Capture-recapture data of Large Whip Snakes *Dolichophis caspius* (GMELIN, 1789), in southern Transdanubia, Hungary

The Large Whip Snake, *Dolichophis caspius* (GMELIN, 1789), is distributed on the Balkans and in adjacent west Asia. At the northwestern edge of its distribution, it occurs at some highly isolated sites in Hungary (DELY 1978; PUKY et al. 2005; KORSÓS 2007), where it is found in three regions: (i) Szársomlyó (part of the Villány Hills) in the south of the country; (ii) in and around Budapest, north of this location; and (iii) on the Danubian Plain in between them.

Hungarian individuals are the northernmost specimens in the western portion of the species range, isolated from the contiguous southeast European distribution area (DELY 1997; KORSÓS et al. 2002; TÓTH 2002; BELLAAGH & BAKÓ 2004; PUKY et al. 2005; BELLAAGH et al. 2006; BELLAAGH et al. 2007), which ranges from the Carpathian Basin to the west side of the Caspian Sea, and covers most of the Balkan Peninsula and several neighboring Near East countries (ŠČERBAK & BÖHME 1993; HERCZEG et al. 2002; BELLAAGH & BAKÓ 2004; PUKY et al. 2005; KRČMAR et al. 2007). Hungarian populations are restricted to small patches located at some distance from each other (DELY 1997; TÓTH 2002; PUKY et al. 2005). The species is protected in Hungary since 1974, and strictly protected since 1996 (BELLAAGH & BAKÓ 2004; PUKY et al. 2005; KORSÓS 2007).

Dolichophis caspius is one of Hungary's rarest and most endangered snake species, the largest and only stable population in Hungary lives on the Szársomlyó Hill (HERCZEG ET AL. 2002, KORSÓS et al. 2002; TÓTH 2002; PUKY et al. 2005; KORSÓS 2007). Although this is a protected area, data on population size, abundance and trends are not available and no long-term studies were conducted on the species.

Quantitative estimates of abundance are essential to the recognition, management and recovery of threatened and endangered populations and species. The primary objective of this paper is to provide quantitative estimates of the current population size of adult Large Whip Snakes in southern Transdanubia, Hungary. Juveniles were excluded from this analysis because of the low numbers observed. This paper builds on the work described in MAJER (2000) [here called survey I] and a series of unpublished reports of BirdLife Hungary (MME) [here called survey II].

Survey I. Between 1988 and 1990, within the framework of a herpetofaunal survey, 117 individuals of *Dolichophis* were caught, and 707 observed. An additional survey in 2000 yielded only fifteen observations of the species (Table 1). The technique applied comprised road surveys along three transects. The transects were 1000 m, 300 m and 330 m in length, respectively, and all were 20 m in width. Snakes were hand-captured, paint-marked and released; observed but not captured animals were also noted. Transects were surveyed once per week from May to September on sunny days between 8:00-18:00 h. In 2000, six additional visits were made along the transects. A detailed description of the survey method can be found in MAJER (2000).

Survey II. Between 1998 and 2003, members of the Baranya County Section of BirdLife Hungary (MME) monitored *D. caspius* in the area, under the supervision of one of the authors (Gy. D.). Altogether, 76 captures of 57 specimens occurred in these six years of the study (Table 1). Occasional road surveys were carried out in the study area two to four times per month from April to September on sunny days between 7:00-17:00 h. Snakes were captured by hand; marking specimens was originally done by ventral scale clipping. From 1999 on PIT-tags (passive integrated transponders) (Model T-IS8010 Datamars, Switzerland) were used.

The numbers of observed and captured specimens of 1988, 1989 and 1990 were standardized by survey distance (underlying data from MAJER 2000) (Fig. 1). The transect capture rate (expressed as the number of specimens per 1000 m survey distance) was rather constant between one and two specimens per 1000 m, whereas the number of observations showed a moderate decline from 12.74 specimens per 1000 m in 1988 to 7.98 specimens per 1000 m in 1990. By

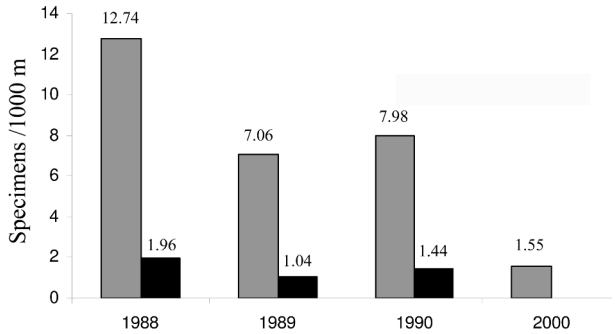

Fig. 1: Transect capture rate. Numbers of *Dolichophis caspius* (GMELIN, 1789) specimens per 1000 meter survey distance on Szársomlyó Hill, as observed during survey I. Grey bars – observed specimens, black bars – captured specimens. Underlying data from MAJER (2000).

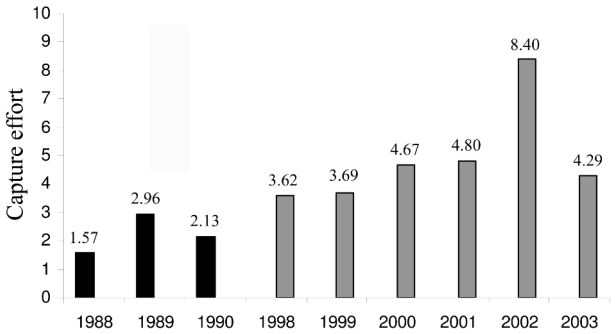

Fig. 2: Capture effort. Person hours spent in the field, required to capture a specimen of *Dolichophis caspius* (GMELIN, 1789) on Szársomlyó Hill. Data from between 1988 and 2003.
Black bars - data from survey I (MAJER 2000), grey bars - data from survey II (MME).
For numerical values see Table 1.

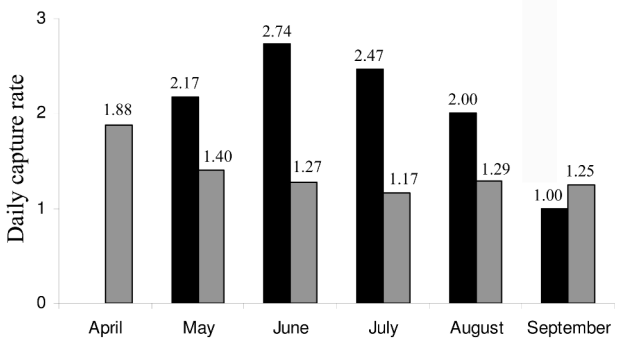

Fig. 3: Average (1988 to 2003) daily capture rates of *Dolichophis caspius* (GMELIN, 1789) on Szársomlyó Hill, shown per month.
Black bars - data from survey I (MAJER 2000), grey bars - data from survey II (MME).

2000, the habitat changed due to the spreading of shrubs and trees, resulting in fewer observations, and no captures of the snake (MAJER 2000; BELLAAGH & BAKÓ 2004).

The captures of survey II could not be standardized by distance, because of ill-defined distances covered during occasional road surveys. Thus, for comparison, the time required (person hours spent in the field) to capture a specimen (i.e. capture effort) was determined for both data series (Fig. 2). This effort increased gradually with a peak in 2002, which may reflect fluctuations in the size of the Large Whip Snake population, as found in other studies showing year to year changes in snake population numbers (KLIMSTRA 1958; LIND et al. 2005). However, the results may reflect a systemic population decline as well, which is supported by the stable, not fluctuating, long term increase in sampling effort (Table 2). The causes for this could be a decrease of the species density, e.g., because of habitat changes (MAJER 2000; BELLAAGH & BAKÓ 2004; BELLAAGH et al. 2007), or the differences in the survey methods applied (transect course and sampling periods).

The average numbers of daily captures are presented per month for surveys I and II in Fig. 3. In the earlier study (survey I) which included a rich sample, the daily capture rate (expressed as the number of snakes captured per day) was about 2.17 in May, increased in June, and decreased continuously to 1.0 in September. The number of captured individuals may correlate with the annual activity cycle of the species (DELY 1978), thus producing higher rates in early summer surveys . In the later study (survey II), the daily capture rate was highest in April and varied from 1.5 to 1.1 over the rest of the year, showing an unorthodox distribution (Fig. 3). Nonetheless, the daily capture rates of the two surveys were significantly different from each other ($t = 2.397$, $p = 0.04$), maybe due to methodological differences or reasons specified earlier under capture effort.

Population size estimates were generated for both data series with the Lincoln-Petersen method, which assumes that population fluctuation (immigration, reproduction, emigration, exitus of individuals) between census periods is negligible (CAUGHLEY 1977). This seems reasonable for snakes, that reproduce once per year, such as the Large Whip Snake (DELY 1978; ŠČERBAK & BÖHME 1993), when censuses are separated by a few months or less (KING et al. 2006). In the years 1988-1990 population number estimates (taken from MAJER 2000) averaged 275 ± 125 SD. In the years 1999-2003, the estimates were much lower (Table 2), but this may be due to the bias resulting from low numbers of captures and recaptures.

Capture effort (time required to capture a snake) correlated well with estimated population size (Spearman correlation coefficient $rs = -0.93$, $p < 0.001$), and, thus, could represent a suitable estimator of population density of the Large Whip Snake. In consequence of the above, the strong linear correlation between the numbers of obser-

Table 1: Numbers of captured, recaptured and observed specimens of *Dolichophis caspius* (GMELIN, 1789) on Szársomlyó Hill. Number of captures refers to first captures of snake specimens in the given year, number of recaptures to all other captures of snake specimens in the given year, and number of observations to seen but not captured specimens (this is available just for survey I).

Year	Number of captures		Number of recaptures		Number of observations
	Survey I	Survey II	Survey I	Survey II	Survey I
1988	60		7		369
1989	24		3		157
1990	33		7		181
1998		27		2	
1999		12		1	
2000		11		1	15
2001		10		0	
2002		5		0	
2003		7		0	

Table 2: Estimates of adult *Dolichophis caspius* population size on Szársomlyó Hill, with 95% confidence interval, and capture effort (person hours spent in the field, required to capture a specimen)

Year	Population size	95% CI	Capture effort
1988	418	351-485	1.57
1989	183	138-228	2.96
1990	225	153-297	2.13
1998	392	320-464	3.62
1999	72	35-109	3.69
2000	27	0-76	4.67
2001	17	3-31	4.80
2002	13	9-17	8.40
2003	20	0-64	4.29

ved and captured specimens (Pearson correlation coefficient $r = 0.98$, $p = 0.016$), suggests that the number of observed specimens could also be a feasible estimator of the population density of the species.

The individual marking of MME made it possible to follow the recapture history of snakes. Fourteen specimens were captured two or more times. Eleven of them were recaptured more than a year after the first capture. The period between first and last captures of the same specimen averaged 676 days, the shortest period was one (between July 19 and 20, 2000), the longest one 1590 days (between May 20, 1999, and September 26, 2003).

The Large Whip Snake population on Szársomlyó shows a decline in the last years. The cause of this is the spreading of shrubs and trees (*Ailanthus altissima*, *Robinia pseudoacacia*, *Syringa vulgaris*), and the human presence on the hill (Majer 2000; Bellaagh & Bakó 2004). The protection of the species requires accurate habitat management, and a systematically planned and executed monitoring activity, wherein the significance of captured and observed specimen numbers can be tested.

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