

***Hystrix cristata* (Mammalia: Rodentia: Hystricidae) newly recorded in South Tyrol (Italy) at its current northernmost distribution limit**

Abstract

The presence of *Hystrix cristata* in the province of South Tyrol was documented by two independent records of quills found at two different locations. While further official confirmations beyond single quill records are required to confirm the occurrence of permanent populations, these findings already provide important information to increase the attention on this protected species and to understand its range expansion mechanisms. *H. cristata* is known to currently spread northwards in Italy and the records reported here represent the northernmost distribution record in Europe, suggesting a potential expansion within the Alpine area and adjacent countries.

Keywords: *Hystrix cristata*, Eastern Alps, Italian Alps, geographic distribution, range expansion, porcupine

Introduction

Two species of porcupines have been recorded in Italy, *Hystrix cristata* Linnaeus, 1758 and *Hystrix indica* (MORI et al. 2017B). *H. cristata* is considered to have been introduced in Central and Southern Italy in late antiquity or early Middle Ages (2500–1500 years ago; TRUCCHI & SBORDONI 2009), probably as a game species (MASSETI et al. 2010). *H. indica* is considered as a recent introduction with a limited distribution in the Marche region (MORI et al. 2017b). *Hystrix cristata* is listed as “least concern” in Italy by the International Union for the Conservation of Nature (IUCN) and is protected by law in Italy since 1980. However, it is also considered a pest species for crops (since it regularly feeds on fruits and vegetables) and riverbanks (due to its digging behavior) and illegally poached upon for meat (AMORI et al. 2008, LOVARI et al. 2017). The distribution range in Italy remained limited to South and Central Italy, from Sicily up to Tuscany, until about 1970 (MORI et al. 2013). In the last few decades, *H. cristata* started to spread to the north, crossing the Po plain and reaching only recently the southern margin of the Alps (MORI et al. 2018). The invasive history is also well described by its genetic diversity, pinpointing the recent north expansion within Italy (TRUCCHI et al. 2016). A total of eight records of the species were reported in the south of the neighboring province of Trentino, from sites between 250 and 1040 m a.s.l. (MORI & BRUGNOLI 2019). However, the nearest confirmed viable population is further south in the Veneto region (SPADA et al. 2008).

The reasons for this recent range expansion are probably related both to legal protection and to changes in climate such as temperature, drought and precipitation regimes (MORI et al. 2018, 2021, TORRETTA et al. 2021). Very likely, there are further facilitating factors that contribute to the porcupine’s distribution expansion such as increased deciduous forest cover (MORI et al. 2018), proximity to agricultural areas for food provisioning (LOVARI et al. 2017, MORI et al. 2017a), and landscape connectivity between forested areas (TORRETTA et al. 2021).

Species distribution models based on topo-climatical variables, landcover and elevation forecast that the species will likely spread throughout northern Italy (MORI et al. 2018, TORRETTA et al. 2021). In these models, the inner Alpine area appears to be a less suitable habitat for the species. However, wide, warm and low elevation valleys, such as the

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Adige/Etsch valley, provide an optimal corridor connecting the Po plains to the Alpine area, as has already been demonstrated for several Mediterranean and other introduced species occurring in the province of South Tyrol (e.g., BALLINI & WILHALM 2014, GUARIENTO et al. 2019). The distribution models computed by MORI et al. (2018, 2021) already denote the major valleys connected to the Po plain as a potentially suitable habitat for the species. However, data is lacking to rate the potential mobility and dispersion of porcupines that can lead to considerable range expansions via less suitable habitats (but see TORRETTA et al. 2021 for the Po plain) and across natural barriers, such as the mountain range of the Alps. Nevertheless, it is known that *Hystrix cristata* can use areas covered in snow in parts of the year up to 1900 m a.s.l. in the Apennine (AMORI et al. 2008). We report here two independent findings of quills that denote the first records of the presence or at least passage of *Hystrix cristata* in the Alpine border province of South Tyrol where it was never recorded before (HELLRIGL 1996), currently being the northernmost record reported in Europe.

Material & Methods

Occasional findings of quills were the trigger for the present study. Where quills had been recorded, visual inspection of the surrounding area was carried out by the authors in summer 2021 looking for further quills, scat, or potential dens. Further, two camera traps (1 Boskon BG 520 and 1 Bushnell Trophy Hd Aggressor) were installed at the first site with sweet corn, apples and dried plums as bait (as demonstrated effective attractant to *Hystrix cristata* in MORI 2017) to increase record probability. Cameras were placed at a height of ~80–150 cm from the ground level and were activated for 24 h/day. The cameras were set up the location of the first quill finding near Vadena/Pfatten and were left unattended throughout the sampling period, ranging between ranging from the 5th August to 14th October 2021. The two cameras were active for a total of 70 days and nights. In the location of Villandro/Villanders, no camera trap was installed since the high elevation of this record probably originated from a dispersing individual crossing the area.

Results

Three quills were found by Andrea Debiasi at the beginning of October 2020 (Fig. 1A) in the vicinity of Pfatten/Vadena (GPS coordinates - EPSG: 4326, 46.4160 N, 11.3042 E). The quills were found on the side of the forest road that starts from Vadena/Pfatten in direction Monticolo/Montiggl. The area is not much frequented by people and is characterized by a steep, south-east exposed and warm forest (mixed forest with downy and sessile oak, hop hornbeam and chestnut) with lots of *Ruscus aculeatus* undergrowth. The site is located at about 260 m a.s.l. and characterized by a mild sub-Mediterranean climate. The steep location, with many larger gravels potentially offers a lot of hiding spots and dens and is closely located to apple orchards near the locality of Vadena/Pfatten.

Two visual searches in the area did not result in any further evidence (quills, scat, or dens). The second independent record was made by Matteo Anderle in the locality of Villandro/Villanders (GPS coordinates - EPSG: 4326, 46.6495 N, 11.5075 E) on the 17th June 2021 (Fig. 1B) and consisted in one single quill found sticking in the soil of a coniferous forest with larch and Swiss pine. In comparison to the first finding, this was a rather short and partly consumed quill. The site is located at 1790 m a.s.l. and characterized by a colder climate. This is a rather high elevation record, more likely originating from an individual passing by rather than inhabiting the surroundings permanently since snow cover for over one month is generally regarded as unsuitable for this species (MORI 2018).

The here reported records extend linearly the northward spread (Spearman rank correlation $r = 0.97$; Fig. 2) of the species in Italy as described by Mori et al. (2013).

The camera traps did not record any individual of *Hystrix cristata* during the exposure period. However, a minimum of four species of meso- and large mammals were occasionally recorded by video in the locality of Vadena/Pfatten (Tab. 1).



Fig. 1: A The quills found at the first location near Pfatten/Vadena (Picture by Andrea Debiasi). B. The single quill found in Villandro/Villanders at 1790 m a.s.l. (Picture by Matteo Anderle).

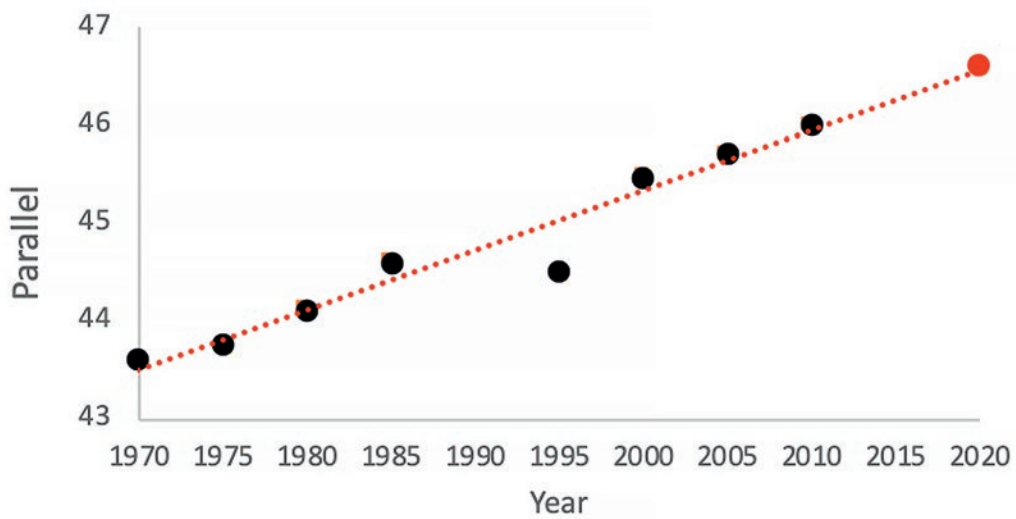


Fig. 2: Northward range expansion (modified from Mori et al. 2013) with the here reported findings in red that match perfectly the previously reported range expansion per time reported by Mori et al. (2013).

Tab. 1: List of mammals recorded by two camera traps in the first location of quill records near the locality of Vadena/Pfatten (GPS coordinates - EPSG: 4326, 46.4160 N, 11.3042 E).

Order	Family	Scientific Name
Artiodactyla	Cervidae	<i>Capreolus capreolus</i>
Carnivora	Felidae	<i>Felis catus domesticus</i>
Carnivora	Mustelidae	<i>Martes sp.</i>
Carnivora	Mustelidae	<i>Meles meles</i>
Carnivora	Canidae	<i>Vulpes vulpes</i>
Carnivora	Canidae	<i>Canis lupus familiaris</i>

Discussion

The recorded occurrence of the species in South Tyrol is of major interest since it represents both the northernmost record that the species appears to have reached so far and one of the highest records in Europe (AMORI & DE SMET 2016, CAPIZZI 2021). The species can be expected to become persistent in the region, especially in the lower and warmer Adige/Etsch valley and the surrounding deciduous forests (MORI et al. 2018, 2021).

The here recorded quills were most likely from dispersing juveniles originating from the nearby province of Trento or region of Veneto, however, further investigations are required to assess the species persistence in the province. Interesting to note is that no records at the northern border of Trentino were reported so far that could be connected to our findings.

The first location close to Vadena/Pfatten is a suitable habitat for the species, well connected to the south with continuous woodlands and agricultural settings nearby for potential foraging (LOVARI et al. 2017, MORI et al. 2018). The second record, however, indicates a potential spread or movement to higher elevations as well making a more consistent colonization of the Alpine arch more likely. If this movement already allows the species to cross the Alpine range and potentially colonize other countries of Central Europe (borders to Austria and Switzerland are at only 1150 to 1400 m a.s.l.) is still an open and interesting question that seems even more likely considering the records presented here.

However, it is important to note that the here reported records still are uncertain to a minor extent and a photographic record (such as a direct sighting or locating of other signs of the species' occurrence) or road kills would be helpful to confirm the species presence. Nevertheless, considering quills only is still regarded as a common approach to denote the presence of the species (MORI et al. 2013, TORRETTA et al. 2021) and we consider the here reported findings as an indication of the species occurrence in or passage through the province of South Tyrol. Finally, we assume that the quills originated from *Hystrix cristata*, as this is the species currently expanding its range north and occurring in the neighboring provinces. However, *H. indica* is also present in Italy with a limited distribution in the Marche region (Central Italy) and the differentiation from *H. cristata* would request a DNA analysis that has not been carried out so far (MORI et al. 2017b).

The presence of the species in the province of South Tyrol is of major importance since it is a protected species, and the nature conservation authorities as well as the public need to acknowledge its presence. This is especially important to guarantee pertinent protection, since unlawfully killings for meat consumptions are known, and the species foraging activity can cause conflicts in agricultural areas where raiding of vegetables and fruits are a common reported behavior (LOVARI et al. 2017).

In conclusion, it appears that the spread of this species is continuing, and its presence can probably be expected in other alpine areas soon, maybe even in other European countries. With climate change proceeding, the habitat suitability in South Tyrol and the Alpine arch is predicted to increase even further (MORI et al. 2018), especially since the days of snow cover tend to decrease for large areas increasing the suitability for the species (TORRETTA et al. 2021).

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