

Short Note

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The raccoon dog *Nyctereutes procyonoides* in Italy: a review of confirmed occurrences

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Abstract: The raccoon dog *Nyctereutes procyonoides* is an Asian canid species which has been introduced to Europe for fur farming. Local escapes and the animal subsequent dispersal have triggered the establishment of self-sustaining populations, particularly in Eastern European countries, but with several populations in Southern Europe as well. Despite being listed amongst the alien species of European concern (EU Regulation 1143/2014), data on raccoon dog distribution in Southern Europe and in particular in Italy are still scanty. In this work, we reviewed all the available data of raccoon dog in Italy. Only five confirmed occurrences are available, suggesting that in this country the species may still be at the beginning of the establishment process.

Keywords: alien invasive species; distribution range; *Nyctereutes procyonoides*; range expansion.

Invasive alien species currently represent a major threat to global biodiversity, particularly in Western countries, through both intentional and accidental releases (Blackburn et al. 2019; Jeschke and Strayer 2005; Westphal et al. 2008).

Fur farming in particular has been one of the main pathways of introduction of invasive mammals to Europe, e.g. the coypu *Myocastor coypus* (Molina, 1782), the American mink *Neovison vison* (von Schreber, 1777), the raccoon dog *Nyctereutes procyonoides* (Gray, 1834) and the northern

raccoon *Procyon lotor* (Linnaeus, 1758) (cf. Bertolino et al. 2020).

For mammals, Italy is the country with the highest number of populations of alien mammalian species listed within the EU Regulation 1143/2014, hosting populations of coypus, grey squirrels *Sciurus carolinensis* Gmelin, 1788, Siberian chipmunks *Eutamias sibiricus* (Laxmann, 1769), Pallas's squirrels *Callosciurus erythraeus* (Pallas, 1779) and northern raccoons (Loy et al. 2019). For most of them, data on distribution and abundance are available (Boscherini et al. 2020; Di Febbraro et al. 2019; Nerva et al. 2021; Schertler et al. 2020), and management actions are, at least partly, ongoing (La Morgia et al. 2017; Mazzamuto 2015; Mazzamuto et al. 2020).

The raccoon dog (Carnivora: Canidae) also occurs in Italy, although it is reported only as occasional (Loy et al. 2019). The last review on the distribution of the raccoon dog in Europe dates back to 2011 (Kauhala and Kowalczyk 2011) and showed a wide distribution and a great invasive ability by this species. In detail, raccoon dogs (individuals belonging to the subspecies *N. procyonoides ussuriensis*) were first released to Bielorrussia between 1927 and 1955 (Kauhala and Kowalczyk 2011), creating self-sustaining populations occurring and expanding throughout several European countries, i.e. Russia, Bielorrussia, Estonia, Latvia, Lithuania, Finland, Norway, Ukraine, Moldova, Poland, Romania, Bulgaria, Hungary, Slovakia, Czech Republic, Germany, Denmark, Serbia, Macedonia, Bosnia Erzegovina, Croatia, Slovenia, Austria, Switzerland and France (Kauhala and Kowalczyk 2011). Impacts of the raccoon dog include potential competition with local carnivores (e.g., the red fox *Vulpes* Linnaeus, 1758 and the European badger *Meles* Linnaeus, 1758), predation on native species, and potential disease/zoonoses transmission including rabies, *Trichinella* spp, *Echinococcus* spp. (Duscher et al. 2017; Kauhala and Kowalczyk 2011; Koshev et al. 2020; Lapini 2006a; Singer et al. 2009). The raccoon-dog was also reported as a reservoir host for SARS-CoV-2 (Kochmann et al. 2021). The last assessment of records of the raccoon dog in Italy dates back to 2005, when Lapini (2006a) collected all available reports of this species, disentangling reliable from unreliable ones. Report of the raccoon dog from late 1980s in Trentino Alto

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Adige and Lombardia cannot be verified, and the only record considered reliable was the one concerning three photo-trapped animals in the province of Udine (North-Eastern Italy) (Fattori et al. 2010; Lapini 2006a). The wide climatic niche of this species may allow the invasion of further countries, thus requiring a tight monitoring of its distribution (Kochmann et al. 2021). Therefore, after twenty years and a newly published national mammal checklist (Loy et al. 2019), an update is urgent, in line with the recommendations by the EU Regulation 1143/2014. In this note we reviewed and summarised all the available records of the raccoon dog in Italy in the last twenty years, updating its distribution.

We searched for published and unpublished records, grey and scientific literature. We also checked on online databases of records, including those obtained through citizen-science and validated by experts (i.e., iNaturalist: www.inaturalist.org; Ornitho: www.ornitho.it. All accessed on 26.06.2022). The occurrence search was conducted in April–December 2022, and we searched for all available free-ranging raccoon dog records. The literature search was carried out by assessing studies in online databases (i.e., ISI Web of Science, Scopus, Zoological Records, and Google Scholar). Search terms included all possible combinations of the words: raccoon dog, *N. procyonoides*, distribution, Italy, alien mammal species. The same words were searched in English, French, German and Italian, i.e., the languages spoken in the scientific literature and in the area of interest. We also directly searched for information on Google, possibly to find newspaper data with reliable raccoon dog records. All collected records were classified adapting the categories used for the reliability of Eurasian lynx (*Lynx* Linnaeus, 1758) records (Molinari-Jobin et al. 2012): (C1) “hard fact” data (e.g. dead and live-captured raccoon dogs, camera-trapping data validated by experts); (C2) signs of presence confirmed by an expert (e.g. footprints, scats); (C3) unconfirmed data (e.g. direct visual observation without pictures or samples, camera-trapping data not validated by experts).

Besides 10–15 unconfirmable (C3) occurrences from late 1980s (Lombardy, Trentino-Alto Adige and Friuli Venezia Giulia, cf. Lapini 2006a) not considered within this work, we were able to collect a total of six records of raccoon dog in Italy since 2005 (Table 1; Figure 1a). The first of these records was collected in 2005 with a first-generation analogical camera trap (Fattori et al. 2010) and was reported as the only Italian record by Kauhala and Kowalczyk (2011). Given that the only available picture from the web regarding this record has low quality (<https://wildfangs.forumfree.it/?t=17194397>. Accessed on 17.11.2022), we sent it to 17 raccoon dog experts asking for their opinions. We obtained 14

answers: 71.42% of the experts considered the camera-trapped animals to be European badgers rather than raccoon dogs. Therefore, we assigned ‘C3’ quality to this record. The first C1 Italian record is represented by two individuals killed during the red fox hunting in San Piero di Cadore (province of Belluno) in 2011. In the same year, an individual was camera-trapped in Southern Lombardy, in the province of Lodi, along the Adda river and confirmed by experts as a raccoon dog; this animal was suggested to be probably an individual escaped from a caged condition. In 2016, a road-killed individual in Gargazzone (province of Bolzano, bordering the western part of Austria) was identified as a raccoon dog by the Local Provincial Council and by experts. The next record was an individual camera-trapped by one of the authors in August 2020 (S.P.), in the framework of a monitoring project of the golden jackal *Canis aureus* Linnaeus, 1758, in the lower stretch of the Torre stream (YouTube video: <https://www.youtube.com/watch?v=mHeAdIEx0vE>; Pecorella 2021: Figure 1b). In the same area, an intensive monitoring on badger burrows has been carried out since 2021 by some of the authors, but no raccoon dog was detected by the camera traps. The final confirmed record was an individual camera-trapped in Colle di Bolzano (Alto Adige) in January 2021. In the rest of Italy, four records initially reported as raccoon dog (one in Trentino Alto Adige, one in Veneto and two in Tuscany) were lately identified by experts as silver foxes, i.e., a melanistic form of the red fox widely used in fur farming.

Given the wide use of camera-trapping in Italy for citizen-science scientific projects and recreational purposes, it is likely that the raccoon dog has not reached other Italian regions away from the North. The recorded individuals were most likely juveniles in dispersal from neighbouring countries, given that no raccoon dog is present in local Italian zoo parks to the best of our knowledge, although we cannot exclude escapes from illegal collections. Confusion with the Eurasian badger can occur (e.g., the record from Socchieve; see Fattori et al. 2010; Lapini 2006a), and opportunistic camera trap users may not be aware of the presence of the species in the country, affecting the collection of records. Lapini (2006a) suggested that the slow colonization of Italy by the raccoon dog may occur through two independent routes, i.e., from NNE (Trentino-Alto Adige) and from ENE (Friuli Venezia Giulia). Moreover, the record from the floodplains of Torre stream suggests that rivers basins may serve as corridors for the invasion (as occurred with the expansion of the European wildcat *Felis silvestris* Schreber, 1777 and the golden jackal *C. aureus* Linnaeus, 1758 in north-eastern Italy, see: Lapini 2006b; Lapini et al. 2009) and therefore should be specifically monitored.

Table 1: Reliable (i.e. confirmed by photos or samples) records of raccoon dog in Italy.

Location	Date (dd.mm.yyyy)	Approximate latitude (°N)	Approximate longitude (°E)	References	Number of individuals	Type of record	Reliability category
San Pietro di Cadore (province of Belluno)	NA.NA.2011	46.5714	12.5793	Bon (2017)	2	Killed during fox hunting	C1
Adda river (Lodi)	NA.NA.2011	NA	NA	This study	1	Camera-trapping	C1
Gargazzone (province of Bolzano)	14.06.2016	46.5919	11.2004	This study	1	Road-kill	C1
Tapogliano (Udine)	01.08.2020	45.8928	13.4031	This study	1	Camera-trapping	C1
Colle di Bolzano (province of Bolzano)	NA.01.2021	NA	NA	This study	1	Camera-trapping	C1

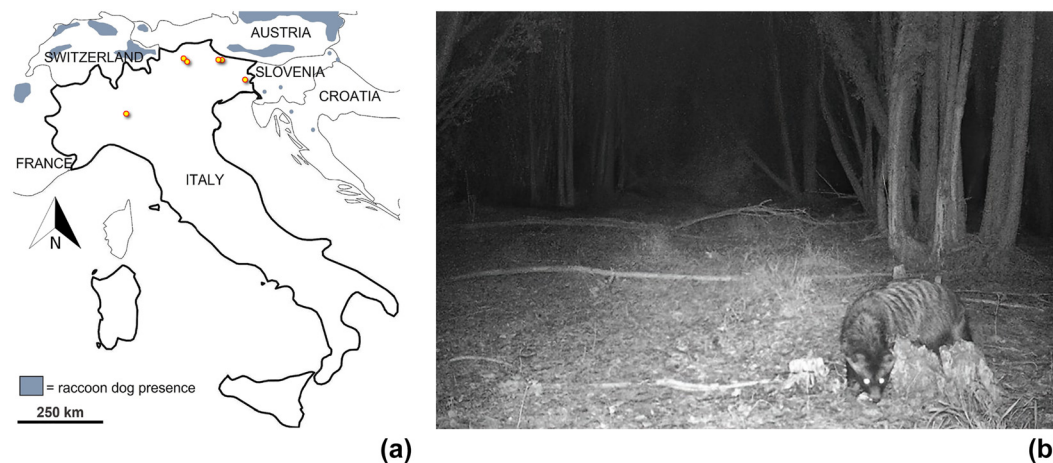


Figure 1: The raccoon dog in Italy. (a) Actual distribution of the raccoon dog in Italy (red dots, C1 occurrences). Occurrences from Slovenia and Croatia follow published literature (Cirovic and Milenkovic 1999; Duplic et al. 2016; Kusak et al. 2021; Popova and Zlatanova 2017). Distribution of the raccoon dog in France (Léger 2008), Austria (Duscher and Nopp-Mayr 2017) and Switzerland (Weber et al. 2004; Centre Suisse de Cartographie de la Faune: www.cscf.ch) was shown as grey areas as actual occurrences were not available; (b) the individual of raccoon dog camera trapped in August 2020 in North-Eastern Italy.

As to neighbouring countries, reproductive populations of the raccoon dog have been present in Northern Switzerland since 2004 (Weber et al. 2004; Centre Suisse de Cartographie de la Faune: www.cscf.ch), in Eastern France (with 4 documented observations of pups and a pregnant female, since 1999: cf. Léger 2008) and in Northern Austria, in continuity with the Central-Eastern Europe populations (Duscher and Nopp-Mayr 2017). Conversely, records from Southern Austria are still scarce, despite being distributed over a large area (cf. Figure 1a), mostly uncertain or related to juvenile individuals in dispersal (Duscher and Nopp-Mayr 2017). As far as the Balkan peninsula is concerned, Popova and Zlatanova (2017) recently reviewed the distribution of the raccoon dog, confirming occurrences in the Easternmost part, in continuity with the Eastern European populations, and also mentioning the first records for Northern Greece, Macedonia and Western Serbia. In Croatia, only two reliable occurrences are available in the literature (Dinarides and

Plitvice Lakes National Park: Cirovic and Milenkovic 1999; Duplic et al. 2016; Kusak et al. 2021). Information from Slovenia is also scattered in nature and the distribution of the species may be wider than that shown in Figure 1a.

Although no information is yet available on the species breeding in Italy, detection of paired individuals (cf. Table 1) suggests that locally, some breeding may have occurred, remaining as yet undetected. Climatic niche analysis suggests that most of the Italian peninsula is suitable for raccoon dog establishment, therefore requiring a constant monitoring of future range expansion (Kochmann et al. 2021).

Research ethics: All procedures performed in this study did not involve animal handling and were in accordance with the 1964 Helsinki Declaration and its later amendments.

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