

Reappraisal of an old cheap method for marking the European hedgehog

Emiliano Mori · Mattia Menchetti · Sandro Bertolino ·
Giuseppe Mazza · Leonardo Ancillotto

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Abstract Marking quilled animals for individual recognition may be challenging. This is particularly true for European hedgehogs *Erinaceus europaeus*, whose defense mechanism involves the concealment of muzzle and underparts. Heat-shrink tubes have been widely used to mark quills, but they do not adapt to the morphological structure of the spines and are rapidly lost, thus reducing method effectiveness. We adapted a cheap and ethical method used to mark crested porcupine quills, which involves the use of colored adhesive tapes applied to quills. The retention period of this marking technique lasts up to 9 months, allowing short-term field

studies and possibly dispersal distances measurements. The method could be improved by doubling the number of marked spines and by reapplying adhesive tape at every recapture event. Moreover, the use of a marking code can be obtained by subdividing the body of the hedgehog into six body areas, to increase the number of marking possibilities, through the combination of tape colors and body areas.

Keywords *Erinaceus europaeus* · Quill marking · Adhesive tape · Retention period · Dispersal

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Emiliano Mori and Mattia Menchetti contributed equally to the manuscript.

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E. Mori (✉) · S. Bertolino
Department of Agricultural, Forest and Food Sciences, University of Turin, Grugliasco (Turin), Largo P. Braccini 2, 10095 Grugliasco, TO, Italy
e-mail: moriemiliano@tiscali.it

M. Menchetti · G. Mazza
Department of Biology, University of Florence, Florence, Italy

G. Mazza
CRA-ABP, Consiglio per la Ricerca e la Sperimentazione in Agricoltura, Florence, Italy

L. Ancillotto
Department of Biology and Biotechnologies “Charles Darwin”, University of Rome “La Sapienza”, Rome, Italy

L. Ancillotto
Wildlife Research Unit, Laboratorio di Ecologia Applicata, Dipartimento di Agraria, Università degli Studi di Napoli Federico II, Naples, Italy

Introduction

Ecological studies involving population dynamics, dispersal movements, spatial behavior, and density estimates require individuals to be marked for future recognition and identification (Silvy et al. 2005). Individual recognition without direct manipulation is possible only for a few species of vertebrates, presenting particular fur or spot patterns (e.g., newts: Cicek and Ayaz 2011; yellow-bellied toads: Mori and Giovani 2012; spotted felids: Anile et al. 2012; dolphins: Sayigh et al. 1998). With regard to small mammals, this is possible only for few species with markedly variable pelage color among individuals (e.g., *Callosciurus finlaysonii*: Mazzoglio et al. 2007). For other species, manipulation by man and application of devices are necessary to distinguish among different individuals.

The marking methods used for small mammals include cheap techniques, such as toe or ear clipping and hair cutting. The first two methods may affect spatial and antipredatory behavior of the studied species (Lindner and Fuelling 2002; Borges-Landaez and Shine 2003); furthermore, an ethic limit

on the number of toes or ear incisions to be cut greatly reduces the number of different possible markings (Petit et al. 2012). On the other hand, hair clipping represents only a short-term method, as markings disappear after the individual molts. Moreover, this technique is also difficult to read if the pelage of the animal is wet when recaptured. Ear tagging is substantially inapplicable in species with small or thin ears, as well as in species which practice allogrooming (Pigozzi 1988); tattoo and hair painting may represent useful techniques for some species, but are not always applicable due to limited space on the mammal's body (Petit et al. 2012).

We tested the effectiveness of a cheap and easy to apply method for marking quilled/spiny mammals. We chose the European hedgehog *Erinaceus europaeus* as a model species, since this is one of the most widespread and synanthropic mammals in Europe (Mitchell-Jones et al. 1999) and because it is characterized by a stocky body covered with dense and short spines ($N=8400\pm300$ per individual, average length=20–30 mm, Pucek 1981; Morris 2006) on the dorsal region. Its ventral parts are not easy to manipulate because of its defense mechanism to roll into a ball with the spines facing outward (Reeve 1994). Due to its locomotion physiology and the habitats used (Boitani and Reggiani 1984; Doncaster et al. 2001; Riber 2006), the application of other marking methods such as spine painting (Campbell 1973; Lindner and Fuelling 2002) seems to be poorly efficient, since paint markings easily fade due to frequent friction with substrate. All of these considerations lead to the conclusion that marking hedgehogs for individual recognition is challenging, mainly because of its physical structure, which may also decrease the possibility to apply ear tags without sedation. In Appendix I, we report a list of published work regarding the marking methods used for hedgehog.

While radiotracking of each individual may last up to 8–12 months (Boitani and Reggiani 1984; Haigh et al. 2013), data on marking retention of other methods are not reported in published studies (see table in Appendix I), with the exception of the spool-and-thread method, which did not last more than

one night (Shanahan et al. 2007). Colored heat-shrink tubings commonly used to insulate wires have been used to mark hedgehogs, by placing them over some spines. Different colors or different marking areas on the body of the hedgehog may allow researchers to identify individuals also at a distance through a spot light (Campbell 1973; Jones and Norbury 2006; Dowding et al. 2006). On the other hand, this method does not alter the behavior of the marked individuals nor their exposure to predators because of their nocturnal habits (Pigozzi 1988). Color coding using combinations of colors and placement on the hedgehog is useful while enough tubes remain on the hedgehog.

We propose an economic quill marking method, already used for crested porcupines (Pigozzi 1988) to maximize adhesion of markings to quills, which is ethically acceptable, harmless to hedgehogs, time saving, and clearly visible at a distance.

Materials and methods

The study area (about 750 ha) is located in a rural hilly landscape (475–650 m a.s.l.) in Southern Tuscany (Central Italy). Habitats in the study site (province of Grosseto, Central Italy: 474–1045 m a.s.l.) included mixed deciduous woodlands (69 %), fallow fields (13 %), cultivated fields (5 %), pinewoods (3 %), human settlements (2 %), and scrubwood (8 %, see also Mori et al. 2014a).

Hedgehogs were captured through traps used in the framework of a research project on the ecology of the crested porcupines and by chance encounters. Recaptures occurred during nocturnal monitoring of other species and while traveling two 3-km line transects, three nights a week, between July and October 2011, and between March and May 2012. The first transect was located in a deciduous woodland (Forcoli oakwood, 43.087817° N, 11.020083° E, hereafter DW), the second one within a human settlement (village of Prata, 43.083111° N, 10.985565° E, hereafter HS). Body

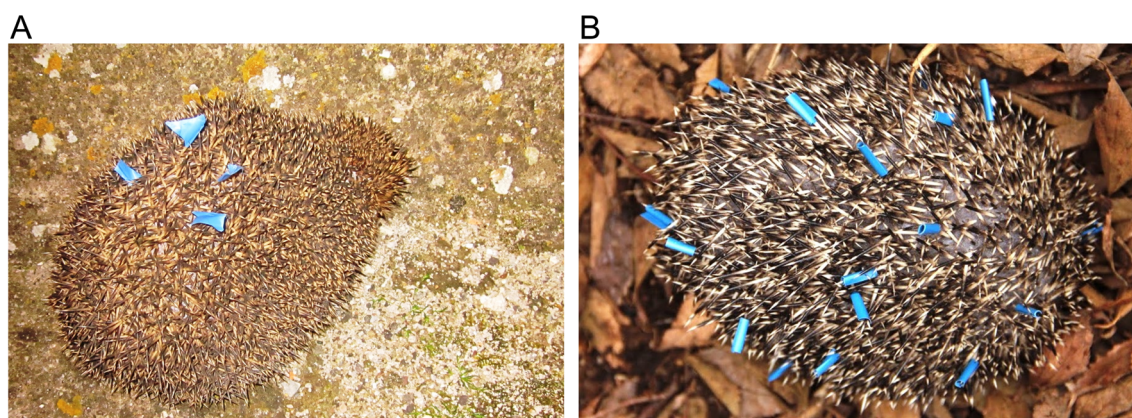


Fig. 1 European hedgehog marked with Method 1 (a) and with Method 2 (b)

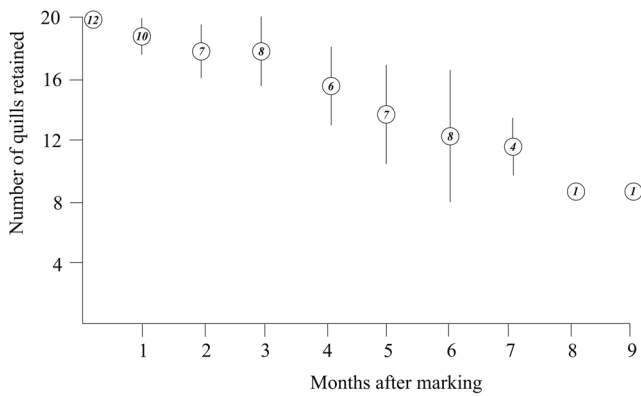


Fig. 2 Median number of marked quills retained by hedgehogs at different times after marking. Bars represented standard deviation; values in *italics* represented the number of hedgehogs observed at each time

weight and sex of captured individuals were recorded. Animals weighting more than 600 g were considered as adults (Parkes 1975; Haigh et al. 2014).

Marking involved the application of 2-cm-long strips of plastic adhesive tape, usually used to repair electrical cables, on 20 quills (Pigozzi 1988). We used tapes of 10 different colors to allow individual recognition in each study site. Each individual was marked with 20 strips of the same color, located randomly in the dorsal region of the individual. Handling required a maximum of 15 min for each hedgehog, which was then released at the point of capture. Recaptures occurred by visual sampling, and handling lasted only for the time employed to recount marked quills (1–2 min).

The first two captured animals were marked with a single turn of tape around the quill, with the extremities of the strip joined to create a kind of colored flag (Method 1: Fig. 1a).

This allowed rapid recognition at a distance, but the marking lasted for a very short time (over 50 % tapes lost in 3 days). So, the colored tape was turned twice around each quill, closing the ends of the strip on the quill itself (Method 2: Fig. 1b).

Differences in number of recaptures and maximum distance from marking point between sexes and age classes were evaluated using Mann–Whitney *U* test, since measurements were not normally distributed (Shapiro–Wilk normality tests: $W=0.741$ – 0.0002 , P value= 0.003 – 0.010). Means are reported $\pm$ SD.

Results and discussion

A total of 12 hedgehogs (8 males, 4 females) were captured and marked with Method 2 (DW, $N=8$; HS, $N=4$); four of them were marked and recaptured after hibernation (November–March: Table 1). Two individuals were never recaptured (Table 1). A road-killed individual was found after 9 months with nine marked quills still present (Fig. 2). No other marked individual has been recaptured after this one.

Juveniles were observed at higher distances than adults from the sites of their respective first capture (Mann–Whitney *U* test= 0 ; $P=0.009$), while distances were not significantly different between sexes (Mann–Whitney *U* test= 8 , $P=0.4762$). All the individuals but two were recaptured within a radius of 1000 m (mean 462.75 ± 337.63) from the site of first capture; 80 % of recaptures of young individuals occurred within 3–4 months after the application of adhesive tapes. Only two juveniles, one from DW and one from HS were

Table 1 Summary of captured individuals, site of capture, sex, age, and biometrical measurements

Individual	Site	Sex	Age	Hindfoot (cm)	Weight (g)	N. recaptures	N. days	Recapture after hibernation	Maximum distance (m)
1	DW	M	Adult	4.8	960	3	205	Yes	543
2	DW	F	Adult	4.6	870	5	193	No	612
3	DW	M	Adult	4.6	990	7	209	No	500
4	DW	M	Adult	4.7	955	5	179	Yes	128
5	DW	F	Juvenile	3.9	370	2	238	No	3766
6	DW	M	Juvenile	4.1	420	0	–	–	–
7	DW	F	Juvenile	4.0	385	4	204	No	907
8	DW	M	Juvenile	3.7	410	6	186	No	860
9	HS	M	Adult	5.0	1000	8	211	Yes	49
10	HS	M	Juvenile	3.6	400	7	283	Yes	2953
11	HS	F	Adult	4.7	1100	3	206	No	103
12	HS	M	Juvenile	4.8	360	0	–	–	–

Number of recaptures was also reported, as well as recapture occurrence after hibernation (November–March) and maximum distances at which each marked hedgehog was observed from the capture site

N. days number of days between first capture and last observation

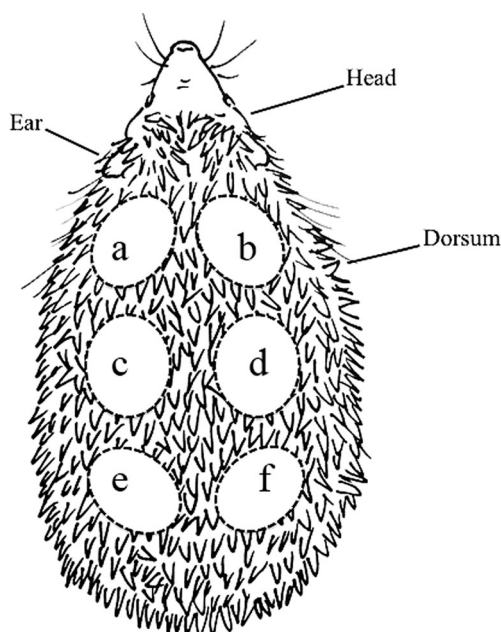


Fig. 3 Body areas for marking hedgehogs

road-killed, as adults, after 7 and 9 months from marking and at a distance of 3766 and 2953 m from their capture sites, respectively.

The marking method proposed in this study seems to be effective to analyze philopatry and dispersal movements of hedgehogs. Colored tapes are also more easily applicable than ear tags in a species whose defense mechanism involves the ability to roll into a ball and are longer lasting than spool and thread (Shanahan et al. 2007).

In our study, hedgehogs retained the colored tapes up to 9 months. Quills of crested porcupines are longer than those of hedgehogs (Mohr 1965) and easily released by contact or drop out when the animal shakes its body, as loosely rooted (Mori et al. 2014b). By contrast, quills of hedgehogs are well rooted and more rarely lost while individuals are walking or contacting with environment or other hedgehogs (Reeve 1994); therefore, marking may be retained for a longer time. However, the reduction in observations of marked hedgehogs may be due also to the movement of the animals outside the study site rather than to the loss of marked quills. Moreover, some hedgehogs may have died while still retaining the marked spines. The method could be implemented by reapplying the missing tape strips at each recapture event or by marking a greater number of spines at the first capture.

A greatly increase in the number of different marking possibilities could be obtained, through the combination of tape colors and by subdividing the body of the hedgehog into up to six body areas (Fig. 3). Considering that at least ten adhesive tape colors are commercially available, it should be possible to mark between 60 (using one body area) and, for example, 720 different individuals marking three body areas.

Although the limited number of recaptures does not allow us to infer general conclusions about the spatial behavior of the European hedgehog in the study area, our results in terms of spatial movements (dispersal patterns) seem to be consistent with previous studies (Boitani and Reggiani 1984; Reeve 1994; Doncaster et al. 2001). Adults seem to be more philopatric than juveniles, and they are always recaptured in the surroundings of the areas of first capture (Reeve 1994). Juveniles become self-sufficient at the age of 2 months, then they move away from the mother and reach sexual maturity at about 1 year of life (Reeve 1994). This would explain the high rate of recapture of young hedgehogs during the first 3–4 months after the first capture and their subsequent disappearance from the study site. Maximum dispersal distances traveled by hedgehogs in unfavorable habitats (farmlands in UK) may reach 10 km, although, in general, they reach around 4 km (Doncaster et al. 2001). The linear distances at which two road-killed hedgehogs were found in our study (3766 and 2953 m) are compatible with dispersal distances known from literature (Morris 1988; Jones and Norbury 2006; Molony et al. 2006; Dowding et al. 2006). Interestingly, the two individuals were recaptured a number of times around first capture areas before the supposed dispersal events.

In conclusion, we highlight that the method we propose is cheap, time saving, and efficient in evaluating the spatial behavior of small bodied spiny mammals, i.e., very difficult mammals to be marked, and thus can be used as main method, e.g., in case of low funding (Cagnacci et al. 2012), or as supplementary to other techniques (e.g., radiotracking).

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