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The effects of a large-scale fire on the demographic structure of a population of Hermann's (*Testudo hermanni boettgeri* Mojsisovics, 1889) and Spur-thighed (*Testudo graeca ibera* Pallas, 1814) tortoises in Eastern Rhodopes Mountains, Bulgaria

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Abstract. The numerous fires during the last decade in the area of Eastern Rhodopes (Southeastern Bulgaria) led to large losses of habitat for the Hermann's (*Testudo hermanni*) and Spur-thighed (*Testudo graeca)* tortoises. The data from this study demonstrate that the fire in the vicinity of Kolets village, Haskovo district, has caused large negative impacts on the population of *T. hermanni* and slightly lower impacts on *T. graeca*. The average density of the populations of *T. hermanni* in the burned areas (D = 0.7 ind./ha) is 7.2 times lower than that of the control areas (D = 5.3 ind./ha). The differences in the population densities of *T. graeca* are smaller, but are still well pronounced – the density for the burned area (D = 0.5 ind./ha) is 4.2 times lower than that of the control area (D = 2.0 ind./ha). The recorded mortality due to fire for *T. hermanni* is 64.3 % (♂ = 58.4 %, ♀ = 73.5 %, juv. = 55.6 %) and for *T. graeca* is 18.4 % (♂ = 10.5 %, ♀ = 42.9 %, juv. = 6.3 %).

Key words: *Testudo graeca, Testudo hermanni*, fire, population density

Introduction

Habitat loss due to human activity is a major threat for most land tortoises (BESHKOV, 1984; CHEYLAN, 1984; LAMBERT, 1984; SWINGLAND & KLEMENS, 1989), in conjunction with international trade of these species (LAMBERT, 1980; CHEYLAN, 1984; LAWRENCE, 1987; PÉREZ et al., 2004; ZNARI et al., 2005).

The effects of fire on the biological diversity practically depend on the frequency, intensity, season, and time of day (GILL, 1975; LEMCKERT et al., 2003; WHELAN, 1995). The impacts of fire on vertebrate species (including land tortoises) include direct mortality of individuals (TEVIS, 1956; ERWIN & STASIAK, 1979; HEINRICH & KAUFMAN, 1985; WHELAN, 1995; DUCK et al., 1997; CHEYLAN & POITEVIN, 1998; ESQUE et al., 2003) or indirectly: changes in the vegetation structure (WHELAN, 1995; BROOKS & ESQUE, 2002); decreased refugia availability and subsequent increase in predation risk (EVANS, 1984; ESQUE et al., 2003) and increased daily temperature fluctuations (ESQUE et al., 2003).

The effects of fire on *Testudo hermanni* have been studied by CHEYLAN (1984) in France, STUBBS et al. (1981, 1985) in Greece, FÉLIX et al. (1989) in Spain and HAILEY (2000) in Greece, but we could not find similar studies for *Testudo graeca* in particular.

This research quantifies the effects of a large-scale fire on the demographic structure of populations of *Testudo hermanni boettgeri* and *Testudo graeca ibera* in the Eastern Rhodopes.

The significance of this study is due to the fact that the two tortoise species are of high conservation importance, but the numerous large-scale fires in Eastern Rhopodes during the years 1999-2008 have likely resulted in substantial decrease in their populations.

Materials and methods

The study site is situated in the Haskovo district and is part of the Haskovo and Mechkovo ridges (YORDANOVA, 2004), situated in the northwest of the Eastern Rhodopes, Bulgaria. According to LINGOVA (1981), the average solar radiation is 5500-6000 MJ / m^2 / y and is amongst the highest for the country. The average annual air temperature in the Haskovo region is 12.5 °C, and the average air temperatures in January and July are 0.2 °C and 23.6 °C, respectively. The average soil temperatures at a depth of 10 cm measured for the same region are: 13.9 °C annual, 2.2 °C for January, and 25.3 °C for July (KYUCHUKOVA, ed., 1983). The rainfall has a summer minimum of 146 mm and winter maximum of 186 mm, with average annual rainfall of 668 mm (KOLEVA & PENEVA, eds., 1990).

The fire next to Kolets village (WGS 84 coordinates N41 51.930 E25 20.995) started on 31.08.2003 and continued until 3.09.2003, burning a total area of 352.1 ha (data obtained from Regional Forestry Board, Kurdzhali; Fig. 1). This fire has been of high intensity in the core areas, and only in the periphery it has been of low intensity.

Transects were chosen in such a way as to allow sampling of different parts of the burned area (Fig. 1.). Transects 1 and 2 are located on the east and west side of stream I, which dries out during the summer months. The surrounding vegetation is comprised of single trees of *Quercus cerris, Q. frainetto, Fraxinus ornus,* and bushes of *Paliurus spina-christi*. The grass reaches heights of 30-40 cm, and green patches persist during the whole summer. Transect 3 is located next to stream II. The vegetation composition is analogous to the one found at the first two transects. Transect 4 is perpendicular to the stream and passes through a thin forest of *Q. cerris, Q. frainetto, F. ornus*, and single *P. spina-christi*. Grass cover attains heights of 30-40 cm and dries at the end of the spring. The fire is of high intensity at all these transects. Transect 5 is situated west of stream III. Vegetation is dominated by *P. spina-christi* and *Carpinus orientalis* shrubs, as well as single *F. ornus*, *Q. cerris and Q. frainetto* trees. The stream is dry during almost all months of the year. This transect falls at the edge of the fire, which has been of low intensity. Transect 6 is situated on both sides of a road, in an old-growth oak forest comprised of *Q. cerris, Q. frainetto*, and single *Cornus mas* and *Carpinus orientalis* bushes. During the summer of 2004 the burned wood has been cut down by Regional Forestry Board, Kurdzhali by hired foresters. Six transects were established in the control area as well. Transect 7 is situated east of stream III, sector A; transect 8 – in sector B, transects 9 and 10 are in sector C, and transects 11 and 12 are in sector D (Fig. 1). The vegetation is identical with the one found in the burn areas.

The study area was visited between 2004 and 2006, with one spring (April – May) and one summer visitation (August – September). Each captured individual was marked by a unique

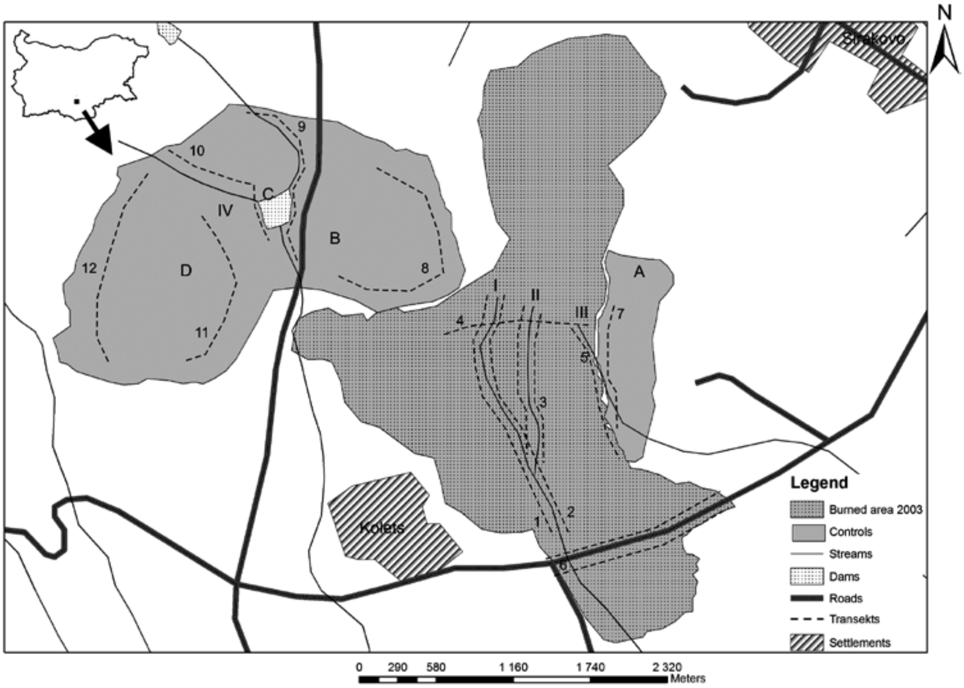

Fig. 1. Map of the study site, indicating the location of Kolets village, the fire of 2003, and the control sample areas

combination of filed marginal notches (BURY & LUCKENBACH, 1977; STUBBS et al., 1984) using a hand saw. This method allows for 1499 different combinations. For each individual the following data were collected: date, precise time, location of the observation (using a Garmin eTrex Summit GPS, with a 5 m accuracy), surrounding vegetation, sex, age, mass to the nearest 0,5 g, straight carapace length (SCL), maximum height from the plastron to the highest point on the carapace, carapace width, and plastron length along the mid-body. Measurements were taken using calipers with 0,5 mm accuracy. Tortoises with SCL less than 10 cm were considered juvenile (STUBBS et al., 1984).

The relative density of the tortoises (D) was calculated based on the transect method (BUCKLAND et al., 1993) using program DISTANCE 5.0 Release 2 (THOMAS et al. 2006). The width of the transect was chosen to be 10 m (5 m on each side). In calculating the effective strip width (ESW), the precise distance to each found individual was measured. The average length of the transects in the burned area is 2500 m, and in the control it is 2000 m. The data were calculated using a confidence interval (CI) of 95 % and presented with coefficient of variation (CV %). The analysis includes a model of uniform key function, chosen based on the minimum value of Akaike's Information Criterion (AKAIKE, 1973).

The statistical calculations were performed using program Statistica for Windows, Release 5.1 (STATSOFT, Inc., 1996). Data were compared using a parametric t-test for independent variables. Data were analyzed for normality of the distribution using the Shapiro-Wilk test (SHAPIRO et al., 1968), and then normalized using the function log (x+1). Results were significant at $p<0.05$ and $\alpha = 5\%$.

Results

Population density

The total number of observations of live Hermann's tortoises in the burned areas was 77, while in the control area their number was 188. The total number of live Spur-thighed tortoises observed was 48 in the burned areas and 96 for the control. The effective strip width (ESW) for *T. hermanni* is 4 m in the burned area and 2.5 m in the control. For *T. graeca* ESW is 3.7 m for the burned area and 3.3 m for the control. The visibility in the burned area is greater than in the control due to the sparse vegetation resulting from the fire. The obtained data for the population density of *T. hermanni* show a major difference between burned and control areas for all years of the study (Tables 1 and 2). Averaged for the three years, the density of the Hermann's tortoise in the control area (D = 5.3 individuals per ha; CI = 4.2-6.7) was 7.2 times higher than the density for the burned area (D = 0.7 ind. / ha; CI = 0.4 – 1.2). This difference is supported by the results from the t-test – the average for all years t = 4.21 (p = 0.002; Table 3). *T. graeca* had a lower average density compared to *T. hermanni* in both study areas, but the difference between the relative density between burned / control for the different years is not so well pronounced. An overlap between the confidence intervals is observed (Table 1), but the average density for the three years is clearly distinct: $D_{(burn)\,=}$ 0.5 ind. / ha (CI = 0.3-0.9) and $D_{(contol)\,=}$ 2.0 ind. / ha (CI = 1.4-3.0). The only statistically significant difference from the t-test is for 2006 (t = 2.60, p = 0.026).

In the control area, the population density for both species was lower during 2004, compared to the densities for 2005 and 2006 (Table 1).

Comparing the effects of the fire on the density by sex (Table 2), for *T. hermanni* the most affected are the females ($D_{(burn)\,=}$ 0.2 ind. / ha and $D_{(control)\,=}$ 2.0 ind. / ha, t = 6.71 and p = 0,0001) and the juveniles ($D_{(burn)\,=}$ 0.1 ind. / ha and $D_{(control)\,=}$ 1.4 ind. / ha, t = 2.9 and p = 0.0158). For *T. graeca* the most significant is the difference for the females ($D_{(burn)}$ = 0.1 ind. / ha and $D_{(control)}$

Table 1

Tortoise population densities in the burned and control area. CV stands for coefficient of variation and CI for a 95 % confidence interval

Year	Area	Density of *Testudo hermanni* (n = 77 for burn and n = 188 for control).			Density of *Testudo graeca* (n = 48 for burn and n = 96 for control)		
		Ind./ha	CV (%)	95 % CI	Ind./ha	CV (%)	95 % CI
2004	Burn	0.6	36.7	0.3 – 1.2	0.5	34.5	0.3 – 1.1
2004	Control	3.5	22. 9	2.2 – 5.6	1.3	36.8	0.6 – 2.7
2005	Burn	1.2	27.1	0.7 – 2.1	0.5	31.1	0.3 – 1.1
2005	Control	7.5	15.8	5.4 – 10.4	2.1	42	0.9 – 5.0
2006	Burn	0.6	58	0.2 – 2.0	0.3	49.5	0.1 – 0.9
2006	Control	4.1	15.7	3.0 – 6.0	2.3	23.1	1.4 – 3.8
Avg.	Burn	0.7	25	0.4 – 1.2	0.5	26.9	0.3 – 0.9
Avg.	Control	5.3	11.9	4.2 – 6.7	2.0	18.7	1.4 – 3.0

Table 2

Tortoise population densities in the burned and control area, by sex. CV stands for coefficient of variation and CI for a 95 % confidence interval

Sex	Area	Density of *Testudo hermanni* (n = 77 for burn and n = 188 for control).			Density of *Testudo graeca* (n = 48 for burn and n = 96 for control)		
		Ind./ha	CV (%)	95 % CI	Ind./ha	CV (%)	95 % CI
♂	Burn	0.4	29	0.2 – 0.7	0.2	36.7	0.1 – 0.4
♂	Control	1.9	15.64	1.4 – 2.6	0.8	24.8	0.5 – 1.4
♀	Burn	0.2	39.9	0.1 – 0.5	0.1	43.8	0.05 – 0.3
♀	Control	2.0	16.38	1.4 – 2.7	0.7	28	0.4 – 1.2
Juvenile	Burn	0.1	69.4	0.01 – 0.4	0.2	43.1	0.1 – 0.5
Juvenile	Control	1.4	22.13	0.9 – 2.1	0.5	49	0.4 – 1.2

Table 3

Differences in tortoise abundance for 1000 meters by year and sex in burn / control (analyzed using a t-test for independent variables). * denotes significant results for $p < 0.05$, $\alpha=5\%$.

Control vs. burn	*Testudo hermanni*			*Testudo graeca*		
	Valid N (transects)	t-value	p	Valid N (transects)	t-value	p
2004 vs. 2004	6	2.61	0.0261*	6	1.38	0.1977
2005 vs. 2005	6	4.05	0.0023*	6	1.52	0.1590
2006 vs. 2006	6	2.81	0.0186*	6	2.60	0.0263*
Avg. (2004 -2006) vs. Avg. (2004 -2006)	6	4.21	0.0018*	6	1.92	0.0834
♂ vs. ♂	6	2.06	0.0665	6	2.33	0.0424*
♀ vs. ♀	6	6.71	0.0001*	6	2.33	0.0420*
Juvenile vs. Juvenile	6	2.90	0.0158*	6	0.22	0.8298

= 0.7 ind. / ha, t = 2.33 and p = 0.0420) and males ($D_{(burn)}$ = 0.2 ind. / ha and $D_{(control)}$ = 0.8 ind. / ha, t = 2.33 and p = 0.0424).

Sex and age structure

The total number of all *T. hermanni* (found both dead and alive) in the burn area was 199 individuals, males being more numerous (1.1:1; n = 199; ♂ = 89, ♀ = 83, juv. = 27). In the control the females are only slightly more numerous (1.04:1; n = 176; ♂ = 68, ♀ = 71, juv. = 37).

After the fire the ratio changes substantially: for the live individuals the males are more numerous (1.7:1; n = 71; ♂ = 37, ♀ = 22, juv. = 12; Table 4), and within the dead individuals the females are more numerous (1:1.2; n = 128; ♂ = 52, ♀ = 61, juv. = 15). The ratio adults : juvenile individuals before the fire is 6.4:1, and after the disaster this ratio is 4.9:1 for the live individuals and 7.5:1 for the dead ones. In the control area, the ratio is 3.4:1.

For *T. graeca*, before the fire the males are more numerous 1.4:1 (n = 49; ♂ = 19, ♀ = 14, juv. = 16), and in the control it is 1.32:1 (n = 77; ♂ = 37, ♀ = 28, juv. = 12). The live male individuals are more numerous after the fire as well (2.1:1; n = 40; ♂ = 17, ♀ = 8, juv. = 15). Within the found dead individuals, the females are more numerous (3:1; n = 9; ♂ = 2, ♀ = 6, juv. = 2). The ratio adult : juvenile *T. graeca* before the fire is 2.75:1, and after the fire this ratio is 1.7:1 for the live captures, and 4:1 for the dead individuals.

It should be noted that the age structure of *T. hermanni* has been impacted differently in the different burn areas. In the low intensity burn area (transect 5; Tables 4 and 5) the level of survival of juveniles is the highest – 41% (5 ind.) from all juveniles have been found there. No such relationship has been established for *T. graeca* however.

Mortality caused by fire

The total number of found dead individuals after the fire is 137: 128 *T. hermanni* and 9 *T. graeca*. From the data presented in table 4 it is clear that in both species the females had the highest mortality – 73.5 % for *T. hermanni* and 42.9 % for *T. graeca* (n = 199 and 49, respectively, including both live and dead individuals from the burn area). Considerable differences can be noted in mortality based on tortoise' size (Fig. 3 and 4). For *T. hermanni* the highest mortality was experienced by individuals with SCL ≤ 60 mm (66.7 % mortality) and those with the largest size of SCL between 180 and 200 mm (100 % mortality). The number of found dead individuals of *T. graeca* is insufficiently low (n = 9) to correlate size and mortality. The mortality was highest for individuals with SCL ≤ 40 mm (100 % mortality) and those with the largest size of SCL between 200 and 230 mm (50 % mortality).

The mortality of *T. hermanni* is highest in transect 4 – 92.6 % (situated in the middle of the burned area) and lowest in transect 5 – 12.5 % (situated on the edge of the burned area; table 4). The mortality of *T. graeca* is the highest in transect 1 – 27.3 % and lowest in transect 2 – 11.1 % (situated in the core of the burned area; table 5). Transects 4 and 6 were not considered because only one live individual was found in each.

From the surviving individuals after the disaster a large portion of the tortoises had body damaged caused by the fire: 21 % (n = 15) of *T. hermanni* and 22.5 % (n = 9) of *T. graeca*.

Natural mortality

From all found Hermann's tortoises in the control (n = 180) 4 individuals (♀ = 2, ♂ = 1, juv. = 1) were dead, a mortality of 2.2 %. For the Spur-thighed tortoise the total number of individuals found is 79. 2 of which were dead (♀ = 1, ♂ = 1), a mortality of 2.5 %. In the burn area old pieces were found of 4 Hermann's tortoises that died before the disaster, that have not been included in the above analyses. Other dead tortoises that died from natural causes during this study were not detected.

Table 4

Number of found individuals of *Testudo hermanni* and the ratio (%) dead : alive by transect. Recaptured individuals (n = 6) were excluded

Transect №	Alive individuals				Dead individuals				% mortality (dead : alive)			
	♂	♀	juv.	Total	♂	♀	juv.	Total	♂	♀	juv.	Total
1	5	4	1	10	10	13	3	26	66.7	76.5	75.0	72.2
2	7	4	1	12	5	14	3	22	41.7	77.8	75.0	64.7
3	7	2	2	11	19	9	6	34	73.1	81.8	75.0	75.6
4	0	1	1	2	10	13	2	25	100.0	92.9	66.7	92.6
5	13	10	5	28	1	2	1	4	7.1	16.7	16.7	12.5
6	5	1	2	8	7	10	0	17	58.3	90.9	0.0	68.0
Total:	**37**	**22**	**12**	**71**	**52**	**61**	**15**	**128**	**58.4**	**73.5**	**55.6**	64.3

Table 5

Number of found individuals of *Testudo graeca* and the ratio (%) dead: alive by transect. Recaptured individuals (n = 8) were excluded

Transect №	Alive individuals				Dead Individuals				% mortality (dead : alive)			
	♂	♀	juv.	Total	♂	♀	juv.	Total	♂	♀	juv.	Total
1	3	2	3	8	1	2	0	3	25.0	50.0	0.0	27.3
2	2	3	3	8	0	1	0	1	0.0	25.0	0.0	11.1
3	2	1	4	7	0	1	1	2	0.0	50.0	20.0	22.2
4	0	0	1	1	0	0	0	0	0.0	0.0	0.0	0.0
5	9	2	4	15	1	2	0	3	10.0	50.0	0.0	16.7
6	1	0	0	1	0	0	0	0	0.0	0.0	0.0	0.0
Total:	**17**	**8**	**15**	**40**	**2**	**6**	**1**	**9**	**10.5**	**42.9**	**6.3**	**18.4**

Discussion

Several studies demonstrate that some reptiles are able to survive fires, depending on the structure of the habitat, the season and time of day, the intensity and length of fire (KAHN, 1960; VOGL, 1973; ERWIN & STASIAK, 1979).

The data from this study demonstrate that fire had a strong negative effect on a population of *Testudo hermanni boettgeri* and a slightly lesser effect on a *Testudo graeca ibera* population. This is supported by the large differences in the mean density of populations of *T. hermanni* compared to a control – for the burned area the density is 7.2 times lower than that of the control. The differences in the density of *T. graeca* populations are smaller, but still well defined – the density in the burned area is 4.2 lower than that of the control.

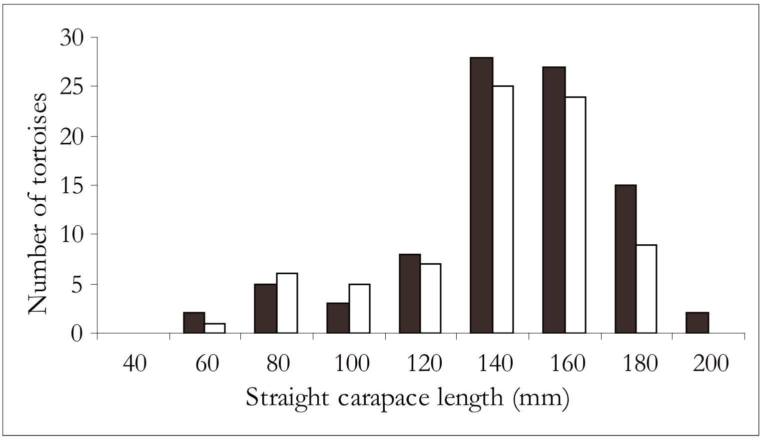

Fig. 2. Distribution of live and dead individuals based on carapace length (SCL) for *Testudo hermanni* in burned area. □ – live individuals; ■ – dead individuals

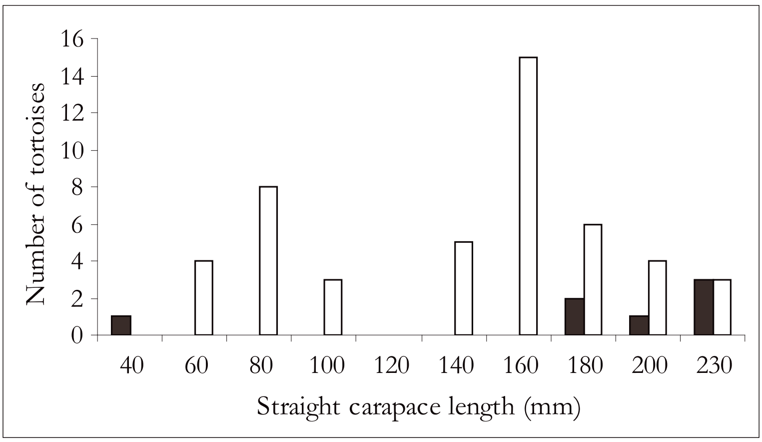

Fig. 3. Distribution of live and dead individuals based on carapace length (SCL) for *Testudo graeca* in burned area. □ – live individuals; ■ – dead individuals

It should be noted that the estimated densities in the control are lower during 2004 than during 2005 and 2006 (Tables 1 and 2). A possible reason is the sudden worsening of the weather conditions (heavy rains for a week in August) during the sampling in the control, while the burned area was sampled the day before. During a sampling after the weather improved the first week of September, tortoise activity was lower than expected for the season, compared to samples carried during the same season but different years.

Natural tortoise mortality in the control is low (2.2 % for *T. hermanni* and 2.5 % for *T. graeca*). The tortoise mortality (dead : alive), or reduction in the population due to fire was 64.3 % for *T. hermanni*, and 18.4 % for *T. graeca*. Comparable mortality rates for Hermann's tortoise are available for the region of the Alyki lake (North Greece), where the reduction of the population caused by the fire was approximately 40 % (STUBBS et al., 1985; HAILEY, 2000), for a fire in South France – 85 % (CHEYLAN, 1984), and for the fire in Albéres Massif, Spain – 30 % (FÉLIX et al., 1989).

Fire impacts differently the sex structure of the populations. Among the discovered dead Hermann's tortoises (n = 128) almost half were females (47.6 %), males and juveniles were respectively 40.6 % and 11.7 %. This observation is further supported by the ratio of dead : live individuals – for the females it is 73.5 %, for the males it is 58.4 %, while before and after the fire the males were more numerous (respectively 1.1:1 and 1.7:1). Among the dead individuals females are more numerous (1.15:1). Higher female mortality was recorded in Greece (STUBBS et al., 1985) and in southern Spain, where the females outnumber the males 2.03:1, with females being predominant in the population before the fire as well – 1.2:1 (FÉLIX et al., 1989). The Spur-thighed female tortoises also had higher mortality than the males – the ratio dead : live for the females is 42.9 %, and for the males it is 10.5%. A possible reason for the higher female individuals mortality due to the fire is their lower activity during the summer months, when the disaster occurred (HAILEY et al., 1984; HAILEY & WILLEMSEN, 2000). Approximately 30% of the observed live females during the second half of the summer were found buried in leaf and grass litter, where they can be affected by fire much easier, while the more active males potentially can reach the streams or other moist places and are therefore able to avoid the flames. Furthermore, males and females have different capabilities for migration, the males being more mobile (CALZOLAI & CHELAZZI, 1991).

A major portion of the surviving individuals after the fire (21 % for *T. hermanni* and 22.5 % for *T. graeca*) have body damage from the fire. From the individuals that survived a fire in Spain 21.8 % had body damage and 21.4 % of these died from infections in the next 60 days (FÉLIX et al., 1989). It is difficult to assess the mortality of the injured individuals in this study because it was carried one year after the fire.

Juvenile individuals are one of the most difficult age classes for study within turtle populations due to their low activity level (KELLER et al., 1997) and their lower detectability in the field (DIEMER, 1991). The damage caused by fire to this segment of the population of *T. hermanni* have been defined as catastrophic by STUBBS et al. (1985), HAILEY (2000), and FÉLIX et al. (1989), and according to CHEYLAN & POITEVIN (1998) this applies to *Emys orbicularis* as well. In our case, the mortality (live : dead) of the juvenile individuals with SCL ≤ 10 cm is also high – 55.6 %, and for the individuals with SCL ≤ 6 cm it is even 66.7 %. The mortality is likely to be even higher than recorded, since due to the low body mass the juveniles might burn down completely and thus finding them is impossible. Comparing the average densities for juvenile individuals between burned and control areas for *T. hermanni* ($D_{(burn)}$ = 0.1 ind. / ha and $D_{(control)}$ = 1.4 ind. / ha, t = 2.9 and p = 0.0158) demonstrates that the reduction of the population is nearly 93 %, 82% for the males and 91 % for the females.

The vegetation cover, the intensity of the fire, and the time the fire starts, have different impacts on tortoise mortality due to fire. CHELYAN (1984) suspects that tortoise mortality in fires in pine woodlands is approximately 85%. Summer fires in grasslands with tall vegetation cover are extremely dangerous for tortoises, in contrast to fires occurring in habitats with low vegetation (HAILEY, 2000). The season also impacts the amount of damage from fire – VOGL (1973) reports a winter fire in Florida with low impacts on the herpetofauna. In this study, the highest mortality was measured for *T. hermanni* (92.6 %) in transect 4, situated perpendicular to the streams in a sparse oak forest composed of *Q. cerris, Q. frainetto, F. ornus*, single *P. spina-*

christi and grass cover with height of 30-40 cm that dries by the end of the summer. The lowest mortality (12.5 %) occurred in transect 5, situated on the outskirts of the burned area, where the fire was of low intensity. It is difficult to make specific conclusions for *T. graeca*, since the number of found dead tortoises is low and the values overlap.

Various taxa respond differently to disasters, for example, populations of the Green Lizard (*Lacerta viridis*) recover almost completely 7-8 years after a fire (POPGEORGIEV & MOLLOV, 2005), while turtle populations have low ability to recover after sudden disturbances (BROOKS et al., 1991). The restoration of the damaged tortoise populations depends either on individuals that survived the flames, or to immigrants from neighboring territories. Similar statement is made by ELBING (2000), who considers that immigration of individuals from neighbouring unburned territories is of high importance for the restoration of the populations of *L. viridis* in burned areas. In this study, tortoise movements were detected (based on mark-recapture) from the burn area to the control and vice versa. In the direction from the control to the burned area for *T. hermanni* were recorded movements of 2 ♂ individuals (1 ♂ captured in the control on 31.07.2005 and recaptured on 04.05.2006 at a distance of 51 m; 1 ♂ captured in the control on 31.07.2005 and recaptured on 03.05.2006 at a distance of 401 m). For *T. graeca*, movement of 2 ♀ from the control to the fire was detected (1 ♀ captured in the control on 19.04.2005 and recaptured on 09.08.2006 at a distance of 154 m; 1 ♀ captured in the control on 31.07.2005 and recaptured on 04.05.2006 at a distance of 100 m). In the direction from the fire to the control only movement for *T. graeca* was detected (1 ♀ captured in the control on 24.04.2004 and recaptured on 19.04.2005 at a distance of 105 m). The restoration of damaged populations is highly dependent on the densities in the neighboring territories (ELBING, 2000).

In conclusion, the fires that occur while *T. hermanni* and *T. graeca* are active have a negative effect on their populations. Most affected from the fire are the juvenile and the female individuals. The future recruitment of both species' populations depends on the surviving individuals and migrants from adjoining territories.

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Влияние на мащабен пожар върху демографската структура на популациите на шипоопашатата сухоземна костенурка (*Testudo hermanni boettgeri* Mojsisovics, 1889) и шипобедрената сухоземна костенурка (*Testudo graeca ibera* Pallas, 1814) в Източни Родопи, България

Георги Попгеоргиев

(Р е з ю м е)

Многобройните пожари през последното десетилетие в района на Източни Родопи (Югоизточна България) доведе до висока загуба на местобитания за шипоопашатата (*Testudo hermanni*) и шипобедрената (*Testudo graeca*) сухоземни костенурки. Данните от проведеното проучване показват, че пожарът в района на с. Колец, Хасковска област, е оказал изключително негативно влияние върху популациите на *T. hermanni* и в по-ниска степен на *T. graeca*. Средната плътност на популациите на *T. hermanni* в пожара (D = 0,7 екз. / ha) е 7,2 пъти по-ниска от тази в контролата (D = 5,3 екз. / ha). Разликите в плътността на популациите на *T. graeca* са по-малки, но отново са ясно изразени – за пожара (D = 0,5 екз. / ha) плътността е 4,2 пъти по-ниска от тази за контролата (D = 2,0 екз. / ha). Отчетената смъртност на костенурките в следствие от пожара за *T. hermanni* е 64,3 % (♂ = 58,4 %, ♀ = 73,5 %, и млади = 55,6 %) и за *T. graeca* 18,4 % (♂ = 10,5 %, ♀ = 42,9 %, и млади = 6,3 %).