

Short Note

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Time is running out! Rapid range expansion of the invasive northern raccoon in central Italy

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Abstract: The northern raccoon, *Procyon lotor* (Linnaeus, 1758), is listed among the invasive alien species of European Union concern. Therefore, an updated monitoring of its distribution is required to design and address management actions. As to Italy, the raccoon has been reported with an established population only in northern regions. In this note, we report a new established raccoon population along the Apennine ridge in central Italy and we estimate the range expansion from 2015 to 2018 both through the minimum convex polygon (MCP) and the kernel estimates. Furthermore, we propose the management actions to limit negative impacts in the Foreste Casentinesi National Park and its surroundings.

Keywords: Apennine ridge; invasive alien species; management actions; *Procyon lotor*; range.

The northern raccoon, *Procyon lotor* (Linnaeus, 1758) (Carnivora; Procyonidae), has been introduced throughout Europe during the past century for fur farming, hunting and the pet trade (Lutz 1984, Salgado 2018).

Currently, the raccoon has been established (i.e. reproduction and population growth) in at least 20 European

countries, including the three Caucasian republics; in 10 of them, expanding invasive populations occur (Salgado 2018). Despite a reliable quantification of the damages by introduced raccoons has not occurred yet, predation on native fauna (Kahuala 1996, Bartoszewicz et al. 2008, García et al. 2012), competition with native species (Kahuala 1996, García et al. 2012) and potential disease transmission by raccoons (Beltrán-Beck et al. 2012, Mazza et al. 2014, Mackenstedt et al. 2015) have been suggested to occur throughout Europe. The raccoon is listed as an alien species of European concern by the EU Regulation 1143/2014 on the prevention and management of the introduction and spread of invasive alien species (Genovesi et al. 2014, Nentwig et al. 2018). The raccoon is reported as invasive in most European countries because of the high rate of population growth and range expansion (e.g. Mori et al. 2015, Fischer et al. 2017, Duscher et al. 2018, Salgado 2018); it may become locally overabundant, and some small local populations of native prey species may decline or even become extinct by high predation pressure (García et al. 2012, Salgado 2018).

As the European law currently stands, raccoons cannot be traded nor kept as pets without special permits. Monitoring of established populations and the early detection of new nuclei require research attention and need to be constantly carried out. The raccoon shows a wide ecological plasticity and a high dispersal ability (Mori et al. 2015, Fischer et al. 2016), thus being adaptable to a number of habitat types including the most anthropized ones (Michler et al. 2004), and it is widespread in many European zoological gardens (<https://www.zootierliste.de/>). Thus, new introductions should also be recorded as a potential risk of further invasions.

As to Italy, the first records of free-ranging raccoons date back to 2004 in Lombardy (Canova and Rossi 2009), along the Adda river, where an expanding population of the raccoon is currently kept under numerical control (Mori et al. 2015; Panzeri et al. 2018). Scattered records of unintentional releases and escapes also occurred in many other Italian regions, but they are mostly related to single individuals or small groups which were recaptured or disappeared

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after a few months (Mori et al. 2015). Conversely, since the detection of two road-killed individuals in 2013 and 2015, a population of northern raccoon has been recorded in central Italy, in the northernmost part of the province of Arezzo (Tuscany), near the border with Emilia Romagna.

This area deserves particular attention, as it encompasses the Foreste Casentinesi National Park (43.820°N–11.800°E), a protected area of about 36,600 ha located along the Apennine ridge between Tuscany and Emilia Romagna. This park houses many species of endangered flora and fauna, including the Apennine wolf *Canis lupus italicus* Altobello, 1921, the wild cat *Felis silvestris* Schreber, 1777, the white-clawed crayfish *Austropotamobius pallipes* complex and the native crab *Potamon fluviatile* Herbst, 1785 (Mazza et al. 2011, Ragni et al. 2014).

In this note, we present the georeferenced records of the northern raccoon in central Italy obtained through addressed citizen science projects (on iNaturalist: <https://www.inaturalist.org/projects/mammiferi-d-italia>; Naturaesocialmapping: <http://www.naturaesocialmapping.it/node/430>), as well as through photographic records reported on the main social networks (Facebook and Twitter: cf. Mori et al. 2018: Appendix 1). Data from the social networks were validated through an expert-based approach, and the coordinates of each sighting were directly asked to the observers. Citizen science projects to analyze and depict the raccoon distribution have been reported to be successful (e.g. Mori et al. 2015, Fischer et al. 2016, Duscher et al. 2018). Given that most records were reported from local people who used to range within

woodlands and the countryside throughout the years of our survey, we assumed that our sampling effort was reliable and almost complete. We considered as “not relevant” a previous raccoon record from Bagno a Ripoli (province of Florence, 2012: Mori et al. 2015), which was most probably set free by a local pet owner. We showed a range expansion between 2015 and 2018, by using the minimum convex polygon (MCP) encompassing all the records per year (Calenge 2006). The 95% kernel probabilistic method was calculated as a more accurate estimation of space use within the home range (Worton 1989). MCP and kernel estimates were calculated using the statistical software R 3.3.1 (free download at <https://www.r-project.org/>, R Development Core Team, Auckland, New Zealand, Accessed on 08.08.2018), packages *ade4* (Dray and Dufour 2007) and *adehabitat* (Calenge 2006). We collected a total of 39 records from 26 localities to describe the raccoon range in central Italy (Figure 1A). The raccoon range in central Italy increased from 2015 to 2018 (21,346 ha of 100% MCP; 12,819 ha of 95% kernel), when it was recorded in Emilia Romagna (near Bagno di Romagna, province of Forlì-Cesena: Figure 1B). Cubs were also observed since 2016 (in three photos), confirming the establishment success of the raccoon in central Italy. The raccoon was probably introduced in Poppi, in the province of Arezzo (Cappai et al. 2016a), because of an accidental escape from the local zoo (Garofalo et al. 2016). The northern raccoon is present in the zoo park of Poppi since 2001 (Figure 2A), although the park was created in 1972 as the first zoo park of European fauna. This was the only zoo hosting raccoons in the study

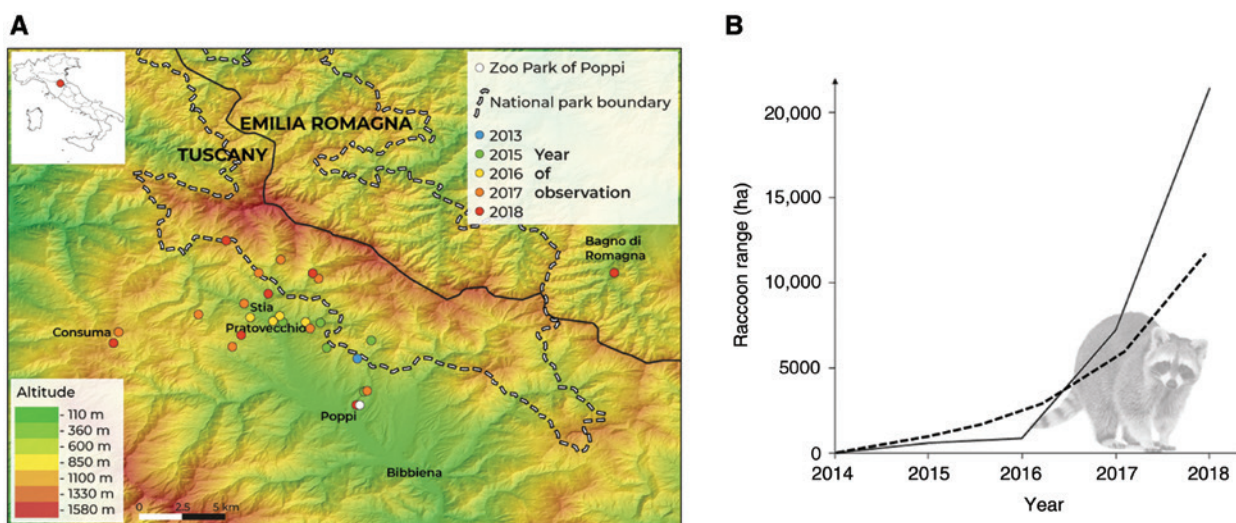


Figure 1: Distribution of the Northern Raccoon in Central Italy.

(A) Distribution of the northern raccoon occurrences (map: high-resolution digital elevation models; Tarquini and Nannipieri 2017, photo used with permission from ●●●). The dotted line shows the national park boundaries; (B) range expansion of the northern raccoon in central Italy (solid line = 100% MCP; dotted line = 95% kernel). <http://tinitaly.pi.ingv.it/>, Accessed on 15.03.2019.

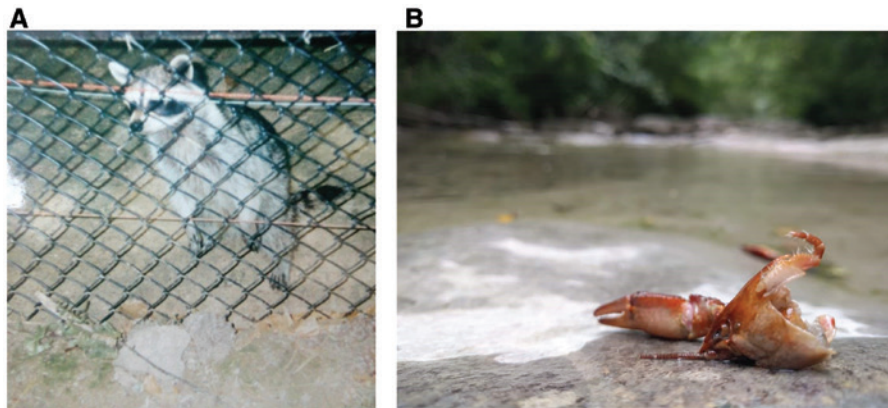


Figure 2: The Northern Raccoon in Central Italy and its potential impact.

(A) A specimen of the northern raccoon photographed in a cage in the Zoo Park of Poppi in 2001. Photo by © G. Mazza; (B) a specimen of *Austropotamobius pallipes* complex eaten by the raccoon in Bagno di Romagna (Province of Forlì-Cesena). Photo by © A. Boscherini.

site, which prevents us from considering the possibility of a multiple introduction.

In 2 years, raccoons overpassed the borders of the national park, located about 7 km northward (Cappai et al. 2016b) from the location of introduction. Raccoons were always recorded near water courses in the surroundings of villages (Poppi, Stia, Pratovecchio, Bibbiena and Bagno di Romagna), forests, glades and uncultivated fields, between 370 (Poppi) and 1032 (Consuma) m above sea level (a.s.l.). No reliable data on the population size are available, although Cappai et al. (2016a) estimated that at least 12 individuals were present in the national park. Data on the impacts are scattered and concern predation on pets, livestock and recently the indigenous crayfish (Figure 2B). Many factors threaten the native crayfish *Austropotamobius pallipes* complex in the Foreste Casentinesi National Park (overexploitation through illegal fishing, introduction of fish predators and drought). Therefore, the raccoon should be managed to protect this native crayfish, which is already compromised (Mazza et al. 2011, 2017). The Italian Institute for Environmental Protection Research (ISPRA) promotes the eradication of the raccoon in the Foreste Casentinesi National Park (Cappai et al. 2016a). Captured individuals are sterilized and translocated to authorized detention centers (Cappai et al. 2016b). Conversely, no management action has been carried out in the non-protected surrounding areas yet.

The most efficient management strategy relies on the prevention and the early detection of the introduced species, followed by the rapid removal of free ranging individuals or even small established populations (Genovesi and Shine 2004). Indeed, the EU Regulation 1143/2014 banned the trading of raccoons (Nentwig et al. 2018). This

is particularly evident for marginal and isolated raccoon populations, like the one reported in this note, which may be more easily managed than the widespread and large ones (Fischer et al. 2016, 2017, Salgado 2018).

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