoianov for their consultations and support.

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Received: 13.12.2005
Accepted: 25.04.2007

Популационна екология и биология на *Testudo hermanni* (Reptilia: Testudinidae) от Еминска планина, България

И. Иванчев

(Резюме)

Малка популация *Testudo hermanni boettgeri* Mojsisovics 1889, беше открита и детайлно проучена в най-източната част на Стара Планина – Еминска Планина. Маркирани и описани са 57 *Testudo hermanni* като съотношението мъжки/женски е 1.52. Намерен и маркиран бе само един мъжки екземпляр *Testudo graeca ibera.* Установена бе силно нарушена възрастова структура - съотношението женски/млади екземпляри е 0.19, което е показателно за намаляване на популацията. Въз основа на детайлни и продължителни наблюдения както на терена, така и в защитена територия с площ 2000 кв. м., са описани сезонна и дневна активност, териториално поведение, сезонност на размножаването. В защитената територия 7 възрастни женски, 3 мъжки и 12 новоизлюпени екземпляра бяха обект на задълбочено изследване. Подробно е описано изработването на гнездо, снасянето на яйца и поведението по време на този процес, както и предпочитаното време за гнездене. Извършен е мониторинг на температурите по време на инкубационния период в естествено гнездо и е направено сравнение на резултатите с тези получени в изкуствени инкубаторни условия. Направено е детайлно описание на новоизлюпените и е проследено тяхното развитие и нарастване през първите 90 дни.