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DISTRIBUTION FEATURES OF CARNIVORANS INTRODUCED IN THE LEFT-BANK UKRAINE (*NEOGALE* & *NYCTEREUTES*)

Denys Lazariev

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introduced species, carnivorous mammals, Left-bank Ukraine, distribution, naturalization

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Affiliations

National Museum of Natural History, NAS of Ukraine (Kyiv, Ukraine)

Correspondence

Denys Lazariev; National Museum of Natural History, NAS of Ukraine; 15 Bogdan Khmelnitsky Street, Kyiv, 01054, Ukraine; Email: lazarevden@ukr.net; orcid: 0000-0002-8663-747X

Abstract

The study examines the distribution patterns of two introduced carnivorous mammals—the American mink (*Neogale vison*) and the raccoon dog (*Nyctereutes procyonoides*)—in the left bank region of Ukraine. The study material included data from open sources, published literature, hunting statistics, zoological collections, and field observations. The history of the species' distribution, population dynamics, current population status, and habitat associations of the introduced carnivores within the main river basins of the region are described. The current distribution of *Neogale vison* is closely associated with the extensive river network and the availability of food resources, primarily in the valleys of large and medium-sized rivers. In contrast, *Nyctereutes procyonoides* exhibits much higher ecological plasticity, manifested in its ability to utilise both natural and anthropogenically transformed habitats, and in its weak dependence on the presence of water bodies. Both species have rapidly colonised a variety of habitat types, including forest-steppe, steppe, and transformed landscapes, and have established stable populations in the basins of the Siversky Donets, Dnipro, Desna, and their tributaries. It was found that, at the present stage, the studied introduced species show signs of stable naturalisation and are permanent components of the fauna of the Left-bank Ukraine. They demonstrate different distribution patterns: *N. vison* remains closely linked to wetland complexes, whereas *N. procyonoides* is an opportunistic omnivore capable of inhabiting a much wider range of habitats. Both species potentially exert a noticeable impact on local ecosystems: *N. vison* competes with native semi-aquatic predators, while *N. procyonoides* may act as a vector of rabies and exert pressure on local terrestrial fauna. The results obtained highlight the need for further monitoring of the population size and spatial structure of introduced carnivores, as their distribution is an important factor in the transformation of biotic communities and has indicative value for assessing ecosystem status and the degree of their transformation.

Cite as

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Особливості поширення видів-інтродуцентів хижих ссавців на лівобережній Україні (*Neogale* & *Nyctereutes*)

Денис Лазарєв

Резюме. У статті розглянуто особливості поширення двох інтродукованих видів хижих ссавців — візона річкового (*Neogale vison*) та єнота уссурійського (*Nyctereutes procyonoides*) — на території лівобережної України. Матеріалом для дослідження слугували дані з відкритих джерел, літератури, дані мисливської статистики, матеріали зоологічних колекцій, а також польові спостереження. Описано історію поширення досліджених видів, динаміку чисельності, сучасний стан популяцій та біотопну приуроченість інтродукованих хижих ссавців у межах основних річкових басейнів регіону. Сучасне поширення *Neogale vison* тісно пов'язане з розгалуженою системою річкових мереж і станом кормової бази, насамперед у долинах великих і середніх річок. Натомість *Nyctereutes procyonoides*, характеризується значно вищою екологічною пластичністю, що проявляється у здатності використовувати як природні, так і антропогенно трансформовані біотопи та слабкій залежності від наявності водних об'єктів. Обидва види швидко опанували різноманітні типи біотопів, зокрема лісостепові, степові, трансформовані ландшафти, та сформували стабільні популяції в басейнах Сіверського Дінця, Дніпра, Десни та їхніх приток. Встановлено, що досліджені інтродуковані види на сучасному етапі мають ознаки сталої натуралізації та є постійними компонентами фауни лівобережної України. Вони демонструють різні особливості поширення: *N. vison* залишається тісно пов'язаним із водно-болотними комплексами, тоді як *N. procyonoides* є всеїдним опортуністом, здатним заселяти значно ширший спектр біотопів. Обидва види потенційно чинять помітний вплив на місцеві екосистеми: *N. vison* конкурує з аборигенними напівводяними хижаками, тоді як *N. procyonoides* може виступати переносником сказу та здійснювати тиск на місцеву наземну фауну. Отримані результати підтверджують необхідність подальшого моніторингу чисельності та просторової структури популяцій інтродукованих хижих ссавців, оскільки їх поширення є важливим чинником трансформації біотичних угруповань і має індикаційне значення для оцінки стану екосистем та ступеню їх трансформації.

Ключові слова: інтродуковані види, хижі ссавці, поширення, натуралізація, лівобережна Україна.

Introduction

Alien mammal species are the focus of modern zoological and ecological research due to their impact on community structure, the dynamics of native populations, and ecosystem functioning [Kolar & Lodge 2001; Bonesi 2004; Pyšek *et al*. 2020]. In the first half of the 20th century, significant changes occurred in the mammal fauna of Ukraine, largely driven by the introduction of fur-bearing mammals [Sokur 1961; Zagorodniuk 2001; Sakhno 2015].

Predatory introduced species, primarily the American mink (*Neogale vison* Schreber 1777) and the raccoon dog (*Nyctereutes procyonoides* Gray 1834), exert a decisive influence on the composition of the regional fauna. These species actively colonise transformed landscapes and river basins and substantially affect local ecosystems and biodiversity, which underscores the need for coordinated monitoring and invasion risk assessment [Vada *et al*. 2023].

Despite numerous studies on the distribution of these species in Europe and Ukraine [Kauhala 2009; Novytskyi *et al*. 2017; Schley *et al*. 2021], regional analyses in Left-bank Ukraine remain fragmented. The specific natural conditions, hydrographic network, and anthropogenically transformed landscapes of the region create prerequisites for the naturalisation of both species; however, these patterns remain insufficiently studied. Given the impact of the studied mammal species on native fauna and ecosystem structure, investigating their current dispersal is necessary for zoogeographical analysis and for substantiating conservation decisions.

The aim of this article is to summarise data from open sources on the spatial distribution of *Neogale vison* and *Nyctereutes procyonoides* in Left-bank Ukraine and to identify key features of their current range.

Materials and Methods

The study utilised diverse sources on the distribution of *Neogale vison* and *Nyctereutes procyonoides* in the Left-bank regions of Ukraine, including open online observation databases (GBIF), scientific publications, official statistics—form 2-TP (hunting), surveys of specialists and hunters, data from natural history forums, and regional reviews of zoological collections.

The spatial structuring of the material was carried out at administrative (oblasts and raions), river-basin (Dnipro, Desna, Sula, Psel, Vorskla, Siversky Donets, etc.), and landscape-geographical levels (riparian-aquatic, forest, open natural, agricultural, and anthropogenically transformed habitats). Left-bank Ukraine was defined as the territories on the left bank of the Dnipro River, its left tributaries, and adjacent areas, which administratively cover Chernihiv, Sumy, Kharkiv, Poltava, Luhansk, and Donetsk oblasts, and the Autonomous Republic of Crimea, as well as the Left-bank parts of Kyiv, Cherkasy, Dnipropetrovsk, Zaporizhzhia, and Kherson oblasts.

For the analysis, cartographic modelling, spatial grouping, and assessment of temporal dynamics were applied, along with a comparative analysis of the two species to identify common and distinct distribution trends. Data were used on 70 records of *N. vison* and 102 records of *N. procyonoides*. For mapping species distributions, data from GBIF were used:

> for *N. vison* (*Neogale* Gray, 1865 in GBIF Secretariat (2023). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org on 20251214),
>
> for *N. procyonoides* (*Nyctereutes procyonoides* (Gray, 1834) in GBIF Secretariat (2023). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org on 20251214).

Additionally, records from open sources were considered, including publications on social networks (Facebook—FB, YouTube—YT), personal communications, and data from zoological collections (collection abbreviations are used, e.g., ZMLU—Zoological Museum of Taras Shevchenko Luhansk National University) [Zagorodniuk & Shydlovskyy 2014]. Data on such records are presented as lists within the text of the article. A number of records were obtained from the Facebook group Animal World of Ukraine (‘Tvarynnyi svit Ukrainy’).

In connection with the 2020 administrative-territorial reform and the consolidation of raions, the administrative affiliation of localities in the lists of records is given according to the current raion division, with the name of the former raion (prior to the amalgamation) indicated in parentheses, within the territory of which the respective record was made.

As a result, a consolidated database of *N. vison* and *N. procyonoides* records was created, which served as the basis for further analysis of their regional distribution. All data used were verified according to several criteria: reliability of the information source, observer expertise, species identification, location accuracy, repeatability, and the presence of photographic or video documentation.

Results

The study focused on the formation of the current range, spatial population structure, and temporal dynamics of abundance of two introduced carnivorans—*Neogale vison* and *Nyctereutes procyonoides*—in the Left-bank regions of Ukraine. The analysis accounted for the history of introduction, data recording specifics, and regional distribution differences.

Historical background

The American mink (*Neogale vison*) appeared in the fauna of Ukraine as a result of fur farming and escapes from farms after the 1950s, which led to the formation of wild populations. In the 1960s, the species was recorded in Chernihiv Oblast, and by the 1980s—in the Kyiv and Kremenchuk reservoirs [Panov 2002]. The source population in Belarus is numerous and exhibits high morphological variability [Savarin 2023].

In the 1950s, populations also formed in the Siversky Donets basin in the northern Donetsk Oblast due to farm escapes [Panov 2002]. Following the start of breeding at the Nyzhniodniprovsk farm in 1969, a stable population also emerged in the southern Dnipro region; from 1968 to 1987, the

American mink was regularly recorded in Skadovsk Raion (territory of the former Hola Prystan Raion) of Kherson Oblast, and in 2008—in Melitopol Raion (territory of the former Yakymivka Raion) of Zaporizhzhia Oblast [Volokh 2016].

The probable presence of populations in Dnipropetrovsk Oblast is linked to the activities of the Lychkivskyi farm, while large farms operated until 2014 in Poltava, Kharkiv, and Donetsk oblasts as well [Volokh 2016]. Thus, the current distribution of *N. vison* in the study area is determined by multiple farm escapes followed by natural dispersal.

The raccoon dog (*Nyctereutes procyonoides*), a canid mammal, was introduced to Ukraine beginning in 1928, when it was first released in Poltava Oblast. More intensive introduction efforts occurred in 1935–1936, when the species was released into the eastern regions of Ukraine (Luhansk, Donetsk, Zaporizhzhia, and Kharkiv oblasts) as well as Kyiv Oblast. Introduction efforts continued until the 1960s in the remaining oblasts of the study area [Kolosov & Lavrov 1968]. At the beginning of World War II, releases of animals from farms into the wild in connection with the advancing front line played an important role in shaping the distribution of *N. procyonoides* in Ukraine [Korneev 1954]. By the 1960s, Kyiv, Chernihiv, Sumy, Kharkiv, Poltava, and Cherkasy oblasts had become the main areas for hunting *N. procyonoides* [Sokur 1961].

Hunting statistics and data from open sources often indicate that the raccoon dog is neither numerous nor widely distributed in mountainous areas. However, literature sources report possible penetration of the species into the Crimean Mountains. For instance, between 1980 and 2004, three *N. procyonoides* were harvested in the Sevastopol area, confirming the species' presence in the mountainous regions of Crimea [Volokh 2014], based on oral communication from the hunting expert S. Samokhin. The success of this introduced species is attributed to its adaptability, high reproductive potential, omnivory, and multiple introductions [Kauhala & Kowalczyk 2011].

Thus, the formation of contemporary populations of the studied species in Ukraine resulted from multiple farm escapes in the case of *N. vison*, and purposeful 'game fauna enrichment' programmes in the case of *N. procyonoides*. Their subsequent dispersal was determined by a combination of anthropogenic factors and natural processes.

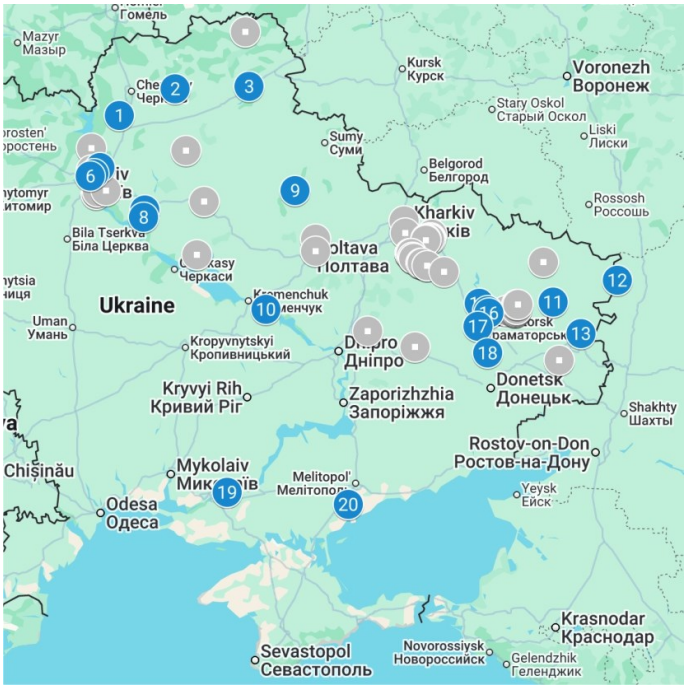
Spatial structure of the range

The analysis of the spatial structure of the studied species' ranges is based on hunting statistics, literature, and open databases, allowing identification of current distribution patterns in Left-bank Ukraine. Hunting statistics suggest that *Neogale vison* is absent from most southern districts, which is inaccurate. The species is now distributed throughout the region; in particular, *N. vison* occurs in the wetlands of the Dnipro, Oril, and Samara rivers [Volokh 2022], and is relatively numerous in Cherkasy Oblast due to regular escapes from a large fur farm[1].

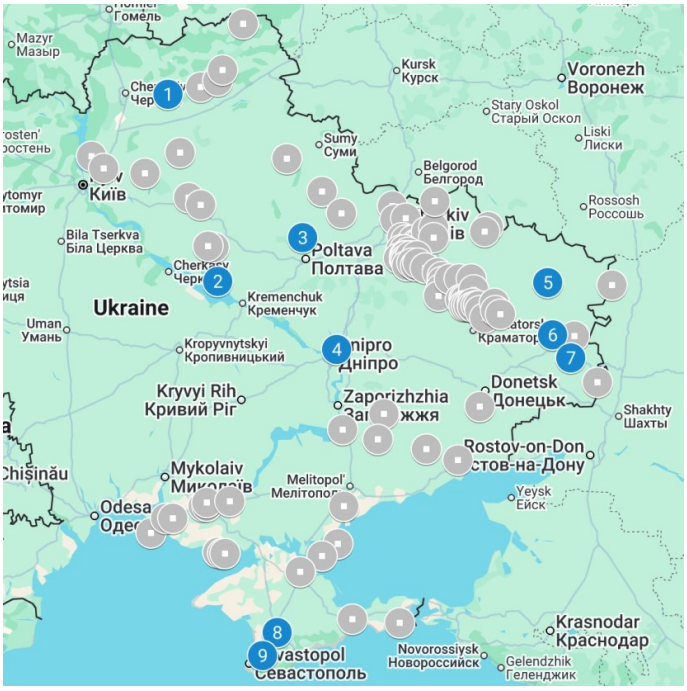
Data on *N. vison* records obtained from open sources indicate its presence across most of Ukraine, including the northern oblasts (Fig. 1). Literature sources confirm that by the late 20th–early 21st centuries, the species was recorded in the southern part of the region, notably in Kherson and Zaporizhzhia oblasts [Volokh 2004]. Although in the early 2000s the species was not reported for Dnipropetrovsk Oblast [Bulakhov & Pakhomov 2006], over the last two decades *N. vison* has spread throughout the Left-bank regions of Ukraine, without reaching the Crimean Peninsula. At the same time, media reports indicate the operation of fur farms breeding *N. vison* in the Ichkinska community of Feodosia Raion. Cases of escapes of individuals kept as pets by local residents have also been reported. Taken together, these facts indicate a high likelihood of the formation of wild populations in the Crimea—if not at present, then in the near future.

Since 1972, the species has been recorded in most tributaries of the Dnipro in the area of the Kremenchuk Reservoir [Volokh & Rozhenko 2011]. From 1985 onwards, *N. vison* has also been recorded in hunting grounds of Poltava Oblast, particularly in the area of the Dykanka Regional Landscape Park, as a result of escapes from one of the fur farms (hunter data).

[1] Data on the population status of the studied mammal species in part of the region are presented in the PhD thesis by N. Ruzhilenko titled '*Modern state of the predatory mammals populations of the Middle Dnipro*', 2010.



a



b

Fig. 1. Distribution of the studied species: (*a*) *Neogale vison*, (*b*) *Nyctereutes procyonoides*. The symbols indicate: records based on GBIF data (grey symbols) and records based on other sources (blue symbols with numbers corresponding to those in the lists of records).

Рис. 1. Поширення досліджених видів: (*a*) *Neogale vison*, (*b*) *Nyctereutes procyonoides*. Значками позначено: знахідки за даними GBIF (сірі значки) та знахідки за даними інших джерел (сині значки з номерами відповідними до номерів у переліках знахідок).

The American mink utilises riparian-aquatic habitats within anthropogenically transformed river valleys, reflecting its ecological plasticity in modified landscapes. This is further supported by observations in Luhansk Oblast, where most collection specimens and sightings concern reservoirs, large fish farms, and anthropogenically modified water bodies.

Below are data on the localities of *N. vison* based on open sources:

Chernihiv Oblast: • (1) Chernihiv Raion (former Kozelets Raion), outskirts of Nadynivka village, confluence of the Nadynivska Starukha River and the Desna River, 51.215586, 31.044309, 26.08.2017 (FB: 'Animal World of Ukraine' group, O. Lazarenko); • (2) Koriukivka Raion (former Mena Raion), 51.517942, 32.047227, 2021 (specimen from the collection of NNHM-z, No. 8664, leg. D. Lazariev).

Sumy Oblast: • (3) Konotop Raion, Lake Svydnia, 51.547535, 33.402245, 26.09.2021 (FB: 'Animal World of Ukraine' group, A. Kovtun).

Kyiv Oblast: • (4) Brovary Raion, outskirts of Pukhivka village, Desna River, 50.627256, 30.685077, 2015 (FB: 'Wildlife of Ukraine' group, O. Lazarenko); • (5) Brovary Raion, Desna River, 50.559689, 30.577450, 19.08.2023 (FB: 'Wildlife of Ukraine' group, S. Romanenko); • (6) Kyiv, Obolon District, Sobache Hyrlo Bay, 50.528780, 30.521459, 10.02.2023 (FB: 'Wildlife of Ukraine' group, K. Erfolh); • (7) Brovary Raion, Trubizh River, 50.134440, 31.506338, 12.2022 (FB: 'Wildlife of Ukraine' group, T. Derevianko); • (8) Brovary Raion, bypass canal in Pereiaslav City, 50.048048, 31.492790, 22.03.2021 (FB: 'Wildlife of Ukraine' group, T. Derevianko).

Poltava Oblast: • (9) Myrhorod Raion (former Hadiiach Raion), pond between Vepryk and Martynivka villages, animal caught in a trap, 50.358219, 34.235699, 12.1989 and 1997 [Lazariev *et al*. 2024]; • (10) Kremenchuk Raion, Keleberda village, visual observation, 48.961600, 33.708880, 2020–2021 [Lazariev *et al*. 2024].

Luhansk Oblast: • (11) Shchastia Raion (former Novoaidar Raion), Spivakivka village, Aidar River, 49.052504; 38.913369, 10.01.2013 (FB: 'Wildlife of Ukraine' group, V. Holovanov); • (12) Starobilsk Raion (former Milove Raion), branch of the Luhansk Nature Reserve 'Striltsivsky Steppe', Cherepakha River, 49.307623, 40.085317, 5.09.2019 (author's observation); • (13) Shchastia Raion, Stanytsia Luhanska settlement, Lake Hlyboke, 48.678177, 39.428038, 08.05.2021 (FB: 'Wildlife of Ukraine' group, V. Holovko).

Donetsk Oblast: • (14) Kramatorsk Raion, Sviatohirsk City, Siversky Donets River, 49.035881, 37.577538, 2020 (FB: 'Wildlife of Ukraine' group, E. Prokhorin); • (15) Lyman Raion, Shchurove village, Siversky Donets River, 48.955227, 37.719344, 2020 (FB: 'Wildlife of Ukraine' group, E. Prokhorin); • (16) Kramatorsk Raion, Brusino railway station, floodplain lakes of the Siversky Donets River, 48.928882, 37.754416, 2020 (FB: 'Wildlife of Ukraine' group, E. Prokhorin); • (17) Kramatorsk Raion, Kazennyi Torets River, 48.765753; 37.560586, 31.08.2020 (FB: 'Wildlife of Ukraine' group, E. Prokhorin); • (18) Kleban-Byk Regional Landscape Park, det. I. Zagorodniuk, 48.441061, 37.733401, 18.02.2020 (YT: 'Kleban-Byk Regional Landscape Park' channel).

Kherson Oblast: • (19) Kherson Raion (former Oleshky Raion), between Kozachi Laheri and Krynky villages, Dnipro River, 12.10.2013 [Volokh 2016].

Zaporizhzhia Oblast: • (20) Melitopol Raion, road between Mala Ternivka and Kosykh villages, two juveniles found dead on the road, 09.2008 [Volokh 2016].

Nyctereutes procyonoides is distributed throughout all oblasts of Left-bank Ukraine. Calculations based on hunting statistics indicate that the highest abundance and density values (individuals/km²) are recorded in Chernihiv, Sumy, Kharkiv, and Poltava oblasts, while medium values are characteristic of the central, southern, and eastern regions (Fig. 1). However, the species remains scarce in mountainous areas and adjacent districts, despite the fact that animal releases were carried out in these regions in the 1950s [Kolosov & Lavrov 1968].

As of 2013, *N. procyonoides* was being introduced into the territory of the Crimea, where eight individuals were released. It has been suggested that mountainous landscapes may act as a barrier to the spread of the raccoon dog, as dispersal may be influenced by climatic factors (snow depth, duration of snow cover, winter precipitation, and mean annual temperature) [Duscher & Nopp-Mayr 2017]. However, as noted earlier, there are records of individuals of this species being harvested near Sevastopol, which may indicate either the penetration of the species into mountainous areas [Volokh 2014], or alternative pathways of animal arrival (introduction) into the region.

Based on the above data, the key factor is not so much species detection (or the number of such records), but rather the degree of establishment of alien animals in the area [Gómez-Suárez *et al*. 2025]. To assess establishment levels within individual districts and biotopes, we analysed their use of different habitat types. Records were grouped into the following biotope categories: riparian–aquatic, forest, open natural, agricultural landscapes, and anthropogenically transformed territories. The percentage composition of records for each species is presented below (Fig. 2), reflecting ecological affinity and spatial distribution structure.

Most *N. procyonoides* records shown on the map are based on GBIF data; however, it is advisable to supplement these with records from areas where GBIF data are insufficient to represent the species' continuous range. Additional records are provided in the list below:

Chernihiv Oblast: • (1) Koriukivka Raion (former Mena Raion), 51.481850, 32.033507, 05.2021, skull in a hunter's collection (hunter's data).

Poltava Oblast: • (2) Kremenchuk Reservoir, 49.329644, 32.939690, 2005 [Ruzhilenko 2005]; • (3) Dykanka Forestry and Hunting Enterprise, 49.837812, 34.485358, 02.2025 (hunters' data).

Dnipropetrovsk Oblast: • (4) Dnipro City, Industrialnyi District, the animal was observed within the city, on Yaskrava Street, 48.513481, 35.080874, 25.12.2024 (media data: dnepr.info).

Luhansk Oblast: • (5) Starobilsk Raion, outskirts of Starobilsk City, 49.310137, 38.919095, 2012 (local residents' data); • (6) Alchevsk Raion (former Slovianoserbsk Raion), 20.10.2012 and 28.10.2013, two skulls in the collection of ZMLU

[Lazariev & Filipenko 2023]; • (7) Luhansk Raion (former Lutuhyne Raion), outskirts of Luhansk Airport, 48.408802, 39.340647, 10.2012 and 20.03.2013, two skulls in the collection of ZMLU [Lazariev & Filipenko 2023].

Autonomous Republic of Crimea: • (8) Simferopol Raion, two individuals entered private agricultural land in one of the villages of Simferopol Raion, the animals were captured and transferred to the petting zoo of the Simferopol Children's Zoo, 05.02.2014 (according to the 'Ukraina' TV channel); • (9) Near Sevastopol City, 1980–2004, three individuals of the studied species were taken [Volokh 2014, citing an oral communication by game expert S. Samokhin].

The limited distribution of the raccoon dog in the south-western part of the Crimean Peninsula, particularly near Sevastopol, is likely caused by a combination of unfavourable landscape and climatic factors: mountainous-plateau relief, arid climate, lack of permanent watercourses and floodplain habitats, as well as low representation of dense shrub–reed associations necessary for shelter and reproduction of the species.

Based on an analysis of known *Nyctereutes procyonoides* record localities, the species is characterised by a wide range of utilised habitats (Fig. 2*b*). The largest proportion of records occurs in riparian–aquatic habitats (33.33 %) and forest habitats (27.45%), indicating the predominant role of floodplain and forest ecosystems in the spatial structure of the species' distribution.

The distribution of *Neogale vison* records by habitat type (Fig. 2*a*) demonstrates a clear preference for riparian–aquatic ecosystems within the spatial structure of the species' occurrence. Most records are associated with riparian–aquatic habitats (72.86%), and a similar habitat distribution is characteristic of other European regions, where almost two-thirds of records are linked to watercourses or riparian habitats [Galanaki & Kominos 2021]. The remaining records in Left-bank Ukraine occur in other habitats, with forest habitats accounting for 18.57%, records in open natural habitats—2.86%, agrolandscapes—1.43%, and anthropogenically transformed habitats—4.29%. This distribution indicates the species' narrow ecological specialisation and close association with aquatic ecosystems.

Data analysis showed that the American mink more frequently uses areas along riverbanks and lakes with dense shrub vegetation and rocky shelters. It is also predominantly found in landscapes with a high density of medium-sized rivers, reflecting its need for vegetation cover and access to water and food resources, as previously described for southern Europe [Bakaloudis *et al*. 2024]. A similar pattern is observed in Left-bank Ukraine, where approximately 70% of records are associated with shrub-covered and rocky riverbanks.

Riparian–aquatic habitats indeed play a significant role in the distribution of this species. Studies from other regions of Europe particularly confirm the dispersal of the raccoon dog along large river systems [Popova *et al*. 2017], as well as its active use of wetland habitats in search of food [Pagh 2025]. A considerable proportion of habitat-type records also correspond to open natural habitats (23.53%). Additionally, the raccoon dog frequently penetrates transformed habitats (9.80 %) and agrolandscapes (5.88%).

This distribution of raccoon dog records by habitat type reflects the species' high ecological plasticity and its ability to utilise human-altered landscapes. Such evidence indicates further expansion and population increase, posing challenges for nature conservation [Schally *et al*. 2024].

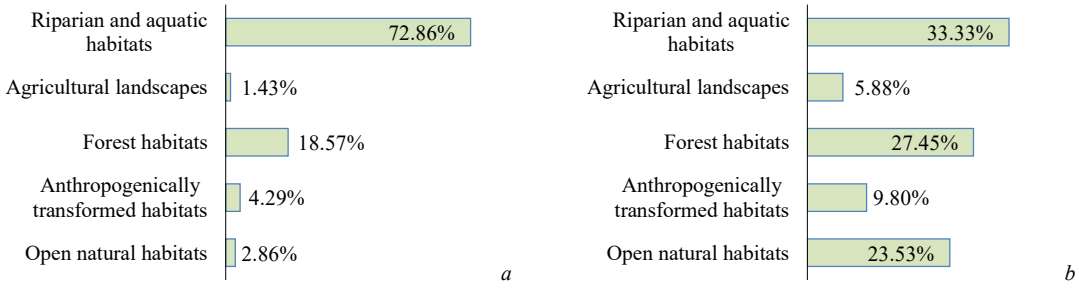


Fig. 2. Distribution of records of the studied species among the main habitat types (percentages): (*a*) *Neogale vison*, (*b*) *Nyctereutes procyonoides*.

Рис. 2. Розподіл знахідок досліджених видів за основними типами біотопів (у відсотках): (*a*) *Neogale vison*, (*b*) *Nyctereutes procyonoides*.

Although most records of the raccoon dog in Ukraine are from natural landscapes, it is noteworthy that the species periodically enters anthropogenically modified areas. Similar behaviour was observed in a study of the species in Shanghai, where spatial distribution modelling showed that the animal actively uses urbanised and human-altered environments [Diao *et al*. 2022]. Such incursions into human settlements increase the likelihood of human–animal contacts, which may have implications for safety and disease transmission.

Thus, the spatial structure of the ranges of *N. vison* and *N. procyonoides* in Left-bank Ukraine differs markedly: the former is characterised by continuous distribution along wetland systems and narrow habitat specificity, whereas the latter exhibits an almost continuous regional range, high ecological plasticity, and the ability to efficiently exploit a variety of natural and anthropogenically transformed landscapes.

Temporal dynamics

The dynamics of abundance and distribution of the studied species were analysed on the basis of official hunting statistics, published literature, and the author's own observations, which made it possible to trace the main stages in the formation and transformation of their populations in Left-bank Ukraine.

Official hunting statistics do not cover all administrative regions where *Neogale vison* populations actually exist. Population data calculated by the author based on form 2-TP (hunting) reports for 2021 are available for Kyiv, Chernihiv, Kharkiv, Donetsk, Luhansk, and Poltava oblasts. For the remaining oblasts, data are either not provided or the population is recorded as 'zero' throughout the observation period.

According to the State Statistics Service of Ukraine, until 2011, the two mink species—the native *M. lutreola* and the introduced *N. vison*—were recorded as a single species under the common name 'free-living mink' ('norka vilna') [Zagorodniuk & Kharchuk 2020]. Given that by that time the introduced species had displaced *M. lutreola* from many areas or the native species' numbers had significantly declined, it can be concluded that the majority of animals recorded under the 'free-living mink' category belonged to *N. vison*.

The rate of *N. vison* expansion proved to be lower than that of several other alien species whose spread occurred through deliberate releases into the wild. A combination of publications [Panov 2002; Volokh & Rozhenko 2011; etc.] and data on the acquisition of 'minks' in museum collections indicate an extremely low abundance of *Mustela lutreola*, confirming the dominance of *N. vison* in the so-called 'free-living mink' category at least since the early 1990s. Previous reviews of alien species distribution showed that expansion continues, at least in the eastern regions [Lazariev 2023].

Since 2011, *N. vison* has been recorded separately from the European mink, but the population dynamics of the 'free-living mink' prior to 2011 and the current dynamics of *N. vison* indicate a stable trend of increasing abundance (Fig. 4*a*). Among the few confirmed records of *M. lutreola* in recent decades are registrations in the early 2000s within the Black Sea Biosphere Reserve [Selyunina 2017], and in Luhansk Oblast, Derkul river region [Melezhyk 2015].

As in other regions of Ukraine, population dynamics of *Nyctereutes procyonoides* exhibit a wave-like pattern with a moderate amplitude of fluctuations occurring in 5–10-year cycles. During the period 1982–2012, a gradual increase in the species' abundance was recorded.

According to historical data, in 1966 the population size of *N. procyonoides* in Ukraine reached 13 700 individuals, of which 7515 occurred in Left-bank Ukraine[2]. At the same time, during the 1950s–1970s, annual harvest levels may have reached up to 7000 individuals [Sokur 1961], which had resulted in a substantial decline in abundance by the 1980s [Yevtushevsky 1985]. Subsequent population growth coincided with a decline in demand for fur, creating favourable conditions for population recovery.

[2] Data from the dissertation abstract by Y. Krainev, 'Game animals of Ukraine, ways of their protection and rational use'. Abstract of a Candidate of Biological Sciences dissertation, 1971.

The main population centres of *N. procyonoides* formed in several stages: a north-eastern centre was established in 1935–1941, encompassing Kyiv, Chernihiv, and Kharkiv oblasts, while the southern centre was reinforced in 1948–1953, particularly through the introduction of the species in northern Crimea. By 1949, *N. procyonoides* had colonised river systems and coastal areas of the Sea of Azov region [Woloch & Roženko 2007], and the main directions of introduction and subsequent spread are shown in Fig. 3 [Kolosov & Lavrov 1968].

Analysis of data for the period 1982–2021 [Yevtushevsky 1985; 2-TP (hunting) data] confirms the wave-like dynamics of *Nyctereutes procyonoides* abundance, with peaks occurring every 5–10 years (Fig. 4*b*), a general increase during the 1990s, and subsequent stabilisation throughout the 2000s. In the following decades, no significant fluctuations in the species' abundance were recorded. The positive population trend of *N. procyonoides* is likely associated with its low dietary requirements and its particular position within the guild with *Vulpes vulpes*, *Canis lupus*, and *Canis aureus*, where the latter two species exhibit low levels of distribution and abundance. At the same time, natural conditions and food availability in southern Ukraine are more favourable for *N. procyonoides* compared to the species' native range [Woloch & Roženko 2007].

As noted above, literature data indicate that *Neogale vison* is distributed throughout Left-bank Ukraine [Volokh 2016]. At the same time, there is no confirmed evidence of wild populations of this species in the Crimea. In contrast, *Nyctereutes procyonoides* records have been documented in most raions within the study region; however, analysis of habitat preferences and mapping data indicate that, while individuals of this species favour riparian and forested habitats, they are considerably less common in open landscapes, particularly in dry steppe habitats and semi-deserts (Kherson Oblast, Autonomous Republic of Crimea), as evidenced by the low number of records and reduced abundance in areas dominated by such landscapes.

In summary, both studied species have long established stable, self-sustaining populations in Left-bank Ukraine. The current distribution of *N. vison* is primarily the result of multiple escapes from fur farms and secondary populations, whereas the dynamics of *N. procyonoides* reflect the outcomes of intentional introductions, wave-like fluctuations in abundance, and subsequent population stabilisation. Taken together, these data indicate different mechanisms of range formation and the current status of both introduced species in the region.

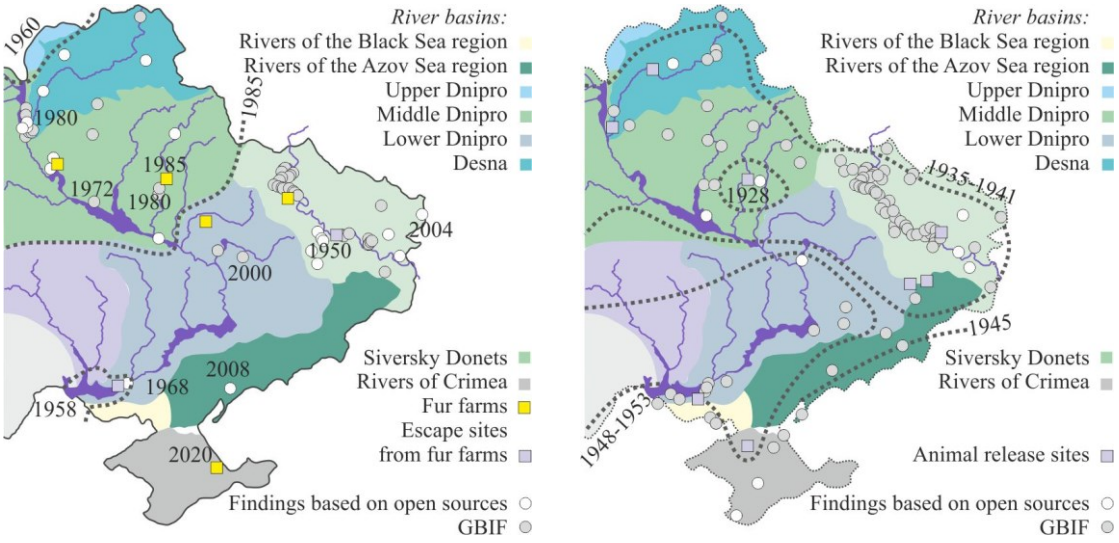
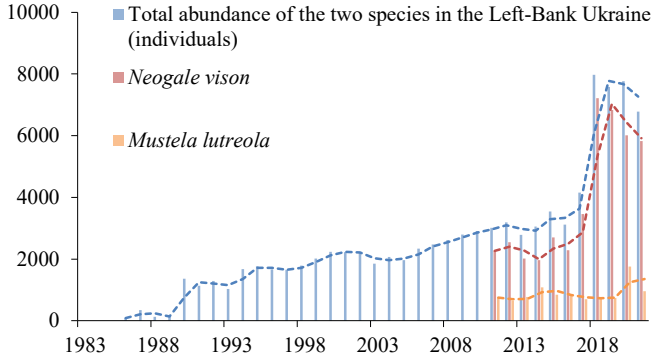
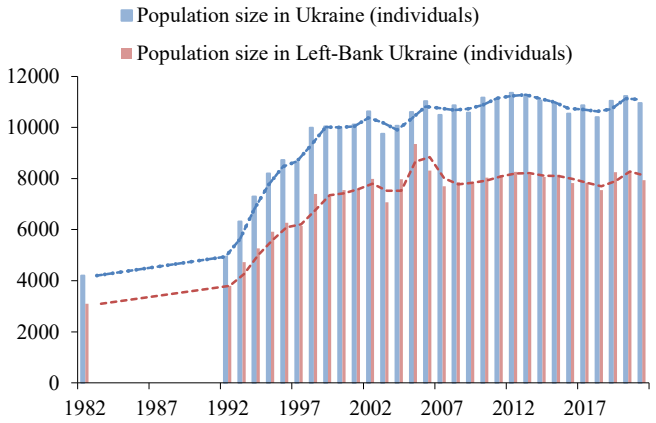


Fig. 3. Temporal dynamics of the distribution of the studied species with consideration of watershed boundaries and major river basins of the region: *Neogale vison* (left), *Nyctereutes procyonoides* (right).

Рис. 3. Динаміка поширення досліджених видів у часі з врахуванням вододілів та основних річкових басейнів регіону: *Neogale vison* (ліворуч), *Nyctereutes procyonoides* (праворуч).



a



b

Fig. 4. Population dynamics of the studied species based on hunting statistics: *Neogale vison* (*a*), *Nyctereutes procyonoides* (*b*).

Рис. 4. Динаміка чисельності досліджених видів за даними мисливської статистики: *Neogale vison* (*a*), *Nyctereutes procyonoides* (*b*).

Discussion

Both studied species entered the fauna of Left-bank Ukraine either through escapes, as in the case of *Neogale vison*, or through deliberate releases from farms, as in the case of *Nyctereutes procyonoides*, and subsequently expanded their ranges independently. For *N. vison*, the key factor driving its spread has been escapes from fur farms combined with the species' high ecological plasticity, which allows it to colonise anthropogenically transformed riparian wetland ecosystems. In addition, the observed rate of range expansion in the 2000s–2010s indicates the species' ability to actively colonise new territories even within transformed landscapes.

The raccoon dog uses a wide range of habitats (forested, open natural, agricultural landscapes, and partly anthropogenic areas), whereas *N. vison* is predominantly associated with riparian environments. These differences reflect distinct landscape-use strategies: *N. vison* exhibits narrow specialisation, ensuring efficient exploitation of resources in river valleys, whereas *N. procyonoides* is characterised by a generalist ability to adapt to diverse food resources and shelter conditions.

Temporal population dynamics reflect different mechanisms of population formation and stabilisation. *N. vison* is characterised by a gradual but stable increase in abundance in many regions, indicating effective colonisation of new wetland territories and secondary foci following escapes from farms. At the same time, *N. procyonoides* demonstrates wave-like population dynamics with periodic peaks every 5–10 years, likely driven by fluctuations in food availability, climatic factors, and the impact of hunting activity. The overall increase in abundance of this species observed in the 1990s–2000s is associated with a decline in fur demand, which led to reduced harvesting pressure and created favourable conditions for population recovery.

From an ecological perspective, *N. vison* exerts competitive pressure on native species, particularly the European mink (*Mustela lutreola*), potentially causing local displacement, population declines, and impacts on waterfowl assemblages in wetland habitats. In turn, *N. procyonoides*, through

its penetration into anthropogenic landscapes and urban ecosystems, potentially increases the risk of human contact and disease transmission, posing a significant epidemiological threat.

The projected dynamics for both studied species suggest stabilisation of abundance under the persistence of current anthropogenic and natural conditions; however, local fluctuations may occur due to climate change, habitat transformations, and interactions with native fauna.

Thus, the current status of *N. vison* and *N. procyonoides* in Left-bank Ukraine reflects a combination of historical anthropogenic interventions, natural expansion processes, and species-specific ecological strategies. The results of this study underscore the importance of monitoring alien species, especially those that may affect local fauna or create epidemiological risks, as well as the need to assess the long-term consequences of their integration into regional ecosystems.

Conclusions

The American mink demonstrates a close association with riverine and riparian–aquatic ecosystems and spreads predominantly along water corridors with rocky banks or banks covered with herbaceous and woody vegetation that provide shelter, whereas the raccoon dog forms an almost continuous range across a variety of habitats, showing a preference for riparian–aquatic biotopes, including both natural and anthropogenically transformed environments.

Analysis of the habitat distribution of animal records confirmed the narrow ecological specialisation of *N. vison* in riparian–aquatic habitats and the high ecological plasticity of *N. procyonoides*, which ensures its ability to effectively colonise diverse landscapes.

For *N. vison*, no confirmed natural populations are known from Crimea; however, the presence of large fur farms and private keeping, with documented cases of escapes, indicates the possible formation of wild populations in the near future.

Although *N. procyonoides* is distributed across all regions, the species avoids dry steppe and semi-desert areas, as evidenced by low abundance or the absence of records in such habitats in Autonomous Republic of Crimea and the Kherson Oblast.

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Declarations

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Conflict of interests. The author has no conflicts of interest relevant to the content of the article.

Handing of materials. The study was conducted in compliance with the requirements of the current legislation of Ukraine regarding work with live and collection material.

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