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Updated checklist of the terrestrial mammals of Krka National Park, Croatia (Mammalia)

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Abstract. Croatia's diverse landscapes host numerous designated protected areas (including eight national parks) which encompass 38.1% of Croatia's terrestrial territory and support a wealth of flora and fauna. One of these, Krka National Park, is in the county of Šibenik-Knin in southwest Croatia. Here we present an updated checklist of the terrestrial (non-Chiropteran) mammals within the park. This revision is based on analysis of baseline historical species lists, comparative data from seven years of recent fieldwork within the park, and a subsequent review of all recently unrecorded species, considering the up-to-date phylogenetic and distribution knowledge. These analyses have resulted in substantial changes to the known assemblage of terrestrial mammals residing in the park. From a baseline of 31 species, the analyses carried out in this study have removed seven species and added one, leaving a current assemblage of 25 resident terrestrial mammals verified as occurring in Krka National Park.

Key words. Balkans, biodiversity, camera trapping, long-term monitoring, Mammalia, small mammal trapping, survey methods.

INTRODUCTION

Croatia's varied landscapes and habitats support an equally diverse faunal assemblage. The country's designated protected areas (which include eight national parks) encompass 38.1% of Croatia's terrestrial territory (EEA 2024a), affording protection to a total of 930 km^2 (MEPE 2024). One such protected area is Krka National Park (KNP) in the county of Šibenik-Knin, south-west Croatia (Fig. 1). It was first designated in 1985 for its 'exceptional natural value', with its boundary being revised in 1997 to comprise 109 km^2 of the Krka River gorge and the lower course of the Čikola River (KNPA 2024). The park lies entirely within the county of Šibensko-Kninska

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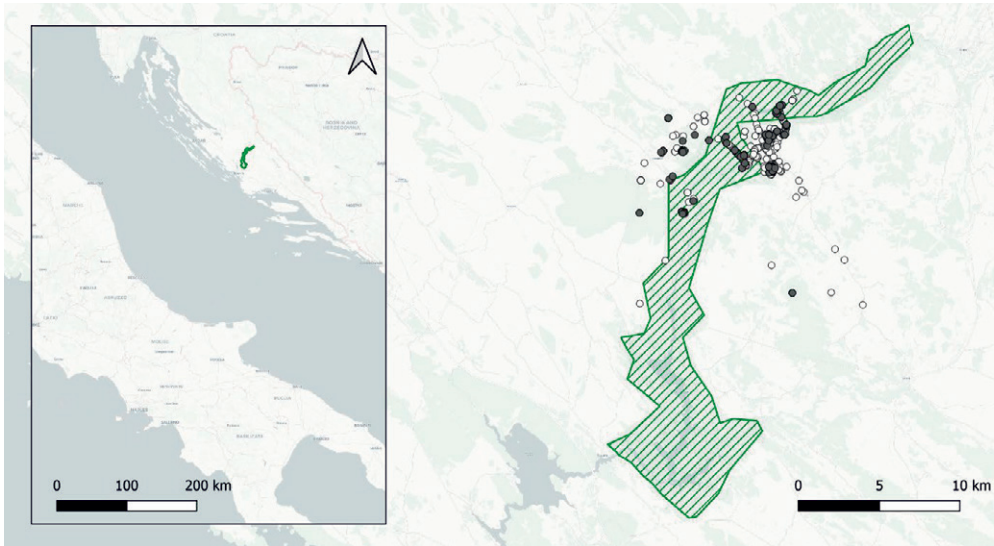

Fig. 1. Location of Krka National Park (hatched green) within Croatia (inset), showing distribution of survey effort for Biota / OpWall surveys 2017–2024. White points denote records from incidental sightings and transect walks; black points denote camera trap records.

and includes parts of the municipalities of Knin, Ervenik, Kistanje, and Promina in the north and Skradin, Drniš, and Šibenik in the south. Important conservation features include the Krka i Okolni Plato – a Natura 2000 (EEA 2024b) within which KNP lies entirely, and the Miljacka II Cave, a site which is home to ca. 9,000 bats comprising eight species (EuroBats 2024).

The majority of the area experiences a Mediterranean climate with temperatures at Knin averaging 23 °C in July and 5 °C in January (KNPA 2024). However, some areas in the northernmost parts of the park lie on a Mediterranean-Alpine ecotone, with the source of the Krka River lying underneath some of the highest mountains in the region (e.g., Dinara Troglav, Ujilica, Uniški Bat). Annual mean precipitation is 1078 mm, mostly falling between October and February, but with occasional heavy thunderstorms in summer (KNPA 2024), and with the plateau around the Krka River having generally less rainfall than surrounding areas. The geology of the region (dominated by a 50–100 m deep layer of calciferous bedrock) results in very little surface water accumulation, as rainfall drains immediately into underground aquifiers to be later released into the Krka River through large cave systems. This combination of low rainfall and porous geology results in predominantly arid surface conditions. The plateau averages an elevation of 230 m a. s. l. with habitats largely comprising rough, dry Mediterranean scrub dominated by *Juniperus oxycedrus*, *Carpinus betulus*, and *Quercus cerris*, although vegetation assemblage within the gorge itself becomes more wooded on its slopes, with riparian and emergent vegetation on the banks of the Krka River. The seminal publication regarding the fauna of the park is *The Krka River*: *A Gift of Nature* (Marguš 2019), a monograph collating available data on the flora and fauna of the park, which cites two sources for its list of mammals, Kovačić & Đulić (1989) and Bogdanović (2014).

This study presents the findings of a systematic literature review and seven years of field observations from 2017–2024 (excluding 2020) including three years (2022–2024) of systematic recording on established transects in and immediately adjacent to Krka National Park. These data have been verified and collated to produce an updated species list of the terrestrial mammalian fauna of the park. The list excludes chiroptofauna, which will be explored in a separate contribution.

MATERIALS AND METHODS

Baseline data search

The baseline dataset for this assessment was based upon three key resources: Kovačić & Đulić (1989), Bogdanović (2014), and Marguš's (2019) monograph which itself cites the former two sources, as well as various other sources. Kovačić & Đulić (1989) is a University of Zagreb report in which the authors began with a literature review of publications from 1882 to 1988. Their field methods comprised live (sherman/longworth) and lethal (pitfall) trapping of small mammals, identification of tracks, trails and signs, and collecting anecdotal records of larger mammal/game species sightings from residents within the park and its surrounding settlements. Status was determined by considering each species' status throughout Croatia (and the wider western Balkans) taking into account preliminary data on the ecological conditions suitable for each species, based on literature from 1976 to 1984. Bogdanović (2014) undertook fieldwork between 2010 and 2013, which involved completing line transects in which he recorded indirect evidence of occurrence (fur, remains, scat, etc.) and undertook animal trapping. However, of the 22 survey sites selected by Bogdanović, fewer than half (10 sites) were within the park boundary, with some sites being up to 30 km away. Marguš's collation of data was not supported by any additional fieldwork, and in spite of adding two novel species to the list, does not add any novel field records after Bogdanović (2014).

Records were checked for updated nomenclature and known species distributions using the IUCN Red List (IUCN 2024). An additional search was undertaken using iNaturalist online biological records repository (iNaturalist 2024) for anecdotal and verified species record distributions.

Fieldwork

Mammal records were collected from mid-June to mid-August each summer between 2017 and 2024 (excluding 2020, where the Covid-19 pandemic precluded any survey work). Surveys were completed by experienced mammalogists and field ecologists from Operation Wallacea (Opwall) and Biota Group Ltd. (Biota). Surveys included: small mammal trapping using Sherman traps (Barnett & Dutton 1995), standardised infra-red camera traps on transects at a density of one per 180 m, as well as targeted camera trapping on an ad-hoc basis (Rovero & Zimmerman 2016), systematic searching for mammal tracks and signs on walked transects (Olsen 2013) and incidental records of visual (MacDonald & Barrett 2005) and auditory (Middleton et al. 2023) field observations (live and dead animals). Camera traps comprised several models (Bushnell, Renkforce, and Browning). Transects all lie within the municipality of Promina.

Literature review

After all fieldwork records had been collated, a subsequent literature search was completed for all mammal species for which our surveys produced no records. The purpose of the review was to determine the likelihood of the presence of these species in the park based on any available historical or recent records, or if any recent data on phylogenetics or known distribution ranges would exclude them from the species list. Searches were carried out using Google Scholar and Semantic Scholar, with general and species-specific phrases (e.g., "Krka" + "species name"). Records were extracted from any manuscripts found. We took a conservative approach to this review, keeping species that we had failed to record in the checklist if existing distribution maps or other sources indicated a high likelihood that they could occur

(albeit with a 'possibly extant' label). We only removed species if sources indicated the occurrence in Krka was highly unlikely.

Data management

Two of our fieldwork transects lie outside of the Krka National Park (KNP) boundary. Transect 1 lies between 800 m and 1000 m from the boundary along its entirety; Transect 6 lies 250 m east of the boundary at its closest point and 700 m east at its furthest point. However, due to the proximity of these locations, their records have been included in this dataset, as have all incidental and observational records from within 1000 m of the boundary. A full records list is provided as online supplementary data at figshare (Hughes 2024).

Assessment criteria

For the purposes of this checklist assessment, IUCN presence codes and definitions (IUCN 2018) are used – namely "Extant" relates to those species with verified records from the last 20 years and "Presence Uncertain" relates to species for which records exist, but which require verification "owing to the uncertainty of the identity or authenticity of the record".

RESULTS

Baseline data search

The baseline data review (Kovačić & Đulić 1989, Bogdanović 2014, Marguš 2019) yielded records of 31 distinct terrestrial mammal species and subspecies in the park (Table 1). Both Kovačić & Đulić (1989) and Bogdanović (2014) list 28 terrestrial mammal species, though the Kovačić & Đulić manuscript includes the eastern broad-toothed field mouse (*Apodemus mystacinus*), while Bogdanović reports the western broad-toothed field mouse (*A. epimelas*) instead. Marguš (2019) (citing the previous two manuscripts in his species list) reports 30 distinct species, adding brown bear (*Ursus arctos*) and chamois (*Rupicapra rupicapra*).

Fieldwork results

Fieldwork carried out by Biota and Opwall resulted in species-level records of a total of 20 terrestrial mammal species (Table 1), comprising three Eulipotyphla, one Lagomorpha, five Rodentia, nine Carnivora, and two Artiodactyla. Genus-level records from camera traps also provided various unidentified *Crocidura* sp., *Rattus* sp., and *Apodemus* sp. Figs. 2 and 3 provide a selection of images of these fieldwork records.

Of the species recorded, least weasel (*Mustela nivialis*) and European polecat (*Mustela putorius*) were determined from indirect evidence only (scat and prints) with no visual or in-hand observations. There is, however, a high degree of confidence in the identification of these field signs, given that they are distinct from one another, and both are much smaller than the other Mustelidae known to inhabit the park. The northern white-breasted hedgehog (*Erinaceus roumanicus*) was recorded during fieldwork but was not in any of the baseline data. Eleven species included in the baseline lists were not recorded during the 2017–2024 fieldwork by any method: southern white-breasted hedgehog (*Erinaceus concolor*), lesser white-toothed shrew (*Crocidura suaveolens*), European rabbit (*Oryctolagus cuniculus*), karst dormouse (*Eliomys quercinus dalmaticus*), snow vole (*Chionomys nivialis*), muskrat (*Ondrata zibethicus*), eastern broad-toothed field mouse (*Apodemus mystacinus*), black rat (*Rattus rattus*), eastern European

Table 1. Summary of all mammal species reported from Krka National Park, Croatia. Records are derived from baseline published data and subsequent fieldwork, by year. The nomenclature has been updated to reflect the most recent taxonomy. Baseline data comprises Kovačić & Đulić (1989), Bogdanović (2014), and Marguš (2019). The 'IUCN' column refers to IUCN-compliant codes related to likelihood of species persistence (IUCN 2018): 1 – Extant; 3 – Possibly Extant; 6 – Presence Uncertain. Species in unerlined font were reported in baseline data but removed from the inventory presented in this paper. Species in **bold** font were not reported in the baseline data, but were added from our fieldwork records

			baseline			fieldwork							IUCN
order	family	species	1989	2014	2019	2017	2018	2019	2021	2022	2023	2024	
Eulipotyphla	Erinaceidae	*Erinaceus concolor*	×	×	×								6
		Erinaceus roumanicus				×	×	×			×	×	1
	Soricidae	*Crocidura leucodon*	×	×	×							×	1
		Crocidura suaveolens	×	×	×								6
		Suncus etruscus	×	×	×						×		1
Lagomorpha	Leporidae	*Lepus europaeus*	×	×	×	×	×	×		×	×	×	1
		Oryctolagus cuniculus	×	×	×								6
Rodentia	Sciuridae	*Sciurus vulgaris*	×	×	×	×				×		×	1
	Gliridae	*Glis glis*	×	×	×				×	×	×	×	1
		Eliomys quercinus	×	×	×								3
	Cricetidae	*Chionomys nivalis*	×	×	×								3
		Ondatra zibethicus	×	×	×								3
	Muridae	*Apodemus sylvaticus*	×	×	×	×	×			×	×		1
		Apodemus mystacinus	×		×								6
		Apodemus epimelas		×					×			×	1
		Rattus rattus	×	×	×								3
		Rattus norvegicus	×	×	×	×					×	×	1
		Mus musculus domesticus	×	×	×								3
		Mus musculus musculus	×	×	×								6
Carnivora	Canidae	*Canis lupus*	×	×	×	×	×	×	×		×	×	1
		Canis aureus	×	×	×	×	×			×	×	×	1
		Vulpes vulpes	×	×	×	×	×	×		×	×	×	1
	Mustelidae	*Meles meles*	×	×	×	×	×	×		×	×	×	1
		Mustela nivalis	×	×	×	×		×					1
		Mustela putorius	×	×	×			×					1
		Martes foina	×	×	×	×	×	×		×	×	×	1
		Lutra lutra	×	×	×					×			3
	Ursidae	*Ursus arctos*			×								6
	Felidae	*Felis silvestris*	×	×	×	×	×	×		×	×	×	1
Artiodactyla	Suidae	*Sus scrofa*	×	×	×	×	×	×		×	×	×	1
	Cervidae	*Capreolus capreolus*	×	×	×	×	×	×		×	×	×	1
	Bovidae	*Rupicapra rupicapra*			×								3

house mouse (*Mus musculus musculus*), brown bear (*Ursus arctos*), and chamois (*Rupicapra rupicapra*). These species were subject to further literature review.

Key corrections and additions

Southern white-breasted hedgehog, *Erinaceus concolor* (Martin, 1838)

All three baseline publications (Kovačić & Đulić 1989, Bogdanović 2014, Marguš 2019) report the presence of the southern white-breasted hedgehog (*Erinaceus concolor*). The IUCN, however, lists the range of *E. concolor* as: "In the Mediterranean region, *Erinaceus concolor* occurs in Greece (Rhodes), Anatolian Turkey, Israel, Syria and Lebanon" (Amori et al. 2021a). The only hedgehog species to occur in most of Croatia (including KNP) is the northern white-breasted hedgehog (*Erinaceus roumanicus*). Whilst the western European hedgehog (*Erinaceus europaeus*) has a range that extends into the northern tip of Croatia, there is one known sympatric zone for *E. europaeus* and *E. roumanicus* in central Europe, comprising Poland, Czechia, Austria, and Italy (Zolotareva et al. 2021). It is therefore almost certain that the records informing the baseline publications pre-date current taxonomic knowledge (Filippucci & Simson 1996).

Result. Removal of *Erinaceus concolor* from the KNP resident species list; addition of *Erinaceus roumanicus* to the KNP resident species list.

Lesser white-toothed shrew, *Crocidura suaveolens* (Pallas, 1811)

Despite all three baseline data sources including the lesser white-toothed shrew (*Crocidura suaveolens*) in the species list for the park, current range assessments indicate that this species is distributed from Ukraine eastwards and is not present in Croatia at all (Kryštufek & Gazzard 2023), though Kryštufek & Griffiths (1999) do suggest the presence of *C. suaveolens* in the Dinaric Alps.

Result. Removal of *Crocidura suaveolens* from the KNP resident species list.

European rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758)

This species is listed in all three baseline data sources as being present in the park. However, the IUCN assessment (Smith & Boyer 2007) shows a distribution map that extends into Croatia only as far south as Zagreb, with the assessment stating that the species occurs "only sporadically on the Balkan peninsula". A search for records on the iNaturalist website (iNaturalist 2024) shows no verified records south of Zagreb.

Result. Removal of *Oryctolagus cuniculus* from the KNP resident species list.

Eastern broad-toothed field mouse, *Apodemus mystacinus* (Danford et Alston, 1877)

Two species of broad-toothed field mouse are reported in the baseline publications species lists, with Kovačić & Đulić (1989) and Marguš (2019) reporting the presence of the eastern broad-toothed field mouse (*Apodemus mystacinus*) and Bogdanović (2014) reporting the presence of the western broad-toothed field mouse (*Apodemus epimelas*). Recent assessments clearly confirm that the species present within Croatia is *A. epimelas* (Kryštufek & Vohralík 2016)

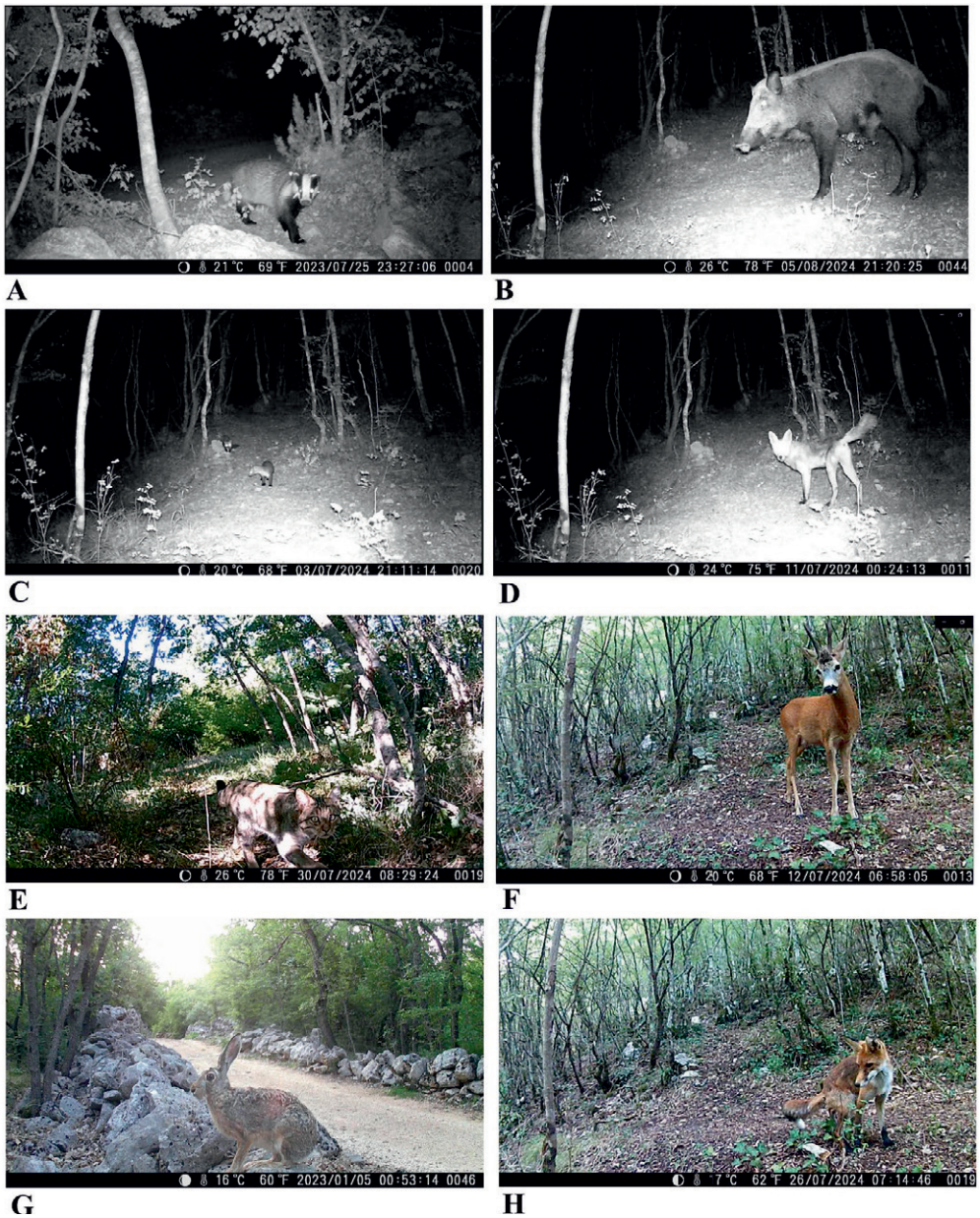

Fig. 2. Selected images from trail cameras deployed in Krka National Park, Croatia. A – Eurasian badger (*Meles meles*); B – wild boar (*Sus scrofa*); C – beech marten (*Martes foina*); D – golden jackal (*Canis aureus*); E – wild cat (*Felis silvestris*); F – roe deer (*Capreolus capreolus*); G – brown hare (*Lepus europaeus*); H – red fox (*Vulpes vulpes*).

rather than *A. mystacinus*, with the latter being restricted to Aegean islands, Turkey, Georgia, Israel, Lebanon, Jordan, Syria, and Iraq (Amori et al. 2021b).

Result. Removal of *Apodemus mystacinus* from the KNP resident species list.

Eastern house mouse, ***Mus musculus musculus* (Linnaeus, 1758)**

All three baseline data sources report the presence of both eastern and western subspecies of the house mouse (*Mus musculus musculus* and *Mus musculus domesticus*, respectively). Recent literature (Amori 2007b, Banker et al. 2022) confirms that the ranges of the two subspecies have little overlap, with *M. musculus musculus* having a distribution extending from central Europe eastwards, and *M. musculus domesticus* from that point westwards and southwards. There is a 22 km-wide hybridization zone which runs broadly from the German/Polish border south to northern Croatia and along the border of Croatia with Bosnia and Herzegovina (Macholán et al. 2008). Evidence suggests, therefore, that all *Mus musculus* records within KNP belong to *Mus musculus domesticus*.

Result. Removal of *Mus musculus musculus* from the KNP resident species list.

Brown bear, ***Ursus arctos* (Linnaeus, 1758)**

Of the three publications used as baseline data for this study, only Marguš (2019) includes brown bear. Current literature indicates that the reported range of the species is 12–15 km from the closest point of KNP at its northern tip (Kocijana et al. 2011, Hipólito et al. 2020) with the occurrence of brown bears being largely restricted to the Dinaric Alps, on the border with Bosnia and Herzegovina, in this part of Croatia. The iNaturalist website's closest verified record is 44 km north of the northern tip of the park (iNaturalist 2024) and the IUCN assessment of the species' range places *U. arctos* as extant within the uplands to the north of the park, but as extinct in the area immediately north of Knin, where the northernmost extent of the park lies (McLellan et al. 2017). In light of the lack of any verified evidence, it is considered that the species is not resident within the park, although the species' range comes close enough that vagrants may occur.

Result. Removal of *Ursus arctos* from KNP resident species list.

CURRENT LIST OF EXTANT RESIDENT SPECIES

The following is a list of all mammal species that we currently believe to be extant residents in Krka National Park, including their IUCN occurrence category (1 – Extant, 3 – Possibly Extant). In accordance with IUCN definitions of presence (IUCN 2018), species for which the most recent record is more than 20 years old (i.e., records pre-2000) are '6 – Presence Uncertain' and are not included below. This new list represents a removal of six species formerly states as occurring in the park (*Erinaceus concolor*, *Crocidura suaveolens*, *Oryctolagus cuniculus*, *Apodemus mystacinus*, *Mus musculus musculus*, and *Ursus arctos*) and the addition of *Erinaceus roumanicus*, resulting in a total assemblage of 26 species.

Eulipotyphla

Northern white-breasted hedgehog, ***Erinaceus roumanicus*** **Martin, 1838**

Most recent KNP record: 7 August 2024; 43°59’46” N, 16°03’23” E. IUCN category: 1. Comments. Replaces *Erinaceus concolor* in the species list. Regularly recorded on camera traps and frequently observed during fieldwork in KNP.

Bi-coloured shrew, *Crocidura leucodon* (Hermann, 1780)

Most recent KNP record: 16 August 2024; 44°00’13” N, 16°03’36” E. IUCN category: 1. Comments. Last recorded observation was a dead specimen.

Etruscan shrew, *Suncus etruscus* (Savi, 1822)

Most recent KNP record: 29 June 2023; 43°59’19” N, 16°02’51” E. IUCN category: 1. Comments. Last recorded observation was an in-hand capture.

Lagomorpha

Brown hare, *Lepus europaeus* Pallas, 1778

Most recent KNP record: 17 August 2024; 43°58’35” N, 16°03’09” E. IUCN category: 1. Comments. Regularly seen and recorded on camera traps. Occurs widely throughout our study area in KNP.

Rodentia

Red squirrel, *Sciurus vulgaris* Linnaeus, 1758

Most recent KNP record: 16 August 2024; 43°59’23” N, 16°01’04” E. IUCN category: 1. Comments. Regularly recorded on camera traps widely throughout our study area in KNP.

Edible dormouse, *Glis glis* (Linnaeus, 1766)

Most recent KNP record: 16 August 2024; 44°00’41” N, 16°02’02” E. IUCN category: 1. Comments. Regularly recorded on camera traps widely throughout our study area in KNP.

Karst dormouse, *Eliomys quercinus dalmaticus* Dulic et Felten, 1962

Most recent KNP record: No recent records – baseline data only. IUCN category: 3. Comments. No records from fieldwork. However, its published biogeographic range includes KNP (Bertolino et al. 2008) so the species is likely to occur.

Snow vole, *Chionomys nivalis* (Martins, 1842)

Most recent KNP record: No recent records – baseline data only. IUCN category: 3. Comments. No records from fieldwork. However, its published biogeographic range includes KNP (Kryštufek 2016) so the species is likely to occur.

Wood mouse, *Apodemus sylvaticus* (Linnaeus, 1758)

Most recent KNP record: 29 July 2023; 43°59'18" N, 16°03'00" E. IUCN category: 1. Comments. Regularly recorded through Sherman trapping and in-hand observations.

Western broad-toothed field mouse, *Apodemus epimelas* (Nehring, 1902)

Most recent KNP record: 16 July 2024; 43°59'18" N, 16°02'51" E. IUCN category: 1. Comments. Regularly recorded through Sherman trapping and in-hand observations.

Black rat, *Rattus rattus* (Linnaeus, 1758)

Most recent KNP record: No recent records – baseline data only. IUCN category: 3. Comments. No records from fieldwork. However, its published biogeographic range includes KNP (Amori 2007a) so the species is likely to occur.

Brown rat, *Rattus norvegicus* (Berkenhout, 1769)

Most recent KNP record: 30 July 2024; 43°59'17" N, 16°02'48" E. IUCN category: 1. Comments. Regularly recorded visually during fieldwork.

Western European house mouse, *Mus musculus domesticus* Schwartz et Schwartz, 1943

Most recent KNP record: No recent records – baseline data only. IUCN category: 3. Comments. No records from fieldwork. However, its published biogeographic range includes KNP (Amori 2007b) so the species is likely to occur.

Muskrat, *Ondatra zibethicus* (Linnaeus, 1766)

Most recent KNP record: No recent records – baseline data only. IUCN category: 3. Comments. All three publications used as baseline data for this study include muskrat. Current literature indicates that the muskrat's published biogeographic range in Europe extends only as far south as northern Croatia (Cassola 2016). However, as publications by Kovačić & Đulić (1989) and Bogdanović (2014) include maps with a broad distribution of records within the park, and recent survey effort may include geographical bias against riparian mammals (see limitations section in discussion), we conservatively assume that this species is likely present, but under-recorded.

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Fig. 3. Selected images of small mammals in Krka National Park, Croatia. A – Etruscan shrew (*Suncus etruscus*); B – bi-coloured shrew (*Crocidura leucodon*); C – western broad-toothed field mouse (*Apodemus epimelas*); D – wood mouse (*Apodemus sylvaticus*); E – brown rat (*Rattus norvegicus*); F – edible dormouse (*Glis glis*); G – northern white-breasted hedgehog (*Erinaceus roumanicus*); H – red squirrel (*Sciurus vulgaris*).

A

B

C

D

E

F

G

H

Carnivora

Grey wolf, *Canis lupus* Linnaeus, 1758

Most recent KNP record: 5 August 2024; 43°59’51” N, 16°03’47” E. IUCN category: 1. Comments. Mostly recorded from evidential signs (tracks and scat), although has been sighted once and heard multiple times during fieldwork in KNP.

Golden jackal, *Canis aureus* Linnaeus, 1758

Most recent KNP record: 16 August 2024; 43°58’58” N, 16°01’52” E. IUCN category: 1. Comments. Regularly recorded on camera traps widely throughout our study area in KNP.

Red fox, *Vulpes vulpes* (Linnaeus, 1758)

Most recent KNP record: 17 August 2024; 43°58’35” N, 16°03’02” E. IUCN category: 1. Comments. Most recorded species on camera traps; occurs widely throughout our study area in KNP.

Eurasian badger, *Meles meles* (Linnaeus, 1758)

Most recent KNP record: 17 August 2024; 43°58’35” N, 16°03’09” E. IUCN category: 1. Comments. Regularly recorded on camera traps widely throughout our study area in KNP.

Least weasel, *Mustela nivalis* Linnaeus, 1766

Most recent KNP record: 15 June 2019; 44°00’27” N, 16°03’22” E. IUCN category: 1. Comments. No visual observations have been recorded during fieldwork, only evidential signs (tracks and scat).

European polecat, *Mustela putorius* Linnaeus, 1758

Most recent KNP record: 15 June 2019; 44°00’33” N, 16°03’29” E. IUCN category: 1. Comments. No visual observations have been recorded during fieldwork, only evidential signs (scat).

Beech marten, *Martes foina* (Erxleben, 1777)

Most recent KNP record: 26 August 2024; 43°54’26” N, 16°04’05” E. IUCN category: 1. Comments. Regularly recorded on camera traps widely throughout our study area in KNP.

Eurasian otter, *Lutra lutra* (Linnaeus, 1758)

Most recent KNP record: No recent records – baseline data only. IUCN category: 1. Comments. Multiple confirmed records of spraints for KNP are known (iNaturalist 2024), and surveys by Biota/OpWall have largely focused on the plateau rather than the river gorge, and as such are less likely to have detected riparian mammals.

European wildcat, *Felis silvestris* Schreber, 1777

Most recent KNP record: 17 August 2024; 43°58'31" N, 16°03'15" E. IUCN category: 1. Comments. Regularly recorded on camera traps. Occurs widely throughout our study area in KNP.

Artiodactyla

Wild boar, *Sus scrofa* Linnaeus, 1758

Most recent KNP record: 18 August 2024; 43°58'58" N, 16°01'52" E. IUCN category: 1. Comments. Regularly recorded on camera traps. Occurs widely throughout our study area in KNP.

European roe deer, *Capreolus capreolus* (Linnaeus, 1758)

Most recent KNP record: 18 August 2024; 43°59'01" N, 16°02'19" E. IUCN category: 1. Comments. Regularly recorded on camera traps. Occurs widely throughout our study area in KNP.

Chamois, *Rupicapra rupicapra* (Linnaeus, 1758)

Most recent KNP record: No recent records – baseline data only. IUCN category: 3. Comments. No records from fieldwork. However, its published biogeographic range extends into the uppermost boundary of KNP (Anderwald et al. 2021), so the species may occur.

DISCUSSION

This analysis of baseline species lists, literature review and fieldwork has resulted in substantial changes to the known assemblage of resident terrestrial mammals in KNP. From the original baseline of 31 species (derived by synthesising data from 1988–2014), the analyses carried out in this study have removed six species from that list and added one species, leaving a current assemblage of 26 distinct species. These changes have mostly been based on current published phylogenetic and known distribution ranges of European species, supported by recent field sightings and records. Notwithstanding this revised list reflecting recent changes, the issues of climate change and invasive species will inevitably affect further changes in the mammalian fauna of the park in years to come. One anticipated change is the encroaching range of the small Indian mongoose (*Urva auropunctata*) which is now established in the closest areas of coastline to KNP (Louppe et al. 2020) and could be recorded in the park in future years.

Issues with the baseline data relate to several idiosyncrasies of biological recording, but our updates primarily result from increasing knowledge and access to up-to-date information on worldwide species range/distributions, better understanding of phylogenetic relationships, and other data. Moreover, there are issues inherent in anecdotal and reported data as they are unverifiable, and which can be based on inherent historical bias, confirmation bias and a general lack of good biological recording principles. For example, the inclusion of European rabbit in the Kovačić & Đulić (1989) mammal inventory was not based on field records (the research did not find any signs of this species); but rather on anecdotal statements of the presence of the species by hunters in Skradin.

While the inventory we present here is the most complete, verifiable and up-to-date summary of KNPs mammal community available, there remain two key limitations in the Biota/Opwall field data supporting this report. These are the limited temporal scope (taking place during the summer months only) and limited geographical scope (covering only the northern half of the full KNP designated area; Fig. 1). The limited survey season is less of an issue with mammals compared to other taxa because mammals are typically most active in spring to autumn. However, a summer field season excludes the time of year when camera traps may be most effective or when certain species (e.g., pine marten *Martes martes*, which could theoretically occur in KNP) might be more detectable due to a reduction of vegetation in the winter months. Overall, we do not consider the temporal limitation on fieldwork to have substantially affected our species list, but additional surveys outside summer would be beneficial going forwards, where feasible. The limited geographical scope may have resulted in under-recording of southerly-distributed species or localised populations of mammals. In addition, most of the fieldwork has focused on transects and incidental recording in the surrounding plateau, with recording efforts having a disproportionate emphasis on the habitats found here (e.g., scrub and mixed oak forests) compared with the river's edge and the riparian habitats of the gorge itself. Whilst the key impact of such uneven sampling would be on species abundance data (which is not assessed here and as such is not considered a constraint), it may also be a factor in the under-recording of riparian-associated species such as otter (which has not been directly observed during fieldwork, but which is assumed to have a resident population within the park). Future monitoring work would ideally be systematic and cover the whole of the national park, although such systematic efforts on such a scale are often prohibitively expensive or fundamentally difficult to undertake. Nevertheless, Biota / Opwall efforts in future field seasons hope to focus on the under-recorded or hitherto not-recorded groups (insectivores, rodents and riparian mammals) and to add supplementary excursions to new areas of the park in addition to continuation of their long-term monitoring on established transects.

REFERENCES

Amori G., 2007a: *Rattus rattus* (Europe assessment). *The IUCN Red List of Threatened Species 2007*: e.T19360A8868513. URL: dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T19360A192565917.en.

Amori G., 2007b: *Mus musculus* (Europe assessment). *The IUCN Red List of Threatened Species 2007*: e.T13972A4375664. URL: dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T13972A197519724.en.

Amori G., Hutterer R., Kryštufek B., Yigit N., Mitsainas G. & Palomo L., 2021a: *Erinaceus concolor* (amended version of 2016 assessment). *The IUCN Red List of Threatened Species 2021*: e.T40605A197506348. URL: dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T40605A197506348.en.

Amori G., Hutterer R., Kryštufek B., Yigit N., Mitsainas G. & Muñoz L., 2021b: *Apodemus mystacinus* (amended version of 2016 assessment). *The IUCN Red List of Threatened Species 2021*: e.T1898A197270494. URL: dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T1898A197270494.en.

Anderwald P., Ambarli H., Avramov S., Ciach M., Corlatti L., Farkas A., Jovanovic M., Papaioannou H., Peters W., Sarasa M., Šprem N., Weinberg P. & Willisch C., 2021: *Rupicapra rupicapra* (amended version of 2020 assessment). *The IUCN Red List of Threatened Species 2021*: e.T39255A195863093. URL: dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T39255A195863093.en.

Banker S. E., Bonhomme F. & Nachman M. W., 2022: Bidirectional introgression between *Mus musculus musculus* and *Mus spretus*. *Genome Biology and Evolution*, 14(1; evab288): 1–15.

Barnett A. & Dutton J., 1995: *Expedition Field Techniques*: *Small Mammals* (*Excluding Bats*). *Second Edition*. Expedition Advisory Centre, Royal Geographic Society, London, 126 pp.

Bertolino S., Amori G., Henttonen H., Zagorodnyuk I., Zima J., Juškaitis R., Meinig H. & Kryštufek B., 2008: *Eliomys quercinus*. *The IUCN Red List of Threatened Species* 2008: e.T7618A12835766. URL: dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T7618A12835766.en.

Bogdanović T., 2014: Inventarizacija kopnenih sisavaca (Mammalia) Nacionalnog Parka "Krka", Njihova zoogeografska raščlamba, ugroženost, i status. Javna ustanova "Nacionalni park Krka", Šibenik, 93 pp.

Cassola F., 2016: *Ondatra zibethicus*. *The IUCN Red List of Threatened Species 2016*: e. T15324A22344525. URL: dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T15324A22344525.en.

EuroBats, 2024: Croatia. Pp. 1–5. In: *Conservation of Key Underground Dites*: *the Database*. EuroBats, Bonn. URL: www.eurobats.org/activities/intersessional_working_groups/underground_sites.

EEA [European Environment Agency], 2024a: Croatia. In: *Biodiversity Information System for Europe*. URL: biodiversity.europa.eu/countries/croatia.

EEA [European Environment Agency], 2024b: Croatia. In: *Natura 2000*: *Birds and Habitats Directives*. URL: www.eea.europa.eu/en/analysis/maps-and-charts/natura-2000-birds-and-habitat-directives-12.

Filippucci M. G. & Simson S., 1996: Allozyme variation and divergence in Erinaceidae (Mammalia, Insectivora). *Israel Journal of Ecology and Evolution*, **42**: 335–345.

Hipólito D., Reljić S., Rosalino L. M., Wilson S. M., Fonseca C. & Huber D., 2020: Brown bear damage: patterns and hotspots in Croatia. *Oryx*, **54**: 511–519.

Hughes M., 2024: *Mammal Records of Krka National Park 2017–2024*. Unpubl. report. URL: figshare.com/articles/dataset/dx.doi.org/10.6084/m9.figshare.27215076.v1.

INaturalist, 2024: *iNaturalist*. URL: https://www.inaturalist.org/

IUCN, 2018: *Definitions for Presence*, *Origin and Seasonal Distribution Codes*. 1 p. URL: nc.iucnredlist.org/redlist/resources/files/1539614211-Mapping_attribute_codes_v1.16_2018.pdf.

IUCN, 2024: *The IUCN Red List of Threatened Species*. *Version 2024-1*. URL: www.iucnredlist.org

KNPA [Krka National Park Authority], 2024: *Krka National Park*. URL: www.npkrka.hr/en_US/

Kocijana I., Galova A., Ćetković H., Kusak J., Gomerčić T. & Huber Đ., 2011: Genetic diversity of Dinaric brown bears (*Ursus arctos*) in Croatia with implications for bear conservation in Europe. *Mammalian Biology*, **76**: 615–621.

Kovačić D. & Đulić B., 1989: *Sisavci Nacionalnog Parka* "*Krka*". Zoologijski zavod, Prirodoslovno-matematički fakultet, Zagreb, 107 pp (in Croatian).

Kryštufek B., 2016: *Chionomys nivalis* (errata version published in 2017). *The IUCN Red List of Threatened Species 2016*: e.T4659A115069366. URL: dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T4659A22379147.en.

Kryštufek B. & Gazzard A., 2023: *Crocidura suaveolens*. *The IUCN Red List of Threatened Species 2023*: e.T221735459A221735673. URL: dx.doi.org/10.2305/IUCN.UK.2023-1.RLTS.T221735459A221735673.en.

Kryštufek B. & Griffiths H. I., 1999: Mediterranean v. continental small mammal communities and the environmental degradation of the Dinaric Alps. *Journal of Biogeography*, **26**(1): 167–177.

Kryštufek B. & Vohralík V., 2016: *Apodemus epimelas*. *The IUCN Red List of Threatened Species 2016*: e.T136816A221784928. URL: dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T136816A519247.en

Louppe V., Leroy B., Herrel A. & Veron G., 2020: The globally invasive small Indian mongoose *Urva auropunctata* is likely to spread with climate change. *Scientific Reports*, **10**(7461): 1–11.

MacDonald D. & Barrett P., 2005: *Mammals of Britain and Europe*. *Collins Field Guide*. Collins, London, 312 pp.

Macholán M., Baird S. J. E., Munclinger P., Dufková P., Bímová B. & Piálek J., 2008: Genetic conflict outweighs heterogametic incompatibility in the mouse hybrid zone? *BioMedCentral Evolutionary Biology*, **8**(271): 1–14.

Marguš D., 2019: *The Krka River*: *A Gift of Nature*. *Natural History Monograph of Krka National Park*. Public Institute of Krka National Park, Šibenik, 223 pp.

McLellan B. N., Proctor M. F., Huber D. & Michel S., 2017: *Ursus arctos* (amended version of 2017 assessment). *The IUCN Red List of Threatened Species 2017*: e.T41688A121229971. URL: dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T41688A121229971.en.

MEPE [Ministry of Environmental Protection and Energy], 2024: *Ministry of Environmental Protection and Energy*. URL: www.mzoip.hr.

Middleton N., Newson S. & Pearce H., 2023: *Sound Identification of Terrestrial Mammals of Britain & Ireland*. Pelagic Publishing, London, 392 pp.

Olsen L. H., 2013: *Tracks and Signs of the Animals and Birds of Britain and Europe*. Princeton University Press, Princeton & Oxford, 272 pp.

Rovero F. & Zimmerman F., 2016: *Camera Trapping for Wildlife Research*. Pelagic Publishing, London, 232 pp.

Smith A. T. & Boyer A. F., 2007: *Oryctolagus cuniculus* (Europe assessment). *The IUCN Red List of Threatened Species 2007*: e.T41291A10414811. URL: dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T41291A170619657.en.

Zolotareva K. I., Belokon M. M., Belokon Y. S., Rutovskaya M. V., Hlyap L. A., Starykov V. P. & Bannikova A. A., 2021: Genetic diversity and structure of the hedgehogs *Erinaceus europaeus* and *Erinaceus roumanicus*: evidence for ongoing hybridization in Eastern Europe. *Biological Journal of the Linnean Society*, **132**: 174–195.