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BASKING COUNTS AS ABUNDANCE INDICES IN POND POPULATIONS OF *EMYS ORBICULARIS*

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The reliability of basking counts as indices of relative abundance for *Emys orbicularis* was tested in a pond system in central Italy. For different field conditions regression was carried out between basking indices and population size estimates obtained by capture and recapture methods. Regression was particularly significant in midday hours of sunny days from May to July, suggesting that in these conditions basking counts can be used as indices of population size.

Key words: Italy, terrapins, turtles, population estimates

INTRODUCTION

The need for an improved methodological framework for population size estimates in freshwater turtles is increased by the threatened status of many species, calling for conservation measures based on good knowledge of population numbers and dynamics. This implies the development of standardized methods that must also maximize the ratio of results to effort, in terms of field work and statistical significance.

Population sizes of freshwater turtles are generally difficult to estimate in field studies. A first general problem, common to other vertebrate groups, is to identify the spatial limits of a population, in order to obtain values that refer to defined areas. Second, the natural complexity of the habitats preferred by many species – and their life-history traits – often make it difficult to observe or catch a large proportion of individuals.

Abundance estimates require long-term studies, taking into account different patterns of distribution in different habitats and possible metapopulation structures (see Burke *et al*., 1995). Among the different approaches to the determination of population size, the most commonly used has been a sampling estimate based on CMR (capture-mark-recapture) methods (Graham, 1979). Nevertheless, individual marking has often been used to collect data on other topics (e.g. growth, movements), with abundance estimates as a secondary, unplanned result.

Relative abundance indices are simple tools for large-scale field sampling, although their use requires a preliminary calibration, i.e. knowledge of the relationships with true abundance estimates and significance levels of the models (Boulanger & Krebs, 1994; Stander, 1998).

In Italy the only native emydid is the European pond turtle *Emys orbicularis*, an endangered species included in national and regional Red Lists. Activity patterns of *Emys orbicularis* include large amounts of time spent basking in all seasons (Dal'Antonia *et al*., 2001). The occurrence of this behaviour, together with a high degree of site fidelity (Lebboroni & Chelazzi, 1991), provides the easiest conditions for detecting this species in the field.

The objectives of this work were to (1) test the reliability of basking counts as an abundance index, through a calibration with CMR estimates; and (2) define the seasonal and daily windows in which the index is best used, in order to obtain a method that could be used to survey a large number of ponds in a relatively short time.

MATERIALS AND METHODS

Data were collected during long-term research on the ecology and the ethology of *Emys orbicularis* in central Italy. Field studies were carried out in the Natural Reserve Monte Rufeno, a hilly (300-600 m asl) area in Latium with a prevalence of woods dominated by turkey oak (*Quercus cerris*). Turtles live in small ponds (water surface 50-800 m^2) scattered in the woods.

Turtles were captured by dip nets or by hand. After capture, turtles were individually marked with numbered tags to allow resighting from a distance. Inter-ponds movements were regularly performed in spring and summer by some individuals that used temporary pools near the permanent ones, where most turtles are found throughout the year. However, each turtle showed a high degree of fidelity to only one permanent pond in consecutive years (Lebboroni, 2000).

Detailed data on individual basking duration were collected for 20 adult and four subadult turtles in pond VH-1, with continuous observation from 08.00 hrs to 2000 hrs along three sunny days from May to July. Basking indices were obtained for six ponds by visual observation (using 10 × 40 binoculars) recorded from fixed points along pond banks. According to pond morphology and vegetation structure, for each pond one or two points were employed, in order to obtain a complete coverage of the whole surface. In the case of two observers, time concordance and detailed maps were used to avoid the possibility of double counting. Each session of observation (BC, basking count) lasted 20 mins, with the final variable BI, the basking index, scored as the total number of different turtles seen basking, regardless of the duration of the individual bout (a single event of

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basking from emersion to immersion). In the analysis, data for sessions of 40 mins were also obtained, merging into two consecutive sessions. Only data on adult turtles were used, because of both low density of immatures in ponds and low detectability of these age classes.

A total of 120 hrs of observations were used for the analysis: each unit of 20 mins was allocated to one of the three corresponding periods of the day (0800-1200 hrs, 1200-1600 hrs, 1600-2000 hrs). In our study area this division was on average quite consistent with major changes in daily air temperature values. Observations relative to early spring (March-April), a period of low activity with some turtles still wintering, were tested separately from late spring/early summer (May to July), when these populations showed higher rates of activity (Lebboroni, 2000). For both seasons and for each daily period the BC was assigned to changeable or sunny weather according to conditions relative prevalence during the 20 mins: in completely overcast or rainy conditions no BC was performed. The interaction of temporal, seasonal, amd meteorological factors gives a total of 24 possible categories (2 seasons × 2 weather × 3 daily periods × 2 count durations).

Population estimates for each pond (NP) from CMR analysis were obtained by Bailey's triple-catch method, considering the detection of individuals visually as capture (Caughley, 1980). The three sessions required by the method were carried out in early March (only marking), May (marking and recapturing) and late July (only recapturing). Analysis of the correlation of basking indices (BI) with population estimates (NP) was carried out using linear regression models (least squares fitting). All statistical analysis was carried out in S-Plus 4.5.

RESULTS

A total of 84 adult turtles were marked in six ponds, with an overall estimate of 105 individuals: population sizes for single ponds ranged from 5 to 29, with narrow standard errors (Table 1). No significant relationship was found between turtle numbers and pond surface (r=0.6, P>0.1, Spearman rank test).

The total daily time spent in basking was divided between several bouts, with turtles changing sites during the day. Average bout duration was not significantly different among males, females and subadults (65, 67 and 71 mins, respectively; Wilcoxon test, P>0.1; Fig. 1).

Because of unpredictable weather, logistic conditions in the field, and avoiding use of small sample size (n<5), linear models relating BI to NP were obtained for 14 out of the 24 possible categories. A significant regression (at least P<0.01) was obtained for three conditions: (1) BC of 20 mins in sunny midday in May-July; (2) BC of 20 mins in sunny mornings in May-July; (3) BC of 40 mins in mornings with changeable weather in March-April (Fig. 2). The best fitting equation was obtained for the first linear model, with NP = 2.84 BI + 1.22 (n=6, r^2=0.89, F=123, P<0.0001).

The lines for which the regression was significant show graphically the different relevance of the slope in the different periods. Computing NP from BI, a lower value of correction is required for midday hours during sunny days in late spring and early summer, meaning that under these conditions basking behaviour is performed by a larger fraction of the population.

TABLE 1. Population estimates (±SE) of adult *Emys orbicularis* for six ponds. Number of marked turtles is the total for March and May sessions (see text). Total number of adult turtles observed is the total of marked and maximum number of unmarked individuals observed.

Pond code	No. of marked adult turtles	Total no. of adult turtles observed	Total estimate ±SE
DR-1	24	27	29±3.6
VH-1	25	26	27±2.2
DR-2	18	21	22±1.7
VH-2	8	11	11±3.1
PO-1	7	10	11±2.8
DR-3	2	5	5±1.8

DISCUSSION

Few studies have specifically investigated the technical and statistical issues involved in field estimates of freshwater turtles (Ream & Ream, 1966; Bider & Hoeck, 1971; Frazer, 1990; Lindeman, 1990). Discussion has often involved the reliability of mantaining assumptions of these methods: particularly, the problem of unequal catchability seems difficult to avoid even after the application of different techniques for correcting bias (Koper & Brooks, 1998).

Population estimates by CMR in our study have proved reliable thanks to the intensive sampling effort. The high numbers of marked *Emys orbicularis* (75% of estimated adults) coupled with a good knowledge of the ponds allowed counts of turtles that were well correlated with true adult population sizes.

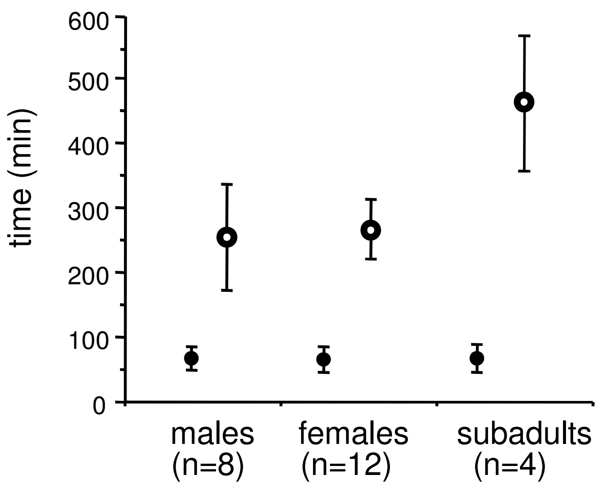

FIG. 1. Mean values (± SE) of basking bout duration (black circles) and total daily basking time (open circles) for adults and subadults in pond VH-1 for May to July. Sample sizes refer to the number of different turtles.

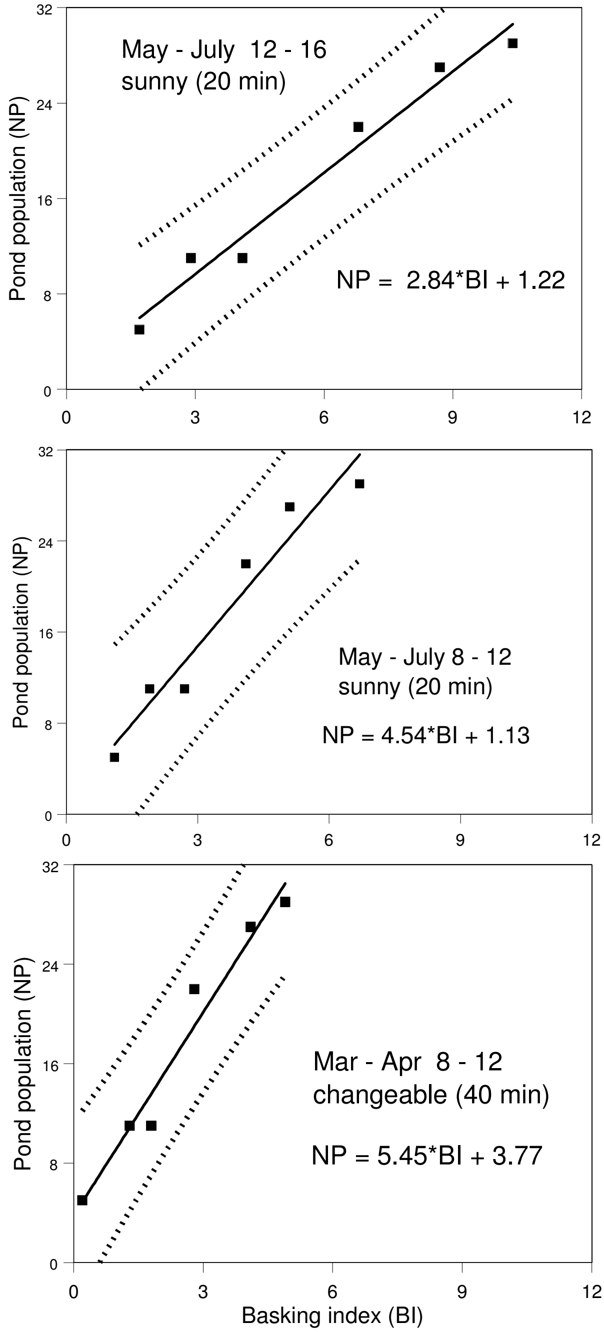

FIG. 2. A comparison of the significant regression lines (with confidence intervals at 95%) in different seasons, hours and weather conditions for all ponds (n=6; points: average values of BI).

Concerning the values of indices, the similarity of basking patterns in males and females avoided bias due to intersexual differences. No significant differences were found between the sexes in total basking time, and similar values of average bout duration have been also reported for male and female *Chrysemys picta* (Lefevre & Brooks, 1995).

Environmental conditions in which a significant correlation of BI with NP was found were consistent with basking pattern reported for this species, in terms of seasonal and daily frequency (Rovero *et al.*, 2000).

For March-April, correlation was significant only for long sessions of observation: water temperature in early spring may not be so uniform in all ponds as from May onwards, affecting basking behaviour.

Concerning the time spent making observations, no significant relationships were obtained for sessions lasting 40 mins in May-July. This could be explained by considering the average bout time of adults, because in a longer session the probability of including emersion and/or immersion is higher. Moreover, the effect of disturbance (by both unpredictable events and movements of the observer) could be more frequent, causing the immersion of turtles.

Midday hours with sunny weather from May to July showed the best conditions for assessment of population sizes in ponds. The value of the intercept of the regression line (1.22) seems ecologically meaningful, considering that single sessions of BC can overlook ponds with only 1-2 specimens.

The application of basking indices is limited to adult turtles not only for their higher detectability, but also because subadults are scarce in each pond, while turtles in age classes up to 3 yrs are spatially separated, living in swamps nearest to the nesting areas (Lebboroni & Chelazzi, 1999).

We are aware that the index we suggest has been tested on only a few ponds, with adult turtles ranging from 5 to 30, a small number when compared with larger populations living in canals and marshes of coastal central Italy (Zuffi *et al.*,1999). Nevertheless, *Emys orbicularis* is widespread in habitats such as ponds in many areas of its European range (cfr. Servan, 1998). In peninsular Italy, because of pond location, difficult access and the general lack of ecological data for these areas, it is possible that ponds – especially those in hilly areas – can support a consistent number of small population of this species.

As with all other relative indices of abundance, the use of basking counts in ponds can be recommended as a monitoring scheme in two main situations: (1) at large spatial scales in similar habitats for a comparison of abundances; and (2) at small spatial scales for a detection of population trends in consecutive years. For both aspects there is an increasing need for a standard field methodology to apply at a national level, in order to carry out identification of endangered habitats and/or species suggested by European directives (i.e. 'Habitat' 92/43/CEE, including *Emys orbicularis*).

Further tests on the reliability of basking counts will assess the possibility of applying the method on a larger scale for this species.

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