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ANNOTATED REVIEW OF THE MAMMAL FAUNA IN THE CHORNOBYL BIOSPHERE RESERVE AS OF 2023

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Exclusion zone, Chornobyl Radioecological Biosphere Reserve, species check-list, adventive species, autochthonous species, rare species

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Abstract

The review of mammals recorded in the Chornobyl Radiation-Ecological Biosphere Reserve (established in 2016, covering 2273 of the 2600 km² area of the former exclusion zone) is carried out for the second time in the entire history of studies in the region. In addition to presenting a checklist of the local mammal fauna, the review details the changes that have taken place over the last 20 years. In total, 61 species have been recorded in the Reserve (compared to 49 in 2006), representing 7 orders and 19 families. Among them, 10–11 species are non-native, of which 5 were introduced in the last 25–70 years. The rest of the species are autochthonous. Nine species are considered to be phantom species, meaning that they are known from neighbouring areas but have not been found in the Reserve. Twenty-two species have protected status in Ukraine (Red Data Book of Ukraine, 2021), and 6 in Europe (IUCN Red List, 2024). The changes in the checklist of the Reserve's mammal fauna have mainly resulted from more intense studies and using revised approaches. Research on bats alone has added nine species to the list of mammals. Additionally, feral domestic animals (cats, dogs, and cattle) have been included in the checklist as they have formed established wild populations. Only two species, the golden jackal and the European bison, arrived naturally in the Reserve for the first time. The abundance of most species shows significant long-term and seasonal fluctuations, influenced by climate change, disease, shifts in vegetation, wildfires, floods, intraspecies dynamics, and occasionally human activity. Certain species (lynx, Przewalski's horse, and bear) continue to increase in number, while the red deer has shifted from being a non-abundant to a dominant species. At the same time, there is limited information on rare and conditionally non-abundant species as they often fall outside the scope of research due to the difficulty of their study. This consideration is not reasonable as those species constitute a substantial portion of the checklist, and many of them are protected species. Nevertheless, the current state of the mammal fauna demonstrates the positive impact of nature conservation and the stable development of autochthonous populations, reinforcing the view that the Chornobyl Radiation-Ecological Biosphere Reserve is a highly valuable wildlife sanctuary in both Ukraine and Europe.

Cite as

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Анотований огляд фауни ссавців Чорнобильського біосферного заповідника станом на 2023 рік

Сергій Гащак

Резюме. Цей огляд ссавців, що зареєстровані у Чорнобильському радіаційно-екологічному біосферному заповіднику (з 2016 р. займає 2273 з 2600 км^2 колишньої зони відчуження), є другим за всю історію досліджень регіону, і надає не тільки контрольний список фауни, а й фіксує зміни, що сталися за останні 20 років. Всього у заповіднику зареєстровано 61 вид (у 2006 — 49), що належать до 7 рядів і 19 родин. З них 10–11 видів — адвентивні, включаючи 5, інтродукованих в останні 25–70 років, решта — автохтонні. Ще 9 видів — фантомні, тобто такі, що відомі з сусідніх територій, але досі не були виявлені у заповіднику. З-поміж 61 виду 22 мають охоронний статус за Червоною книгою України (2021), а 6 — охоронну категорію у Європі (The IUCN Red List, 2024). Зміни у контрольному списку теріофауни, в першу чергу, пов'язані зі збільшенням обсягів досліджень і переглядом підходів. Дослідження кажанів додали зразу 9 видів. Також до переліку додано здичавілих свійських тварин, що утворили стійкі угруповання: кота, собаку і бика. Лише 2 види (шакал і зубр) дійсно з'явилися тут вперше, і — природним шляхом. Чисельність більшості видів характеризується виразною багаторічною і сезонною динамікою внаслідок кліматичних змін, хвороб, змін у рослинному покриві, пожеж, повеней, внутрішньовидових процесів, та іноді — від дій людини. Деякі види (рись, ведмідь, кінь Пржевальського) продовжують зміцнювати свій статус, збільшуючись у чисельності, а олень шляхетний взагалі з нечисленного перетворився у домінуючого. Разом з тим, дуже мало інформації щодо рідкісних та умовно нечисленних видів, бо ними, внаслідок складності, займаються не часто, або взагалі не займаються. Це невірно, бо такі види складають більшу частину списку і з-поміж них більше всього охоронних. Попри це, сучасний стан теріофауни в черговий раз демонструє позитивний вплив заповідання і сталий розвиток автохтонних комплексів, і підтверджує тезу, що заповідник є ціннішим резерватом дикої природи в Україні і Європі.

Ключові слова: зона відчуження, Чорнобильський радіаційно-екологічний біосферний заповідник, контрольний перелік видів, адвентивний вид, автохтонний вид, рідкісний вид.

Introduction

The first detailed review of all available information on the species composition and population status of vertebrates in the exclusion zone and the zone of mandatory resettlement (= Chornobyl Exclusion Zone, CEZ) was published in 2006 [Gashchak *et al.* 2006]. This included a chapter on the mammal fauna, providing not only a review of data collected over the 20 years since the Chornobyl nuclear power plant accident, but also reflecting changes in the ecosystems that occurred primarily during the first years after the disaster. These changes were significant and widespread, mainly due to the cessation of agricultural and forestry activities, and the evacuation of the human population from an area of 2600 km² in northern Kyiv Oblast and 2150 km² in the southern part of the Homel region (Republic of Belarus). This 'rewilding' allowed the gradual natural development of ecosystems, aligning them with the typical characteristics of the given natural zone. Interest to the CEZ was high, although with a strong radioecological focus. There were relatively few purely faunistic studies, and much of the faunal information was obtained as a byproduct of radioecological research. Consequently, knowledge of the CEZ fauna remained fragmentary and limited (see a review of mammalogical studies in the CEZ [Gashchak *et al.* 2024]).

In subsequent years, the CEZ continued to be *de facto* protected; forests gradually occupied former agricultural lands, their structure evolved, and long-term droughts, large-scale wildfires, and floods occurred [Matsala *et al.* 2021]. The level of anthropogenic impact also varied, across both specific areas and the entire territory. Interest in the CEZ fauna grew. The use of new techniques and the development of new research directions significantly expanded our knowledge [Gashchak *et al.* 2023]. More and more endangered and protected species were identified [Gashchak 2018]. Scientists began to realise that, as a result of radiation countermeasures that were largely unrelated to environmental conservation, a valuable wildlife reserve of continental significance had emerged in the CEZ,

which deserves special protection [Gashchak 2006]. Finally, in 2016, recognising the impracticality of using these lands for other purposes, the Chornobyl Radioecological Biosphere Reserve was established within the CEZ [Decree of the President of Ukraine "No. 174/2016, 26.04.2016].

The aim of this work is to summarise how the CEZ mammal fauna and our understanding of it have developed over the last 20 years. Compiling all of the known data (even if incomplete and fragmented) into a single article would be an exceedingly difficult task. Therefore, this review takes the form of an annotated species list (checklist) verifying the presence of each species in the CEZ as of 2023. The review addresses the presence status of each species as well as general issues of mammal research within the CEZ.

Materials and Methods

Although this review focuses on mammals of the Chornobyl Radioecological Biosphere Reserve, it is important to note that the Reserve was established only in 2016 and covers 87.6% (2273 km²) of the total CEZ area (2600 km²)[1]. The central part of the CEZ has retained its initial industrial function as a radioactive waste management zone. Nevertheless, up to 60% of this area is not significantly affected by technological activity and consists of natural complexes similar to those in surrounding areas. Faunistic studies are also conducted in this industrial zone, both historically and currently. Moreover, most of the information used in this review was collected before the Reserve's establishment in 2016. Therefore, this review does not strictly cover the fauna of the administrative and territorial entity of the 'Exclusion Zone' or the national environmental entity, the 'Chornobyl Biosphere Reserve', but rather the entire 2600 km² area containing these designated areas. Consequently, in this article, the abbreviation 'CEZ' applies to both contexts.

The taxonomic hierarchy and nomenclature follow Zagorodniuk & Emelyanov [2012].

This review draws on both published information and unpublished original observations. Since mammal studies conducted after 1986 have not been comprehensive (sporadic, short-term, partial, covering only specific areas and species), the lack of data made impossible high-quality assessment of species presence. Therefore, species statuses reflect relative expert assessment based on the entire body of available information. The status of each species in this article aligns with the presence categories proposed by Zagorodniuk *et al.* [2002]:

> • Phantom (0)—Species that may inhabit the CEZ, as they were recorded there before 1986 or in adjacent lands after 1986, but there have been no confirmed sightings within the CEZ since 1986. • Occasional (1)—Species recorded less than three times since 1986, with their status remaining uncertain due to lack of data. • Rare (2)—Species or their signs are observed irregularly. • Non-abundant (3)—Species or their signs are typically recorded in relevant studies, but in relatively low numbers and often within specific habitats. • Common (4)—Species or their signs are almost always recorded in relevant studies and are widespread throughout the CEZ, though they rarely dominate in samples. • Abundant (5)—Species that are frequently recorded in samples and usually dominate within them.

Species composition and relative abundance and distribution of large and medium-sized mammals were primarily analysed using camera traps [Gashchak 2008; Gashchak *et al.* 2016, 2017, 2022; Gashchak & Paskevich 2019]. The abundance was estimated as the number of individuals per day recorded by the camera trap, recalculated per 100 trap-days (ind/100 TD). To assess seasonal dynamics, summaries for the calendar months were created. To compare different sites, data were grouped by study location. Days without recordings were also considered in calculations. Camera traps were typically deployed for 10–12 months, except for Site S8 in 2021, where exposure lasted six months. The locations of study sites are shown in Fig. 1.

Bat studies primarily relied on mist-netting, with species-specific ultrasonic vocalisation analysis as a supplementary method. The locations of bat study sites from 2007–2018 are shown in Fig. 2, with detailed descriptions of methods and results presented in Gashchak *et al.* [2013]. Relative abundance of bats is expressed as the number of individuals captured per trap-hour (ind/TH).

[1] Decree of the President of Ukraine About Establishment of CRBR, No. 174/2016, 26.04.2016.

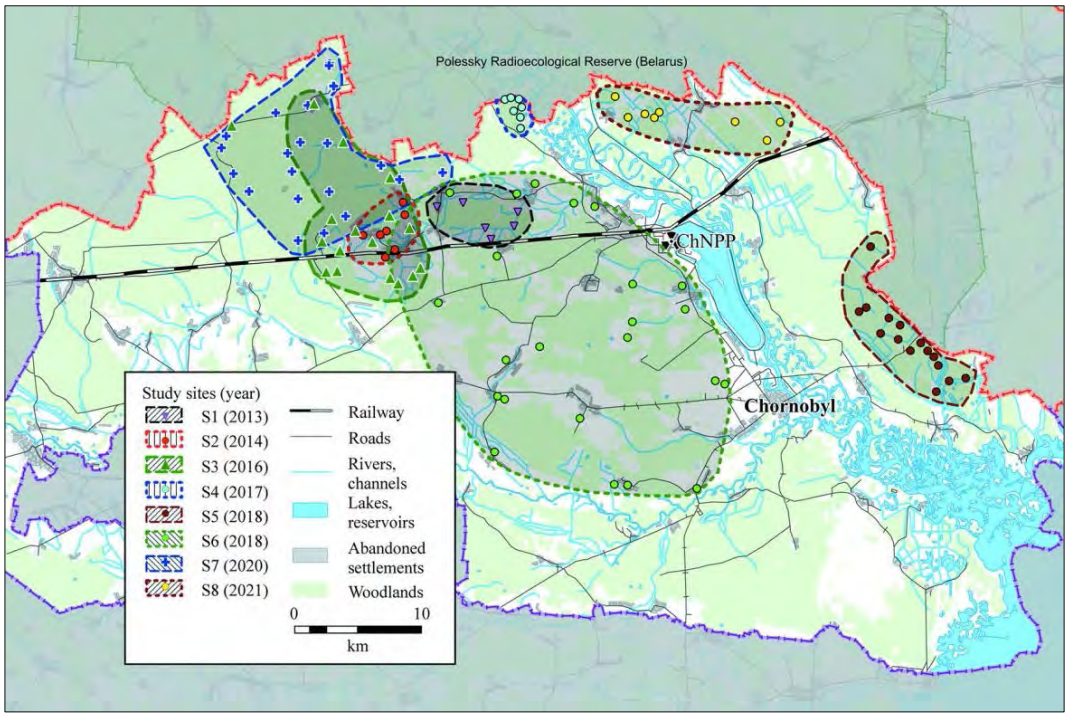

Fig 1. Study sites and locations where the camera traps were deployed in 2013–2021.

Рис. 1. Дослідні ділянки і точки розміщення фотопасток у 2013–2021 роках.

Small-mammal studies (shrews and murids) were conducted through trapping [see Gashchak *et al.* 2000]. Since these trappings were primarily for radioecological studies, they did not comprehensively represent the entire CEZ and its natural habitats. The locations of small mammal study sites from 1995–2018 are shown in Fig. 3, with relative abundance expressed as the number of individuals captured per 100 trap-nights (ind/100 TN).

Due to certain limitations, some mammal species were not consistently covered by these methods or were recorded only sporadically, inconsistent with their status in the CEZ. In such cases, their status was assessed based on visual observations, evidence of activity, and other indicators.

A brief overview of the current natural conditions of the CEZ and analyses of changes over the past 35 years can be found in articles by Gashchak *et al.* [2022] and Matsala *et al.* [2021]. For illustrative cartographic material, see the Chornobyl Radioecological Biosphere Reserve's website: [Chornobyl Biosphere Reserve GIS] (https://zapovidnyk.org.ua/index.php?fn=gis). Coordinates of findings (records) are presented in degrees of latitude/longitude using the WGS84 system.

Although this review is based on information gathered directly within the CEZ boundaries, to broaden the understanding of species statuses in the region, data from the neighbouring Polesski State Radioecological Reserve (PSRER) in the Republic of Belarus are also referenced. The PSRER shares similar natural conditions and developmental history with the CEZ, and its faunistic studies have been more comprehensive and systematic.

Table 1 includes the following abbreviations:

- National conservation categories [The Red… 2009, Order… 2021]: (I) Extinct in the wild, (II) Endangered, (III) Vulnerable, (IV) Rare, (V) Data deficient, and (na) No category.
- International conservation categories [The IUCN… 2024]: (CR) Critically endangered, (DD) Data deficient, (EN) Endangered, (LC) Least concern, (NT) Near threatened, and (VU) Vulnerable.
- Sources of information on species in the CEZ: (o) Visual observation, (c) Camera trap record, (a) Audio record, (f) Other signs of activity (e.g. footprints), and (t) Trapping (including temporary capture and subsequent release).

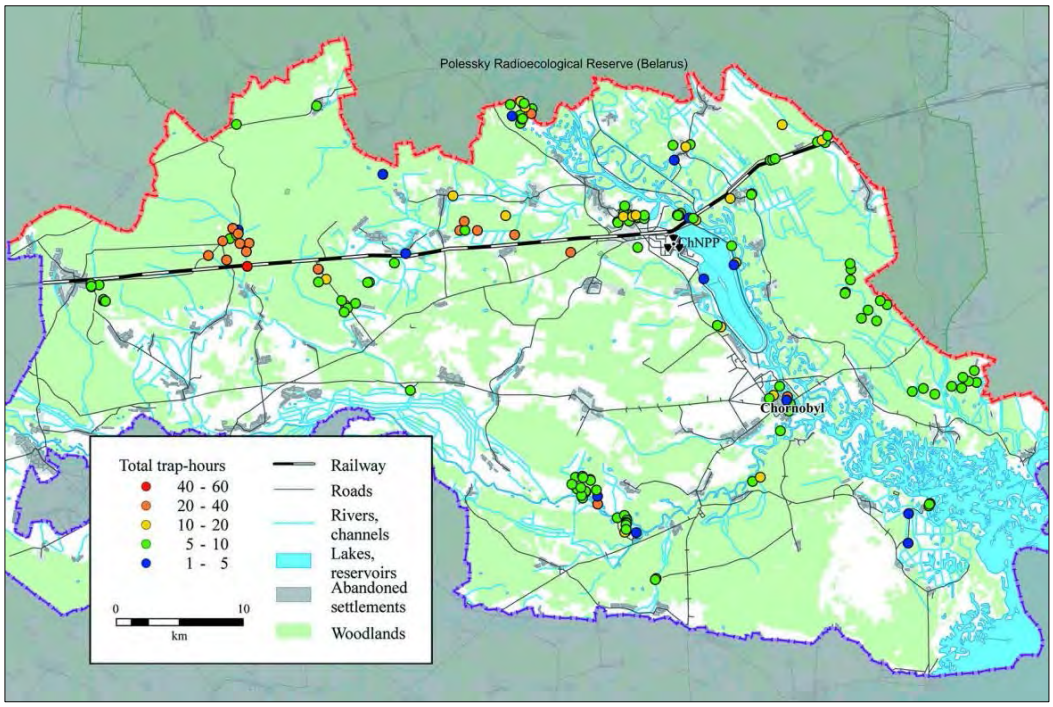

Fig 2. Study sites of bats in the CEZ in 2007–2018 and total duration of mist-netting (hours) (more detailes in Gashchak *et al.* [2013]).

Рис. 2. Дослідні ділянки рукокрилих у ЗВ у 2013–2021 роках та загальна тривалість відлову павутинними тенетами (години) (більш детально у Gashchak *et al.* [2013]).

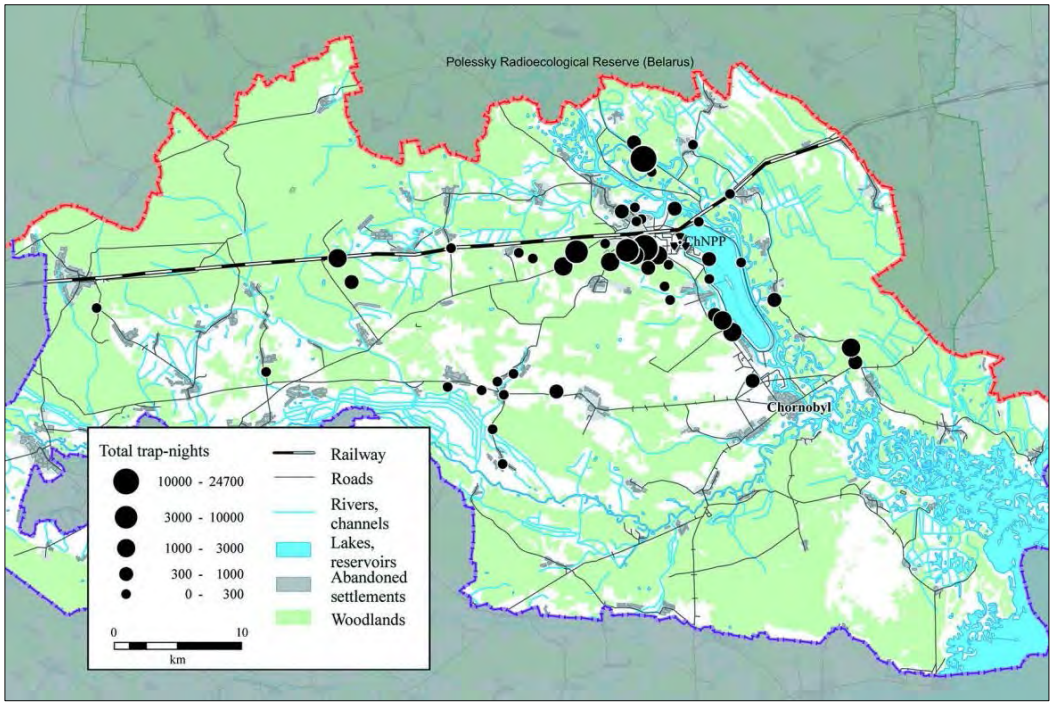

Fig 3. Study sites for trappings of small mammals in 1995–2018 in the CEZ and the total amounts of trap-nights at each site.

Рис. 3. Дослідні ділянки для відлову дрібних ссавців у 1995–2018 роках у ЗВ, та загальний обсяг пастко-ночей на кожній ділянці.

Results

As of 2023, 61 mammal species have been recorded in the CEZ (excluding humans and domestic animals), with confirmed observations since 1986. These species belong to 7 orders and 19 families (see: Table 1).

Order Leporiformes, seu Lagomorpha

The order is represented by two species from a single family, one of which is phantom species.

Family Leporidae Fischer, 1817

Lepus europaeus. Currently, this is the only member of the family confirmed in the CEZ. It is common and widespread, though present population numbers and trends remain uncertain. In the early 1990s, its relative abundance reached 10 ind/1000 ha [Boiarchuk *et al.* 1990; Gaichenko *et al.* 1990], and in the PSRER in the 2000s, this figure was 2.8–3.7 ind/1000 ha [Kuchmel 2008]. Most hares inhabited fallow lands, with densities up to 6.7 ind/1000 ha [Voronetskyi *et al.* 1999]. Between 2013 and 2021, hare detection frequency in the CEZ, based on camera trap records, ranged from 0.2 to 24 ind/100 TD, depending on site conditions and the year (Table 4). Additionally, meadow habitats exhibited hare detection rates several times higher than woodland areas. Given the ongoing reforestation in the CEZ, it is anticipated that the optimal habitat area for hares could gradually decrease, potentially leading to a future population decline.

Lepus timidus L., 1758. Another representative of the family, which is currently considered phantom due to the lack of reliable evidence.

A single low-quality image of a 'white hare' was taken by a camera trap on 16 February 2013, north of the village of Bovysche (N51.355/E29.764) (Fig. 4). Additionally, 'white hares' were observed on several occasions under vehicle lights (e.g. on 18 December 2002, northeast of the village of Paryshev, N51.321/E30.383; on 16 January 2020, north of the village of Stara Krasnytsia, N51.378/E29.848), though these observations were too brief to confirm the species. On 18 January 2018, numerous hare tracks were found in a wet forest dominated by alder and oak trees with a well-developed understorey (east of Paryshev, N51.292/E30.403). These tracks could have belonged to *L. timidus*, as *L. europaeus* typically prefers meadow habitats. Reports of *L. timidus* in the PSRER are also conflicting. No records were available before 1997, but in 1997–1998, its population was estimated at 360 individuals; however, from 2001–2006, no further records were reported [Kuchmel 2008]. It was noted that *L. timidus* in the PSRER prefers wet forests with dense understory [Voronetskyi *et al.* 1999].

Order Muriformes, seu Rodentia

This order has the highest species diversity within the CEZ, represented by four non-Muroidea superfamilies (with five species, plus one phantom species) and the superfamily Muroidea, which includes 13 species (plus two phantom species).

Superfamily Sciuroidea

Family Sciuridae Fischer, 1817

Sciurus vulgaris. It is a non-abundant species widely distributed in woodlands, including former settlements and reforested regions. While the exact population numbers are unknown, the frequency of observation suggests a stable population (Table 4). In the PSRER in the 1990s–2000s, the relative abundance was estimated at 1–9 ind/1000 ha [Kuchmel 2008].

Fig. 4. 'White hare' recorded on 16 February 2013 by a camera trap in the CEZ (N51.355, E29.764).

Рис. 4. «Білий заєць», знятий фотопасткою 16.02.2013 р. у ЗВ (N51.355, E29.764).

Table 1. The checklist of mammals recorded in the CEZ as of 2023

Таблиця 1. Перелік ссавців, зареєстрованих у ЗВ, за станом на 2023 рік

Species name: scientific and local vernacular	Status*	Invasive**	Source***
1. *Lepus europaeus* Pallas, 1778 (Заєць сірий)	4; na (LC)		ocft
2. *Sciurus vulgaris* Linnaeus, 1758 (Вивірка лісова)	3; na (LC)		ocaft
3. *Muscardinus avellanarius* (Linnaeus, 1758) (Ліскулька руда)	3; na (LC)		oft
4. *Dryomys nitedula* (Pallas, 1779) (Соня лісова)	2; na (LC)		oft
5. *Castor fiber* Linnaeus, 1758 (Бобер європейський)	4; na (LC)		ocaft
6. *Sicista betulina* (Pallas, 1779) (Мишівка лісова)	2; III (LC)		ot
7. *Micromys minutus* (Pallas, 1771) (Мишка лучна)	2; na (LC)		oft
8. *Apodemus agrarius* (Pallas, 1771) (Житник пасистий)	5; na (LC)		ot
9. *Sylvaemus tauricus* (Pallas, 1811) (Мишак жовтогрудий)	5; na (LC)		oct
10. *Sylvaemus sylvaticus* (Linnaeus, 1758) (Мишак європейський)	4; na (LC)		ot
11. *Mus musculus* Linnaeus, 1758 (Миша хатня)	3; na (LC)		oft
12. *Rattus norvegicus* (Berkenhout, 1769) (Пацюк мандрівний)	3; na (LC)	AS2b-expans	oft
13. *Ondatra zibethicus* (Linnaeus, 1766) (Ондатра мускусна)	2; na (LC)	AS3c-intr	ocf
14. *Myodes glareolus* (Schreber, 1780) (Нориця руда)	5; na (LC)		ot
15. *Microtus subterraneus* (Selys-Longchamps, 1836) (Полівка підземна)	2; na (LC)		ot
16. *Microtus agrestis* (Linnaeus, 1761) (Полівка темна)	3; na (LC)		ot
17. *Microtus levis* Miller, 1908 (Полівка лучна)	2; na (LC)		ot
18. *Microtus arvalis* (Pallas, 1779) (Полівка європейська)	5; na (LC)		ot
19. *Alexandromys oeconomus* (Pallas, 1776) (Шапарка сибірська)	2; na (LC)		oft
20. *Erinaceus roumanicus* Barrett-Hamilton, 1900 (Їжак білочеревий)	3; na (LC)		ocft
21. *Talpa europaea* Linnaeus, 1758 (Кріт європейський)	4; na (LC)		oft
22. *Crocidura suaveolens* (Pallas, 1811) (Білозубка мала)	2; na (LC)		ot
23. *Neomys fodiens* (Pennant, 1771) (Рясоніжка велика)	2; na (LC)		ot
24. *Sorex minutus* Linnaeus, 1766 (Мідиця мала)	3; na (LC)		ot
25. *Sorex araneus* Linnaeus, 1758 (Мідиця звичайна)	5; na (LC)		ot
26. *Myotis brandtii* (Eversmann, 1845) (Нічниця північна)	1; III (LC)		ot
27. *Myotis mystacinus* (Kuhl, 1817) (Нічниця вусата)	1; III (LC)		ot
28. *Myotis dasycneme* (Boie, 1825) (Нічниця ставкова)	2; II (NT)		oat
29. *Myotis daubentonii* (Kuhl, 1817) (Нічниця водяна)	4; III (LC)		oat
30. *Plecotus auritus* (Linnaeus, 1758 (Вухань бурий)	3; III (LC)		oaft
31. *Barbastella barbastellus* Schreber, 1774 (Широковух європейський)	1; II (VU)		oat
32. *Nyctalus leisleri* (Kuhl, 1817) (Вечірниця мала)	4; III (LC)		oat
33. *Nyctalus noctula* (Schreber, 1774) (Вечірниця дозірна)	5; III (LC)		oat
34. *Nyctalus lasiopterus* (Schreber, 1780) (Вечірниця велетенська)	1; II (DD)		oat
35. *Pipistrellus lepidus* Blyth, 1845 (Нетопир білосмугий)	2; III (LC)	AS2b-expans	oat
36. *Pipistrellus nathusii* (Keyserling, Blasius, 1839) (Нетопир лісовий)	5; III (LC)		oat
37. *Pipistrellus pygmaeus* (Leach, 1825) (Нетопир пігмей)	4; III (LC)	AS2b-expans	oat
38. *Vespertilio murinus* Linnaeus, 1758 (Лилик двоколірний)	3; III (LC)		oat
39. *Eptesicus serotinus* (Schreber, 1774) (Пергач пізній)	3; III (LC)	AS2a-expans	oat
40. *Felis catus* Linnaeus, 1758 (Кіт свійський)	3; na (LC)		of
41. *Lynx lynx* (Linnaeus, 1758) (Рись євразійська)	3; III (LC)		ocf
42. *Nyctereutes procyonoides* (Gray, 1834) (Єнот уссурійський)	4; na (LC)	AS3b-intr	ocaf
43. *Canis familiaris* Linnaeus, 1758 (Пес свійський)	3; na (LC)		ocaft
44. *Canis lupus* Linnaeus, 1758 ([Пес] вовк)	3; na (LC)		ocaft
45. *Canis aureus* Linnaeus, 1758 ([Пес] шакал)	1; na (LC)	AS2b-expans	cf
46. *Vulpes vulpes* (Linnaeus, 1758) (Лис рудий)	3; na (LC)		ocaf
47. *Ursus arctos* Linnaeus, 1758 (Ведмідь бурий)	2; II (LC)		cf
48. *Mustela nivalis* Linnaeus, 1766 ([Мустела] ласиця)	3; na (LC)		oct
49. *Mustela putorius* Linnaeus, 1758 (Тхір темний)	1; III (LC)		oc
50. *Neogale vison* (Schreber, 1777) (Візон річковий)	3; na (LC)	AS3c-intr	oc
51. *Martes martes* (Linnaeus, 1758) (Куниця лісова)	3; na (LC)		oc
52. *Martes foina* (Erxleben, 1777) (Куниця кам'яна)	3; na (LC)		ocf
53. *Meles meles* (Linnaeus, 1758) (Борсук європейський)	3; na (LC)		ocf
54. *Lutra lutra* (Linnaeus, 1758) (Видра річкова)	3; III (NT)		ocft

Species name: scientific and local vernacular	Status*	Invasive**	Source***
55. *Equus ferus* (Boddaert, 1785) (Кінь тарпан)	3; I-II (EN)	AS3a-re-intr	ocaft
56. *Sus scrofa* Linnaeus, 1758 (Свиня лісова)	3; na (LC)		ocaft
57. *Cervus elaphus* Linnaeus, 1758 (Олень шляхетний)	5; na (LC)		ocaft
58. *Capreolus capreolus* (Linnaeus, 1758) (Сарна європейська)	4; na (LC)		ocaf
59. *Alces alces* (Linnaeus, 1758) (Лось європейський)	4; III (LC)		ocaf
60. *Bos taurus* Linnaeus, 1758 (Бик свійський)	2; na (LC)	(AS1c?)	ocaf
61. *Bison bonasus* (Linnaeus, 1758) ([Бізон] зубр)	2; I (VU)	AS3a-re-intr	cf

Note. *Status (***AA; BB (CC)***): ***AA*** (status of the species in the CEZ); ***BB*** (category of the Red Data Book of Ukraine (2021); ***CC*** (category of IUCN 2024-1). 'I–II'—conservation category of *Equus ferus* is unclear, since the taxonomy of this species in Ukraine is unresolved and remains contradictory [Zagorodniuk & Emelyanov 2012].

**Invasive (status of non-native species after Zagorodniuk [2023]). ***Source (source of information about the species in the CEZ).

Superfamily Gliroidea

Gliridae Muirhead, 1819

Glis glis (Linnaeus, 1766). Currently classified as a phantom species.

In the past, this species was recorded in woodlands located in the north-west part of the present-day CEZ, near the village of Vilcha [Bezrodnyi 1991]. No records have been confirmed since 1986, though V. Gaichenko reported an unverified sighting nearby to abandoned forestry buildings approximately 5 km east of the village of Buriakivka (N51.382/E29.989). In the PSRER, the edible dormouse was documented in bird nest boxes (nine instances) in the early 2000s, ca. 35 km north of the CEZ [Kuchmel 2008]. Additional sightings were found in 2014 [Biodiversity… 2022]. Thus, it is likely that this species may still exist in the CEZ.

Muscardinus avellanarius. Its status is non-abundant, with a scattered distribution throughout the CEZ. The species prefers relatively wet forest habitats with birch and dense undergrowth. It was trapped in a few central areas of the CEZ (Prypiat, Buriakivka, Chystohalivka, Hlynka, Leliv), with a relative abundance of ca. 0.15 ind/100 TN (Table 2) in 1998–2018. In the left-bank part of the CEZ along the Prypiat River, this species has been found only in owl pellets (Krasno, N51.457/E30.120). It commonly occupies bird nest boxes in the second year after deployment. In 2004–2005, *M. avellanarius* nests were found in 13.4% of nest boxes across two sites (N51.384/ E30.056, N51.330/ E30.155), and, in 2018, they were observed in 13.1% of nest boxes across five sites (N51.283/ E29.882, N51.288/E29.843, N51.382/E30.038, N51.372/E30.096, N51.380/E29.938) (unpubl. data).

Dryomys nitedula. This species is considered rare due to limited data, and its distribution and abundance within the CEZ remain unclear. In 1998–2018, it was only captured in wet forests dominated by birch with well-developed undergrowth in a few locations on the left bank of the Prypiat River (N51.468/E30.130, N51.446/E30.157, N51.447/E30.065, N51.314/E30.297, N51.457/ E30.121, N51.422/E30.162), with a total of 17 individuals caught, including 13 individuals at sites with complete data (Table 2). Additionally, three mandibles were found in owl pellets in the village of Krasno (the 2000s, N51.457/E30.120). *Dryomys nitedula* also inhabits bird nest boxes (beginning from the second year after deployment), with a 15% occupancy rate in 2018 (two sites: N51.468 /E30.130, N51.446/E30.157) (unpubl. data). In the PSRER, this species is distributed throughout the reserve (2003–2006), though at a low abundance of 0.03 ind/100 TN [Kuchmel 2008].

Superfamily Castoroidea

Family Castoridae Hemprich, 1820

***Castor fiber*.** An autochthonous, non-abundant species that nearly went extinct due to overhunting in the early 20th century, and it was reintroduced in the 1950s [Panov 1990]. In the first years after the Chornobyl accident, more than 500 ind. were counted in the CEZ [Boiarchuk *et al.* 1990]. Although no formal beaver census has been conducted since, general observations indicate that the population has increased over time, spreading to nearly all water bodies. However, there have been periodical significant population declines, with disappearing from previously occupied habitats. Within the CEZ, beavers primarily inhabit bank burrows along waterways and build lodges in marshes. Dams are commonly constructed on drainage ditches or small streams.

Fig. 5. *Sicista betulina*, 31.07.2010, near the village of Richytsia.

Рис. 5. *Sicista betulina*, 31.07.2010, біля с. Річиця.

The PSRER reported similar population trends, with an initial increase followed by stabilisation between 1000–1500 ind. in 1997–2007. Beaver settlements numbered 2.0–3.7 per 10 km along ditches and small streams, and fewer than 0.8 settlements per 10 km along the Prypiat River [Kuchmel 2008]. Population distribution and abundance fluctuated with water availability, and a significant population reduction occurred in 2015–2019 due to prolonged droughts [Biodiversity… 2022].

Superfamily Dipodoidea

Family Sminthidae Brandt, 1855

***Sicista betulina*.** Rare. Between 1995 and 2003, only 42 individuals were captured, in just 10 of 65 locations, and observed in only 5.3% of trappings (Table 2). Skull remains (n = 9) were also found in owl pellets in the village of Krasno (N51.457/E30.120) in the early 2000s [Gashchak *et al.* 2006]. However, no individuals were captured from 2003–2018 despite numerous trapping efforts, except for a single specimen caught on 31 July 2010 near the village of Richytsia (Fig. 5). All records were associated with wet meadows with sparse, young forest vegetation or shrubs. The species was similarly rare in the PSRER (2003–2006), with a relative abundance of 0.03 ind/100 TN [Kuchmel 2008].

Superfamily Muroidea

Family Muridae Illiger, 1811

***Micromys minutus*.** Rare. In 1995–2018, only 21 individuals were captured across nine locations throughout the CEZ, observed in only 1.9% of trappings (Table 2). Of these, 15 were captured before 2000. A few skulls were also found in owl pellets [Gashchak *et al.* 2006]. This species is typically found in meadows with dense tall-grass or shrub vegetation. It is also rare in the PSRER (2003–2006), with 0.02–0.33 ind/100 TN [Kuchmel 2008; Biodiversity… 2022].

***Apodemus agrarius*.** The species' status is abundant, and it is among the most frequently captured species in the CEZ (1995–2018): 1.5 ind/100 TN, appearing in 35% of trappings (Table 2). Seasonal and long-term population density of the species vary. Recorded throughout the CEZ, it favours relatively wet habitats with dense grass and shrub cover. Similar population characteristics are reported in the PSRER (2003–2020), with 0.6–3.1 ind/100 TN [Kuchmel 2008; Biodiversity… 2022].

***Sylvaemus tauricus*.** The species' status is abundant, and it is frequently captured in the CEZ (1995–2018): 2.7 ind/100 TN, recorded in 55% of trappings (Table 2). Seasonal and long-term population density of the species vary. This species is distributed throughout the CEZ and prefers deciduous forests, though it is also common in other habitats with dense woody vegetation. In the PSRER, its numbers and distribution are not fully confirmed; in locations where it was trapped in 2003–2006, it was moderately abundant, at 0.5 ind/100 TN [Kuchmel 2008; Biodiversity… 2022].

***Sylvaemus sylvaticus*.** In 1995–2018, the species' status was common (sometimes and in certain areas, abundant), with 0.5 ind/100 TN, observed in 18% of trappings (Table 2). Seasonal and long-term population fluctuations are typical. It was captured in multiple locations within the CEZ, especially in semi-open arid habitats with tall grass and shrubs, as well as young reforested areas. As the forest expands, the abundance of this species seems to decline. In the PSRER, this species was common in the 1990s, but only a few findings have been reported since then [Kuchmel 2008; Biodiversity… 2022].

***Mus musculus*.** Following the Chornobyl accident, this species experienced a population explosion and spread across all former agricultural areas [Gaichenko *et al.* 1993]. However, by the mid-

1990s, it had nearly vanished from natural habitats and was only found in and around buildings where people stayed. While it undoubtedly exists within the CEZ, its population size and distribution remain unclear due to the lack of targeted trapping in areas where people live and work. Its status is therefore considered as non-abundant. Similar trends are reported in the PSRER: 0.02 ind/100 TN in natural habitats, and up to 2.5 ind/100 TN near human settlements [Biodiversity… 2022].

Rattus rattus (Linnaeus, 1758). This species has phantom status within the CEZ.

It was last recorded in the area in the 1960s [Hyrenko 1950; Zagorodniuk 1996; Shevchenko & Zolotukhina 2002]. Since 1986, there have been no confirmed sightings. The only dubious visual observation ('rat', likely 'black') was made by Oleksandr Naglov (pers. com.) on 4 August 2009 in an old oak forest (N51.363/E29.715), very far from any human constructions. In the PSRER, the species was recorded in abandoned villages in the 1990s, but no findings have been reported in the decades since [Kuchmel 2008; Biodiversity… 2022].

Rattus norvegicus. Non-abundant. This species has been observed and captured in locations where people live and work. However, due to the lack of targeted surveys, there is no accurate data on its abundance or distribution. A similar situation is observed in the PSRER [Kuchmel 2008; Biodiversity... 2022].

Family Arvicolidae Gray, 1821

***Ondatra zibethicus*.** Currently is a likely rare species. Introduced to the region in the mid-20th century [Panov 2002], it was observed in several water bodies during the 1990s, though no specific survey was conducted. General observations indicated unstable numbers. Its current status is unknown, as sightings and signs of activity are infrequent. During a 2018 CEZ-wide otter survey, *O. zibethicus* was recorded only at two locations (pers. comm. by Eugene Skorobagatov). In the PSRER, the species was common and widely distributed in the 1990s, with an estimated population size of 720 ind. [Kuchmel 2008]. However, by 2005–2007, it had become rare and it was found in 2015–2021 only in two locations [Biodiversity... 2022].

***Myodes glareolus*.** The species' status is abundant. The most common small mammal in regular captures, excluding meadow, marshy, and riparian habitats, with a relative abundance of 5.7 ind/100 TN, recorded in 77% of trappings (Table 2). Seasonal and long-term population fluctuations are typical. Found almost everywhere in the CEZ, particularly in forested areas with dense undergrowth, but less common in dry, young, sparsely vegetated woods. In the PSRER, it was a dominant species in the 1990s (up to 8 ind/100 TN), distributed across the entire area [Kuchmel 2008]. However, in certain years, its numbers dropped to as low as 0.5 ind/100 TN [Biodiversity... 2022].

Arvicola amphibius (Linnaeus, 1758). This species has phantom status in the CEZ.

It was last recorded in the mid-20th century [Korneev 1950], with no subsequent data. However, a few occurrences have been noted in the northern PSRER [Kuchmel 2008; Biodiversity... 2022].

***Microtus subterraneus*.** Considered rare. Despite hundreds of trapping campaigns in 1995–2021, only two individuals were captured, both in July 2000 (N51.360/E29.737). However, skulls have been found in owl pellets at several CEZ locations (early 2000s: N51.41/E29.74; N51.38/E29.99; N51.48/E29.93; N51.46/E30.12) [Gashchak *et al.* 2006], suggesting a potentially wider distribution. According to Zagorodniuk [2020], the boundary between two chromosomal forms (2n=52/54) of this species lies somewhere in the Polissia, but which one occurs in the CEZ remains unknown. In the PSRER (1994–2014), it was also infrequently caught in various habitats and detected in owl pellets [Kuchmel 2008; Biodiversity... 2022].

***Microtus agrestis*.** Based on trapping results (1995–2021), this species is non-abundant, recorded in only 10 locations (in the central industrial area, and near the villages of Illintsi, Zamoshnia, and Rozizdzhe). It was present in just 9.3% of trapping campaigns, with a relative abundance of 0.24 ind/100 TN (Table 2). It was found in habitats with dense grass and young, sparse reforestation. Skulls were also found in owl pellets at several locations (early 2000s: N51.41/E29.74; N51.38/E29.99; N51.48/E29.93; N51.46/E30.12) [Gashchak *et al.* 2006]. The species' relative abundance in the PSRER ranged from 0.03 to 0.7 ind/100 TN, and in some areas up to 3–4 ind/100 TN [Biodiversity... 2022]. This species occupies a broad range of habitats [Kuchmel 2008].

Microtus levis. This species is considered rare, mainly due to the technical difficulties of identification (requiring at least cytogenetic analysis). Information on its distribution and abundance is incomplete. In the study period, *Microtus levis* was identified only in six locations (near the Chornobyl NPP) and only in 1995–2000, despite the application of cytogenetic methods afterward also. In captures together with its sibling species (*M. arvalis*), *M. levis* was notably less abundant. It was found mainly in meadow habitats in early stages of reforestation. Its presence in the PSRER is assumed but has not been checked [Biodiversity... 2022].

***Microtus arvalis*.** During trappings in 1995–2021, this species was common in meadow complexes, with a relative abundance of 0.59 ind/100 TN and recorded in 11.8% of trappings (Table 2). When both sibling species were undifferentiated, these values rose to 1.4 ind/100 TN and 39.4%, respectively (Table 2). It was captured throughout the CEZ, mainly in meadows, including young reforested areas, and occasionally in birch–alder–aspen forests. Seasonal and long-term fluctuations in population density are typical. In the PSRER (2003–2020), *M. arvalis* and *M. levis* were not distinguished, with a total abundance 1–6 ind/100 TN [Kuchmel 2008; Biodiversity... 2022].

Alexandromys oeconomus. The current status of this species is unclear and provisionally considered rare. In 1995–2002, it was common and numerous in relatively wet meadows (up to 1–4 ind/100 TN, 67% of trappings). However, no individuals were recorded in the CEZ after 2002, despite extensive small-mammal trapping. It remains unknown whether this decline is due to forest expansion, habitat redistribution, increased droughts, or other factors. The species' presence in the region remains possible. In the neighbouring PSRER, it was also common in the 1990s, mainly in wet meadows, with a relative abundance of 0.14 ind/100 TN (2003–2006) [Kuchmel 2008], and up to 1.4 ind/100 TN in northern PSRER in autumn 2020 [Biodiversity... 2022].

Order Soriciformes, seu Soricomorpha

The regional fauna includes six species, and one more species classified as phantom.

Family Erinaceidae Fischer, 1814

Erinaceus roumanicus. Limited information is available regarding its abundance and distribution. Based on visual observations, the hedgehog is considered conditionally non-abundant, with most sightings occurring in areas inhabited by people. Its predominantly nocturnal lifestyle and lack of targeted studies significantly limit detection in the CEZ. Sightings have been incidental and may not reflect its actual population size and distribution. Identification of local hedgehogs as *Erinaceus roumanicus* follows Zagorodniuk & Emelyanov [2008]. A similar situation is observed in the PSRER, where the species has been recorded throughout the territory [Kuchmel 2008].

Family Talpidae Fischer, 1814

***Talpa europaea*.** No targeted surveys have been conducted in the CEZ; however, moles and molehills are widespread across the region suggesting that the species is common. The situation is similar in the PSRER [Kuchmel 2008].

Family Soricidae Fischer, 1814

***Crocidura suaveolens*.** This is a rare species. Since 1986, it has been captured only three times: in 1989 near the village of Kopachi [Gaichenko *et al.* 1993]; in 2001, within work premises in the city of Chornobyl (in 2001 and 2003, dead individuals were found there also); and in 2007, on a dam between the Chornobyl NPP cooling pond and the Prypiat River (N51.374/E30.174). The species is also rare in the PSRER, with all records occurring in buildings where people work [Kuchmel 2008]. Since 9 of the 11 records were made in buildings where people work, this species likely has a synanthropic distribution in the region.

***Neomys fodiens*.** The species status is rare; it has been captured only 13 times across six locations (five in the central CEZ: N51.374/E30.027, N51.337/E30.145, N51.382/E29.990, N51.384/E30.066, N51.382/E30.038; and one on the left bank of the Prypiat River at N51.447/E30.065).

It was primarily captured near natural water bodies and only once near a small artificial pond in a forest. This species is also rare in the PSRER, where it was sporadically captured near water bodies from 1988 to 2021 [Kuchmel 2008].

Sorex minutus. The species' status is non-abundant, with a relative abundance of 0.12 ind/100 TN, recorded in 8.4% of trappings (Table 2). It is found across various habitats in the region, primarily in areas with well-developed forest litter, sod, and grass cover. It is also non-abundant in the PSRER, where relative abundance ranged from 0.1 to 0.3 ind/100 TN in 2003–2020 [Kuchmel 2008; Biodiversity... 2022].

Sorex caecutiens Laxmann, 1788 so far considered a phantom species.

No sightings have been recorded within the CEZ. However, the species was captured in the northern PSRER in the 1990s and has been recorded approximately 15 km east of the CEZ, between the Prypiat and Dnipro rivers [Biodiversity... 2022].

***Sorex araneus*.** The species' status is abundant. This is the most frequently observed member of the family in the CEZ, with an average abundance of 2.53 ind/100 TN, occurring in 59% of trappings (Table 2). It is found throughout the CEZ, particularly in habitats with rich forest litter, sod, and grass cover. Seasonal and long-term population fluctuations are typical for this species. In the PSRER (2003–2020), it is considered a subdominant species, with relative abundance ranging from 0.3 to 2.0 ind/100 TN [Biodiversity… 2022].

Order Vespertilioniformes, seu Chiroptera

To date, 14 bat species have been recorded in the CEZ, all belonging to a single family. An additional two species have phantom status.

Family Vespertilionidae Gray, 1821

Myotis nattereri (Kuhl, 1817) currently has phantom status.

No records exist for the CEZ, but it has been documented across the broader Polissia region, including the Rivnensky Reserve [Godlevska *et al.* 2016] and the Belarusian Stary Zhaden Zakaznik, approximately 150 km west of the CEZ [Dombrovski *et al.* 2017]. Therefore, the presence of this species in the CEZ remains possible.

***Myotis brandtii*.** This species is classified as occasional. It has only been recorded once during the entire period of bat studies (2007–2018): a young male was captured in July 2011 near the village of Vilcha (N51.358/E29.459) in a mixed old-growth forest close to a forest pond (Fig. 6a) [Gashchak *et al.* 2013]. However, two maternal colonies were discovered in the neighbouring PSRER in 2016–2017 (about 20 km north of the CEZ) [Dombrovski 2018], located in a sparse oak forest with a significant amount of dead wood.

***Myotis mystacinus*.** Another occasional species, recorded only once in August 2009, approximately 7 km west of the village of Denisovichi (N51.472/E29.613) in an old deciduous forest with a significant amount of dead wood and small water bodies (Fig. 6b) [Gashchak *et al.* 2013]. This species has not been recorded in the PSRER.

***Myotis dasycneme*.** Classified as rare. This species was caught only four times (in 2007 and 2011), including two occasions involving the same individual (Fig. 6c). It was captured three times along the Prypiat River (N51.480/E29.946; N51.375/E30.176) and once in the village of Zymovyshche (N51.423/E30.193, also relatively close to the river). In each case, only mature males were found [Gashchak *et al.* 2013]. In the PSRER, the species is known exclusively from ultrasonic detections, also near the Prypiat River [Biodiversity... 2022].

***Myotis daubentonii*.** This is a common species near large water bodies and, occasionally, near small forest ponds. Its relative abundance is 0.03 ind/TH (Table 3), with captures occurring in 8.2% of the surveyed locations. The species is represented by all sex and age groups, breeds within the CEZ, and hibernates outside the CEZ [Gashchak *et al.* 2013]. In the PSRER, it has been recorded acoustically at three sites, most abundantly along the Prypiat River [Biodiversity... 2022].

***Plecotus auritus*.** The species is non-abundant; it is sedentary, possibly partially nomadic, and recorded in various parts of the CEZ [Gashchak *et al.* 2013]. Its relative abundance is 0.05 ind/TH,

and it was found at 22% of mist-netting sites (Table 3). Its abundance may be underestimated due to its ability to detect and avoid mist-nets. Captures include individuals of all sex and age groups, and the species both breeds and hibernates within the CEZ. In the PSRER, it is considered rare, likely due to challenges in detecting it acoustically and capturing it in mist-nets [Biodiversity... 2022].

***Barbastella barbastellus*.** This is an occasional species in the CEZ. In the past, it has been recorded near the village of Vilcha [Abelentsev *et al.* 1956]. The species was observed only twice recently: a female on 28 July 2010 (N51.398/E29.885) [Gashchak *et al.* 2013] and an immature male on 6 July 2018, in the town of Prypiat (N51.409/E30.062; Fig. 6*d*). Monitoring of bat ultrasonic vocalisations from May to August 2018 at three locations on the left bank of the Prypiat River did not detect *B. barbastellus* (unpubl. data). However, ultrasonic detections from the PSRER [Biodiversity... 2022] indicated its presence there, in spring and autumn in 2016–2019, and during the entire warm season in 2020–2021. Finally, one immature individual was caught in the same location (Babchin) in October 2021. This suggested that breeding might occur in the area. Two of these three captures occurred in urban settings (Prypiat, Babchin), and one in an old oak-hornbeam forest. The species was also acoustically detected in wet oak forests in the PSRER [Biodiversity... 2022].

Fig. 6. (*a*) *Myotis brandtii*, male, sad, 01.08.2011, E29.459, N51.358; (*b*) *M. mystacinus*, ♂ ad, 01.08.2009, E29.613, N51.472; (*c*) *M. dasycneme*, ♂ ad, 14.06.2007, E30.176, N51.375; (*d*) *Barbastella barbastellus*, ♂ sad, 06.07.2018, 30.062, 51.409; (*e*) *Nyctalus lasiopterus*, ♀ sad, 22.07.2013, E29.616, N51.395.

Рис. 6. (*a*) *Myotis brandtii*, самець, нестатевозрілий, 01.08.2011, E29.459, N51.358; (*b*) *M. mystacinus*, ♂ ad, 01.08.2009, E29.613, N51.472; (*c*) *M. dasycneme*, ♂ ad, 14.06.2007, E30.176, N51.375; (*d*) *Barbastella barbastellus*, ♂ sad, 06.07.2018, 30.062, 51.409; (*e*) *Nyctalus lasiopterus*, ♀ sad, 22.07.2013, E29.616, N51.395.

Table 3. Relative abundance and distribution of bats in the CEZ in 2001–2018 according to mist-net trappings
Таблиця 3. Відносна чисельність і поширення рукокрилих у ЗВ у 2001–2018 роках. За результатами відлову

Species	Number of cases 'location-date', where and when the species was caught	Percentage of succesful cases 'location-date', %	Total number of caught individuals	Relative abundance, ind/TH
Nyctalus noctula	85	46.2	1592	0.979
Pipistrellus nathusii	81	44.0	679	0.392
Pipistrellus pygmaeus	74	40.2	483	0.295
Nyctalus leisleri	66	35.9	424	0.242
Vespertilio murinus	45	24.5	181	0.115
Plecotus auritus	40	21.7	96	0.051
Eptesicus serotinus	24	13.0	88	0.045
Myotis daubentonii	15	8.2	57	0.029
Barbastella barbastellus	2	1.1	2	0.002
Myotis dasycneme	2	1.1	4	0.001
Pipistrellus lepidus	2	1.1	14	0.001
Myotis brandtii	1	0.5	1	0.001
Nyctalus lasiopterus	2	1.1	2	0.001
Myotis mistacinus	1	0.5	1	0.0004
All species total	138	77.2	3624	2.154

Notes: Calculations were based on the total results obtained during July–August of 2007 to 2018. Overall, there were 184 instances of 'location-date' mist-netting, with 46 cases where no bats were captured, though ultrasonic detections confirmed their presence at those sites. Average values were calculated, taking into account these null results.

***Nyctalus leisleri*.** The species' status is common [Gashchak *et al.* 2013]. The species comprises up to 11.7% of all bats caught in the CEZ, with a relative abundance of 0.24 ind/TH, recorded at 36% of surveyed locations (Table 3). It is represented by all sex and age groups, but the number of mature females exceeds nine times of that of mature males. The species breeds in the CEZ but leaves the region for the winter. It prefers old deciduous (oak-hornbeam) and mixed forests and is often captured near small forest ponds [Gashchak *et al.* 2013]. The species has similar status in the PSRER [Biodiversity... 2022].

***Nyctalus noctula*.** The species' status is abundant [Gashchak *et al.* 2013], constitutes 44% of all bats caught in the CEZ, with a relative abundance of 0.98 ind/TH and recordings from 46% of surveyed locations (Table 3). It includes all sex and age groups, with a mature female-to-male ratio of nearly 2 : 1. The species breeds in the CEZ and typically leaves for winter, although a few individuals are occasionally detected (acoustically) in winter. During summer, the species is recorded almost everywhere, especially in old deciduous and mixed forests near small water bodies [Gashchak *et al.* 2013]. Similar observations have been reported from the PSRER [Biodiversity... 2022].

***Nyctalus lasiopterus*.** This is an occasional species in the CEZ, recorded only twice, both times at the same location above the small Illia River in old oak-beam and mixed forest (N51.395/E29.616): an immature male on 30 July 2009, and an immature female on 22 July 2013 (Fig. 6e) [Gashchak *et al.* 2013]. Acoustic signals of this species were also detected from May to August 2018 at three locations (N51.447/E30.216, N51.333/E30.334, N51.283/E30.402) on the left bank of the Prypiat River (unpublished data). This species has not been recorded in the PSRER [Biodiversity... 2022], although a maternal colony was identified 150 km west in the Staryi Zhaden Reserve [Dombrovsky *et al.* 2017].

***Pipistrellus lepidus*.** This species is classified as rare within the CEZ. Nearly all captures (n=11) and findings of dead individuals occurred near the Chornobyl NPP and the town of Prypiat, some animals were observed within the power plant's technological premises during winter [Gashchak 2018]. Both adult females and males have been recorded, suggesting that breeding within the CEZ is possible. The species has not been recorded in the PSRER; however, an adult male was captured slightly to the north (Khoiniki) in June 2020 [Biodiversity... 2022].

***Pipistrellus nathusii*.** The species status within the CEZ is abundant [Gashchak *et al.* 2013], almost 19% of all bats captured, with a relative abundance of up to 0.39 ind/TH. It was mist-netted at 44% of sites (Table 3), showing a preference for forest habitats near water bodies but was also recorded across various locations. Both sex and age groups are represented, with a nearly 1 : 1 ratio of adult females to males. The species breeds in the CEZ but leaves the region in August until the next April–May [Gashchak *et al.* 2013]. It holds a similar status in the PSRER [Biodiversity... 2022].

***Pipistrellus pygmaeus*.** According to our studies in 2007–2018, this is the only representative of the sibling species *Pipistrellus pipistrellus* s.l. in the region. Species identification was confirmed through acoustic vocalisation analysis and morphological examination of captured individuals. Its status is common, constituting 13.3% of all bats captured, with a relative abundance of 0.30 ind/TH, and was recorded at 40% of locations (Table 3) [Gashchak *et al.* 2013]. The species inhabits a variety of habitats but is most frequently observed in forests. Mature females and juveniles were commonly recorded, while adult males were rarely observed. The species breeds in the CEZ and migrates out for the winter [Gashchak *et al.* 2013]. A similar pattern is observed in the PSRER [Dombrovskyi 2017; Biodiversity... 2022].

Vespertilio murinus. The species' status is non-abundant, representing 5.0% of all bats captured in the CEZ, with a relative abundance of 0.12 ind/TH and recorded at 24.5% of locations (Table 3). Most captures occurred in forests and human settlements. The sex ratio of adult females to males is 3.3 : 1. The species breeds in the CEZ, and it is likely that some individuals hibernate within the region [Gashchak *et al.* 2013]. It has also been recorded in the PSRER, where it is considered rare [Dombrovskyi 2017; Biodiversity... 2022].

***Eptesicus serotinus*.** The species' status is non-abundant in the CEZ, accounting for 2.4% of all bats captured, with a relative abundance of 0.05 ind/TH and recorded at 13% of locations (Table 3), primarily in and around human settlements [Gashchak *et al.* 2013]. The number of adult males exceeds that of females by a factor of 2.7. The species both breeds and hibernates in the CEZ. In the PSRER, it is also considered rare [Dombrovskyi 2017; Biodiversity... 2022].

Eptesicus nilssonii (Keyserling, Blasius, 1839) currently has phantom status in the CEZ.

It has not been recorded within the CEZ; however, it was detected during the migration season 55 km to the south on the left bank of the Kyiv Reservoir [Miropolskyi 2001]. Also, lactating females were captured 150 km to the west in the Stary Zhaden Zakaznik [Dombrovskyi *et al.* 2017]. Thus, the occurrence of this species within the CEZ is considered possible.

Order Caniformes, seu Carnivora

The regional fauna includes 15 species of this order, representing four families, with two species having phantom status.

Family Felidae Fischer, 1817

Felis silvestris Schreber, 1777 has phantom status in the CEZ.

The first observation of a cat resembling a wildcat was reported after a camera trap recorded a cat near the abandoned village of Rozhava in the PSRER in the summer of 2017 [Biodiversity... 2022]. Due to the low quality of this nighttime photo, it was not possible to confirm whether the animal was indeed *Felis silvestris*. However, given the proximity to the CEZ boundary (5–7 km north), in autumn 2017, we deployed camera traps at the closest Ukrainian location, Medin Les, along the state border (6 points in deciduous and mixed forests along the Prypiat River floodplain, approximately N59.48/E29.93). Additional traps were placed in floodplain habitats near the Chornobyl NPP (5 locations, approximately N51.41/E30.11). Each camera trap had a stick treated regularly with valerian solution in front of it. Throughout a year of monitoring, no cats were recorded at these sites, nor at other locations where camera traps were also active during the same period. Only in 2020, a camera trap recorded a cat in the village of Denisovichi (N51.484/E29.696), about 7 km west of where the 'wildcat' was recorded in 2017 in the PSRER. Our camera trap captured the cat twice, on 12 May and 7 August 2020, both times at night, and it was likely the same animal in both instances (Fig. 7). Its dimensions (body length from nose to tail base, tail length, and height at pelvis) were 60–62, 25–28, and 35–37 cm, respectively. The cat had a black, broad tail tip, approximately four rings, with no ring near the tail base. It also had outer stripes on the hind legs and an inner stripe on the front legs. The overall colouration was uniform, lacking distinctive spots or stripes. While these nocturnal images were of low quality, they did not provide reliable features to confirm the

identification as *Felis silvestris*. Denisovichi is an abandoned village, and the CEZ personnel visit this remote site infrequently, making it unlikely that a domestic cat would have arrived from the Ukrainian side. However, the neighbouring PSRER territory has a more regular human activity, so the cat(s) photographed in 2017 and 2020 could potentially be feral domestic cat(s) originating from Belarus. However, it remains plausible that the recorded animal could indeed be a true *Felis silvestris*. A recent review of available data on wildcat sightings in Ukraine [Zagorodniuk *et al.* 2014] shows that the species expanded its range significantly northward and eastward in the 2000s, with recent records reported even from western Polissia and the Dnieper River area. If this expansion continues, *Felis silvestris* could plausibly appear in the CEZ (Kyiv Polissia), though the nearest confirmed locations are still hundreds of kilometres away. The cat recorded in Denisovichi was somewhat smaller than wildcats documented in the eastern part of the species' range but closer in size to wildcats from the Carpathian region and Central Europe [Zagorodniuk *et al.* 2014]. In terms of possible wildcat presence in the CEZ, it is noteworthy that between 2012 and 2022 camera traps were placed at 500–700 points within the CEZ, with a total exposure of tens of thousands of trap-days. These traps captured numerous animals, including very rare species represented by only a few individuals (e.g. bear, bison). *Felis* sp. was recorded only a few times, with the Denisovichi cat as the only animal resembling a 'wildcat'.

***Felis catus*.** The species' current status is non-abundant. Following the evacuation of all residents in 1986, domestic cats disappeared from most locations despite their ability to survive without human support. In recent years, they have persisted only in some villages in the southern and western sectors of the CEZ, where people still reside, especially in Chornobyl town. Feral cats also inhabit certain industrial areas, with some individuals occasionally moving several kilometers from these locations. The population of *F. catus* in the CEZ is unknown. In the PSRER, feral cats are likewise found primarily in areas with human presence [Biodiversity... 2022].

***Lynx lynx*.** The species' status is non-abundant. As a result of persecution, this autochthonous species had nearly vanished in the region by the mid-20th century, and reappeared only in the 1990s, after the Chornobyl accident. Its population gradually grew, and in 2013–2018 was estimated at 53–68 ind. of various ages and sexes [Gashchak *et al.* 2022]. The ratio of mature females to males was 1 : 2.7, and yearlings comprised about 22% of the population. Density was recorded at 2.2–2.7 ind/100 km². The average frequency of camera trap records ranged from 0.3–0.9 ind/100 TD in meadows to 1–5 ind/100 TD in forests (Fig. 8a, Table 4).

Lynxes inhabit the entire CEZ and occasionally approach areas where people work and stay. The species prefers habitats with fertile, moist soils and dense tree cover [Gashchak *et al.* 2022]. Similar trends of recovery have been observed in the PSRER, where the species is also not numerous (at least 34–39 ind), inhabiting the entire region [Biodiversity... 2022], the frequency of camera trap records was estimated at 2.9 ind/100 TD [Dombrovskyi *et al.* 2018].

Fig. 7. A cat recorded by camera trap on 7 August 2020 near the village of Denisovichi. An image of the measuring pole (with marks at every 20 cm), at the same position, was laid over the cat image using graphic software.

Рис. 7. Кіт знятий фотопасткою 7.08.2020 біля с. Денисовичі. Зображення калібрувальної жердини (з мітками кожні 20 см), у тій самій позиції, накладене на зображення кота за допомогою графічного редактору.

Family Canidae Fischer, 1817

***Nyctereutes procyonoides*.** This is a common non-native species, introduced in the neighbouring districts of Homel and Kyiv oblasts in 1936–1941, and quickly dispersed including the area of present CEZ, which was considered favourable for the species [Pavlov *et al.* 1974; Litus 1986]. Detailed population assessments have not been carried out in the CEZ, but camera trap data show record frequencies of 2–11 ind/100 TD, sometimes even higher (Fig. 8b, Table 4). The species occurs throughout the region, preferring moist habitats with dense vegetation, especially near water bodies. In the PSRER, relative abundance was estimated at 1.3–1.8 ind/1000 ha (1996–2006) [Biodiversity... 2022], while camera traps recorded 8.1 ind/100 TD [Dombrovskyi *et al.* 2018].

***Canis familiaris*.** The species' status is non-abundant. Similar to the domestic cat, the dog disappeared from most of the region following the relocation of the human population in 1986. In recent decades, semi-feral dogs have been found only near human settlements and industrial areas, occasionally roaming a few kilometers beyond. Exact population data are not available, though it is believed that there were over 800 individuals at their peak, primarily in two groups near the Chornobyl NPP and Chornobyl town, some of which were sterilised to limit growth [Spatola *et al.* 2023].

Canis lupus. The species' status is non-abundant, but the wolf remains the most numerous and important large predator in the region (if to admit the negligible wildlife role of domestic dog that is more abundant). It is an autochtonous species. This part of the Polissia has always had a relatively high wolf density (>0.1 ind/1000 ha in the past), and is considered a refugium for the species [Wolf 1985]. Wolves are present throughout the area and occasionally enter human-occupied sites. Recent camera trap records vary from 1.7 to 26.7 ind/100 TD (Fig. 8c, Table 4).

After 1986, the wolf population increased significantly, leading to periodic control measures in the 1990s–2000s, which have mostly ceased over the last decade. In the 2000s, at least six reproductive packs and up to 40 ind (around 0.15 ind/1000 ha) were estimated [Shkvyria & Vishnevsky 2012]. In the same period, in the PSRER, where systematic and large-scale surveys were conducted every year, wolf densities were reported as 0.4–1.5 ind/1000 ha [Kuchmel 2008], suggesting potentially higher numbers in the CEZ as well. The survey of wolves in the PSRER varied in methodology, and periodic hunting influenced the population estimates. Therefore, estimates ranged at 14–15 packs and 90–300 individuals in the 2000s [Kuchmel 2008; Biodiversity... 2022]. After some animals were marked with satellite transmitters in 2016–2017, researchers investigated the home range and territorial behaviour of two packs. This analysis suggested a wolf density closer to 0.4–0.5 ind/1000 ha, with a total estimated population size of 80–100 individuals [Dombrovskyi *et al.* 2017]. Thus, taking into account the comparable size of the CEZ and PSRER territories, a similar magnitude of the wolf population can be expected in the CEZ as well (i.e., 104–130 individuals or 13–19 packs).

***Canis aureus*.** The species' status is occasional. Despite its spread across Ukraine since the late 1990s, with sightings even further north in Europe [Zagorodniuk 2014], it has only recently appeared in this region. Extensive use of camera traps in the CEZ since 2012 yielded no evidence of jackals. However, only 50 km west of the CEZ, a jackal was first recorded in 2014 [Zhyla 2023]. Later, jackal-like tracks were seen in the CEZ near the village of Zalissia [Zhyla 2023]. The first verified sighting in the CEZ occurred on 8 March 2024, when a camera trap captured an image of a *Canis aureus* near the village of Bovische (pers. comm. A. Simon[2]). So far, the species has not been recorded in the PSRER.

***Vulpes vulpes*.** The species' status is non-abundant, autochtonous. Information on population size and long-term trends is limited, with only general estimates available [Gaichenko *et al.* 1994]. Following an increase in small rodents in 1987–1989, the fox population grew significantly, with reproductive dens reaching 2–3 per 1000 ha. Soon, the species population experienced depression, and stabilised only by the mid-1990s, though exact population estimates are lacking. Camera trap records from 2013–2021 showed a frequency of 0.2–3.6 ind/100 TD (Table 4). Foxes are found in

[2] Source link: https://www.facebook.com/share/p/s3pDVcFRBahLj1zL/

various habitats but prefer semi-open areas like sparse woodlands, meadows, and abandoned settlements. In the PSRER, the fox population dropped from 10–12 ind/1000 ha in 1986 to 1.7 ind/1000 ha in 2007 [Kuchmel 2008], and their numbers have remained low in recent years [Biodiversity... 2022]. PSRER camera traps recorded a frequency of 4 ind/100 TD [Dombrovskyi *et al.* 2018].

Fig 8. Carnivorans of the CEZ: (*a*) *Lynx lynx*; (*b*) *Nyctereutes procyonoides*; (*c*) *Canis lupus*; (*d*) *Ursus arctos*; (*e*) *Meles meles*; (*f*) *Lutra lutra*.

Рис. 8. Хижі ссавці ЗВ: (*a*) *Lynx lynx*; (*b*) *Nyctereutes procyonoides*; (*c*) *Canis lupus*; (*d*) *Ursus arctos*; (*e*) *Meles meles*; (*f*) *Lutra lutra*.

Table 4. Relative abundance of medium- and large-sized mammals at study sites in the CEZ in 2013–2021 on the camera-trap records, ind/100 TD (standard deviations are shown in parentheses)

Таблиця 4. Відносна рясність ссавців середнього і великого розміру на дослідних ділянках ЗВ у 2013–2021 р. за результатами роботи фотопасток, ос./100 ПД (в дужках — стандартне відхилення)

Species	Study sites (starting year of the study) (see: Fig. 1). Number of trap-months (n)							
	S1 (2013) n = 64	S2 (2014) n = 51	S3 (2016) n = 165	S4 (2017) n = 87	S5 (2018) n = 122	S6 (2018) n = 153	S7 (2020) n = 188	S8 (2021) n = 55
Cervus elaphus	24.8 ± 27.1	16.9 ± 26.8	14.8 ± 27.6	44.2 ± 65.1	3.2 ± 8.2	123.0±187.1	14.1 ± 25.1	28.4 ± 41.2
Equus ferus	6.58 ± 26.0	1.9 ± 7.3	6.24 ± 22.5	0.64 ± 4.24	–	140.1±280.0	2.16 ± 8.2	14.8 ± 30.1
Alces alces	16.5 ± 18.1	9.6 ± 10.8	11.8 ± 14.9	13.3 ± 18.6	18.5 ± 28.7	3.57 ± 7.72	28.8 ± 39.2	58.8 ± 93.1
Sus scrofa	30.3 ± 46.4	27.6 ± 53.7	1.99 ± 6.67	15.4 ± 39.3	16.2 ± 41.7	2.34 ± 8.87	7.0 ± 27.7	1.3 ± 4.8
Lepus europaeus	18.0 ± 109.4	4.4 ± 17.1	17.2 ± 35.6	0.4 ± 1.5	0.2 ± 1.0	30.5 ± 68.3	2.5 ± 7.6	2.0 ± 7.4
Nyctereutes procyonoides	66.9 ± 107.4	10.8 ± 21.7	7.74 ± 25.6	4.0 ± 9.8	3.5 ± 8.4	2.80 ± 9.51	2.4 ± 6.3	11.1 ± 18.3
Capreolus capreolus	8.32 ± 11.1	3.8 ± 9.4	8.8 ± 13.2	6.8 ± 12.5	4.6 ± 7.9	3.21 ± 11.5	11.7 ± 24.1	17.5 ± 21.6
Canis lupus	10.0 ± 32.0	26.7 ± 90.7	10.0 ± 17.2	3.7 ± 7.0	1.7 ± 5.7	7.03 ± 13.5	9.7 ± 24.8	12.9 ± 26.4
Meles meles	14.0 ± 24.9	7.5 ± 13.2	5.8 ± 12.0	0.9 ± 3.3	0.9 ± 2.5	2.08 ± 8.3	2.9 ± 7.2	9.5 ± 20.4
Vulpes vulpes	0.7 ± 2.7	3.6 ± 9.7	2.3 ± 8.2	0.8 ± 2.3	0.2 ± 0.9	3.6 ± 8.3	1.4 ± 4.0	3.1 ± 4.7
Lynx lynx	4.9 ± 8.0	0.9 ± 2.5	0.8 ± 4.8	0.4 ± 1.1	0.9 ± 3.1	0.5 ± 1.8	1.1 ± 3.2	1.1 ± 2.8
*Sciurus vulgaris**	0.3 ± 1.1	2.2 ± 8.7	1.6 ± 8.9	–	1.4 ± 4.0	–	0.2 ± 1.2	1.7 ± 9.8
Martes sp.*	1.1 ± 2.9	0.2 ± 1.0	0.5 ± 1.6	1.2 ± 4.6	1.0 ± 3.5	0.13 ± 0.9	0.2 ± 1.1	2.0 ± 3.8
*Lutra lutra**	5.2 ± 17.0	0.3 ± 1.8	0.02 ± 0.3	0.2 ± 1.4	0.2 ± 1.4	–	0.02 ± 0.3	0.4 ± 2.6
*Ursus arctos**	–	0.1 ± 0.5	0.2 ± 1.1	0.1 ± 0.5	0.1 ± 0.6	0.02 ± 0.36	0.1 ± 1.2	0.2 ± 0.8
Castor fiber *	+	+	–	+	–	+	+	+
*Bison bonasus**	–	–	+	–	–	–	+	–
*Mustelidae**	+	+	+	+	+	–	–	–
*Erinaceus roumanicus**	–	–	–	–	–	+	–	–
*Equus caballus**	–	–	–	–	–	+	–	–
*Felis catus**	–	–	–	–	–	+	+	–
*Canis familiaris**	+	–	–	–	–	+	–	–

Notes: The camera trap records represent individual frequencies per 100 trap-days (ind./100 TD), either as monthly averages or for the full period of trap operation (10–12 months). 'Trap-month' denotes a calendar month (28–31 days) during which the camera trap was active; the exact number of 'trap-days' (TD) in each trap-month varies based on when the camera was set up or stopped. An asterisk (*) indicates species considered incidental within this study due to factors like small body size, arboreal or aquatic lifestyle, or low population. Single records are marked as '+'. Camera traps occasionally captured images of bats and mice/voles, which were excluded from this table.

Family Ursidae Fischer, 1817

Ursus arctos. The current status of the species is rare. Bears were once common but disappeared by the 19th century due to human persecution and deforestation [Sokur 1961]. Evidence of their return was first noted in the 1990s, and up to four individuals were recorded in the neighbouring PSRER in the 2000s, and a female with cubs was observed there in 2007 [Deriabina 2008]. Evidence from the CEZ has been limited to unconfirmed reports, occasional footprints, and scratches on trees [Gashchak *et al.* 2006; Shkvyria & Vishnevsky 2012]. The first bear capture by a camera trap occurred in the village of Tovstyi Lis in October 2014, and by the end of 2016, there had already been 17 photo-records [Gashchak *et al.* 2016]. Later, up to 10 photo-records and visual observations occured across the territory annually (Fig. 8d).

The bears are most frequently recorded in productive wet forests or nearby meadows with rich grass cover. Despite these regular sightings, the total population size, sex and age structure, and reproduction remain unknown as of 2023. A similar situation exists in the PSRER, where the bear population is believed to be stable without growth [Biodiversity... 2022].

Family Mustelidae Fischer, 1817

Mustela erminea Linnaeus, 1758 is currently considered a phantom species.

In the entire observation period (1986–2023), there has been no confirmed sightings or reliable reports. Nevertheless, this species is regarded as present in the region according to the Red Data List [Volokh 2009]. In the neighbouring PSRER, the ermine was considered to be common, with an estimated abundance of up to 10 ind/1000 ha in wet meadows during the 1990s [Sydorovych 1995]. Later, this abundance had declined to 0.5–0.9 ind/1000 ha by the mid-2000s [Kuchmel 2008]. The species is thought to prefer wet habitats with tall grasses [Kuchmel 2008; Volokh 2009].

Mustela nivalis. The species is non-abundant. It has been recorded visually and through small mammal traps. It is found almost everywhere but prefers meadows and young reforested areas. Data on population size and long-term trends are absent. In the PSRER, the species was estimated at 20 ind/1000 ha in the 1990s [Sydorovych 1995], and it has remained common in the last decade [Biodiversity... 2022].

Mustela putorius. In the mid-20th century this species was common in the Polissia, though already in 1960s a decrease of its population was noted [Abelentsev 1968]. Currently, this species is occasional in the CEZ. During the entire observation period, there have been only two reliable records: 1) by camera trap on 4 October 2002 at N51.409/E29.883 and 2) visually on 1 August 2012 at N51.222/E30.012. In both cases, sightings occurred in old deciduous or mixed forests. The relative population density of polecats in the PSRER was estimated at 10 ind/1000 ha in the 1990s, although it had declined to 0.2 ind/1000 ha by 2005 [Kuchmel 2008].

***Neogale vison*.** The species' status is non-abundant. It is an introduced species that arrived in the region in the 1950s, likely due to the dispersal of animals that escaped from fur farms [Panov 2002]. In the CEZ, the American mink is found in nearly all water bodies and has been recorded in various ways, but abundance data remain unavailable. The species is common in the PSRER, although its numbers fluctuate annually from 0.5–1 to 4–10 ind/10 km of stream [Sydorovych 1995; Biodiversity... 2022].

***Martes martes*.** The species is non-abundant. It has been recorded by different methods, though population data are absent. Camera trap footage typically does not distinguish between *Martes martes* and *Martes foina*, both of which inhabit the region; thus, they are considered together (Table 4). The species is present throughout the territory, mainly in wooded areas and abandoned settlements. In the PSRER, the population of *Martes martes* decreased from 0.4–1.9 ind/1000 ha in the 1990s to 0.6–0.9 ind/1000 ha in 2005–2007 [Voronetskyi *et al.* 1999; Kuchmel 2008] and has remained relatively low in the last decade [Biodiversity... 2022].

***Martes foina*.** This species is also non-abundant and precise or relative population data are absent. It is more frequently observed near settlements or industrial areas. In the PSRER, its population density was estimated at 15–20 ind/1000 ha in the 1990s, declining to 2.3–4.3 ind/1000 ha in 2005–2007, likely due to reforestation [Sydorovych 1995; Kuchmel 2008; Biodiversity... 2022].

***Meles meles*.** The badger's status in the CEZ is non-abudant. Camera trap records vary from 0.9 to 14.0 ind/100 TD (Fig. 8e, Table 4). There are no other assessments available. Badgers have been recorded across various habitats in the CEZ, including settlements. In the PSRER, population density ranged from 0.14–0.60 ind/1000 ha in the 1990s–2000s [Deriabina 2008] and about 0.4 ind/1000 ha in 2020–2021 [Biodiversity... 2022], with camera trap records (2016–2018) of 2.7 ind/100 TD [Dombrovskyi *et al.* 2018]. It is believed that despite the absence of human pressure, the badger population remains relatively low due to unfavourable natural conditions (high groundwater levels and light soil) [Deriabina 2008].

***Lutra lutra*.** The species' status is non-abudant; it has been recorded in most water bodies of the region (Fig. 8f). A 2018 survey estimated its population at 72–153 individuals, or up to 3.8 ind/10 km along large rivers (Prypiat, Uzh) and around 1.0 ind/10 km along channels and small streams [Skorobagatov *et al.* 2019]. In the PSRER, the otter was common, reaching 450–500 individuals or 2–5 ind/10 km of stream in 2005–2006 [Kuchmel 2008]. By 2010, the population had declined to 0.5 ind/10 km, reflecting a general decrease in otter populations nationwide [Biodiversity... 2022].

Fig 9. Przewalski's horse (tarpan) *Equus ferus*, introduced in 1998–2004 in the CEZ.
Рис. 9. Кінь Пржевальського *Equus ferus*, інтродукований у 1998–2004 роках у ЗВ.

Order Equiformes, seu Perissodactyla

This order is presented by only one family and one species in the regional fauna.

Family Equidae Gray, 1821

***Equus ferus*.** The current status of this species is non-abudant. This is an introduced species, brought to the region in 1998–2004 (Fig. 9), with a total of 44 individuals released into the CEZ; 23 survived, of which only 17 became founders of the current herd [Zharkykh & Yasynetskaia 2008]. By 2018, the population had grown to at least 137 individuals, organised in 12 harem herds and some smaller groups; some individuals showed signs of past hybridisation with domestic horses. In 2018, one domestic mare joined a harem herd and participated in reproduction [Gashchak & Paskevich 2019]. Since the domestic horse (*E. caballus*) is not currently considered part of Ukraine's fauna [Zagorodniuk & Emelyanov 2012], it is also excluded from the list of species in the CEZ. The growth rate of the *Equus ferus* population slowed in 2008–2018 compared to the previous period, which was explained by changes in the age structure of mares [Gashchak & Paskevich 2019].

Between 2007 and 2010, some horses migrated to the PSRER, establishing a local herd; later, a few individuals crossed the Prypiat River [Deriabina 2013] and began appearing in the Ukrainian left-bank part of the CEZ. Since 2018, they have been regularly recorded near the villages of Usov, Krasno, and Mashevo. As of 2019, the horse population in the PSRER numbered approximately 50 individuals in five harem herds, along with some smaller groups [Biodiversity... 2022].

Thus, the total population of *Equus ferus* in 2018–2019 reached 180–190 individuals, most of which reside within the CEZ. The horses predominantly inhabit meadow areas, though they do not avoid long stays in large forested areas. In summer 2020, we observed a harem herd deep within a large deciduous and mixed forest in the northwest part of the CEZ. The horses often enter abandoned human structures, especially farms, using them as shelters (particularly in spring and summer) or seeking mineral supplements [Paskevych 2021].

Order Cerviformes, seu Artiodactyla

In the CEZ, this order comprises three families and six species.

Family Suidae Gray, 1821

Sus scrofa. This species is currently non-abundant, though its numbers have fluctuated widely since 1986. Population estimates have primarily relied on selective assessments [Legeida & Panov 1993; Vyshnevskyi & Kotliarov 2008] or relative estimates [Gashchak 2008], with no high-quality surveys conducted. In the early 2000s, the CEZ was home to up to 2500 wild boars [Gashchak *et al.* 2006] making them the most frequently recorded species on camera traps (21.6%) [Gashchak 2008]. However, in 2013–2021, the frequency of camera trap records varied from 30 ind/100 TD in 2013–2014 to 1.1 ind/100 TD in 2021 (Fig. 10a, Table 4). In 2017–2018, near the villages of Benivka and Rechitsa, camera traps captured a few individuals showing hybrid traits (large spots of different colours) from domestic pigs. The species is found throughout the CEZ, including areas with human presence. Seasonal territorial redistribution depends on food availability in the habitats. In the PSRER, the wild boar population was monitored almost annually. In the early 1990s, numbers peaked at up to 36 ind/1000 ha. From then until 2014, the population varied within 10–20 ind/1000 ha. The numbers were artificially reduced after 2014 as a preventive measure against African swine fever, bringing the population down to 5 ind/1000 ha; by 2020–2022, wild boars were the rarest of the ungulate species [Kuchmel 2008; Biodiversity... 2022]. In 2016–2018, the PSRER camera trap frequency was 3.3 ind/100 TD [Dombrovskyi *et al.* 2018].

Family Cervidae Goldfuss, 1820

***Cervus elaphus*.** This species is currently classified as abundant. This autochthonous species was once common, and had nearly vanished by the 20th century [Kirikov 1960]. In 1986, red deer existed only in small herds on some game farms [Boiarchuk *et al.* 1990]. Following human evacuation, the species gradually spread throughout the area and increased in number significantly [Gashchak *et al.* 2006]. Camera trap recordings from the last decade vary widely (3–80 ind/100 TD), depending on conditions at the study sites (Fig. 10b, Table 4). The total CEZ population in January 2021 was estimated at 3400 individuals, nearly twice the number of other ungulate species combined [Zhyla 2022]. Red deer are widespread and regularly move between resting, grazing, and watering areas. Seasonal shifts occur based on food availability, and they frequently enter abandoned farms searching for mineral supplements. It is believed that red deer in the PSRER migrated from the Ukrainian CEZ in the 1990s. They are now the most numerous ungulates in the PSRER, with densities reaching 5.6–9.3 ind/1000 ha (2018–2020) [Biodiversity... 2022].

***Capreolus capreolus*.** This common autochthonous species was one of the most abundant ungulates in the 1990s–2000s, though population assessments were rarely conducted [Gashchak *et al.* 2006]. Over time, however, roe deer populations appear to have declined, possibly due to competition with the growing *Cervus elaphus* population [Zhyla 2021a]. In the early 1990s, roe deer densities reached up to 25 ind/1000 ha [Boiarchuk *et al.* 1990]; by 2020–2021, densities had dropped to just 4 ind/1000 ha, with a total population of around 1000 individuals [Zhyla 2021a]. The species inhabits a variety of locations, including areas with human presence, and favours forest habitats with high trophic capacity. In 2013–2021, camera trap records ranged from 3.8–18 ind/100 TD (Fig. 10c, Table 4). In the PSRER, a similar trend was observed. Roe deer densities reached 8.2 ind/1000 ha in 2005 [Kuchmel 2008] but had declined almost eightfold by 2015. As in the CEZ, the roe deer population has recently increased again [Biodiversity... 2022]. In 2016–2018, PSRER camera traps recorded 4.8 ind/100 TD [Dombrovskyi *et al.* 2018].

***Alces alces*.** Currently classified as common in the CEZ. This autochthonous species was estimated at 7 ind/1000 ha in the late 1980s [Boiarchuk *et al.* 1990], though no comprehensive elk surveys have been conducted since. Indirect assessments suggested that elk populations could have reached up to 1500 individuals by the early 2000s [Gashchak *et al.* 2006]. By 2020–2021, the population was estimated at 900 individuals (or 3–3.5 ind/1000 ha), with higher densities in the northeastern CEZ, on the left bank of the Prypiat River [Zhyla 2023].

Camera trap records from 2014–2021 varied between 5.5 and 59 ind/100 TD (Fig. 10d, Table 4). Elk are found in most habitats but prefer wetter environments and exhibit seasonal movements to richer feeding areas. In the PSRER, the elk population tripled between 1986 and 1996 [Kuchmel 2008] and grew 5.4 times by 2018, with annual density variations from 6–10 ind/1000 ha in the last decade [Kuchmel 2008; Biodiversity... 2022].

Fig 10. Even-toed ungulates of CEZ: (*a*) *Sus scrofa*, (*b*) *Cervus elaphus*, (*c*) *Capreolus capreolus*, (*d*) *Alces alces*, (*e*) *Bos taurus*, (*f*) *Bison bonasus*.

Рис. 10. Оленеподібні ЗВ: (*a*) *Sus scrofa*, (*b*) *Cervus elaphus*, (*c*) *Capreolus capreolus*, (*d*) *Alces alces*, (*e*) *Bos taurus*, (*f*) *Bison bonasus*.

Family Bovidae Gray, 1821

Bos taurus. After the Chornobyl NPP accident, all cattle in the region were either evacuated with the local population or culled. A small number of surviving cattle were kept in a few private farms under human care. Inclusion of cattle in the regional fauna list became relevant only in the 2010s, when a small herd of black-and-white cattle in the village of Lubianka became completely feral following the death of their owners. These animals now live without any human support or care. According to unconfirmed reports, there were initially 'up to 30 individuals', though in 2012–2013, we observed no more than seven animals, including calves. In 2019, the herd included 13–14 individuals; by October 2020, the herd had increased to 18 animals, comprising two adult bulls (Fig. 10e), 11 adult cows, three immature females, and two calves born that year; in 2021, 19 animals were recorded [Zhyla 2021b; Nature… 2021]. Throughout these years, the herd remained a single group, showing good health with an annual birth rate of 2–4 calves. They have displayed signs of restored defensive behaviour toward predators and humans and early signs of splitting into separate groups [Zhyla 2021b]. The limited growth of the herd suggests possible issues with reproduction, potentially due to a predominance of a single old bull, embryonic mortality, or low juvenile survival rates. The herd mainly roams meadows and sparse young woodlands within a 4 km radius around the village of Lubianka, occasionally seeking refuge in older forests and frequently resting in abandoned farm structures [Zhyla 2021b; Nature… 2021]. The cattle survived the 2020 wildfire (which partially burned the village and surrounding forest) and the temporary Russian invasion in 2022, and observations continued into 2024. The current status of this species is considered rare.

Bison bonasus. This species is rare in the region. Historically common, the bison had disappeared from the area by the 18th century [Kirikov 1979a–b]. Evidence of its presence resurfaced in spring 2012 in woodlands north of the village of Lubianka, with a bull captured on camera trap in spring 2015. By 2016, there were 19 records across seven locations [Gashchak *et al.* 2017]. The most probable source of these bison is located 30 km north, across the Prypiat River in the PSRER, where European bison were introduced in 1996 [Deriabina 2008, 2012]. During repeat studies in 2020 in the same district, six additional sightings were documented, all between October and December at a single location (N51.418/E29.686) (Fig. 10f). Each observation recorded an adult male, though it is unknown if it was the same or different individuals.

To date, there have been no confirmed records of the species on the Ukrainian left bank of the Prypiat River, although this area is likely the most suitable habitat for potential future migrations from the PSRER. The military activity after February 2022 has limited wildlife monitoring in the frontier zone with Belarus, leaving the fate of the observed bison and any potential new arrivals uncertain. Since 1996, the total bison population in the PSRER has grown by 11.5 times to 184 individuals (5.8 indi/1000 ha), and they are now spread throughout the reserve's left bank [Biodiversity... 2022]. The preferred habitats by this species in both the CEZ and the PSRER are wet woodlands dominated by deciduous trees (oak, hornbeam, aspen) or nearby meadows.

Species with unlikely presence

Several species (actually 9) are occasionally suggested as potentially present in the region, though their current ranges are distant from the CEZ. These species are considered improbable for the area based on historical records and present distribution:

Pteromys volans (L., 1758). There are no historical or recent records of this species in the region. The only mention of flying squirrels in Ukraine was recorded in the northern part of present-day Sumy Oblast in the 18th century [Bagaliy 1887, on: Sokur 1961]. Historical limits of the range were approximately 100 km northeast of the current CEZ [Zagorodniuk 2022]. The closest confirmed habitats for the species are now 300 km northeast [Sitnikova 2004, on: Zagorodniuk 2022] and 450 km north [Abramchuk 2021]. In theory, such distance does not seem too large for the flying squirrel. It is more important how the local habitats correspond to the species demands. The CEZ has several mature deciduous and mixed forests with old aspen stands, which are attractive to this species [Abramchuk 2021].

Sylvaemus uralensis (Pallas, 1811). Some publications (e.g., [Panteleev 1998]) suggest that this species' natural range includes the area of the present CEZ. Additionally, two specimens labeled *Sylvaemus uralensis* (catalogue No. 1432, 1433) were obtained in 1925 near the village of Poliske (western CEZ) and are stored in the Zoological Museum of the National Museum of Natural History in Kyiv [Shevchenko & Zolotukhina 2002]. However, these specimens require further verification, as other specimens from this collection came from more distant locations. No records of the species have been reported from the CEZ or nearby areas in recent decades, consistent with current species distribution maps that place the CEZ outside of the species' range [Zagorodniuk 2005, 2020].

Cricetus cricetus (Linnaeus, 1758). The CEZ region is sometimes considered part of this species' range [Emelyanov *et al.* 1987]. In the past, the European hamster was documented in nearby areas, including the districts of Kyiv, Chernihiv (S. V. Kirikov, 1934, as cited in [Tymofeev-Resovskyi *et al.* 1973]), and even in the Homel region (A. V. Fediushin, 1930, as cited in [Kirikov 1960]). In each case, the hamsters were found in areas with alfisols, which are nearly absent in the CEZ. Presently, *Cricetus cricetus* is observed more southward in the forest-steppe zone, where soils are heavier, though the species remains rare in these areas as well [Mezhzherin 2009].

Crocidura leucodon (Hermann, 1780). Over the past sixty years, there have been no reports of this species in the CEZ or surrounding areas. Historically, it was considered common in the Polissia and noted south of the Teteriv River (Kyiv Oblast) and westward near Ovruch (Zhytomyr Oblast) [Abelentsev *et al.* 1956].

Neomys anomalus Cabrera, 1907. There have been no reports of this species in the CEZ or neighboruing regions in the past fifty years. Historically, it was rare and primarily recorded in the forest-steppe zone [Mishta 2009], with the nearest sightings in Zhytomyr Oblast, near the western boundary of the present CEZ [Abelentsev *et al.* 1956].

Plecotus austriacus (Fischer, 1829). To date, there is no information about this species in the CEZ or surrounding areas, despite the eastward and northward range expansion in Ukraine from 2000 to 2020 [Zagorodniuk 2019]. It is currently found only farther south in the forest-steppe zone.

Pipistrellus pipistrellus (Schreber, 1774). At the beginning of bat studies in the CEZ, this species was considered common and perhaps even numerous [Gashchak *et al.* 2006]. However, the species' identification was later questioned. In 2007–2018, in annual chiropterological studies using both ultrasonic detectors and morphological investigation of mist-netted bats, no *P. pipistrellus* were recorded [Gashchak *et al.* 2009, 2013; Gashchak 2018]. A recent review of all available data on *P. pipistrellus* s.l. in Ukraine [Zagorodniuk 2018, 2019] suggests that *P. pipistrellus* mainly inhabits the western, southern, and possibly eastern regions, while only *P. pygmaeus* was recorded in the Polissia. Identification by vocalisation of *P. pipistrellus* (40–45 kHz) is deemed unreliable, as it can match frequencies of *P. lepidus* and *P. nathusii*, which are confirmed in the CEZ. This species was initially included in the fauna of the PSRER also [Dombrovskyi 2017] but was later removed due to unreliability of vocalisation-based identification [Biodiversity... 2022].

Procyon lotor Linnaeus, 1758. Attemts to introduce this North American species in the Polissia took place in 1954–1958 in Homel Oblast of Belarus, followed by population growth and spread in the Prypiat River basin [Pavlov *et al.* 1973]. Moreover, in the adjoining (to the current CEZ) Narovliansky Raion of Homel Oblast the species was recorded in 1965 [Savitsky *et al.* 2005]. However, the raccoon had almost vanished already by the 1970s, and by the end of 20th century became a phantom species [Savitsky *et al.* 2005]. In Ukraine, the species has only been observed as single escapees [Nikolaichuk & Zagorodniuk 2019]. According to the last review, all claims of this species in the CEZ and nearby PSRER were unconfirmed, often incorrect or fabricated. None of the hundreds of camera traps in the area over the last decade has recorded this species.

Mustela lutreola (Linnaeus, 1761). This species has not been recorded in the region since 1986. The last capture was in 1978 near the Yakovetske forestry (N51.395/E29.634), and the last observation occurred in 1984 near the Poliske settlement [Panov 2002]. The extinction of this species in the region aligns with the decline of its range, and current surviving populations are far from the CEZ [Volokh & Rozhenko 2009].

Discussion

Thus, compared to the initial summary [Gashchak *et al.* 2006], the list of mammal species has significantly increased, from 49 to 61 species (Fig. 11). This expansion is primarily due to studies on bats, which added nine new species. However, the status of one previously listed species, *Pipistrellus pipistrellus,* was revised after it was determined to have been misidentified and is not present in the region; as a result, it was excluded from the fauna list. Importantly, the addition of these bat species is not due to their recent colonisation of the region but rather the initiation of targeted studies beginning in 2007. These species likely inhabited the area before these investigations. Additionally, the domestic *Felis catus* and *Canis familiaris* have been included in the checklist due to the presence of feral or semi-feral populations near Chornobyl town, the Chornobyl NPP, and other locations within the CEZ.

Three species genuinely appeared in the region after the previous review in 2006: 1) *Canis aureus* (spread into the region as part of its ongoing range expansion in Europe from the south); 2) *Bison bonasus* (came to the area naturally from Belarus, where it had been reintroduced in 1996); and 3) *Bos taurus*, a feral herd that has been living and reproducing independently for over 10 years in the vicinity of its former domestic range. Formally, this species shifted its status from 'domestic in culture' to 'feral domestic' (AS1c) [Zagorodniuk 2023]).

In the future, this checklist may be further expanded by up to nine currently phantom species (*Lepus timidus*, *Glis glis*, *Rattus rattus*, *Arvicola amphibius*, *Sorex caecutiens*, *Myotis nattereri*, *Eptesicus nilssonii*, *Felis silvestris*, and *Mustela erminea*). These species either have been recorded in neighbouring territories (e.g., the PSRER) or are likely to visit the region during seasonal migrations.

Most of the recorded species (83.6%) are autochthonous. Some of these species previously experienced range reductions or population declines but have recovered recently, particularly after the Chornobyl NPP accident, which effectively established a de facto protected regime in the affected lands. This recovery is evident in game species such as *Lynx lynx, Canis lupus*, *Ursus arctos*, *Lutra lutra*, *Sus scrofa*, *Cervus elaphus*, and *Alces alces*.

The recovery of some species, such as *Castor fiber* in the 1950s and *Bison bonasus* in the 1990s, was facilitated by reintroduction programmes.

The following nine non-native species have been identified in the CEZ (non-native status of each species after [Zagorodniuk 2023]):

Rattus norvegicus (expanded during the 19th century);
Ondatra zibethicus (introduced in the mid-20th century);
Pipistrellus lepidus (expanded from the south over the last 40 years);
Pipistrellus pygmaeus (expanded in the early 20th century);
Eptesicus serotinus (expanded in the mid-20th century);
Nyctereutes procyonoides (introduced in the mid-20th century);
Canis aureus (expanded from the south over the last 30 years);
Neogale vison (introduced deliberately via escapes from fur farms in the mid-20th century);
Equus ferus (introduced between 1998 and 2004).

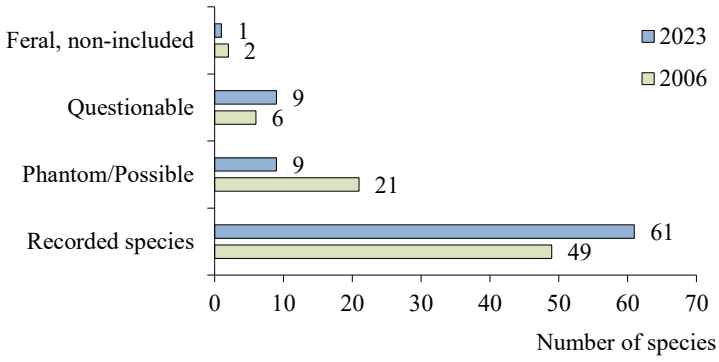

Fig 11. Composition of the two checklists of mammals of the CEZ as of 2006 [Gashchak *et al.* 2006] and 2023 (the present study)

Рис. 11. Порівняння двох контрольних переліків ссавців ЗВ — відповідно до знань у 2006 [Gashchak *et al.* 2006] і у 2023 роках (дана робота).

Additionally, *Bison bonasus*, which historically inhabited this region but had been extirpated by the 17th century, appeared in 2012 from the neighbouring PSRER, where it was reintroduced in 1996. Formally, this species is considered adventive as it meets the criteria of an 'artificially introduced former indigenous species' [Zagorodniuk 2023]. Most of the non-native species (excluding *Pipistrellus lepidus* and *Canis aureus*) have become at least partially naturalised. Lastly, *Bos taurus*, a feral cattle herd near the village of Lubianka, could also be classified as an adventive species (AS1c). However, its ecological significance and impact on natural ecosystems remain unchanged from the period when it was managed under human care.

Most of the mammal species recorded in the CEZ live and reproduce within the area. An exception is the bat fauna, where 9 out of the 14 known species are present only during the warm period (approximately April–August) for breeding. These bats hibernate outside the region.

Assessments of species statuses and abundances in this review are somewhat conditional, as no comprehensive surveys have been conducted over the entire period of investigation. On one hand, the immense size of the CEZ and socio-economic challenges in Ukraine present significant obstacles. On the other hand, the methods most frequently used in studies—such as camera trapping, live-trapping, and mist-netting—are highly specific to certain groups of mammals (e.g., large- and medium sized terrestrial mammals, shrews and small rodents, bats) and are not equally effective for all mammal species. Consequently, the results are difficult to compare across species. Seasonal and long-term fluctuations in population sizes, uneven spatial distribution, and the lack of systematic, large-scale research further contribute to uncertainty in these estimates. Additionally, ecological and biological characteristics of certain species decrease their likelihood of detection without targeted research efforts. For instance, species inhabiting riparian or marsh complexes rarely venture into terrestrial habitats, arboreal species may be overlooked as the traps are normally near the ground, and careful species can easily detect and avoid recording or trapping devices.

Synanthropic species are often excluded from research priorities, as the focus tends to be on wild species, which are perceived as more 'interesting'. As a result, abundance estimates should only be considered valid within species groups studied using consistent methods. Also, it is likely that species with low abundance values are underestimated, while those with high values may be somewhat overestimated.

Analysis of record data shows that most individual detections are concentrated among a small number of species. For example, nearly 96% of all individuals recorded by camera traps belong to only 9 of 26 species; 88% of bats belong to just 4 of 14 species; and 87% of small mammals (rodents and shrews) are represented by 4 of 18 species (Table 5). Thus, the majority of species have relatively rare or occasional records, often overlooked due to methodological limitations or lack of research focus. This trend is especially significant as many of these 'non-abundant' or 'occasional' species include a large proportion of protected or endangered species (see: Table 5). This underrepresentation is common, but it is particularly concerning because this 'non-abundant' or 'occasional' status is likely due to a lack of targeted studies while such species often form the foundation of the region's biodiversity and frequently hold conservation status.

Due to the insufficient extent of research, it is challenging to assess negative trends in the populations of certain species. The absence or low frequency of some species in surveys does not necessarily indicate population declines, as this could simply result from a lack of targeted investigations. Evidence for this can be seen when examining where and how intensively research has been conducted within the CEZ (see Figs 1–3).

Examples of species potentially affected by this limitation include *Sicista betulina*, *Micromys minutus*, *Microtus subterraneus*, *M. levis*, *Alexandromys oeconomus*, *Crocidura suaveolens*, *Neomys fodiens*, *Mustela putorius*, and the set of nine phantom species.

The CEZ is undergoing continuous change, both naturally over time and as a result of wildfires and human activities. Restricting research efforts to specific 'field stations', focusing primarily on radioecological studies, or relying on traditional methods creates significant knowledge gaps and reduces the efficiency of conservation efforts.

Table 5. General distribution pattern of mammal abundance classes in the CEZ. Number of species and their total share (%) of all recorded individuals (n) over the studies

Таблиця 5. Загальний розподіл класів рясності ссавців у ЗВ. Кількість видів і їх сумарна частка (%) від загальної кількості особин зареєстрованих під час досліджень (n)

Abundance class (% total sample of recorded individuals)	Camera-trapping in 2013–2021, n = 30 358 ind in total		Mist-netting of bats in 2007–2018, n = 3624 ind in total		Trapping of shrews and rodents in 1995–2018, n = 6002 ind in total	
	Number of species (incl. RL)*	Share (%) in the total sample	Number of species (incl. RL)	Share (%) in the total sample	Number of species (incl. RL)	Share (%) in the total sample
7 (>30.1%)	0	0	1 (1)	43.9	1	41.5
6 (10.1–30%)	3 (2)	56.7	3 (3)	43.8	3	45.7
5 (3.1–10.0%)	6	38.9	1 (1)	4.99	1	4.85
4 (1.1–3.0%)	1	1.46	3 (3)	6.65	3	5.70
3 (0.3–1.0%)	3 (1)	2.14	1 (1)	0.39	3 (1)	1.65
2 (0.11–0.3%)	2 (1)	0.40	1 (1)	0.11	3	0.50
1 (0.03–0.1%)	5 (3)	0.33	4 (4)	0.17	3	0.12
0 (<0.03%)	6	0.05	0	0	1	0.02
???**	3 (3)	0	–	–	–	–

Note: * RL—including species from the Red List [Order… 2021]. ** ???—means species not recorded by this way, nevertheless they were recorded earlier in the CEZ or in the PSRER.

Despite these challenges, there is no doubt that the mammal fauna of the CEZ continues to grow richer. The confirmed species (n = 61) account for nearly half of Ukraine's current mammal fauna (n = 133, [Emelyanov & Zagorodniuk 2012]). Moreover, one-third of these species (n = 22) are listed in the Red Data Book of Ukraine [Order… 2021], and six species are included in the European Red List [IUCN 2024]. Over the past two decades, populations of species that were once rare or uncommon, such as *Ursus arctos*, *Lynx lynx*, *Bison bonasus*, and *Equus ferus*, have continued to grow. The CEZ's large size has proven beneficial for the recovery of species with extensive individual ranges. Without human interference, predator–prey dynamics are developing naturally, enriching the CEZ and allowing it to act as a source of wildlife for surrounding areas. The CEZ plays a critical role in conserving Ukraine's natural resources, and the importance of the Chornobyl Radioecological Biosphere Reserve will only continue to grow in this regard.

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References

Abelentsev, V. I., I. G. Pidoplichko, B. M. Popov. 1956. *General Characteristics of Mammals. Insectivores, Bats*. Acad. Sci. Ukr. RSR, Kyiv, 1–448. (Series: Fauna of Ukraine; Vol. 1: Mammals, Is. 1). [Ukrainian]

Abelentsev, V. I. 1968. *Mustelids*. Naukova Dumka, Kyiv, 1–280. (Series: Fauna of Ukraine; Vol. 1: Mammals, Is. 3). [Ukrainian]

Abramchuk, A. V. 2021. The Siberian flying squirrel (*Pteromys volans*) in Belarus: distribution, abundance, threats, and conservation. *Theriologia Ukrainica*, **22**: 69–79. CrossRef

Bezrodnyi, S. V. 1991. Distribution of dormice (Rodentia, Gliridae) in Ukraine. *Vestnik zoologii*, No. 3: 45–50. [Russian]

Biological ... 2022. *Biological diversity of animals in Poleski state radioecological reserve*. Ed.: M. Y. Nikiforov [*et al.*]. Belaruska navuka, Minsk, 1–407. [Russian]

Boiarchuk, V. P., V. I. Kryzhanovskyi, A. D. Kolesnik [*et al.*]. 1990. Game animal resources of the 30-km zone and strategy of their use. *In: Proceedings of 2nd All-Union ... Meeting on the Results of the Accident Consequences Elimination on Chernobyl NPP*. Chernobyl, **6** (3): 435–448.

Deriabina, T. G. 2013. Przewalski's horse (Equus przewalskii Poljakov): observation results of an invasive species. *In: Ecosystems and radiation: aspects of being and development*: Collection of articles. Ed. by Y. I. Bondar. Institute of Radiology, Minsk, 301–308. [Russian]

Deryabina, T. G. 2008. Distribution and number of the large mammals (bison, bear, lynx, badger) included into the Red Book of Belarus Republic in the territory of Paliessie State Radiation and Ecology Reserve. *In: Faunal Studies in Paliessie State Radiation and Ecology Reserve*. Institute of Radiology, Homel, 19–35. [In Russian]

Deriabina, T. G. 2012. Polissya population of European bison (1996–2011). *In: Wildlife of Belarus*. (3.12.2012) [Russian] https://goo.gl/IL5HVg

Dombrovski, V. C. 2018. Maternity colonies of Myotis brandtii in the Polesie State Radiation-Ecological Reserve. *Theriologia Ukrainica*, **16**: 91–94. CrossRef

Dombrovskyi, V., V. Fenchuk, D. Zhurauliou. 2017. The bat fauna (Mammalia, Chiroptera) of Stary Zhaden Zakaznik, Southern Belarus. *Proceedings of the Theriological School*, **15**: 3–9. CrossRef

Dombrovskyi, V. C. 2017. Survey results of bats (Chiroptera) in Polesskyi state radioecological reserve in 2016–2017. *In: Actual Problems of Zoological Science in Belarus. Volume 1:* Proceedings of XI International Conference (Belarus). Minsk, 105–112. [Russian]

Dombrovskyi, V. C., D. I. Shamovich, J. Beasley, [*et al.*] 2017. If do not shoot: Number, territorial structure and predation of the wolf in winter period 2016–2017 in the exclusion zone of Chernobyl NPP. *In: Modern Problems of Game Management and Biodiversity Conservation*: Proceedings of International Conference (Minsk). Minsk, 93–97. [Russian]

Dombrovskyi, V. C., P. Schlichting, J. Beasley. 2018. Application of camera traps to study relative abundance and daily activity of big and medium sized species of mammals in Polesskyi state radioecological reserve (Belarus). *In: Problems and Prospects of Development of Territories Affected in a Result of the Catastrophe on Chernobyl NPP, on the Modern Stage*: Proceedings of International Conference (Khoiniky). Minsk, 30–34. [Russian]

Emelyanov, I. G., I. V. Zagorodniuk, S. I. Zolotukhina. 1987. Ecologcial and systematic review of the recent hamsters (Cricetidae, Rodentia) of fauna of Ukraine. *In: Hamsters of Fauna of Ukraine: Faunistics, Systematics, Ecology and Practical Value*. Kyiv, 3–18. (AoS USSR. I. Shmalhausem Institute of zoology; Preprint 87.6, part 1). [Russian]

Gaichenko, V. A., I. V. Zhezherin, I. V. Nebogatkin. 1993. Changes of species composition and abundance of small mammals in 30-km zone of ChNPP during the post-accidental period. *Mammals of Ukraine*. Naukova Dumka, Kyiv, 153–164. [Russian]

Gaichenko, V. A., V. I. Kryzhanovskyi, V. N. Stovbchatyi, [*et al.*]. 1990. Ecological situation in 30-km zone of ChNPP and its change over the last 3 post-accidental years. *In: Proceedings of 2nd All-Union ... Meeting on the Results of the Accident Consequences Elimination on Chernobyl NPP*. Chernobyl, **6** (3): 4–11. [Russian]

Gaichenko, V. A., V. I. Kryzhanovskyi, V. N. Stovbchatyi. 1994. State of faunistic complexes of the ChNPP exclusion zone in the post-accidental period. *Ecological and faunistical studies in the zone of Chornobyl NPP*. Kyiv. 4–18. (Preprint of Schmalhausen Institute of zoology, NAS Ukraine, 94.5, iss. 1). [Russian]

Gashchak, S. P. 2006. 'Reserved problems' of the Chornobyl zone. *Zapovidna sprava v Ukraine*, **12** (2): 83–90. [Ukrainian]

Gashchak, S. P. 2008. About an experience of automatic photography of wild animals in Chornobyl zone. *Rarity Theriofauna and Its Conservation*. Luhansk, 28–36 (Proceedings of the Theriological School. Vol. 9) [Ukrainian]

Gashchak, S. P., A. S. Vlaschenko, A. V. Naglov. 2009. Study results of bats fauna and its radioactive contamination in Chernobyl exclusion zone in 2007–2009. *Problems of the Chornobyl Exclusion Zone*, **9**: 102–124. [Russian]

Gashchak, S. P., E. G. Buntova, G. A. Rudenska, [*et al.*]. 2000. Species structure peculiarities of Insectivores and Rodents in the Chornobyl Exclusion Zone (Ukraine). *Vestnik Zoologii*, **34** (6): 51–56. [Russian]

Gashchak, S. P., D. O. Vishnevsky, O. O. Zalissky. 2006. *Fauna of Vertebrates of Chornobyl Exclusion Zone (Ukraine)*. Slavutych, 1–100. [Ukrainian]

Gashchak, S. P., A. S. Vlaschenko, A.V. Naglov, [*et al.*]. 2013. Bats fauna of the exclusion zone in concern of assessment of environmental value of its areas. *Problems of Chornobyl Exclusion Zone*. Slavutych, **11**: 56–79. [Russian]

Gashchak, S. P., Y. O. Gulyaichenko, N. A. Beresford, [*et al.*]. 2016. Brown bear (Ursus arctos L.) in Chernobyl exclusion zone. *Proceedings of Theriological School*, **14**: 71–84. CrossRef

Gashchak, S. P., Y. O. Gulyaichenko, N. A. Beresford, [*et al.*]. 2017. European bison (*Bison bonasus*) in the Chornobyl exclusion zone (Ukraine) and prospects for its revival. *Proceedings of Theriological School*, **15**: 58–66. CrossRef

Gashchak, S. P. 2018. Vertebrates of Chornobyl zone (Chornobyl radiation and ecological biosphere reserve) included into Red list of Ukraine (2009). *Problems of the Chornobyl exclusion zone. Slavutych*, **18**: 5–54. [Russian]

Gashchak, S., S. Paskevich. 2019. Przewalski's horse (Equus ferus przewalskii, Poljakov, 1881) in Chornobyl exclusion zone 20 years after introduction: number, population structure and distribution. *Theriologia Ukrainica*, **19**: 80–100. CrossRef

Gashchak, S., C. L. Barnett, N. A. Beresford, [*et al.*]. 2022. Estimating the population density of Eurasian lynx in the Ukrainian part of the Chornobyl Exclusion Zone using camera trap footage. *Theriologia Ukrainica*, **23**: 47–65. CrossRef

Gashchak, S., D. Vyshnevskii, S. Zhyla. 2024. Theriological studies in the exclusion zone (Chornobyl, 1986–2021). *Novitates Theriologicae*, **17**: (in press).

Godlevska, L. V., S. V. Rebrov, P. S. Panchenko. 2016. New data on bat fauna of Rivne oblast (Ukraine). *Zapovidna sprava*, **1** (22): 72–77. [Ukrainian]

Hyrenko, L. L. 1950. In concern of distribution of Black rat in USSR. *Proceedings of the Zoological Museum of Kyiv State University,* **2**: 75–95. [Russian]

Kirikov, S. V. 1960. *Changes of Fauna in Natural Areas of the USSR (in the 13th–19th centuries). Forestlands and Forest Tundra.* Publishing House of the USSR Academy of Sciences, Moscow, 1–158. [Russian]

Kirikov, S. V. 1979a. Distribution of European bison on territory of Soviet Union in XI–XX centuries. *In: European bison. Morphology, Systematics, Evolution, Ecology.* Ed. by V. E. Sokolov. Nauka Publishers, Moscow, 476–487. [Russian]

Kirikov, S. V. 1979b. *Man and Nature in the Eastern European Forest Steppe in the 10th — Early 19th Centuries*. Nauka, Moscow, 1–184. [Russian]

Korneev, O. P. 1950. *Wolf and Its Abolition*. Publ. House of Agricultural Literature of URSR, Kyiv & Kharkiv, 1–104. [Ukrainian]

Kuchmel, S. V. 2008. Species composition of mammals of Orders Insectivora, Lagomorphs, Carnivorans, Rodents and Odd-toed Ungulate in Paliessie State Radiation and Ecology Reserve. *Faunal Studies in Paliessie State Radiation and Ecology Reserve*. RNIUP Institute of Radiology, Homel, 38–64. [Russian]

Legeida, I. S., G. M. Panov. 1993. Some peculiarities of wild boar biology in the zone of ChNPP. *Abstracts of Reports of Radiobiological Congress* (Kyiv, 20–25 September 1993). Puschino, 587–588. [Russian]

Litus, I. E. 1986. *Acclimatization of wild animals*. Urodzhai, Kyiv, 1–192. [Russian]

Matsala, M.; A. Bilous, V. Myroniuk, [*et al.*]. 2021. The return of nature to the Chernobyl exclusion zone: increases in forest cover of 1.5 times since the 1986 disaster. *Forests*, **12**, 1024. CrossRef

Mezhzherin, S. V. 2009. European hamster *Cricetus cricetus* (Linnaeus, 1758). *In:* I. A. Akimov (ed.). *The Red Data Book of Ukraine. Animals.* Hlobalkonsaltynh, Kyiv, 531. [Ukrainian]

Miropolskyi, V. 2001. Autumn finding Eptesicus nilssonii on Kyivshiny. *In: Migration status of bats in Ukraine*. 114. (Novitates Theriologicae; Pars 6). [Ukrainian]

Mishta, A. V. 2009. Mediterranean water shrew Neomys anomalus (Cabrera, 1907). *In:* I. A. Akimov (ed.). *The Red Data Book of Ukraine. Animals.* Hlobalkonsaltynh, Kyiv, 489. [Ukrainian]

Nature Chronicles of 2020 of Chornobyl Radioecological Biosphere Reserve. Volume 4. Kyiv, 1–221. URL [Ukrainian]

Nikolaichuk, O., I. Zagorodniuk. 2019. The northern raccoon (*Procyon lotor*) in urban environment of Kyiv and persp-?ctives of formation of its wild populations in Ukraine. *Theriologia Ukrainica*, **18**: 108–112. CrossRef

Order of Ministry of Environmental Protection and Natural Resources of Ukraine No 29 on 19.01.2021 'About confirmation of the animal species list which are put down into the Red Data Book of Ukraine (Fauna), and the list of species that are excluded from the Red Data Book of Ukraine (Fauna). Supplement 1. [Ukrainian] URL (web)

Panov, G. M. 1990. *Beavers*. Urozhai, Kyiv, 1–176. [Russian]

Panov, G. M. 2002. Dynamic of home ranges and abundance of semi-aquatic fur mammals in Ukraine in the second part of 20th century. *Visnyk of L`viv University. Biology series*, **30**: 119–132. [Ukrainian]

Panteleev, P. A. 1998. *Rodents of Palearctic: Composition and Home Ranges*. Moscow, 1–117. [Russian]

Paskevych, S. 2021. Behavior peculiarities of Przewalsky horses in the conditions of abandoned urbolandscapes of Chornobyl exclusion zone. *Chornobyl science HUB*, **1-2** (2-3): 16–23. [Ukrainian]

Pavlov, M. P., S. B. Korsakova, N. P. Lavrov. 1974. *Acclimatization of game mammals and birds*. Part 2. Kirov, 1–460. [Russian]

Savitskyi, B. P., S. V. Kuchmel, L. D. Burko. 2005. *Mammals of Belarus*. Publishing Center of BSU, Minsk, 1–319. [Russian]

Shevchenko, L. S., S. I. Zolotukhina. 2002. *Mammals. Issue 1: Murids (Muridae).* Zoological Museum NAS of Ukraine, National Museum of Natural History, Kyiv, 1–217. (Collection catalogue of Zoological Museum of NMNH NAS of Ukraine) [Russian]

Shkvyria, M., D. Vishnevsky. 2012. Large carnivores of the Chornobyl NPP exclusion zone. *Vestnik of Zoology*, **46** (3): 239–246. CrossRef

Sidorovych, V. E. 1995. State of Weasel family species in Chernobyl zone. *In:* Suschenia, L. M. [*et al.*] (eds). *Wildlife in the Zone of the Accident on Chernobyl NPP.* Navuka i Tekhnika, Minsk, 193–198. [Russian]

Skorobagatov, I., A. Atemasov, S. Gashchak. 2019. Preliminary results of first-ever otter survey in Chornobyl exclusion zone, northern Ukraine. *OTTER, Journal of the International Otter Survival Fund*, **5**: 30–38.

Sokur, I. T. 1961. *Historical Changes and Use of Mammals Fauna in Ukraine*. AS Ukr. SSR, Kyiv, 1–84. [Ukrainian]

Spatola, G. J., R. M. Buckley, M. Dillon, [*et al.*]. 2023. The dogs of Chernobyl: Demographic insights into populations inhabiting the nuclear exclusion zone. *Science Advances*, **9**: eade2537(2023). CrossRef

The IUCN Red List of Threatened Species. 2024-1. https://www.iucnredlist.org/

The Red... 2009. *The Red Data Book of Ukraine. Animals.* Hlobalkonsaltynh, Kyiv, 1–540. [Ukrainian]

Timofeev-Resovskyi, N. V., A. V. Yablokov, N. V. Glotov. 1973. *Essay of Population Theory*. Nauka, Moscow, 1–278. [Russian]

Vishnevskyi, D. O., O. Kotliarov. 2008. Estimation of abundance of the mammal macrofauna in the exclusion zone of the Chornobyl NPP: analysis of different sources of data. *In:* Zagorodniuk, I. (ed.). *Rarity Theriofauna and Its Conservation*. Luhansk, 21–27. (Series: Proceedings of the Theriological School. Vol. 9) [Ukrainian]

Volokh, A. M. 2009. Ermine Mustela erminea (Linnaeus, 1758). *In:* Akimov, I. A. (ed.). *The Red Data Book of Ukraine. Animals.* Hlobalkonsaltynh, Kyiv, 539. [Ukrainian]

Volokh, A. M., M. V. Rozhenko. 2009. European mink *Mustela lutreola* Linnaeus, 1761. *In:* Akimov, I. A. (ed.). *The Red Data Book of Ukraine. Animals.* Hlobalkonsaltynh, Kyiv, 540. [Ukrainian]

Voronetskyi, N. N., V. F. Dunin, V. S. Piskunov, [*et al.*]. 1999. Number and biotopic distribution of wild animals in Polesskyi radioecological reserve. *Biological Diversity of National Park 'Prypiatsyi' and Other Special Protected Natural Territories*: Collection of scientific papers. Belyi veter Publ. House, Turov, Mozyr, 312–315. [Russian]

Wolf: History, Systematics, Morphology, Ecology / Ed. D. I. Bibikov. Moscow: Nauka publisher, 1985, 1–608. [Russian]

Zagorodniuk, I. 1996. Natural history of the black rat (Rattus rattus) in Ukraine. *In: Urbanized Environment: Protection of Nature and Human Health*: Proceedings of Ukrainian republic meeting. Kyiv, 228–231. [Ukrainian]

Zagorodniuk, I., O. Kysselyuk, I. Polischuk, [*et al.*]. 2002. Units of measure of population abundance and the minimal scheme for census of mammals. *Visnyk of Lviv University. Biology series*, **30**: 8–17. [Ukrainian] URL (pdf)

Zagorodniuk, I. 2005. Biogeography of mammals' cryptic species in the Eastern Europe. *Scientific Bulletin of the Uzhhorod University. Series Biology*, **17**: 5–27. [Ukrainian]

Zagorodniuk, I., I. Emelyanov. 2008. Cryptic diversity of mammals in Eastern Europe as reflection of variety of species phenomena. *Scientific Bulletin Uzhhorod University. Series Biology*, **22**: 166–178. [Ukrainian]

Zagorodniuk, I. V., I. G. Emelyanov. 2012. Taxonomy and nomenclature of mammals of Ukraine. *Proceedings of the National Museum of Natural History*, **10**: 5–30. [Ukrainian] https://bit.ly/3Y8cVRB

Zagorodniuk, I. 2014. Golden jackal (Canis aureus) in Ukraine: Modern expansion and status of species. *Proceedings of the National Museum of Natural History*, **12**: 100–105.

Zagorodniuk, I., M. Gavrilyuk, M. Drebet, [*et al.*]. 2014. Wildcat (*Felis silvestris* Schreber, 1777) in Ukraine: Modern state of the populations and eastwards expansion of the species. *Studia Biologica*, **8** (3–4): 233–254. CrossRef

Zagorodniuk, I. 2018. Close bat species in Ukrainian fauna: differences and position in structure of communities. *Theriologia Ukrainica*, **16**: 51–76. [Ukrainian] CrossRef

Zagorodniuk, I. 2019. Range dynamics in sibling species: facts and reconstructions for the mammal fauna of Eastern Europe. *Theriologia Ukrainica*, **18**: 20–39. CrossRef

Zagorodniuk, I. 2020. Close species of rodents of the superfamily Muroidae in the fauna of Ukraine: taxonomy, biogeography, diagnostics, and ecomorphology. *Theriologia Ukrainica*, **19**: 3–26. [Ukrainian] CrossRef

Zagorodniuk, I. 2022. The Siberian flying squirrel (*Pteromys volans*) in south of Eastern Europe: distribution boundaries and its changes. *Theriologia Ukrainica*, 23: 66–77. [Ukrainian] CrossRef

Zagorodniuk, I., M. Korobchenko, K. Ocheretna. 2022. Checklists of fauna and designations of species status. *Visnyk of Cherkassy University. Series Biological Sciences,* **2**: 21–31. [Ukrainian] CrossRef

Zagorodniuk, I. 2023. *Terrestrial Vertebrates of Ukraine: Adventive Component*. NAS of Ukraine, National Museum of Natural History, Kyiv, 1–62. ISBN 978-617-14-0080-1. [Ukrainian] Electronic edition: https://museumkiev.org

Zharkikh, T. L., N. I. Yasynetska. 2008. Demographic indices of population of Przewalski horses (Equus przewalskii Polj., 1881) in the exclusion zone of Chernobyl NPP. *Bulletin of Moscow Society of Nature Investigators. Division of Biology*, **113** (5): 3–9. [Russian]

Zhyla, S. 2021a. Roe deer in Polyssia and in Chornobyl radioecological biosphere reserve: Ecology, behavior, number. *Chronbyl Science HUB*, **1–2** (2–3): 42–51. [Ukrainian]

Zhyla, S. 2021b. Behavior and social structure of the feral cattle (*Bos taurus*) in Chornobyl radioecological reserve. *In: Chornobyl: Open Air Lab.* Proceedings I International Conference. Krok, Kyiv, Ternopil, 43–49. [Ukrainian] https://bit.ly/3b3neUl

Zhyla, S. 2022. Red deer (Cervus elaphus) in the Chornobyl Biosphere Reserve: monitoring, ecology, and behaviour. *Theriologia Ukrainica*, **24**: 151–170. [Ukrainian] CrossRef

Zhyla, S. 2023a. The elk (*Alces alces*) at the southern limit of its geographic range: population status in the Central Polissia, wolf predation, and vulnerability to climate warming. *Theriologia Ukrainica*, **25**: 173–186. [Ukrainian] CrossRef

Zhyla, S. 2023b. The golden jackal (Canis aureus) in the northern Polissia of Ukraine: occurrence in the wild, status, and slow dispersal. *Theriologia Ukrainica*, **26**: 96–104. [Ukrainian] CrossRef