

# Non-volant mammals of the ‘Lago di Tarsia’ Regional Nature Reserve and Special Conservation Area (IT93100055; Cosenza, Southern Italy)

Agostino Brusco<sup>1</sup>, Roberto Marchianò<sup>1</sup>, Giuseppe Dodaro<sup>2</sup>,  
Corrado Battisti<sup>3\*</sup>

**Abstract** - In this study we improved the knowledge on terrestrial mammals (excluding Chiroptera) of the ‘Lago di Tarsia’ Regional Nature Reserve (Special Conservation Area; Cosenza; Southern Italy), collecting a large amount of both direct and indirect original data (including road kills, small mammal trap catches, owl pellets, and camera traps), and bibliographic ones. We obtained 424 records belonging to 23 taxa classified at species level. *Hystrix cristata*, *Vulpes vulpes* and *Martes* sp. were the taxa with the highest number of records (> 10%). *Sciurus meridionalis*, *Martes foina*, *Glis glis*, *Apodemus* cfr. *flavicollis*, *Lepus europaeus*, *Talpa romana*, *Rattus* cfr. *rattus*, *Arvicola italicus* were the taxa with the lowest number (<1%). Almost half of the records have been obtained by indirect traces (hairs, excrements, fingerprints, burrows, etc.). Records from owl pellets represented an important percentage. Notwithstanding the small size of the study area, the high environmental heterogeneity allows the co-occurrence of a high number of species, including specialized taxa (e.g., forest mammals, mustelids and Soricomorpha). Some species, occurring in the neighbouring areas, although not recorded in our study (e.g. *Sorex* spp., *Neomys* sp., *Elyomys quercinus*), could be confirmed improving the research effort. Further studies are necessary in this regard, also focusing on the role of this reserve as dispersal corridor for rare carnivores, occurring in the massifs and rivers neighbouring to the Reserve (e.g. *Lutra lutra* and *Canis lupus*).

**Key words:** Atlas data, Calabria, camera trapping, owl pellets, road kill, small mammal traps.

**Riassunto** - Mammiferi non volanti della Riserva Naturale Regionale e Zona Speciale di Conservazione “Lago di Tarsia” (IT93100055; Cosenza, Italia meridionale).

<sup>1</sup> Riserve naturali regionali “Lago di Tarsia - Foce del fiume Crati”, Palazzo Rossi, Via Garibaldi 4, 87040 Tarsia (Cosenza), Italia.  
E-mail: segreteria@riservetarsiacrati.it

<sup>2</sup> Fondazione per lo Sviluppo Sostenibile, Via Garigliano 61a, 00198 Roma, Italia.  
E-mail: dodaro@susdef.it

<sup>3</sup> Torre Flavia wetland’ LTER (Long Term Ecological Research) Station, Protected areas - Regional park Service, Città Metropolitana di Roma Capitale, Viale G. Ribotta 41, 00144 Roma, Italia.

Corresponding author: c.battisti@cittametropolitanaroma.it

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Con questo studio abbiamo voluto incrementare le conoscenze sui mammiferi terrestri (esclusi i Chiroterteri) della Riserva naturale regionale (e Sito di Importanza Comunitaria) “Lago di Tarsia” (Cosenza, Calabria, Italia meridionale), raccogliendo una grande quantità di dati originali sia diretti che indiretti (compresi dati ottenuti da investimenti stradali, trappole per piccoli mammiferi, borre di Strigiformi, fototrappole) e bibliografici. Abbiamo ottenuto 424 record appartenenti a 23 taxa classificati a livello di specie. *Hystrix cristata*, *Vulpes vulpes* e *Martes* sp. sono stati i taxa con il maggior numero di record (> 10%); *Sciurus meridionalis*, *Martes foina*, *Glis glis*, *Apodemus* cfr. *flavicollis*, *Lepus europaeus*, *Talpa romana*, *Rattus* cfr. *rattus*, *Arvicola italicus* quelli con il numero più basso (<1%). Quasi la metà dei record sono stati ottenuti da tracce indirette. Le borre di Strigiformi hanno costituito una percentuale importante. Sebbene l’area di studio abbia una superficie ristretta, l’elevata eterogeneità ambientale rende possibile la co-occorrenza di un elevato numero di specie, inclusi taxa specializzati (es. Mammiferi forestali, mustelidi e Soricomorpha). Alcune specie, presenti nelle zone limitrofe, sebbene non registrate nel nostro studio (es. *Sorex* spp., *Neomys* sp., *Elyomys quercinus*), potrebbero essere presenti incrementando lo sforzo di ricerca. Ulteriori studi sono necessari al riguardo, focalizzando anche sul ruolo di questa riserva come corridoio di dispersione per carnivori rari, presenti nei massicci montuosi e negli affluenti del Crati limitrofi alla riserva (es. *Lutra lutra* e *Canis lupus*).

**Parole chiave:** Atlante, borre di Strigiformi, Calabria, fototrappolaggio, road kill, trappolaggio.

## INTRODUCTION

Calabria has been the subject of research on mammals since the 17<sup>th</sup> Century when Marco Aurelio Severino (1580-1656) of Tarsia (Cosenza) was involved in the study of this group of animals when staying in Naples (Nappi & Maio, 2002). However, mammal studies have been conducted in this region mainly since the 20<sup>th</sup> Century by Lucifero (1909) who described the Southern Italian subspecies of squirrel (*Sciurus vulgaris meridionalis* Lucifero 1907), recently elevated to the rank of species (Wauters *et al.*, 2017). In the 1950s, other studies mainly concentrated on the Pollino Massif (Pasa, 1955) and, in the following decades, on Sila and Aspromonte (von Lehmann, 1961; 1964; 1977; Pavan, 1983; Pavan & Mazzoldi, 1983). In the mid-1980s, other studies were carried out in Calabria, mainly focused on small mammals (e.g., Amori *et al.*, 1984; Cagnin *et al.*, 1984; Aloise *et al.*, 1985; Aloise & Cagnin, 1987; Cagnin & Aloise 1988a, 1988b; Aloise *et al.*, 1989; Barbieri *et al.*, 1989) which continued in the 1990s (e.g., Aloise *et al.*, 1990; Cagnin *et al.*, 1991; Scaravelli & Aloise, 1994; Cagnin & Aloise, 1994; Cagnin *et al.*, 1996, 1998) and 2000s and

2010s (e.g., Aloise & Scaravelli, 2002; Aloise & Cagnin, 2003; Aloise *et al.* 2003; Aloise & Bertolino, 2005; Nappi *et al.*, 2005; Grill *et al.*, 2009; Piras *et al.*, 2010; Aloise *et al.*, 2011). Among them, some revisions have used data from local research for new biogeographical and ecological analyses (e.g., on the peninsula effect: Contoli, 2002; Contoli *et al.*, 2002; review in Battisti, 2014a).

Thanks to this large number of studies, the level of knowledge of mammals in most of Calabria can be considered high. However, the significant latitudinal extension, the orographic heterogeneity and the high environmental diversity of this region, rich in taxonomic, ecological and biogeographical implications, make a continuous research effort necessary. However, for the Cosenza area (Northern Calabria), excluding the research of Barbieri *et al.* (1989), and local studies (e.g., Brusco, 2004), there is still a lack of fine-grained investigations on the mammal fauna. In this regard, this study aims to improve the knowledge about the mammals inhabiting the regional nature reserve (and Special Conservation Area) ‘Lago di Tarsia’ (Cosenza), located between the Pollino and the Sila ranges to the East and the Catena Costiera to the West, summarizing the database of the local Atlas of mammals recently published (Brusco *et al.*, 2017).

## MATERIALS AND METHODS

### Study area

The Regional Nature Reserve ‘Lago di Tarsia’ (Regional Law Calabria n. 52/1990) has been identified as a Special Area of Conservation (code: IT93100055 ‘Lago

di Tarsia’; Dir. 92/43/CEE; Fig. 1). It includes the homonymous artificial lake, sited upstream of the dam of the Strette di Tarsia (Municipalities of Tarsia and S. Sofia d’Epiro; Cosenza; 39°36’33.5”N; 16°17’31.3”E). The size of the protected area is about 450 ha (altitudinal range: 50 - 200 m a.s.l.; Brusco *et al.*, 2017).

The area covered by this study is characterized by alluvial plains with substrate consisting of Holocene and Pleistocene sediments, where the use of the soil is mainly for orchards and irrigated arable land. The hilly reliefs of the Crati basin have a moderately steep morphology, with frequent presence of terraced surfaces of marine origin, with Pliocene formations of varying granulometry (Agenzia Regionale per lo Sviluppo e per i Servizi in Agricoltura, 2003). Above the deposits of the mid-Pliocene cycles are Pleistocene terraced deposits of marine and continental origin.

The following types of habitats locally occur (standard codes of habitat types included in 92/43/EEC Directive as in Biondi *et al.*, 2009): 5330 - Thermo-Mediterranean and pre-desert scrub: i.e. formations with Mediterranean shrubs and bushes characteristic of the hottest and driest situations, with garrigue formations; 9340 - *Quercus ilex* and *Quercus rotundifolia* forests: these are the typical habitats of the Mediterranean scrub that characterizes large areas of the Reserve and the contiguous areas (Biondi *et al.*, 2009); 3170 - Mediterranean temporary ponds; they are present only in winter or late spring, with typical flora of wetlands. There are also mixed woods with thermophilic deciduous broad-leaved trees (details in Brusco *et al.*, 2017).

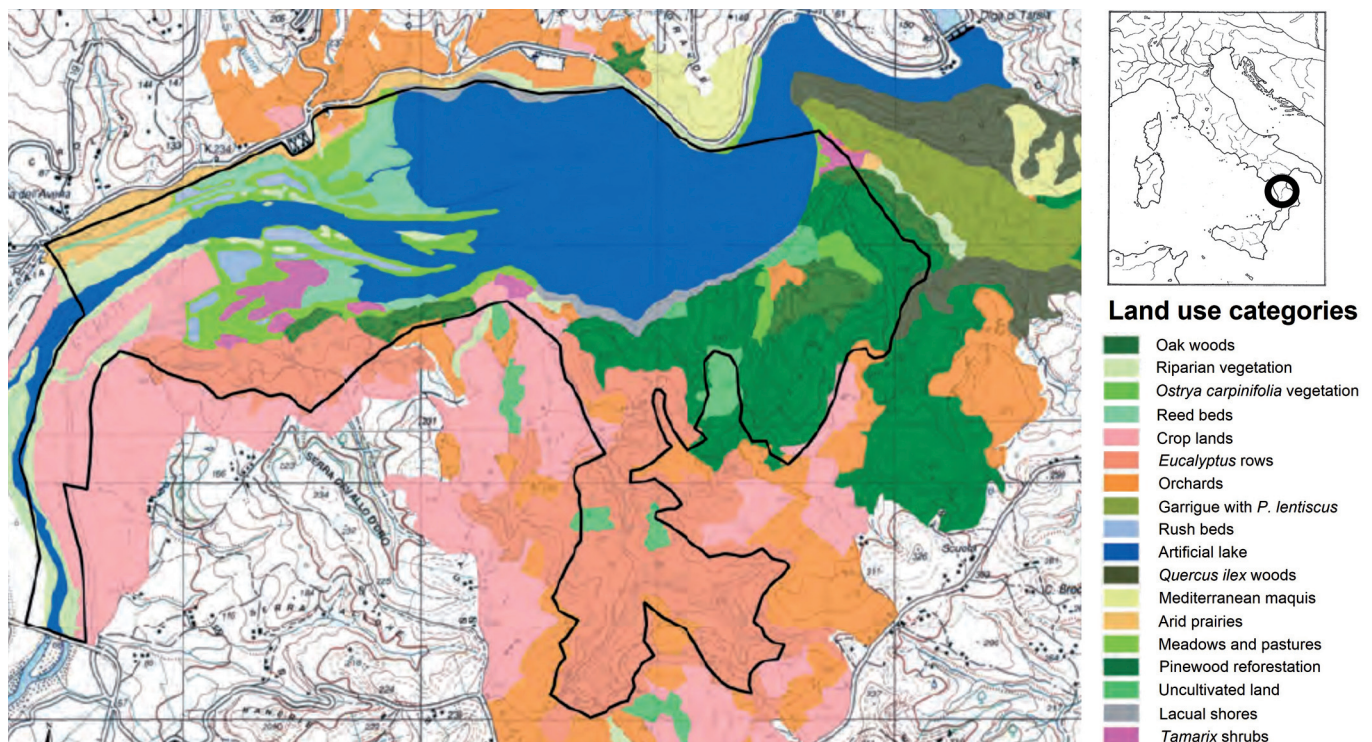


Fig. 1 - Land use map of the study area (Source: Brusco *et al.*, 2017). Grid corresponds to 1x1 km squares. Black line: border of the ‘Lago di Tarsia’ Regional Nature Reserve and Special Conservation Area (IT93100055; Cosenza, Southern Italy). On the right: black circle represents the location along Italian peninsula. / Carta dell’uso del suolo dell’area di studio. Linea scura: confine della Riserva Naturale Regionale “Lago di Tarsia” e Zona Speciale di Conservazione (IT93100055; Cosenza, Italia meridionale). Sulla sinistra: la localizzazione nella penisola italiana.

The forest vegetation is fragmented and showing no clearly dominant species. It includes mixed woods characterized by deciduous tree species [dominance of *Quercus pubescens* L Willd., *Quercus cerris* L., *Quercus virgiliana* (Ten.) Ten., *Celtis australis* L., *Acer monspessulanum* L., *Fraxinus ornus* L.]. The most significant species is *Carpinus orientalis* Miller which prefers cool places with high humidity, and rather sporadic presence of *Acer monspessulanum* L. In the undergrowth are present *Crataegus monogyna* Jacq., *Cornus sanguinea* L., *Erica arborea* L. and *Ruscus aculeatus* L. In the arboreal layer, there are *Quercus ilex* L. formations accompanied by *Fraxinus ornus* L. and by species of the shrub layer formed by *Erica arborea* L., *Phillyrea latifolia* L., *Pistacia terebinthus* L., *Viburnum tinus* L. and low Mediterranean scrub and garrigue (e.g., *Cistus monspeliensis* L.). Along the small ephemeral streams and along the shores of the lake there is a vegetation consisting mainly of shrubs, among which *Tamarix gallica* L., *T. africana* Poir. and *Vitex agnus-castus* L. Along the Crati River there is a disturbed riparian forest vegetation with *Salix alba* L., *S. fragilis* L., *Populus alba* L., *P. nigra* L., *Alnus glutinosa* (L.) Gaertner and *Populus canadensis* L., introduced, often accompanied by *Arundo donax* L. and some lianas such as *Humulus lupulus* L. and *Clematis vitalba* L. Finally, meadows with *Ferula communis* L. on a clayey substrate, rushes and reed-bed along the banks. Reforestations with *Eucalyptus* sp., *Pinus* sp. and *Cupressus sempervirens* L. are present (further details in Brusco *et al.*, 2017; Maiorca *et al.*, 2020).

The Mammal Atlas Project and Database of the Regional Nature Reserve "Lago di Tarsia" (PMLT) started on 15 September 2014 with the aim of deepening the fine-grained knowledge on the presence and distribution of non-volant terrestrial mammal species (i.e. excluding bats) within the protected area.

### Data collection and database setting

In order to allow data archiving and subsequent analysis, a specific Data Bank (hereafter, DB) has been prepared in Excel format. The data collected were divided into the following macro-categories: a) original or anecdotal data collected during the time period (PMLT), directly or indirectly obtained (direct observations, carcasses, owl pellet remains); b) bibliographic data (present in scientific or grey literature and on web platforms). A survey was also carried out on the available museum data ("Longino Contoli" micro-teriological collection of the Civic Museum of Zoology in Rome; private collections). G. Aloise, University of Arcavacata, Cosenza, pers. comm.) provided further useful data.

The following categories have been defined by type of survey: (i) direct surveys: records relating to living specimens observed directly in the field (occasionally obtained outside standardized sampling protocols); (ii) indirect detection: records related to species indirectly detected through traces (footprints, excavations, burrows, nests, hairs, excrements); (iii) finding of carcasses: records relating to carcasses (e.g., deriving from predation or relating to individuals who died of other natural causes); (iv) road kill remains (related to impact by motor-vehicles); (v)

records relating to individuals caught with traps focused on small mammals; (vii) records relating to camera/video images obtained with camera traps; (viii) owl pellets: records relating to osteological findings (mainly cranial parts: upper skull and mandibles) belonging to specimens of micro-mammals preyed on by owls (Strigiformes: *Tyto alba* Scopoli 1769 and *Athene noctua* Scopoli 1769) (Avenant, 2005). The taxonomic classification of the specimens was carried out on site or, subsequently, through photographic documentation or expert advice. For the collection of data obtained from specific sampling methods (indirect detection, trapping, camera-trapping and collection of owl pellets) different methods were used, as described below.

*Indirect detection.* Hairs have been identified following the diagnostic keys in De Marinis & Agnelli (1993) and expert advice). For the correct species-specific assignment of burrows, excrements and traces, we relied on expert advice and classic reference handbooks (Olsen, 2013).

*Trapping activity.* This data collection activity includes a series of techniques that make it possible to obtain presence information through the capture of individuals by means of specifically designed traps.

A total of 79 traps of different types (Longworth traps, handcrafted fall traps and commercial mouse traps) were authorized and placed. The traps were placed in the following periods: 1 October - 30 November 2014, 1 March - 30 November 2015, 1 March - 30 June 2016, for a total of 60 weeks (3 sessions/week with 5 trap placement/session; total: 180 sessions and 900 trap placements). During each session, the possible presence of captured individuals was recorded. In case of capture, animals were classified, reporting the data on a special sampling card. Individuals belonging to species whose taxonomic diagnosis required the advice of specialists were photographed and the images sent to experts (C.N.R. and 'Sapienza' University of Rome) for the necessary morphometric or genetic diagnosis (e.g., in the case of *Apodemus* sp.).

*Camera trapping.* From 1 April to 30 July 2016, cameras (Scout Guard, model 550M and Keep Guard, model 560) were placed in 15 sites (all characterized by Mediterranean scrub vegetation and mixed woods) in order to verify the presence of more elusive species. In case of doubts about the specific attribution of the individuals photographed, the images were sent to experts for the determination of the species (C.N.R. and 'Sapienza' University of Rome).

*Owl pellet analysis.* A number of surveys were carried out in areas suitable for the potential presence of owls, in order to collect the pellets periodically regurgitated by these animals, important predators of small mammals and other vertebrates and invertebrates (Contoli, 1976, 1977, 1981, 1986). In total, 13 sites were identified, corresponding to abandoned buildings and other structures (e.g. power plants). Pellets both intact and partially destroyed, and pellet debris from pellets altered by meteoric agents or decomposed by detritivorous organisms, were placed in sterile bags and sorted in the laboratory. The still intact pellets were opened dry, separating the hair from the bone material (Nappi, 2001). The latter was in turn cleaned by selecting only the cranial parts (upper skull and lower

jaws), which are essential for the taxonomic diagnosis (Contoli, 1977), which was carried out using diagnostic keys. In particular, given the known difficulty in the specific attribution of *Apodemus* (Panzironi *et al.*, 1994), the diagnosis of intact skulls of these species was carried out using the morphometric index by Amori *et al.* (1984; see Amori *et al.*, 2008). The classification of the genus *Crociodura* was performed using Contoli (2002; see also Amori *et al.*, 2008). The cranial parts that showed a better level of conservation were placed in sterile containers for educational and scientific use (microteriological collection of the Reserve, as suggested by Contoli & Associazione Teriologica Romana, 1985). Since the collections of pellets were not systematic, we did not further elaborate the data using quantitative diversity univariate metrics (see: e.g. Ferri *et al.*, 2021).

**Bibliographic data.** They include all the information obtained from scientific and grey literature, also relating to research carried out previously in neighbouring areas of Calabria. For the Lago di Tarsia previous works are lacking, except for: the publications of Pavan (1983), Pavan & Mazzoldi (1983), Barbieri *et al.* (1989), Barbieri (1999). For some species of dubious presence, we obtained information also from the literature on a larger scale (Boitani *et al.*, 2003; Amori *et al.*, 2008) and through experts (G. Amori; G. Aloise).

**Other data.** Finally, further information was acquired from interviews, occasional communications from local inhabitants, news in local newspapers, web platforms, etc. This information, showing different level of reliability, was checked by the PMLT coordinators.

Taxonomic nomenclature follows Loy *et al.* (2015) and the recent reference of Kryštufek *et al.* (2020) for genus *Clethrionomys* (ex *Myodes*).

To compare frequencies, we performed a  $\chi^2$  test (Dytham, 2011) using the Past 4.01 software for Windows (Hammer *et al.*, 2001).

## RESULTS

A total of 424 records were collected in the period 1987-2016. Among them, 310 records (73.11%) were determined at the species level; in the other cases, i) the taxon could not be clearly assigned to a species (e.g. *Crociodura* spp., or (ii) the level of taxonomic detail could not be assessed below the genus level (e.g. *Apodemus* sp.). In addition, 642 images and 180 video frames were acquired by camera trapping (Tab. 1).

We obtained evidence for 23 taxa classified at the species level (check-list in Tab. 2). *Hystrix cristata* L. 1758, *Vulpes vulpes* (L. 1758) and *Martes* sp. were the taxa with the highest number of records (> 10%), with a significant difference between the second and third ranked species ( $\chi^2=10.498$ ,  $p<0.001$ ). *Sciurus meridionalis*, *Martes foina*, *Glis glis*, *Apodemus* cfr. *flavicollis* (Melchior 1834), *Lepus europaeus*, *Talpa romana*, *Rattus* cfr. *rattus* (L. 1758), *Arvicola italicus* were the taxa with the lowest number (<1%).

Twenty-one taxa (20 species and vole individuals of the *Microtus* cfr. *savii* group) are listed as Least Concern by the IUCN, 12 species are included in Appendices II

Tab. 1 - Number of records of mammals by taxon (n) entered in the local database and percentage of total (%). / Numero di record di mammiferi per taxon (n) inseriti nella banca dati locale e percentuale sul totale (%).

| Taxon                                   | n          | %          |
|-----------------------------------------|------------|------------|
| <i>Hystrix cristata</i>                 | 87         | 20.52      |
| <i>Vulpes vulpes</i>                    | 77         | 18.16      |
| <i>Martes</i> sp.                       | 44         | 10.38      |
| <i>Meles meles</i>                      | 19         | 4.48       |
| <i>Microtus brachycercus</i>            | 17         | 4.01       |
| <i>Rattus</i> sp.                       | 15         | 3.54       |
| <i>Mus musculus</i>                     | 15         | 3.54       |
| <i>Talpa</i> sp.                        | 14         | 3.30       |
| <i>Erinaceus europaeus</i>              | 14         | 3.30       |
| <i>Apodemus sylvaticus</i>              | 13         | 3.07       |
| <i>Apodemus</i> sp.                     | 13         | 3.07       |
| <i>Apodemus</i> cfr. <i>sylvaticus</i>  | 13         | 3.07       |
| <i>Crociodura suaveolens</i>            | 12         | 2.83       |
| <i>Mustela nivalis</i>                  | 9          | 2.12       |
| <i>Crociodura leucodon</i>              | 9          | 2.12       |
| <i>Rattus rattus</i>                    | 6          | 1.42       |
| <i>Muscardinus avellanarius</i>         | 6          | 1.42       |
| <i>Suncus etruscus</i>                  | 5          | 1.18       |
| <i>Myocastor coypus</i>                 | 5          | 1.18       |
| <i>Lepus</i> cfr. <i>europaeus</i>      | 5          | 1.18       |
| <i>Crociodura</i> sp.                   | 5          | 1.18       |
| <i>Sciurus meridionalis</i>             | 4          | 0.94       |
| <i>Martes foina</i>                     | 4          | 0.94       |
| <i>Glis glis</i>                        | 4          | 0.94       |
| <i>Apodemus</i> cfr. <i>flavicollis</i> | 4          | 0.94       |
| <i>Lepus europaeus</i>                  | 2          | 0.47       |
| <i>Talpa romana</i>                     | 1          | 0.24       |
| <i>Rattus</i> cfr. <i>rattus</i>        | 1          | 0.24       |
| <i>Arvicola italicus</i>                | 1          | 0.24       |
| <b>Total</b>                            | <b>424</b> | <b>100</b> |

and III of the Bern Convention and two (*Hystrix cristata* and *Muscardinus avellanarius*) are included in the Annex IV of the Habitat Directive 92/43/EEC (Tab. 2).

We obtained a significant difference among different records when categorized according to the method of data collection ( $\chi^2=550.74$ ,  $p<0.001$ ), being the indirect record category the most represented (Tab. 3): almost half of the records inserted in the DB are traces (hairs, excrements, fingerprints, and burrows). Records from owl pellets represented an important percentage (> 20%). The least represented categories (<5%) were those including road-kills and carcasses (excluding those in the owl pellets). The camera traps made it possible to acquire 30 georeferenced records relating to four common species: *Hystrix cristata*, *Vulpes vulpes*, *Martes* sp. and *Meles meles*.

Tab. 2 - Check-list of mammal species recorded in the 'Lago di Tarsia' Regional Nature Reserve (Special Area of Conservation). For each species the inclusion in the IUCN threat category (cfr. [www.iucnredlist.org/static/categories\\_criteria\\_3\\_1](http://www.iucnredlist.org/static/categories_criteria_3_1); Rondinini *et al.*, 2013) and in the Appendices of Berna Convention and 92/43/EEC 'Habitat' Directive have been reported. / Lista delle specie di mammiferi registrate per la Riserva Naturale Regionale "Lago di Tarsia" (Zona Speciale di Conservazione). Per ciascuna specie sono stati riportati l'inserimento in specifiche categorie di minaccia IUCN (cfr. [www.iucnredlist.org/static/categories\\_criteria\\_3\\_1](http://www.iucnredlist.org/static/categories_criteria_3_1); Rondinini *et al.*, 2013) e nelle Appendici della Convenzione di Berna e della Direttiva 92/43/CEE 'Habitat'.

| Taxon                                              | IUCN | Berna    | Habitat  |
|----------------------------------------------------|------|----------|----------|
| 1 <i>Erinaceus europaeus</i> L. 1758               | LC   | App. III |          |
| 2 <i>Talpa romana</i> (Thomas 1902)                | LC   |          |          |
| 3 <i>Suncus etruscus</i> (Savi 1822)               | LC   | App. III |          |
| 4 <i>Crocidura suaveolens</i> (Pallas 1811)        | LC   | App. III |          |
| 5 <i>Crocidura leucodon</i> (Hermann 1780)         | LC   | App. III |          |
| 6 <i>Lepus europaeus</i> Pallas 1778               | LC   | App. III |          |
| 7 <i>Sciurus meridionalis</i> (Lucifero 1907)      | LC   | App. III |          |
| 8 <i>Hystrix cristata</i> L. 1758                  | LC   | App. II  | Annex IV |
| 9 <i>Myocastor coypus</i> (Molina 1782)            |      |          |          |
| 10 <i>Glis glis</i> (L. 1758)                      | LC   | App. III |          |
| 11 <i>Muscardinus avellanarius</i> (L. 1758)       | LC   | App. III | Annex IV |
| 12 <i>Microtus brachycercus</i> (von Lehmann 1961) | LC   |          |          |
| 13 <i>Arvicola italicus</i> Savi 1839              | LC   |          |          |
| 14 <i>Rattus norvegicus</i> (Berkenhout 1769)      | .    |          |          |
| 15 <i>Rattus rattus</i> (L. 1758)                  | LC   |          |          |
| 16 <i>Apodemus flavicollis</i> (Melchior 1834)     | LC   |          |          |
| 17 <i>Apodemus sylvaticus</i> (L. 1758)            | LC   |          |          |
| 18 <i>Mus musculus</i> L. 1758                     | LC   |          |          |
| 19 <i>Vulpes vulpes</i> (L. 1758)                  | LC   |          |          |
| 20 <i>Mustela nivalis</i> L. 1766                  | LC   | App. III |          |
| 21 <i>Martes foina</i> (Erxleben 1777)             | LC   | App. III |          |
| 22 <i>Meles meles</i> (L. 1758)                    | LC   | App. III |          |
| 23 <i>Sus scrofa</i> L. 1758                       | LC   |          |          |

The category of data obtained from owl pellets required a specific analysis. We obtained 1091 osteological items from 13 sites: among them we could come to a taxonomical diagnosis for 99 records belonging to 10 taxa, among which *Microtus brachycercus* was the most preyed taxon (details in Brusco *et al.*, 2017). Voles of the *M. cfr. savii* group represented the most preyed taxon (over 40%), immediately followed by wild mice (*Apodemus* sp. and *Apodemus cfr. sylvaticus*, as a whole, did not reach 40%). Soricomorpha were only marginally represented (about 5%).

The chronological analysis of data (Tab. 4), although limited to 59.4% of the records for which time was registered, showed a peak in 2015, a year characterized by the greatest research effort (PMLT project; over 70% of records; Tab. 4).

Tab. 3 - Number of records for sampling method (n) and percentage of total (%). / Numero di records per metodo di campionamento (n) e percentuali sul totale (%).

| Sampling method                                | n   | %     |
|------------------------------------------------|-----|-------|
| indirect observation                           | 201 | 47.41 |
| owl pellet                                     | 99  | 23.35 |
| direct observation                             | 49  | 11.56 |
| camera trap                                    | 30  | 7.08  |
| small mammal trap                              | 22  | 5.19  |
| road kill                                      | 15  | 3.54  |
| carcass (excluding road kills and owl pellets) | 8   | 1.89  |
| Total                                          | 424 | 100   |

Tab. 4 - Number of mammal records/year entered in the database (n) and percentage of total (%). The undated records are also reported. / Numero di record di presenza dei mammiferi/anno inseriti nella banca dati (n) e percentuale sul totale (%). Sono anche riportati i record senza data.

| Year         | n          | %             |
|--------------|------------|---------------|
| Pre 2005     | 10         | 2.36          |
| 2005         | 1          | 0.24          |
| 2008         | 1          | 0.24          |
| 2010         | 1          | 0.24          |
| 2012         | 1          | 0.24          |
| 2014         | 20         | 4.72          |
| 2016         | 218        | 51.42         |
| Undated      | 172        | 40.57         |
| <b>Total</b> | <b>424</b> | <b>100.00</b> |

## DISCUSSION

Even if the study area was restricted in size, the high environmental heterogeneity (including wet habitats and reed-beds, agro-ecosystems, Mediterranean scrubs, holm oaks and anthropogenic pinewoods, urbanized environments with moderate anthropization) make possible the co-occurrence of a high number of mammal species (n=23). However, although only a limited number of species show a conservation interest, the presence of specialized taxa (e.g. forest mammals, mustelids and insectivores) underlines the ecological value of this reserve, at least at a regional scale.

The georeferenced atlas data (for detailed maps, see Brusco *et al.*, 2017) showed that *Vulpes vulpes*, *Hystrix cristata*, *Martes foina*, *Mus musculus* L. 1758, *Apodemus flavicollis*, *Meles meles* (L. 1758) and *Rattus rattus* (L. 1758) were the species with the largest distribution in the Reserve.

Some species have shown a very small number of records (*Sciurus meridionalis*, *Glis glis*, *Apodemus flavicollis*, *Talpa romana*, *Arvicola italicus*). For this reason, it may be useful for the future to foresee investigations with

species-specific techniques (e.g. using hair tubes and nest boxes). Among the Lagomorphs, the only species found in the areas was *Lepus europaeus* Pallas, 1778, introduced for hunting purposes by the local hunting reserves (ATC CS2).

Rodents constitute the most represented Order. As expected from the ecological characteristics of the study area, there are both forest species (*Glis glis*, *Muscardinus avellanarius*, *Sciurus meridionalis*), and others related to open, mosaic and human-transformed environments (*Microtus brachycercus*, *Rattus* sp., *Apodemus sylvaticus*). We did not make an original diagnosis on the osteological remains: however, although Amori *et al.* (2008) reported the presence of the two congeneric microtines in Calabria, *Microtus savii* (de Selys Longchamps 1838) and *M. brachycercus* (von Lehmann 1961), we assigned all the microtine records to the taxon *M. brachycercus*, as suggested by Amori & Castiglia (2018). The noteworthy presence of *Arvicola italicus* was stressed in the only scientific reference available for the Reserve (Barbieri *et al.*, 1989) and confirmed in this study.

The group of mustelids is well represented, with ascertained *Martes foina*, *Meles meles*, *Mustela nivalis* L. 1766: however also in this case it would be appropriate to deepen the investigations in order to ascertain the presence of *Martes martes* (L. 1758) in the area (many records have been ascribed to *Martes* sp. because in most cases it was not possible to come to a specific attribution). As a matter of fact, *M. martes* has been recorded in the neighbouring areas (Boitani *et al.*, 2003). Finally, the only artiodactyl species present was *Sus scrofa* L. 1758, largely introduced by local hunting authorities (ATC CS2).

Only one species, *Myocastor coypus* (Molina 1782), is of recent allochthonous origin while another four were introduced in Italy in historical times: *Hystrix cristata* (see Masseti *et al.*, 2010), two rats (*Rattus* sp.) and *Mus musculus*.

For other species, known for the neighbouring areas, further investigations are necessary. The presence of forests, although fragmented and limited in size, could suggest the presence of populations of Soricinae linked to woody environments: *Sorex antinorii* Bonaparte 1840 and *Sorex samniticus* Altobello 1826 (occurring in Sila and Catena Costiera: Amori *et al.*, 2008), and *Sorex minutus* L. 1766 (occurring in the neighbouring massifs of Sila, Catena Costiera: Aloise *et al.*, 1985; Aloise & Cagnin, 1987; Amori *et al.*, 2008). Other forest species could be present: *Elyomis quercinus* (L. 1766), recorded in the 1980s in the Cosenza province (Pavan, 1983; Pavan & Mazzoldi, 1983) and in the neighbouring massifs of Pollino, Sila, Catena Costiera (Amori *et al.*, 2008; see also Cagnin & Aloise, 1984) and *Clethrionomys glareolus* (Schreber 1780), this last occurring along the Catena Costiera and in the Sila Massif (Amori *et al.*, 2008).

The presence wet habitats along the Crati River could suggest the presence of *Neomys milleri* Mottaz 1907 occurring in the neighbouring massifs of Sila and Catena Costiera (Amori *et al.*, 2008), and of *Neomys fodiens* (Pennant 1771), showing a localized distribution in the Sila mountains (Aloise *et al.*, 2005).

*Lutra lutra* L. 1758 has been historically recorded in Calabria (Cassola, 1986; Prigioni & Fumagalli, 1992; Fu-

magalli & Prigioni, 1993; Prigioni *et al.*, 2006) and for the Crati valley in the 80s (Pavan, 1983; Pavan & Mazzoldi, 1983; Cassola, 1986; Prigioni & Fumagalli, 1992; Fumagalli & Prigioni, 1993; Amori *et al.*, 2008). Today, it is apparently locally extinct although evidences of presence are available for the neighbouring Crati network rivers (Savuto, Neto, Lese, Tacina, Simeri rivers: Prigioni *et al.*, 2007; Marcelli *et al.*, 2007; Marcelli & Fusillo, 2010; Loy *et al.*, 2015; Balestrieri *et al.*, 2016). In recent years, the species showed signs of expansion in Southern Italy (Loy *et al.*, 2009; Marcelli & Fusillo, 2009).

Although *Lepus corsicanus* De Winton 1898 was not detected during this research, the study area falls within the species distribution range in Calabria (Amori *et al.*, 2008). Furthermore, the species shows preference for agro-forestry mosaics, a habitat largely occurring in the Reserve.

*Canis lupus* L. 1758, a highly vagrant species, can use the area as a dispersal corridor between the Sila, Catena Costiera and Pollino mountain massifs (Pavan, 1983; Pavan & Mazzoldi, 1983; Lovari, 1993; Boitani *et al.*, 2003; historical data of presence are available for the neighbouring areas of Tarsia; Contrada Lozzi: G. Aloise, pers. comm.). This predator is experiencing a demographic increase and range expansion in recent years (Galaverni *et al.*, 2016) and local records for this species can be expected to be available soon. Among the mustelids, more accurate investigations should be focused on verifying the presence of *Mustela putorius* (L. 1758), for which reports of the 1980s are available for most of the surrounding area (Pavan, 1983, Pavan & Mazzoldi, 1983; recorded for the Reserve: Barbieri, 1999; see also Boitani *et al.*, 2003). Finally, among carnivores, the presence of *Felis silvestris* Schreber 1777, a species historically occurring in the Province of Cosenza (Pavan, 1983; Pavan & Mazzoldi, 1983), should be ascertained.

Considering the different survey methods employed, indirect data make the most represented part: tracks, burrows, nests, excrements, etc. are the easiest way to collect data of presence with the minimum research effort. In particular, during this work owl pellets permitted the detection of 10 taxa among which the first evidence of presence of *Apodemus flavicollis* in the area.

The temporal articulation of the data showed a clear “Atlas effect” (i.e., exponential increase in the number of records collected in the 2014-2016 period; see Amori *et al.*, 2009 for an example). In this regard, local check-lists and data banks are a useful tool for the management of nature reserves (e.g. Battisti, 2014b, Battisti *et al.*, 2021; Ferri *et al.*, 2014; Mori *et al.*, 2014). The data collected during this work has been entered into the database located at the ‘Lago di Tarsia’ Regional Nature Reserve. This database, if kept up-to-date, can be a useful tool for all scientific research and management purposes.

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