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Assessing the Establishment of American Mink (*Neogale vison*) Escapees from the Fur Industry in Bulgaria

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Abstract: Mink farming has seen a resurgence in Bulgaria since 2013, and this has led to a high risk of American mink escaping and establishing feral populations. The largest active commercial farm in the country has a capacity of nearly 130,000 animals. The aims of this study were to gather first-hand evidence of the presence of mink in the wild around the farm, assess their level of establishment, and document the native species and local communities for future impact assessment. Surveys were conducted using camera traps within a 3.7 km radius around the farm in the period 2020–2021 at ten stations with 1943 realised trap-nights. Some early signs of the establishment of the American mink in Bulgaria were documented. A large number of registrations was made, as frequently as the Eurasian otter and golden jackal and more frequently than other mustelids in the study area. Mink were observed throughout the two-year study, and escaped mink have been registered in the region as early as 2017. These factors are interpreted as signs of the early stages of establishment. When considering environmental, economic, public health, and social factors, we recommend that mink farming should be banned in Bulgaria and further monitoring and management actions must be undertaken for the individuals in the wild.

Keywords: invasive alien species; camera trap; circadian activity; naturalisation; fur farming; seasonality; invasion pathway; escape from confinement; unintentional release; mammal monitoring

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1. Introduction

An invasive alien species (IAS) that is frequently cited as having some of the largest impacts on native biodiversity is the American mink (*Neogale vison*) (further referred to as "mink"). It was recently renamed, formerly known as *Neovison vison* and *Mustela vison* [1]. The mink has been placed in lists of the most dangerous IAS concerning Europe [2] and Russia [3]. A mustelid native to North America, the mink is a strict carnivore and a generalist and opportunist predator [4]. Like other invasive alien mammals, the mink has been introduced in Europe and other parts of the world via the fur industry [5–9]. Fur farming is its primary invasion pathway, by which it has escaped confinement and established itself in Europe, South America, and Asia [10]. The mink is considered one of the most widespread IAS in Europe [11]. Globally, the mink has established itself in at least 32 countries beyond its native range, with very few regions being free of its presence [12].

The rearing of mink in high densities in mink farms greatly increases the risk of zoonosis and transmitting infectious diseases, such as COVID-19 [13–17], leishmaniasis [18], avian influenza A (H5N1) [19], and toxoplasmosis [20]. The risk of horizontal disease transmission threatens not only humans but also native mustelids and other mammals [21–23]. Once they escape into the wild, the mink's negative impacts on native species also stem from their trophic interactions with them. In Europe, the mink is considered a competitor of the Eurasian otter *Lutra lutra* [24–26], European mink *Mustela lutreola*, and Eurasian polecat *M. putorius* [27]. Simultaneously, their generalist diet also makes small mammals, ground-nesting birds, amphibians, fish, rodents, crustaceans, insects, and molluscs vulnerable to depredation [7,28–33].

In Bulgaria, mink were imported for fur farming in the early 1950s [34], but there is limited information on the scale of operations before the 21st century [35]. Other than the farms, there are records of deliberate acclimatisation and release of mink [34], as well as escapees being found by hunters [35]. There are no records on exactly when these old fur farms closed down, but they might have done so around the same time as coypu fur farms did—in 1989, when socio-economic changes in Bulgaria made this type of business unprofitable [36]. As of 2013, there is a resurgence in mink farming in the country [35]. The largest commercial fur farm has a capacity of nearly 130,000 animals [37]. There are only a few other farms in Bulgaria that have a very limited capacity, especially in comparison to the Madzherito farm [35]. Bulgaria had a peak of 150,000 exported furs in 2021 [38]. Multiple reliable records from local people showed that a large number of animals were found in the nearby villages in the period 1 August 2017–11 March 2019 [35]. The majority of these records were in the vicinity of the mink farm, and the records elsewhere were likely escapees that had migrated further away in search of habitat with less intraspecific competition. However, these published records were only from within human settlements, so there is currently no data on the presence of this IAS in the wild. In light of these and other social and ethical issues [35], the importation and breeding of mink in Bulgaria was prohibited in July of 2022 [39,40]. After only two months, the government that produced the ordinance dissolved and the Madzherito farm owner litigated the ban at the Supreme Administrative Court, and mink fur farming resumed in Bulgaria [41]. As of the submission of this manuscript, the legal case is still ongoing.

As the risks of mink farming are being disputed on a governmental level, there is a great need for a scientific assessment of this issue. We need to know if there are mink in the wild, how many are there, how frequently do they escape, are they forming self-sustaining populations, and what effect are they expected to have on native biodiversity if there are not any impacts already detectable. This kind of information is necessary in order to make the best-informed management decisions going forward. The aims of this study were to gather first-hand evidence of the presence of mink in the wild in the area around the largest mink farm in Bulgaria, assess their level of establishment, and document the native species composition for future impact assessment.

2. Materials and Methods

2.1. Study Area

The largest mink farm in Bulgaria is located less than a kilometre from the villages of Madzherito and Zagore in Stara Zagora District (42.3488, 25.6548). The study area included a radius of approx. 3.2 km around the mink farm. Their average annual dispersal rate is 2–5 km [25,42]. The habitat is heterogeneous. The mink farm itself was assumed to be the source of the mink, as there were no other establishments that kept mink in the area and there was no historic data on the species being there prior to its construction. It is part of a larger animal husbandry enterprise, and mink are fed offal left over from poultry production. Northeast of the farm is the river Sazliyka. Approx. 3.7 km south is the NATURA 2000 site of the same name. Northwest of the farm are artificial fish ponds, and eastward and southward are rice fields with interspersed irrigation channels. North and east of the farm are the villages Madzherito and Zagore, respectively.

2.2. Camera Trap Placement

The locations were defined by their microhabitat conditions and the frequency of human presence: mink farm—the area immediately around the farm, where it was predicted that there would be a high density of recently escaped mink; fish farms—an area of aquaculture farming, where there is high food availability attractive to non-established mink that are not deterred by human presence; irrigation channels—artificially made water courses that are somewhat disturbed by human agricultural activities; and river—the most undisturbed habitat in the vicinity. The cameras (Table S1) were placed consistently at 10 locations called "stations" (n = 10), on animal paths mostly along a water body. This opportunistic approach maximised detection, as they are rarely found beyond 100 m from water [43–45]. The camera traps were checked, i.e., swapped memory cards and changed batteries, on average once a month. The placement of the camera traps was limited by the high risk of equipment theft and the negative perceptions of the mink farm owners towards mink escape investigations. Regarding the limited number of camera trap deployments in the river, the quantity of data suffered from equipment theft and illegal logging.

A total of 57 camera trap placements were made, where between 3 and 7 camera traps were deployed at any one time (Table S2). The study was conducted in the period of 13 February 2020–21 September 2021, during which cameras were deployed for 586 calendar days, though their image capture success was inconsistent (Figure S2). This accounted for a total of 1943 trap-nights, where the timeframe calculated for each deployment was between the date of placement and the date of the last captured image, not when the camera was collected, to account for any technical issues (e.g., depleted battery, full memory) as well as obstacles related to the COVID-19 lockdown during the study period. The cameras took photos and 10 s videos alternatingly. The trap-nights were distributed between the microhabitats as follows: mink farm, 118; fish farms, 1039; irrigation channels, 693; and river, 93. Most of our camera trap deployments were concentrated at the Fish Farms because the equipment was under limited surveillance by being on private land with permission and the presence of the owner. Simultaneously, the fish farms are in an area where the ecological, social and economic impacts of this IAS can be documented.

2.3. Mink Occurrence and Seasonality

Image captures with mink that were at least 5 min apart were labelled as registrations. In order to account for uneven trapping effort, the results were represented as registrations per 100 trap-nights per station. The dependence of mink detection on the distance from the fur farm was also analysed using Spearman's rank correlation test. When noting seasonality, the cut-offs between seasons were taken as the 21 March, June, September, and December, approximately when the solar equinoxes or solstices occur, representing winter, spring, summer, and autumn, respectively. The results are presented as an extrapolation of mink registrations per 100 days of the given season that could be observed with a camera trap, called "trap season days".

2.4. Measuring Circadian Activity

In the wild, mink are crepuscular or nocturnal animals that rest during the daytime in den sites [43]. In captivity, they synchronise their activity with their feeding regimen, i.e., it shifts from nocturnal to diurnal activity [46]. The mink at the farm were fed exclusively during the day. Therefore, if nocturnal activity was prominent in escapees, then this is interpreted as a sign of early establishment. The circadian cycle for each day was determined by the average time the sun sets for each season. Graphing of the hourly circadian activity was achieved using all mink observations, where an observation, for example, within the third hour of the day was noted as any image captured between 02:00:00 h and 2:59:59 h.

2.5. Documenting the Presence of Other Species

All detected animals were manually identified to species, or at least to order in some unclear cases. A list of all detected species was compiled and sorted into classes (mammals, birds, and reptiles) and trophic relationships (competitor, prey, sympatric carnivore, potential prey, and no relationship). Feral cats and dogs were excluded from the data in order to focus on the impacts on wildlife. The competitors of the mink that are still extant in Bulgaria are the Eurasian otter [24–26] and the Eurasian polecat [27,47]. They also compete with the Eurasian mink [27], but it has been extinct in Bulgaria since the early 1950s [48]. The relationship between mink and the golden jackal (*Canis aureus*) is uncertain, as American mink have not been reported to be part of their diet [49], so they were noted as sympatric carnivores. Prey species were defined by having direct evidence in the scientific literature that they have been found in the mink's diet. The additional grouping as potential prey was an attempt to cover the mink's wide-ranging diet that may not have been studied completely. All other detected bird species, except the predatory *Accipiter* sp., *Buteo buteo* and Strigidae, were included as potential prey.

The incidence frequency of every species was calculated as the percentage of days they were present from the total number of trap-nights per station. This information was used to produce species accumulation curves (SACs) and sample completeness curves for each station using the "iNEXT" v.3.0.0 package in R [50,51]. Using the incidence frequency data of all identified species at each of the ten stations, the SACs were computed with 100 bootstrap replications and extrapolated up to 600 trap-nights.

The effects of mink on local fauna were assessed with correlation tests. The number of mink registrations per 100 trap-nights was tested against total species richness and species richness of prey, potential prey, sympatric carnivores, mammals, and birds. Reptiles were excluded due to their rarity in the collected photo materials. The percentage of days occupied by mink during the study was tested against the percentage of days occupied by their competitor, the Eurasian otter, along with other mammals—golden jackals, European badgers (*Meles meles*), beech martens (*Martes foina*), and coypus (*Myocastor coypus*).

2.6. Statistical Software

All formal analyses were performed using R version 4.2.2 (2022-10-31 ucrt) Innocent and Trusting [52] with IDE RStudio 2022.07.2 Build 576 [53] and QGIS 3.22.12 Białowieża [54]. Visualisations were made using the R packages "ggplot2" v.3.4.2. [55], "devtools" v.2.4.5 [56], "ggpubr" v.0.6.0 [57], "ggpattern" [58] v.1.0.1, and "cowplot" v.1.1.1 [59].

3. Results

3.1. Distribution and Occurrence Frequency

Mink were observed in all sampled microhabitats, and there were a total of 123 observations representing 82 registrations (Figure 1; Table S2), which were made on 55 out of 586 calendar days across the entire study area. In terms of distribution between stations, the most mink registered per 100 trap-nights were at Station 1 (n = 11.0), followed by Station 4 (n = 6.8) (Figure 2). No registrations were made at Stations 2, 7, and 8. Due to the uneven sampling effort, no discrete distribution or density data could be provided. With regard to microhabitats, it was most likely to observe mink at the irrigation channels, followed by the area immediately around the mink farm (Table S3).

Figure 1. *Cont.*

Figure 1. Example image captures of American mink (*Neogale vison*) around the largest commercial mink farm in Bulgaria from different microhabitats and times of day. Two are from nighttime (**A**,**B**) and the other two from daytime (**C**,**D**).

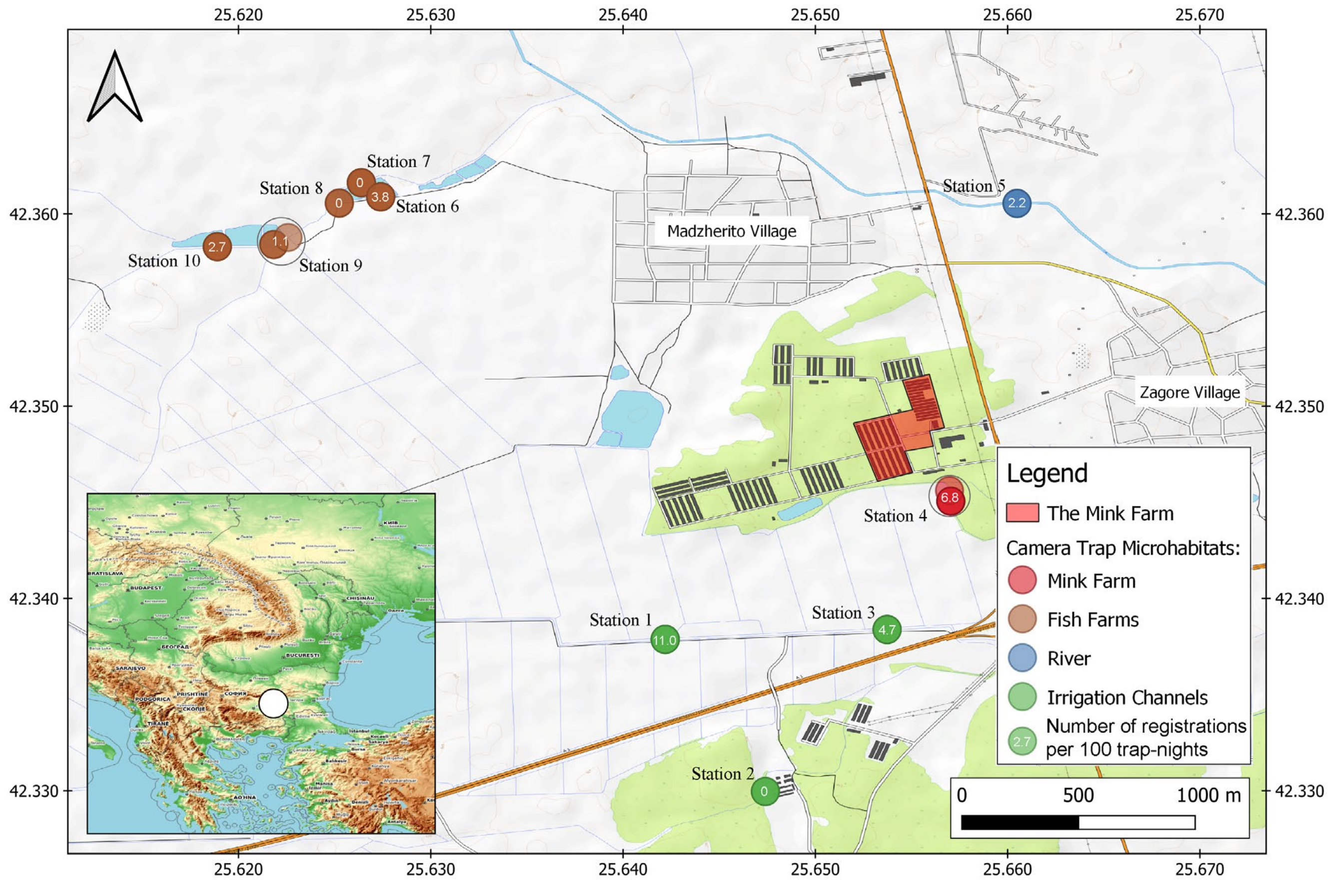

Figure 2. Placement of camera trap stations and their trapping success in the study area around the largest active mink farm in Bulgaria. Trapping success is represented as the number of registrations of American mink per 100 trap-nights. The stations are categorised into four distinct microhabitats based on the immediate environmental characteristics: mink farm (*n* = 5), fish farms (*n* = 31), irrigation channels (*n* = 18), and river (*n* = 3). The camera deployments were regularly placed in the same locations (stations; *n* = 10). An inset map of the study area in the Balkans is shown in the bottom left corner, where the area of the point is not proportional to the actual study area. Base map ©OpenStreetMap OpenTopoMap (CC-BY-SA) and is available at https://opentopomap.org/ (accessed on 7 November 2024).

The number of mink that could have been observed per 100 days could not be predicted by distance from the farm. The distribution of the distances was not normal (Shapiro–Wilk normality test; W = 0.8825; $p < 0.0327$). A non-parametric Spearman's rank correlation test revealed no correlation between registrations/100 trap-nights and distance from the mink farm ($\rho = -0.0957$; N = 57; $p = 0.4791$).

3.2. Circadian Activity and Seasonality

Regarding the minks' circadian activity in the area, it was more likely to observe a mink during nighttime (76.09%) (Table S3). With regard to their total circadian activity, it seems to have one peak during the night between 2:00 h and 3:00 h, followed by another peak around daybreak after 6:00 h (Figure 3). There were also two smaller daytime peaks at around noon and before sunset. Another small peak was observed around midnight. No activity was recorded between 8:00 h and 10:00 h or 18:00 h and 19:00 h. With regard to seasonality, they were most active during autumn and least active during spring, though this may be caused by unequal trapping effort between the seasons. There were only two summer observations, which were made at noon. Peaks seem equivalent between seasons, but some deviation was observed during spring nights, when mink activity would peak only once before sunrise.

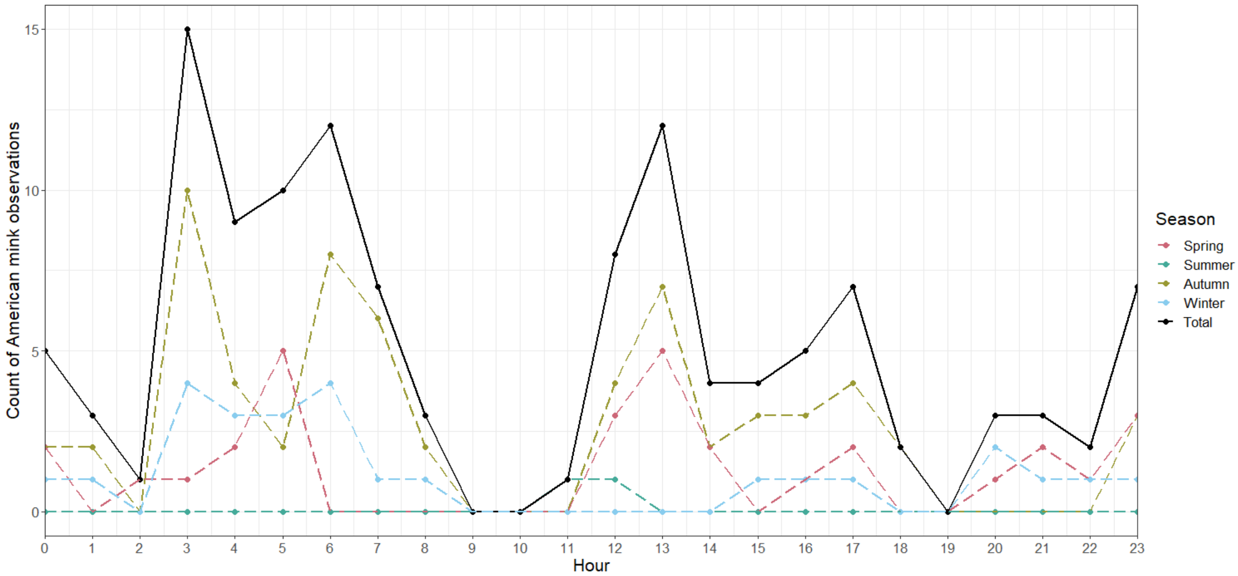

Figure 3. Hourly circadian activity of American mink in Bulgaria, showing total observed (n = 123) and seasonal distribution.

Mink were mostly found during autumn (n = 25.5/100 trap season days), while it was least likely to encounter them during the summer (n = 1.0/100 trap season days) (Figure 4). However, there were no image captures during summer for two of the microhabitats, and there was a great number of images captured at the irrigation channels in autumn, so the overall results for summer and autumn may be skewed by an undefined process or error. There were no observations of mink at the fish farms during summer or at the river during winter, while they could be observed throughout the year at the irrigation channels. The most mink by a large margin were found at the irrigation channels during autumn (n = 60/100 trap season days). The second most likely time and place to find mink was in the vicinity of the mink farm during autumn and winter (same value for both, n = 16.7/100 trap season days).

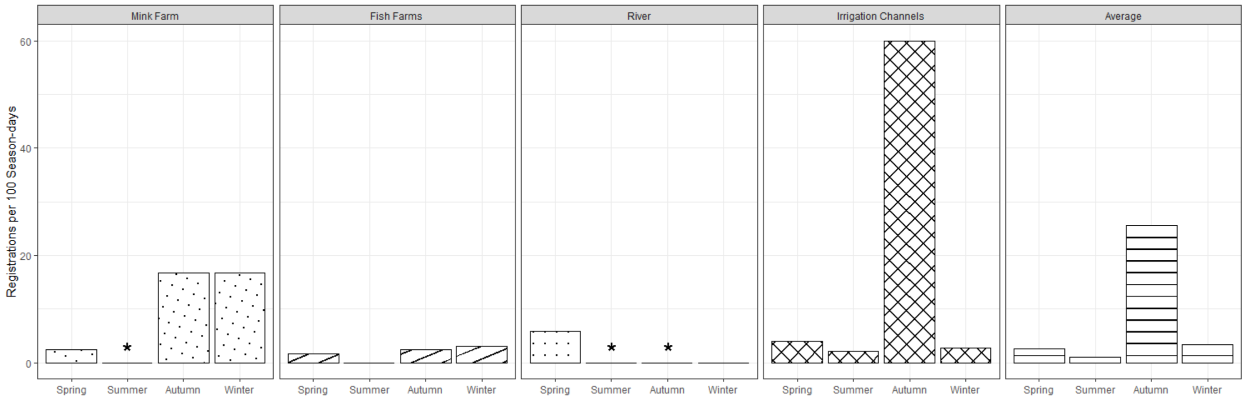

Figure 4. Frequency of American mink registrations at four distinct microhabitats and an average between them across all seasons. Bars marked with an asterisk show where no camera trap data were available.

3.3. Presence of Other Species

A total of 51 taxa were identified in the study area: 34 birds, 14 mammals, and 3 reptiles (Table S4). Of these, 29 are protected under national law, 26 are protected under the EU Habitats Directive, 20 under the Bern Convention, and 10 are included in the Bulgarian Red Data Book. A taxon can be protected under multiple instruments. Of these, 20 taxa were reported in the literature as prey species, 18 were grouped as being potential prey, 9 were sympatric carnivores, 3 had no trophic relationship, and 1 was a competitor species—the Eurasian otter. The highest observed species richness was at Station 1 (29 species; Figure 5) and the lowest at Station 2 (6 species; Figure 5). The sample coverage estimate of the observed species at each station was >85% (Figure 5A,B) and their respective accumulation curves approached asymptotes (Figure 5C,D). Rare species played a significant role in the species composition of most stations.

With regard to the relationship between mink and other observed species in the communities, it was found that mink registrations per 100 trap-nights were positively correlated with total species richness (Spearman, $\rho = 0.69$; N = 10; $p = 0.027$), prey species richness (Spearman, $\rho = 0.83$; N = 10; $p = 0.003$), and mammal species richness (Spearman, $\rho = 0.65$; N = 10; $p = 0.044$) (Figure S2). The correlation between mink registrations and the percentage of days occupied by Eurasian otters was negative but very weak (Spearman, $\rho = -0.13$; N = 10; $p = 0.72$). Correlations with potential prey, sympatric carnivores, birds, coypus, golden jacks, stone martens, and badgers were also not significant ($p > 0.05$).

Across the entire study area, the mink was the sixth most frequently observed animal based on the sum of days it has been observed (n = 55 out of a total of 586 calendar days when cameras had been deployed for the entire study), followed by the otter (n = 60), mallard duck (*Anas platyrhynchos*; n = 72), coypu (*Myocastor coypus*; n = 87), mice and rats (Muridae; n = 147) and Eurasian magpie (*Pica pica;* n = 148). Compared to other mammalian sympatric carnivores, the mink was nearly as frequently found as the golden jackal (*Canis aureus*; n = 54), and it was seen for more days than the stone marten (*Martes foina*; n = 36), red fox (*Vulpes vulpes*; n = 17), Eurasian badger (*Meles meles;* n = 7), and European wildcat (*Felis silvestris*; n = 5). There were no records of the Eurasian polecat, the mink's other extant competitor species in Bulgaria, though this was expected given their range [60].

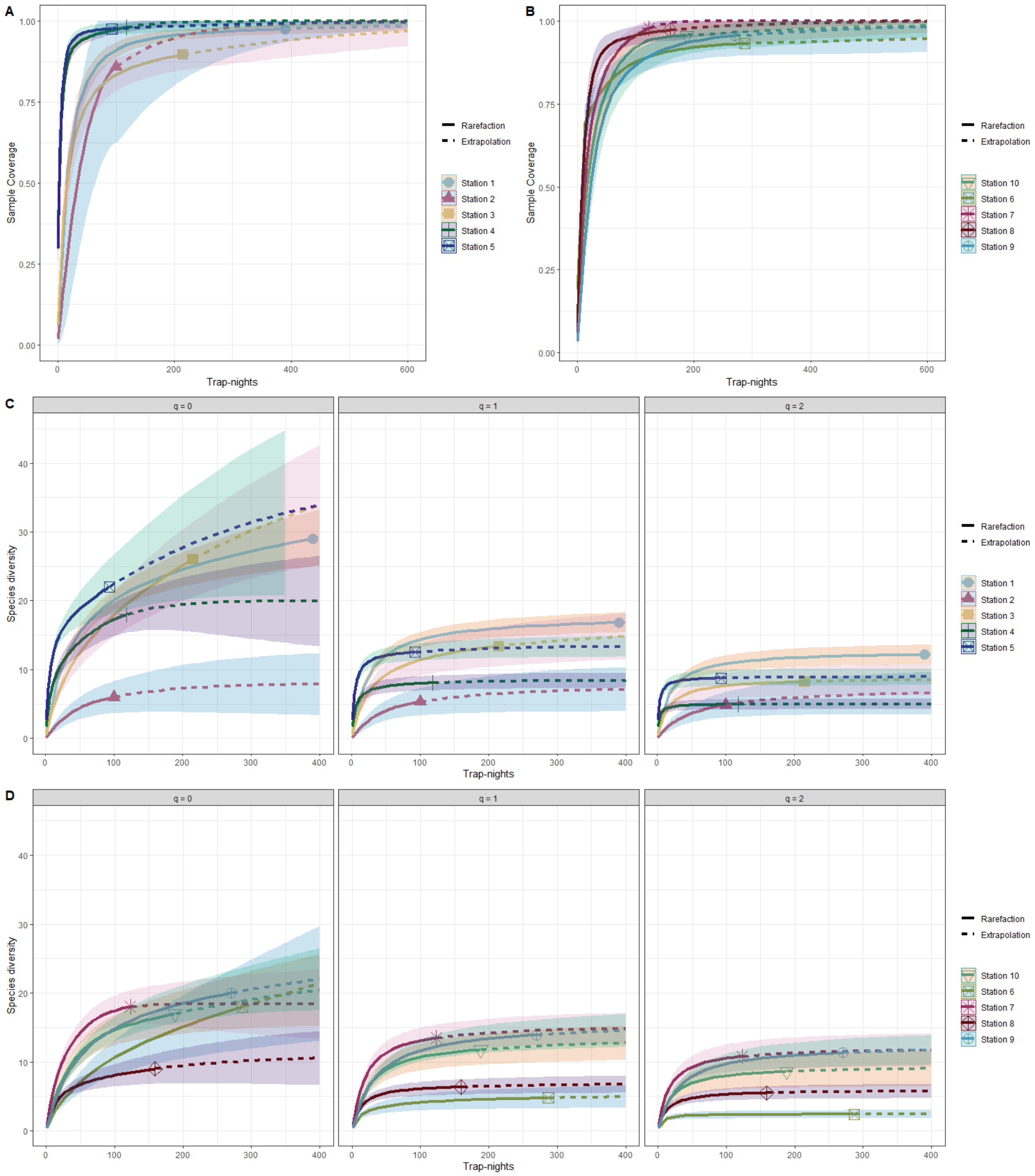

Figure 5. Sample completeness curves (**A**,**B**) and species accumulation curves for Hill numbers 0, 1, and 2 (**C**,**D**) for the observed species richness at camera trap stations (n = 10) placed around the largest commercial mink fur farm in Bulgaria. Only five stations were plotted per graph for clarity. Solid lines represent rarefaction curves and dashed lines—extrapolations. Shaded areas represent 95% confidence intervals.

4. Discussion

4.1. Distribution and Dispersal

From the camera trap survey presented in this study that was carried out in the period 2020–2021, it was found that mink were consistently present in the area around the fur farm near Madzherito Village, Bulgaria. Furthermore, the species has been documented since at least 2017 [35], and there have been nine registrations of mink roadkill casualties in the region on a national database hosted by the Bulgarian Society for the Protection of Birds—SmartBirds.org between 2021 and 2023. Therefore, it is reasonable to conclude that the mink is invading Bulgaria using the unintentional invasion pathway in the category of "Escape from confinement", subcategory "Fur farms" [61,62], and that the farm presents a significant risk for native biodiversity that needs to be addressed immediately.

Mink territories are usually estimated as linear lengths of an occupied riparian habitat and range from approx. 6 km for males and 3 km for females, where a male's territory usually overlaps with that of one or more females [63]. Other papers cite their invasive home ranges to be slightly over 1 km [28]. Therefore, the study area of a 3.2 km radius around the farm could have encompassed several mink territories, but the number of mink registrations was much higher than what would be generally expected. Adult dispersal has been documented to extend up to 6 km and can occur several times per season [64,65]. On the other hand, juveniles have a greater propensity for dispersal, where they are known to travel 10–50 km away from their natal home range during their mating season or in autumn [7,63,66–69]. On a regional level, the mink's average dispersal rate is 2–5 km per annum [25,42]. The frequent escape of mink since at least 2017 calls for future studies that greatly extend the radius of the study area to be able to track the invasion front.

4.2. Seasonal Activity

A high occurrence of mink was observed in the immediate vicinity around the farm in autumn. The high recorded autumnal activity coincides with the mink's kit-dispersal and early overwintering seasons [63,70]. Higher autumnal population peaks were also observed in Greece [71]. Other reports have documented mink populations to be higher in spring rather than autumn [35,63,72], while in the northeastern Iberian Peninsula their activity peaks in winter [73]. This discrepancy may be due to the different sampling methods, or there could be a difference in the mink's population dynamics between the north and south European climates. The observed low activity in summer was likely skewed by reduced trapping effort. The low activity observed during winter may be due to their short fur and high surface-area-to-volume ratio, making mink more vulnerable to low temperatures than native mammals of similar size [74,75].

4.3. Circadian Activity

Mink in Bulgaria showed several peaks in activity, where the largest ones were during the night. The predominantly nocturnal activity is congruent with previous data on well-established populations in Europe [43,64,76,77]. On the other hand, there are also records showing diurnal activity in well-established populations in Spain [75,78], Finland [79], and Slovakia [80]. The multitude of peaks that were recorded here shows some uncertainty in the circadian activity of the mink, which could be due to a large proportion of them being escapees from the farm in different stages of becoming established. However, the mink's circadian activity in its invasive range may need further study.

4.4. Establishment

With the available data, could the mink be considered an established species in Bulgaria? With regard to neighbouring countries, there are established populations in Greece [81,82] and Romania [83,84]. The establishment of the mink in countries north and south of Bulgaria provides some evidence that the country offers a suitable habitat for the mink to establish here as well. The primary evidence of establishment is, of course, reproduction in the wild [85]; however, this can be difficult to observe, including in mink, where neither juvenile mink nor other mammals were recorded during this study. It should also be noted that there is not a universally accepted methodology for determining the level of establishment of IAS [86], and neither has one been developed specifically for the mink. In some cases, indirect evidence is enough to conclude whether the mink is established or not. One method that has been used in countries where the species is believed to have been established is the necropsy of female mink and performing isotope analysis of teeth to determine diet, age, and reproductive status [87]. Other methods have used body length and detection of tetracycline as fluorescent marking of their canine teeth [88].

In the current case, even if the mink are not reproducing in the wild, the effect of the constant flow of individuals in the environment that we have registered is comparable with that of a self-sustaining population. Furthermore, this could also increase genetic diversity and enhance adaptation to living in the wild [88]. The impact could be even bigger as the number of animals is not subjected to natural regulation as if it were a self-sustaining population. The presence of animals for a long period after a fur farm has closed is also considered a sign of establishment [42,83], but in this case, this is not applicable. In some other cases, the mass presence of mink in the region around a fur farm or at long distances away from it without any other farms nearby (16 km) [82] or straightforward survey data are considered definitive evidence for establishment without direct data on reproduction in the wild [81]. In Greece, the species was declared as established after collecting 86 records from surveys in the span of 11 years in a region where 250,000–1 million mink are kept in farms [82].

Several signs for the establishment of the mink in Bulgaria were documented. Firstly, a large number of mink was registered from our observations (n = 82). Secondly, they were found about as frequently as their competitor, the Eurasian otter, and other sympatric carnivores like the golden jackal, and more frequently than other mustelids in the area. Thirdly, the majority of mink observations were made during the night, which was a deviation from their regimen in the fur farm, where they were fed exclusively during the day. Fourthly, they were found in habitats without human presence, suggesting that some have become avoidant of humans in comparison to their daily interactions with the workers at the fur farm [28,77]. Fifthly, the observations were consistent throughout the two-year study. Further considering other occurrence data and that there are reliable observations of females with young in the wild by locals [35], we consider the mink to be in its early stages of establishment in Bulgaria.

4.5. Potential Impacts on Native Species

The diversity investigation was carried out primarily for documentation purposes, as there was no historical data available for comparison to estimate impacts, though some inferences could still be made. The farm itself was in close proximity to a NATURA 2000 site, and it is interesting that there is a tendency for this to be the case in other countries in Southern Europe, but the impacts of escaped mink on these protected areas are largely understudied [82].

Mink have a wide-ranging and adaptive diet, as the components and proportions of animal species or even groups they predate on vary widely in their introduced ranges and between seasons [26,28,30–33,65,89–94]. Their impacts on native fauna can also be rapid and severe [5]. We found that mink prefer habitats with higher diversity of their prey. This result is similar to other conclusions that their distribution is dependent on prey availability [77], though their tendency to prefer greater species richness, in general, may lead to greater impacts on native fauna in the study area and beyond. It must be noted that the documented species assemblages of the observed riparian communities were incomplete as the camera traps could mostly photograph medium-to-large terrestrial species. Therefore, no impacts could be estimated for fish, crustaceans, or amphibians, and most small mammals and reptiles must have also remained undetected. The effect mink would have on every detected native species was not documented in the literature. In order to account for this, we assessed the correlation between mink occurrence and a grouping of potential prey species that did not have direct evidence for depredation by mink in the literature, though it did not show a significant effect. However, it was notable that the majority of the recorded species in the area were protected under multiple pieces of legislation.

The mink's impacts on native fauna have been extensively studied in the water vole (*Arvicola amphibius*). Even after only a few months of the introduction of a single mink, the native water vole population crashed in lowland England [95], but this, of course, was not the only factor that contributed to their decline [96]. Similar rapid outcomes of mink introduction have been documented in Belarus [97]. We found no evidence of water voles, despite their presence being well known in the area [60,98]. This may mean that consequences have already occurred in the region since the first reports of escaped individuals from the Madzherito fur farm in 2017, though it would need to be further researched using other methods.

Apart from being as frequently detected as the Eurasian otter, our data shows that the mink did not have any detectable interactions with it. In the literature, the species are suggested to be antagonistic towards each other [25,26,99,100], where some publications state that the otter even repels the mink by being the stronger competitor of the two because they are larger and more specialised in hunting underwater [24,26]. Other sources provide data that there is limited niche overlap between the two species [28]. Most recently, it has been argued that previously observed effects are actually within expected variation for the species, i.e., there is no causal relationship between otter and mink population variation [70]. The presence of otters may not prevent the establishment of mink; however, avoidance behaviours are performed by mink when otters are present [70].

Another consideration for the potential impacts of the American mink is that it can prevent the return of the European mink (*Mustela lutreola*) to Bulgaria. The European mink is another mustelid competitor to the American mink; however, unlike the otter, it has been proven to be a weaker competitor than its American congener [27,91,101,102]. The spread of the American mink is considered one of the key factors in the decline of the native European mink throughout its range [47,101,103,104]. Their decline is also believed to be influenced by the transmission of the Aleutian mink disease virus from the American mink [22], and the virus is also known to affect other native predators [21,22,105–107]. The European mink has been extinct in the country since the early 1950s [108], and any future plans for its reintroduction would be thwarted if the American mink definitively establishes and spreads in Bulgaria.

4.6. Other Considerations

Mink pose an economic risk to the local fish farms, especially during winter. Similar impacts have been noted in northern Germany [32]. While the otter can be deterred from entering the fish farms using electric fences, this is not applicable for the smaller mink. Furthermore, the impacts on the livelihoods of local people should not be neglected. The fur farm emits a strong pungent odour, and escaped mink kill entire coups of family-owned chickens. These disturbances have affected local people in the adjacent villages to the point that some have emigrated to live elsewhere and housing prices have dropped in the area (Koshev 2019, pers. comms. with locals). Furthermore, rearing mink in high densities poses a significant health risk to both humans and native fauna. Recent examples of the consequences of poor biosecurity at mink fur farms are the permanent cessation of mink fur production in the Netherlands and a temporary stop in Denmark due to SARS-CoV-2 outbreaks in mink and from them into humans [23]. Another major concern for mink for farming is the ethical aspects of rearing undomesticated animals in conditions that are well documented to not satisfy any of the "Five Freedoms" and do not offer a "Life worth Living" [109,110]. The conditions in which mink in fur farms are kept are not in accordance with Council Directive 98/58/EC, which stipulates: "No animal shall be kept for farming purposes unless it can reasonably be expected, on the basis of its genotype or phenotype, that it can be kept without detrimental effect on its health or welfare". All these additional considerations presented here demonstrate that the issue of mink fur farming is multidimensional and requires appropriate and swift management.

4.7. Future Management

This case presents two aspects that require management—the source population of mink within the fur farm and the escaped mink in the wild. With regard to the farm, the owners have stated that they have undertaken all measures possible; however, the evidence presented here demonstrates that either the animals are continuously escaping or they already have viable populations in the wild. Therefore, the limited measures applied by the owners are ineffective, and the best solutions might be the closure of the fur farm and banning mink fur farming in its entirety. While attempts to restrict fur farming on a national level are ongoing [39,111], on a European level, the fur farming and trade sector have impeded the inclusion of the American mink in the List of Invasive Alien Species of Union Concern of the European Union's Invasive Alien Species Regulation № 1143/2014 [12,112]. However, there are attempts at achieving this goal through other means, such as the 'Fur Free Europe' citizen's initiative [113]. The opinions of stakeholders and policymakers on this issue must be better informed from the available scientific literature and reliable reporting on local impacts before any effective solutions can be enacted.

With regard to the escaped mink, we believe that the risk for a population to establish in Bulgaria is significant. Future actions, other than changes in legislation regarding mink fur farming, would include a better understanding of their current extent and further search for signs of breeding [85,87,88], followed by regular monitoring, modelling future spread, and using that information for appropriate trapping [71,114]. Mink monitoring should also be carried out in parallel with monitoring of native species in areas where they are discovered in order to document any impacts. As there is a lack of biodiversity data for this region, the data provided here can be a benchmark. Such actions are necessary for effective management [115]. Furthermore, local people should be educated to identify this species to ensure effective reporting and potentially involve hunters in management actions [42,72,116]. We acknowledge that a potential closure of fur farms may impact the livelihoods of former workers; however, the context involves primarily one large company with few local employees. These risks need to be compared with those posed by fur farming.

5. Conclusions

In this study, we offer evidence that the American mink is constantly present in the riparian ecosystem in the vicinity of the largest commercial mink farm in Bulgaria. We also believe to have observed early signs of establishment, which further calls for immediate action. American mink farming is a major risk to biodiversity and public health, raises serious ethical concerns, and impacts the livelihoods of local people. Measures should be undertaken as soon as possible to prevent further escape and control the escaped mink to prevent the establishment of a viable population in the wild.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ecologies5040036/s1, Table S1: Camera specifications and duration of deployment, Table S2: Table of localities and camera trap success, Figure S1: Camera trap deployment chart, Table S3: Camera trap deployment success per microhabitat, Table S4: Local biodiversity list showing all taxa identified during the study along with the pieces of legislation that protect each taxon. The trophic relationship between each taxon with the American mink is also noted along with the appropriate references, Figure S2 Species relationships correlations represented by eleven scatter plots of Spearman's rank correlation tests between mink registration frequency and occurrences of animal groups and select species. Black dots indicate point data, the regression lines are in black with grey shading for their 95% CI.

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