The arrival of the golden jackal (*Canis aureus*) in the Netherlands

A fact-finding study

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This study was conducted by Wageningen Environmental Research and funded by the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature in the framework of the Scientific Support for Policies research theme "Dark-green terrestrial habitats" ('Donkergroene landnatuur') (project number BO-43-108-040).

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In 2016 the first golden jackal appeared in the Netherlands. This report assesses the European knowledge on the species concerning the ecology, distribution status, legal status and possible consequences for Dutch nature conservation and society.

Keywords: Goudjakhals, Golden jackal, Goldschakal, Canis aureus, ecology, legal status, policy, management, distribution, origin, carrying capacity, behaviour, damage, monitoring, diet

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Confirmation of Team Leader regarding content:

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Foreword & acknowledgements

This document is the fact-finding study 'The arrival of the golden jackal (*Canis aureus*) in the Netherlands'. The report was written by Wageningen Environmental Research and commissioned by the Ministry of Agriculture, Fisheries, Food Security and Nature (Ministry of LVVN). The fact-finding study provides a factual and scientifically substantiated overview of the latest situation regarding golden jackals in Europe and has been written in part to support the policy to be formulated by central government and the provinces. It was originally published in Dutch in 2024 (Lammertsma et al., 2024[1]) and subsequently translated in English.

We would like to thank the Ministry of Agriculture, Fisheries, Food Security and Nature (Ministry of LVVN) for its constructive cooperation in the compilation of this report.

More particularly, we would like to offer our heartfelt thanks to Dr Jennifer Hatlauf from the Institute of Wildlife Biology and Game Management (IWJ) at the BOKU University in Vienna and project manager of the Golden Jackal project in Austria, for her shared knowledge, advice and permission to use illustrations. We also thank Dr John Linnell (Norsk Institut for Naturfoskning, Noorway) and Dr Kent Olsen (Naturhistorisk Museum, Aarhus) for providing information concerning the protected status of golden jackals.

This report has been beautifully illustrated and features several photographs by Han Bouwmeester, www.hanbouwmeester.nl and Marielle van Uitert, www.paralleluniversum.nl and a stunning illustration by Jeroen Helmer, www.ark.eu, for which we offer our thanks!

The authors

[1] https://research.wur.nl/en/publications/de-komst-van-de-goudjakhals-canis-aureus-naar-nederland-een-factf

Summary

The first golden jackal to be observed in the Netherlands was in 2016 and there have since been occasional appearances in the Netherlands. Over recent decades, the species has increased its range naturally from its original habitat in south-east Europe. The Netherlands is currently in the colonisation phase and there is no established population as yet. In the years ahead, the species is expected to extend its range further into Europe and increasingly appear in the Netherlands, potentially leading to more frequent interactions with human interests and (protected) fauna. For this reason, the Ministry of Agriculture, Nature and Food Quality has asked Wageningen Environmental Research to collate the existing knowledge about golden jackals and relate it specifically to the Netherlands, in order to inform society and policy of the current situation and what can be expected in the future.

The golden jackal is a medium-sized canid. Its social structure is flexible and depends on the availability and distribution of food. Golden jackals are social group animals and generally form monogamous breeding pairs that live in a territory with their young (around 2-4) and possibly with the young from the previous year. Dispersal takes place as a result of sub-adult animals who go in search for a partner and a territory of their own. In this process, animals can cover hundreds of kilometres before establishing a new territory. These are opportunist omnivores who show a high level of flexibility in exploiting food sources. In Europe, they mainly consume small mammals (mostly mice) supplemented by farm animals and wild ungulates (both primarily in the form of carrion), and plants and fruit. Although golden jackals are usually solitary hunters, cooperative hunting may occur in small packs of 2 to 4 individuals, enabling larger prey to be caught. Predation of sheep has been observed in various European countries, including the Netherlands. Golden jackals can compete with other carnivores, such as the red fox and mustelids. As a result of predation, there could be a potential (local) impact on populations of mammals, reptiles, amphibians and birds. However, there has so far been no scientific evidence of the golden jackal having any negative ecological impact in Europe. In addition to negative effects on rare species, there could also be a potential (local) impact on more common species, such as geese and (field) mice.

Golden jackals occur in a wide range of types of habitat, both in natural areas and in agricultural landscape rich in cover (small-scale landscape with scrubland and forest). In its use of habitat, the golden jackal appears to have adopted a niche that is slightly more restricted than the red fox and there has been no colonisation of urban areas. The average density varies widely from an average of 1 to 10 territorial packs/100 km^2, with the highest density being 50/100 km^2. In areas where wolves are prevalent, golden jackals appear to become outcompeted. According to modelling, the estimated carrying capacity for the Netherlands is around 1,400 packs in areas of the Netherlands without wolves up to around 800 packs in cases where wolves have already colonised the suitable habitat for them in the Netherlands. The average home range size is also highly variable, ranging from approximately 1-30 km^2. This makes it difficult to clearly ascertain the expected average size of a territory in the Netherlands.

The golden jackal is included in Annex V of the Habitats Directive, which means that the species must enjoy a favourable conservation status in European Union countries. The species is not subject to strict protection in accordance with the Habitat Directive and there is no designation of Natura 2000 areas. In addition, the golden jackal is covered by the basic regime of the Bern Convention and is not considered to be an Appendix II or III species (endangered or vulnerable species). In the Netherlands, the golden jackal is not subject to any specific protection in accordance with the Environment and Planning Act. For that to happen, this would require an amendment to the Living Environment (Activities) Decree, Article 11.54, Annex IX. Its status in Europe varies from protected to unprotected through to (year-round) huntable status. Canids that are closely related to the golden jackal, such as wolves, coyotes and dogs can interbreed and produce (fertile) hybrids. In the early stage of establishment, the chance of hybridisation tends to be mainly at the edge of the distribution area. In cases where hybridisation can be demonstrated, removal (with an environmental permit) is permitted in accordance with the Habitat Directive and the Bern Convention.

Conflicts with human interests may occur as a result of attacks on farm animals and pets, attacks on humans, collision with vehicles and the transmission to humans of zoonoses. Attacks on humans and frequent attacks on farm animals and pets would appear to be unlikely. Golden jackals generally avoid human environments, especially by day. So far, there have been no known golden jackal attacks on humans in Europe. Any problematic situations that may be expected are mainly possible in the case of habituation or conditioning in the process of foraging. Golden jackals that could constitute a problem are individuals that demonstrate excessively bold behaviour towards humans and therefore form a risk of bites, those specialising in pet or farm animals or those that repeatedly attack properly protected livestock.

There is a real risk of vehicle strikes involving golden jackals, but in view of the animal's size and weight, the impact of any collision with a vehicle is unlikely to be significant. There would appear to be only occasional instances of golden jackals actively hunting ungulates. Farm animals are part of the diet, but mostly in the form of carrion. Any (significant) increase in the number of collisions involving ungulates, as a result of pursuit by jackals, would therefore not be expected. Golden jackals can carry a range of zoonoses, with the worldwide list covering more than 190 zoonotic diseases. Most of the zoonoses also occur in foxes and also have low to moderate prevalence in European golden jackals. This means that there will be no additional risk if golden jackals become established in the Netherlands since they would constitute a very limited additional source of infection for humans.

Depending on the situation, preventive measures can be taken against the predation of farm animals. Many of the applicable methods are similar to those used to combat wolves and foxes. In the event of a pack or individual golden jackal causing systematic damage, the option of removing the animal or animals (with an environmental permit) by shooting or capture may be considered. This would also apply in the event of unexpected negative effects on rare species or ecosystems. Any such decisions will be based on the need to safeguard the favourable conservation status of the species. The monitoring of (problem) individuals or packs can be based on information obtained by means of acoustic monitoring, wildlife cameras, tagging and genetic monitoring of carcasses of dead animals, faecal matter and prey, etc.

1 Introduction

The first golden jackal (*Canis aureus)* to be observed in the Netherlands was in 2016 and there have since been occasional appearances. Over recent decades, the species has increased its range naturally from its original habitat in south-east Europe. The Netherlands is currently in the colonisation phase and there is no established population as yet. In the years ahead, the species is expected to extend its range further into Europe and increasingly appear in the Netherlands, potentially leading to more frequent interactions with human interests and (protected) fauna. For this reason, the Ministry of Agriculture, Fisheries, Food Security and Nature (Ministry of LVVN) has asked Wageningen Environmental Research (WENR) to collate the existing knowledge about golden jackals and relate it specifically to the Netherlands, in order to inform society and policy of what can be expected and what potential action may be taken. This information is also of relevance in determining the protected status of the species in the Netherlands.

The aim of this project is to bring together existing knowledge about the golden jackal. This report focuses primarily on information available from Europe based on existing literature and much of this knowledge comes from the habitat in south-east Europe where this species has long been present. Since the situation in the Netherlands is very different from that in these other European countries, for example with regard to the use of land and population density, existing knowledge from other countries cannot be applied directly to the Netherlands. This means that expert assessments are necessary. For this purpose, an international expert, Dr Jennifer Hatlauf from the Institute of Wildlife Biology and Game Management (IWJ) at the BOKU University in Vienna and manager of the Golden Jackal project in Austria[2], was also approached for advice on relevant literature and her ideas on some of the questions relating to what could happen in the Netherlands in the future.

This project aims to answer the questions posed by the Ministry of LVVN, which relate to:
1. The ecology of the golden jackal
2. Its distribution and carrying capacity
3. Its legal status, monitoring and favourable conservation status
4. Potential effects on nature
5. Its behaviour and relationship with humans
6. Damage and management

Photo 1.1 *Golden jackal (Photo: Han Bouwmeester).*

[2] https://www.goldschakal.at/

2 General ecology of golden jackals

This chapter addresses the golden jackal's taxonomic status and aspects relating to the species' general ecology. More specifically, it looks at identification, the social system, behaviour, reproduction, choice of diet and potential related impact on species and ecosystems.

2.1 Taxonomy, appearance and behaviour

Taxonomy and subspecies
Jackals in general belong to the canid family (*Canidae*). In North America and Europe, canids occur in similar ecosystems. In recent centuries, there has been occasional intermixing between ancestors of the modern *Canidae* via the frozen sea straits between North America and Eurasia. This is why the fox and wolf appear very similar on both continents. This may also be the case for the golden jackal (*Canis aureus*) and the coyote (*Canis latrans*) who both share a common ancestor in *Canis edwardii* but have evolved differently on different continents (Flores, 2016).

Within the Canidae family, the golden jackal has the same genus (*Canis*) as coyotes, wolves and dogs, and is more closely related to these canids than to other jackals, such as the side-striped jackal (*Canis adustus)* and the black-backed jackal (*Canis mesomelas*) (Alvares et al., 2019). Historically, as many as 13 subspecies of the golden jackal *Canis aureus* have been described, but a taxonomic revaluation has been conducted in recent years partly based on additional genetic and morphological research (Sillero-Zubiri et al., 2004; Moehlman and Hayssen, 2018; Krofel et al., 2021). For example, recent studies have shown that the African *Canis (aureus) lupaster* is more closely related to the wolf (*Canis lupus*) than to the golden jackals in Eurasia (Rueness et al., 2011; Koepfli et al., 2015; Stoyanov, 2020).

In terms of size, the golden jackal and the coyote bear a strong resemblance (see Table 2.1.1), although coyotes can become slightly larger than golden jackals. The biometrics are similar to those of the red fox, with the golden jackal and coyote being somewhat larger. However, the biometrics of the golden jackal and coyote are different from the wolf. Wolves are considerably heavier. In the light of these similarities in biometrics, it may be that the golden jackal and coyote occupy the same niche in the ecosystem as medium-size predators between the red fox and wolf, but on different continents.

Where possible, this report has taken account of the various subspecies and the information presented concerns the European golden jackal, *Canis aureus moreoticus* (and possibly also *Canis aureus ecsedensis* in Hungary, the subspecies status of which is in some doubt; Moehlman and Hayssen, 2018). However, much of the literature about golden jackals does not refer to the geographic region or subspecies and the different subspecies are not always assessed separately. For example, the behavioural ecology and biogeography of the European golden jackal and *C. lupaster*, previously regarded as an African subspecies and now seen as a species, have therefore not been researched or described independently from each other (Moehlman and Hayssen, 2018; Alvares et al., 2019).

Photo 2.1.1 *Golden jackal (Photo: Han Bouwmeester).*

Appearance and identification
The golden jackal is a medium-sized canid that owes its name to its golden coat (Photo 2.1.1; Figure 2.1.1 and other photos in this report). The colour of the coat can vary significantly with the season from a pale creamy yellow in the summer to a darker tawny in the winter. The underparts are slightly lighter in colour and the coat on the back often consists of a mixture of pale and dark hairs that give the impression of a dark saddle (Moehlman & Hayssen, 2018). Melanistic and piebald (unpigmented spots on a pigmented background) coat variants also exist (Wilson & Mittermeier, 2009). It is often possible to visually distinguish individuals within a population based on their unique pale markings on the throat and chest (Moehlman, 1983). The dental formula is I3/3 (incisors), C1/1 (canines), PM4/4 (premolars), M2/3 (molars) = 42 elements (Wilson & Mittermeier, 2009).

Figure 2.1.1 provides an overview of the other typical characteristics of golden jackals, including the size and pawprint comparison with the red fox and wolf. The legs are relatively long and the soles of the feet relatively small (Wilson & Mittermeier, 2009). The soles of the feet are characterised by conjoined toe pads (Figure 2.1.2).

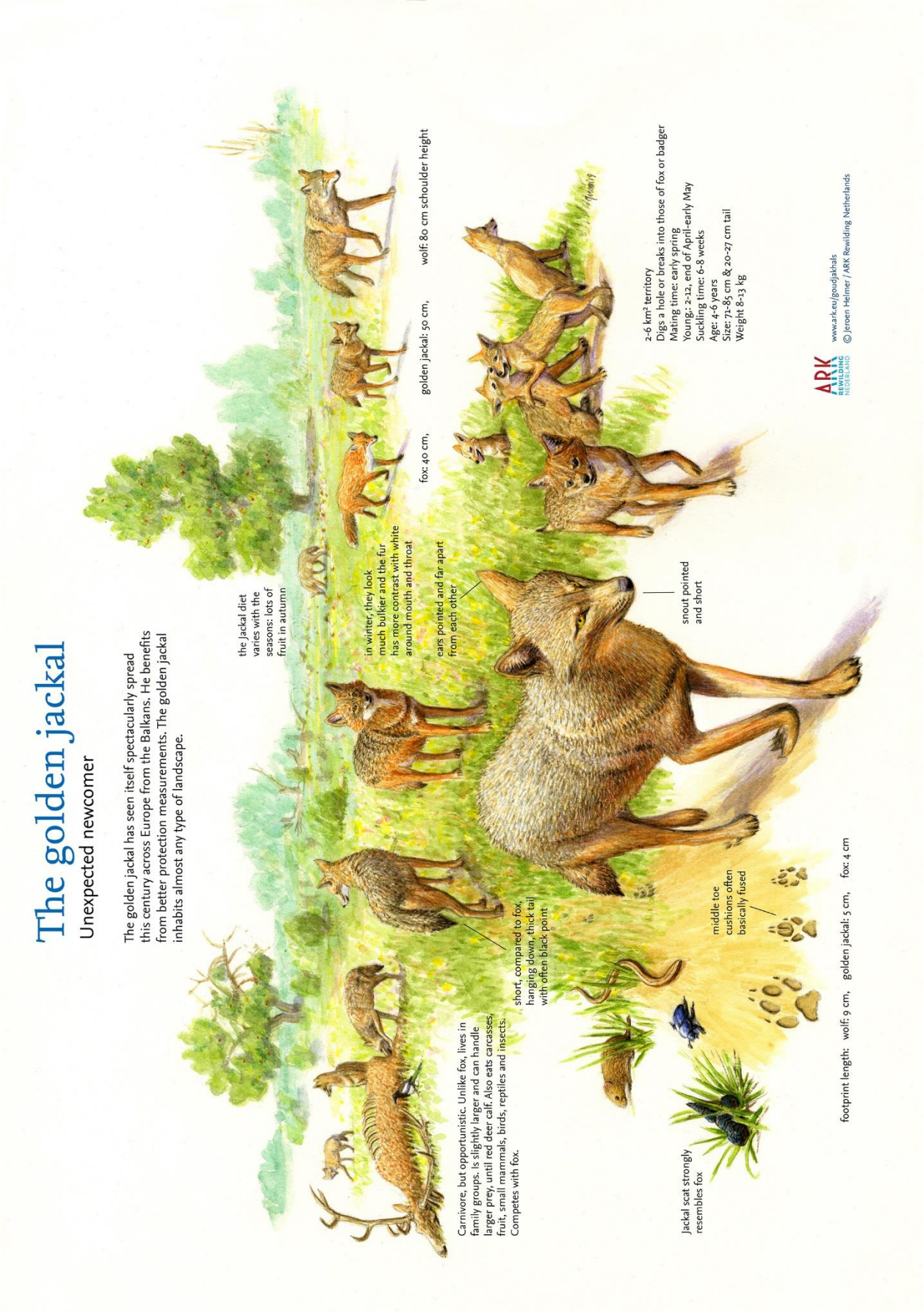

Figure 2.1.1 *Illustration featuring the Golden Jackal including characteristics and tracks (Illustration: Jeroen Helmer, ARK Rewilding Nederland).*

As a typical representative of the Canidae, the golden jackal is not always easy to distinguish from other members of the same family, such as the red fox (*Vulpes vulpes)* and the wolf (*Canis lupus*). With a body/torso length (including tail) of 120-125 cm, shoulder height of 40-50 cm and a weight of 6-15 kg, the golden jackal lies just between these two other related species (Grimmberger & Rudloff, 2009; Table 2.1.1). Hatlauf & Böcker (2021) have compiled an illustration showing the typical characteristics of the golden jackal, red fox and wolf (Figure 2.1.3).

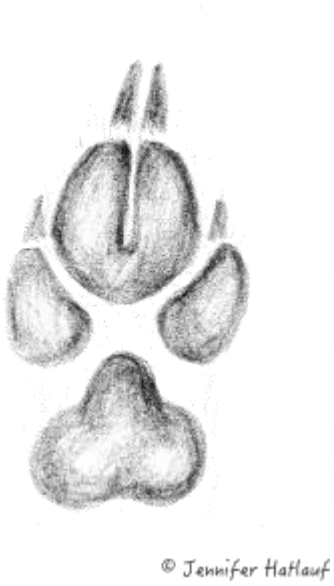

Figure 2.1.2 *Sketch of the sole of the golden jackal's paw with conjoined central toe pads (Hatlauf, 2021).*

One important characteristic that distinguishes the golden jackal from foxes and wolves is its relatively short bushy tail with black tip. At a length of 20-30 cm, this is much shorter relative to the body than the fox's tail, which also has a white tip. These two species can also be distinguished by the colouring on the back of the ears: the golden jackal's ears are unremarkable in colour and do not differ from the rest of the coat on the head, whereas the ears of the fox feature striking black tips. The difference between the golden jackal and the wolf is slightly more subtle, since the wolf's tail is also relatively small and has a black tip. But the tail-to-body ratio on golden jackals tends to be just a little bit smaller than on wolves. However, without a direct comparison, it is still not easy to distinguish between the three species and some experience is required in order to assess and/or confirm observations (from videos, for example) with any reliability. Especially when assessing camera trap footage, including some kind of measure in the background can prove useful in correctly estimating the size of the suspected golden jackal and rule out confusion with the wolf, for example (Tillmann et al., 2020).

Table 2.1.1 *Sizes and weights for the golden jackal, coyote, red fox and wolf in the northern hemisphere (Wilson & Mittermeier, 2009; https://www.lcie.org/Largecarnivores/Wolf.aspx accessed on 12-12-2023).*

Species	Head-body length F (centimetres)	Head-body length M (centimetres)	Weight F (kg)	Weight M (kg)
Golden jackal	74-80	76-84	6-8	7-15
Coyote	74-94	74-94	7-14	7-16
Red fox	45-68	59-60	3-7	4-14
Wolf	87-117	100-130	15-55	20-60

Figure 2.1.3 *Characteristics of the red fox, golden jackal and wolf (Hatlauf & Böcker, 2021).*

Behaviour and reproduction of golden jackals

Golden jackals have an extremely flexible social structure which depends on the availability and distribution of food. Like wolves, golden jackals are social group animals and generally form monogamous breeding pairs that live in a territory with their young (around 2-4) and possibly with the young from the previous year (Stoyanov, 2012; Moehlman & Hayssen, 2018). Although primarily active at night, their pattern of activity is flexible and can be adapted according to the circumstances, such as the location or season. Within the group, social behaviour includes ceremonial greeting when members of the pack reunite, grooming and howling in chorus. Territorial animals use urine to mark higher-lying places, such as bushes and trees, and both males and females lift a rear paw when marking their territory (Moehlman & Hayssen, 2018). Tagging data has shown that packs mark and defend a core area around the location of the den. Territorial golden jackals can easily be triggered to howl, which can be used to demonstrate their presence when monitoring (Wilson & Mittermeier, 2009).

Just like their social structure, the timing of golden jackals' reproduction is also flexible and oestrus cycles can occur throughout the year (Alderton, 2004). The mating season varies within the distribution area and is timed to coincide with the peak in food availability (Wilson and Mittermeier, 2009). In Europe, reproduction

generally starts in January-February. The mating season can last beyond February, but it lessens in intensity (Vlasseva et al., 2020). The young are born from early April to the end of May (Böcker et al., 2022; Pecorella et al., 2023). The maximum number of pups per female is nine, and the average litter is 5-7 young, but 40-50% often fail to survive the first few months (Vlasseva et al., 2020; Wilson & Mittermeier, 2009). The nursing period is around 6-8 weeks. The sites used for breeding tend to be dens with 1-3 openings, 2 to 3 m in length and 0.5-1 m deep. Non-natural sites, such as embankments and underneath concrete structures, may also be used for breeding. Like other Canidae, golden jackals are able to move the young within the territory, especially if the parents consider the existing breeding site to be dangerous. This can happen as many as five times during the first three months (Alderton, 2004).

If present, the parents and young from previous years (referred to as the 'helpers') all contribute to collecting food and defending the pups. During the pregnancy, the male feeds the female. The male and the helper(s) care for the nursing female (Wilson & Mittermeier, 2009). A case was recently discovered where it appears that the litters of two different females were born and raised in the same den (Pecorella et al., 2023). This involved a subordinate female who may have mated with another male before joining the territorial pair's social group. It is not known whether the subordinate female was related to the territorial pair, but it was established by means of camera trap footage that the pups from both litters were cared for jointly by the two females.

Young jackals first leave the den from the age of two weeks. By licking towards the muzzle and wagging their tails, the pups encourage the parents and helpers to regurgitate food for them. From the age of three months, the young join the rest of the pack when hunting, and although clumsy and awkward at the start, they quickly learn. Most golden jackals, especially the males do not become sexually active until their second year.

Mortality
In the wild, golden jackals can reach the age of around 13 and around 16 in captivity (Alderton, 2004). Little is known about natural causes of death. As is the case for wolves and other predators, road traffic is expected to prove to be a key cause of death for golden jackals who share our territory (Photo 5.5.1). In the Netherlands, a golden jackal drowned in a canal with steep shoring (Photo 2.1.2; C3.1). In some countries, there can be significant population management through culling, up to 50% of the population each year (Stoyanov 2012; see C6.1).

Photo 2.1.2 *Dead golden jackal in the Ter Apel canal, 16 February 2023 (Photo: Dierenambulance Groningen).*

Dispersal and migration

As in the case of the wolf, dispersal takes place as a result of sub-adult animals who go in search of a partner and a territory of their own (Böcker et al., 2022; Lanszki et al., 2018). In this process, animals can cover hundreds of kilometres before establishing a new territory. Lanszki et al. (2018) identified a dispersion distance of 61 km, with a total distance covered of 224 km, in the case of a tagged one-year-old Hungarian female. In late November 2023, a tagged golden jackal in Slovenia covered more than 1,000 km, overcoming several mountains in the process and has now arrived in Austria (Photo 2.1.3)[3]. Since the animal has yet to establish a territory, this dispersal distance could increase further. Not all animals cover such large distances when dispersing. Individuals can apply a different strategy and show little or no dispersal behaviour, instead waiting on the edge of an established pair's territory until an alpha animal dies in order to take its place (Csanyi et al., 2023).

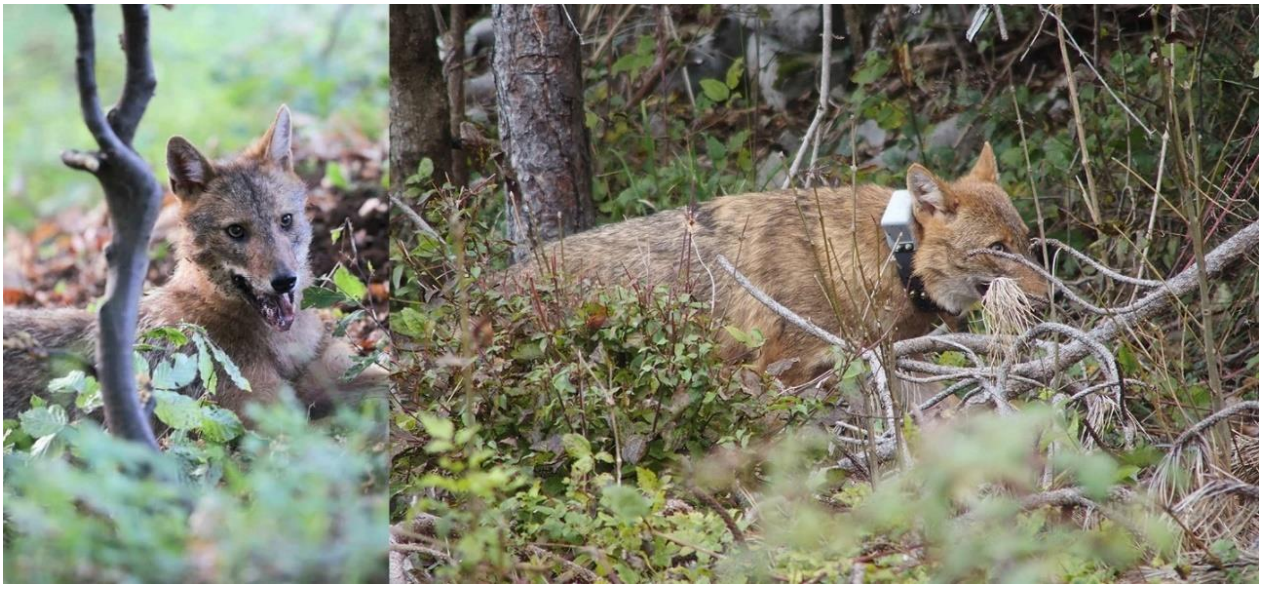

Photo 2.1.3 *Tagged golden jackal 'Maj'. A GPS collar transmitter was attached to this golden jackal captured in Slovenia to enable dispersal and use of terrain to be studied[2] (Photo: Jennifer Hatlauf (left), & Hubert Potocnik (right)).*

2.2 Diet and hunting: what do golden jackals eat?

Diet

The diet of golden jackals varies according to the season and the supply of food in the area in which they live (Tsunoda, & Saito 2020). These are opportunist omnivores who show a high level of flexibility in exploiting food sources (Wilson & Mittermeier, 2009). Lange et al. (2021) reviewed the European literature concerning the diet of golden jackals: they generally mainly eat small mammals, which make up an average of 54 +/- 32% of their dietary intake in terms of biomass. These are mainly mice and voles, as well as shrews, moles, muskrats and rats. Other foods include farm animals (17 +/- 28%), wild ungulates (11 +/- 12%) and plants & fruit (10 +/- 11%), supplemented by birds (3.8 +/- 8.1%) and hares/rabbits (1.4 +/- 3.9%). The diet also includes invertebrates, fish, reptiles, carnivores and amphibians, with percentages below 1%. It should be noted that farm animals and ungulates are mainly consumed as carrion and jackals do not generally hunt and kill these animals (Photo 2.2.1). It is estimated that golden jackals in Serbia consume more than 3,700 tonnes of animal waste products (carrion) and more than 13.2 million rodents and vermin (Ćirović et al., 2016).

[3] https://boku.ac.at/universitaetsleitung/rektorat/stabsstellen/oeffentlichkeitsarbeit/themen/presseaussendungen/presseaussendungen-2023/28112023-ein-goldschakal-auf-wanderschaft-gluecksfall-fuer-die-forschung (accessed on 7 December 2023).

Although small mammals are the main source of food, farm animals can sometimes account for 62-78% of the biomass in the diet, especially in areas where these are (illegally) dumped (Lange et al., 2021). The ungulates consumed are mainly dead animals (natural death, roadkill, culled animals, etc.) and entrails left in nature following evisceration (Lange et al., 2021; Lanzki et al., 2016). However, the predation of sheep by golden jackals recently revealed by means of genetic research shows that this is not always the case. Sheep predation has also been observed in Germany, Denmark and Italy (Hatlauf et al., 2021). Packs can also demonstrate active hunting behaviour, pursuing the young of wild boars and wounded ungulates (Lanzki et al., 2016; Lange et al., 2021).

Photo 2.2.1 *Golden jackal in conflict with a white-tailed eagle over a piece of carrion in Eastern Europe (Photo: Han Bouwmeester).*

The proportion of the different items in the diet depends on the supply, which varies throughout the seasons. In the summer and early autumn, more plants (mainly fruit) are consumed and mainly rodents in the late autumn. Ungulates are generally included in the diet in winter and spring. Farm animals (carrion) and other organic waste (supplementary food given to ungulates, washed-up dead fish, etc.) are mainly eaten in the winter when other sources of food are in short supply (Lange et al., 2021; Kojola et al., 2023).

Hunting

Golden jackals are generally solitary hunters, as a result of which most of their prey is small. Individual animals usually hunt by stalking, listening for rodents etc. in the grass and then pouncing. They also dig out prey from their burrows in the ground. It has also been established that they will sometimes take on sick farm animals that weigh 4-5 times as much as a golden jackal. In Europe, the largest prey that they are able to take on in the wild are red deer calves (*Cervus elaphus*; Boskovic et al., 2013). Although golden jackals are generally solitary hunters, cooperative hunting in small packs of 2-4 individuals is often more successful and makes it possible to obtain larger prey (Sillero-Zubiri et al., 2004). There have been cases in which several family groups hunt cooperatively. However, this only occurs when a population reaches high densities (Markov, 2012). Hunting as a group would appear primarily to provide safety, since foraging tends to be a case of 'everyone for oneself' (Ballmer, 2015) While foraging, golden jackals can easily cover distances of 12-15 km (Wilson & Mittermeier, 2009).

2.3 How are golden jackals expected to affect the ecosystem?

The golden jackal's recent colonisation of new habitats within Europe could in theory lead to other small carnivores, such as martens (*Martes martes, Martes foina*) and red foxes (*Vulpes vulpes*), being outcompeted by the golden jackal (Lanszki et al., 2006; Tsunoda, 2022). Competition may emerge indirectly (for food) or directly (as a result of aggression, killing). Tsunoda (2022) conducted a literature review on the overlap in the use of terrain and choice of food between the golden jackal and the red fox in Eastern Europe. The golden jackal's food niche overlaps significantly with that of the fox. Both species are omnivores and forage for small mammals, invertebrates, fruit and mammal carcasses. The temporal niche also overlaps, since both species forage primarily at night. This means that golden jackals could compete with foxes if they occur at the same time in the same area. It is known that fox populations respond to persecution and food competition by increasing the size of the litter and the number of females that reproduce. A case of increased reproduction capacity in foxes in response to sympatric populations of golden jackals (i.e. living in the same area) has been described in Vlasseva et al. (2020).

Because, as apex predators, wolves can have an impact on the prevalence of golden jackals through competition and facilitation (carcasses that can serve as a source of food for smaller carnivores), any potential effects of the golden jackal on smaller carnivores may differ between habitats with and without wolves (Stoyanov, 2012; Krofel et al., 2017; Männil & Ranc, 2022; Tsunoda, 2022). Spatial separation of species on an intricate scale within the home ranges and temporal variation in the choice of diet would appear to be the key factor for the occurrence of several carnivore species sharing the same area (Lanszki et al., 2016; Torretta et al., 2021). Species such as the golden jackal, stone marten and red fox are opportunist generalists that are unlikely to represent an ecological obstacle for each other because of their wide food spectrum (Miller et al., 2001). However, it does appear that raccoon dogs are in the process of being outcompeted by jackals in Estonia (Männil & Ranc, 2022).

As a result of predation, there could be a potential impact on populations of small mammals, reptiles, amphibians and birds. In addition to predation by other species such as foxes, grassland birds and eggs could also fall victim to the golden jackal. In Estonia, predation has been observed involving the nests of northern lapwings (*Vannellus vanellus*) and common redshanks (*Tringa totanus*) (Männil & Ranc 2022). The impact on these bird populations is unknown. Interactions between predators and their prey are complex and depend on the population dynamic in space and time within a food web. While predation and disruption by jackals may have negative effects, it is possible that predation by golden jackals will simply replace predation by foxes and raccoon dogs, resulting in no effect on balance or even a positive impact.

Rare small mammals, such as hamsters (*Cricetus cricetus*), could experience negative effects as a result of the golden jackal alongside predation by other carnivores. This is not inconceivable; European edible and hazel dormice have been shown to be part of the golden jackal's diet (Lange et al., 2021; Juškaitis, 2023). In this, it should be borne in mind that it is not predation alone that plays a negative role in the effect on the populations of prey animals, but also other factors such as land use (intensive agriculture; La Haye et al., 2020). However, most of the golden jackal's diet is made up of common small mammals, and mainly includes species of mice that are common (*Microtus* and *Apodemus* species) (Lange et al., 2021). Birds, lagomorphs and herpetofauna account for a very limited share of the diet only and any large-scale impact on the species groups would seem unlikely (Stoyanov, 2012; Lange et al., 2021). Moreover, opportunist predators rarely disrupt the diversity in ecosystems, because they switch between the most abundant types of food, which should apply to the golden jackal in the same way as it does to the closely-related coyote (Miller et al., 2001; Lange et al., 2021; MacCracken & Hansen, 1987). However, there has so far been no scientific evidence of the golden jackal having any negative ecological impact in Europe (Hatlauf et al., 2021).

In addition to negative effects on rare species, there could also be a potential (local) impact on more common species, such as geese and (field) mice (Ćirović et al., 2016). This is a case of positive frequency-dependent selection (FDS) of prey species. Since golden jackals are capable of consuming large quantities of field mice (>20 kg, or 400 mice) per golden jackal per year in a territory of 1-12 km^2; Lange et al., 2021), they could have a moderating effect on field mice population fluctuations, thereby potentially reducing pest infestations in agriculture. Negative selection of rare species can also occur. In Australia, foxes and dingoes

continue to predate rare species (Sheldon et al., 2023). When golden jackals were culled en masse by poisoning in Israel, this was followed by a significant increase in the number of venomous snake bites. When the cull of golden jackals was discontinued, the number of jackals increased and the number of venomous snake bites fell (Alderton, 2004). Because golden jackals eat a lot of carrion, they can serve as a kind of 'health police', making it less easy for animal diseases and zoonoses to spread. This is what we refer to as a 'nature-based solution'.[4]

Photo 2.3.1 *Golden jackal sees off a magpie from a carcass (Photo: Han Bouwmeester).*

[4] https://www.iucn.org/our-work/nature-based-solutions

3 The arrival of the golden jackal: past, present and prospects for the future

This chapter looks at the historical distribution of the golden jackal in Europe, the recent expansion of its range in Europe and the situation in the Netherlands. It includes an assessment of the current situation and an outline of prospects for the future in the Netherlands. This focuses on the question of where there are potential opportunities for golden jackals to establish themselves in the Netherlands and what densities and numbers can be expected.

3.1 Original and current distribution

History and trend in Europe

Golden jackals are widespread in North and East Africa, Europe, the Middle East and Central and South-east Asia (Moehlman & Hayssen, 2018). The European subspecies, *Canis aureus moreoticus*, was originally most prevalent in south-east Europe, but in the second half of the nineteenth century, it expanded its range into the south-eastern Balkans (Trouwborst et al., 2015; Spassov & Acosta-Pankov, 2019). In the twentieth century, this expansion continued (Arnold et al., 2012). Established, self-sustaining populations now occur in most of south-east Europe and parts of Eastern and Central Europe. Its range of distribution encompasses Albania, Armenia, Austria, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Greece, Hungary, Italy, Kosovo, North Macedonia, Moldova, Montenegro, Romania, Russia, Serbia, Slovenia, Turkey and Ukraine. The species continues to spread further and has been observed in Belarus, the Czech Republic, Estonia, Germany, Denmark, France, Norway, Latvia, Lithuania, Poland, Slovakia, Switzerland, Finland, Liechtenstein and the Netherlands (Figure 3.1.1; Spassov & Acosta-Pankov, 2019, s*upplemented by Felix Böcker*; Trouwborst et al., 2015; WUR, 2016; Böcker et al., 2022; Hatlauf et al., 2021). For the first time, there is recent evidence of reproduction in Poland, the Czech Republic, Germany and Estonia, raising expectations that it is only a matter of time before there is also an established population in these countries (Hatlauf et al., 2021; Böcker et al., 2022). *Additional comment, March 2025: In 2024 an update of the large carnivore distribution in Europe was published (Kaczensky et al., 2024)*[5]

[5] https://lciepub.nina.no/pdf/638672209981921829_2024_11_14_Large_Carnivore_range%20and%20population%20estimate%20update%202017-2022_1.2.pdf.

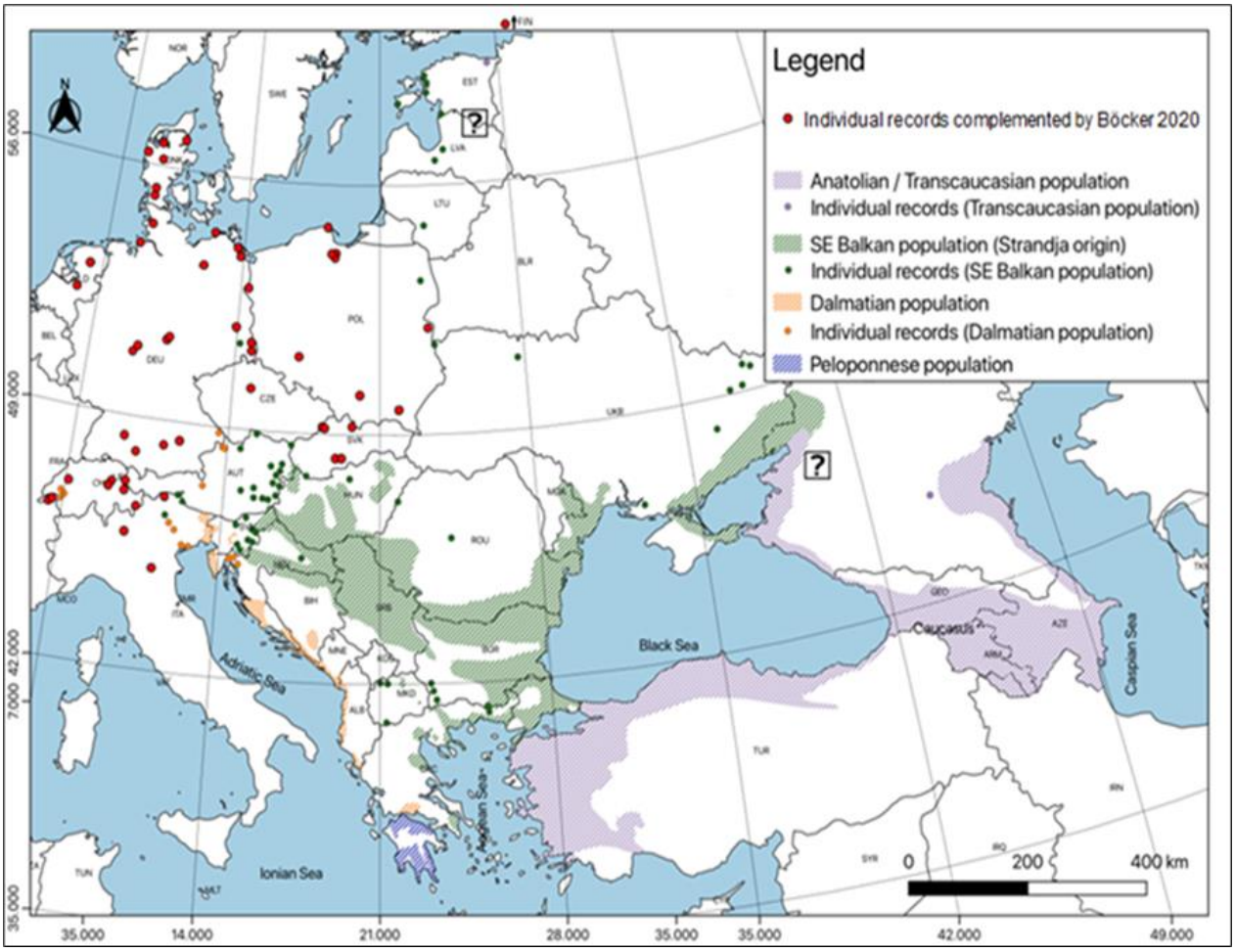

Figure 3.1.1 *Distribution of the European golden jackal (Canis aureus moreoticus) at the end of the twentieth to the start of the twenty-first century (Spassov & Acosta-Pankov, 2019, supplemented by Felix Böcker).*[4]

Background to continued expansion

There are several factors that may be instrumental in the expansion of the golden jackal. One potential cause that is often cited is the historical persecution, often leading to its disappearance, of the wolf in (parts of) Europe. The resulting lack of a larger predator at the apex of the food chain can lead to a so-called mesopredator release, which means that numbers of medium-size carnivores, such as the golden jackal, are no longer limited by the presence of a strong competitor and natural enemy (Krofel et al., 2017). A second factor that may contribute to the increasing distribution area is climate change and the rising average temperatures it is causing. This is because golden jackals do not seem to be adapted to colder environments with long-term snow cover (Jhala & Moehlman, 2004; Spassov & Acosta-Pankov, 2019). The increasingly milder winters with little snow have therefore probably increased the chances of survival of individuals moving around Central Europe and beyond and facilitated their expansion (Tillmann, 2020). However, the recent expansion in the golden jackal's distribution is also happening in areas with harsh winters, even above the Arctic Circle (including Norway, Russia, Finland, Estonia; (Cunze & Klimpel, 2022; Kojola et al., 2023). In Finland, they do seem to be heavily reliant on carrion and bait used for hunting (Kojala et al., 2023), but there may also be some genetic adaptation to cold conditions. Thirdly, changes in hunting and agriculture in several European countries could also have been a factor. For example, golden jackals benefit directly (hunting) and indirectly (carcasses) from increasing numbers of ungulates and wild boar (Spassov & Acosta-Pankov, 2019). This increase in the number of ungulates is caused in part by a move to more extensive farming or even the abandonment of agricultural land.

First observations in the Netherlands

From 2016, golden jackals have occasionally also begun to appear in the Netherlands. The cases so far have involved individual animals (Bij12 Goudjakhals).[6] The very first golden jackal was observed by means of a camera trap in the Veluwe (WUR, 2016, see Figure 3.1.2). A second observation, also via a camera trap, followed in 2017. In 2020, genetic research on dead sheep identified a golden jackal in the Ooijpolder (Gelderland) on two occasions. Determining whether golden jackals play a role in attacks on farm animals has actually become possible thanks to monitoring of wolves, where, in cases of attacks on livestock – with wolves suspected to be the culprit – DNA is collected for research. The genetic monitoring works in the same way as for wolves, with the Senckenberg Institute issuing a unique code for each unique DNA profile. This consists of the letters GG (genetic individual golden jackal), a unique serial number and finally an f (female) or m (male). The animal in the Ooijpolder was male (GG010m). In December 2021, a dead golden jackal was discovered alongside the A28 near Zeist (Utrecht) (GG019m). In two places in Friesland in 2022, sheep fell prey to a golden jackal (GG021m). In February 2023, a dead golden jackal was removed from the canal at Ter Apel (Groningen; GG025m). In accordance with the addendum to the Interprovincial Wolf Plan (IPO, 2023), these animals were investigated in the same way as dead wolves (Photo 3.1.1). So far, there have been twelve observations of golden jackals in the Netherlands included in the national Flora and Fauna Database (NDFF; see Figure 3.1.2). So far all of the four genetically identified individuals were male animals. This pattern, where male animals are the first to appear in new habitat, was also seen when they became established in Austria (Hatlauf, pers. info.).

Figure 3.1.2 *Observations of golden jackals in the Netherlands to date. Map created using QGIS 3.28.8 (Sources: NDFF https://www.verspreidingsatlas.nl/1202809#, accessed on 31-10-2023; BIJ12, 13-11-2023).*

[6] https://www.bij12.nl/onderwerpen/faunazaken/diersoorten/goudjakhals/

Where do the golden jackals observed in the Netherlands come from?
Because the first two observations in the Netherlands were confirmed via a camera trap and not with DNA, it is impossible to say with any certainty which individual was involved. In Germany, individual animals have been increasingly observed since 2007 and since 2014, animals have been observed at a distance from the Dutch border that a golden jackal could easily cover in several weeks or months.

For three of the four male golden jackals identified by genetic research in the Netherlands, it is not possible to draw any firm conclusions regarding their origin. GG019m, GG021m and GG025 were first observed in the Netherlands and are therefore not known from other countries. It is only possible to say anything with any certainty about the origin of the first golden jackal in the Netherlands to be identified via genetic research. This male was given his individual code (GG010m) when he was identified on 18 August 2020 in Mülheim an der Ruhr in Germany via DNA testing on a dead sheep (LANUV, 2023). GG010m remained nearby until the end of August 2020, which was confirmed by analysis of DNA traces on a dead deer calf. A month later, on 25 and 28 September, DNA from GG010m was identified on dead sheep around 80 km away in Kranenburg, approximately 2 km from the Dutch border. A month after that, it was confirmed based on DNA that the same male had since crossed the border with the Netherlands, heading to the Ooijpolder.

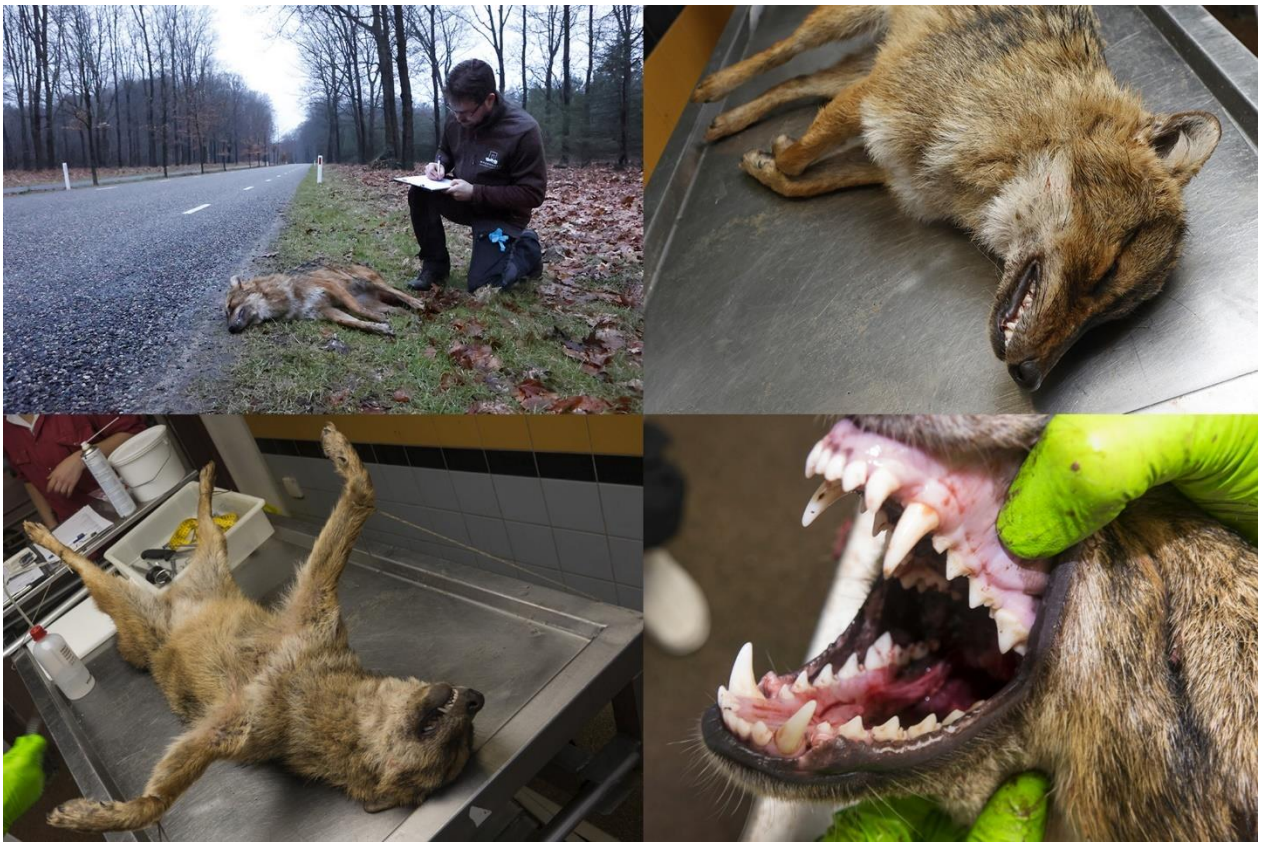

Photo 3.1.1 *Dead golden jackal photo compilation. According to the Addendum to the Interprovincial Wolf Plan (IPO, 2023), dead golden jackals in the Netherlands are treated according to the same protocol as wolves. In practice, this means that WENR researchers study the circumstances at the site where the dead animal was found (photo top left) before taking the animal away. An autopsy is then conducted in collaboration with the Dutch Wildlife Health Centre (DWHC) in Utrecht, with WENR focusing on the ecological aspects and DWHC on the veterinarian aspects. WENR then conduct DNA testing to identify which individual it concerns and whether it has been observed previously (Photos: Marielle van Uitert).*

3.2 Prospects for establishment in the Netherlands

Known habitat of the golden jackal in Europe

There have so far been few studies conducted into the use of terrain and territory size of golden jackals. Golden jackals occur in a wide range of habitat types (Šálek et al., 2014). In the Balkans, the highest densities are achieved in heterogenous agricultural landscapes with sufficient cover (forest, tall herbaceous vegetation and scrubland) and in marshland (Šálek et al., 2014; Fenton et al., 2021), whereas, in Estonia, they occur along the coast or on islands and peninsulas where the vegetation is dominated by grasses, reeds, scrubland and forest (Männil & Ranc, 2022). In areas where agriculture is more intensive and there is less cover (less forest, tall vegetation and scrubland), the density decreases (Šálek et al., 2014). In its use of habitat, the golden jackal therefore appears to have adopted a niche that is slightly more restricted than the red fox, something that has also been observed in Italy (Torretta et al., 2021). Currently, golden jackals have not yet colonised urban areas in Europe, but in view of its plasticity (adaptability) in use of territory, this can probably be expected in the long term, as has happened in the case of foxes (Fenton et al., 2021; Frangini et al., 2022) and coyotes (in North America; Flores, 2016) However, in some cases urban areas are part of the foraging area (Hoffmann et al., 2018). But the question still remains as to whether golden jackals are capable of adapting to urban areas. So far, they have been seen to be more wary than the related coyote (Hatlauf, pers. info.). It would appear that areas where wolves (Canis lupus) are prevalent tend to be avoided (Stoyanov, 2012; Krofel et al., 2017; Männil & Ranc, 2022).

Available habitat in the Netherlands

It can therefore be expected that suitable habitat in the Netherlands will mainly consist of areas with sufficient cover that can serve as a daytime resting place or somewhere to reproduce (such as nature reserves and agricultural landscape rich in cover with (agricultural) grassland, fields, orchards, deciduous and coniferous forest, heathland, dune areas and marshland). These are places primarily found in the east and centre of the Netherlands and to a lesser extent in the west of the country. Alongside the suitability of the habitat in the Netherlands, the climate will also play a role in the likelihood of establishment. Golden jackals do not occur in higher-lying mountainous regions with cold winters and snow cover (Hoffmann et al., 2018; Wennink et al., 2019). Based on the current, ongoing spread of the golden jackal and a range of IPCC climate change scenarios, Cunze & Klimpel (2022) estimate that the Netherlands will not be part of its distribution area up to the end of this century. This prediction may be on the conservative side since point data concerning the recent establishment of golden jackals in Europe were excluded from the model by Cunze & Klimpel and the Netherlands now has very few 'genuine' winters. The recent expansion in the golden jackal's distribution is also happening in areas with a climate that is deemed to be unsuitable (including Norway, Russia, Finland, Estonia; Cunze & Klimpel, 2022; Kojola et al., 2023). The future will tell if this is permanent or just a case of temporary establishment in suboptimal climate conditions. Kojola et al. (2023) have reported that several golden jackals in Finland have survived at least one winter, and one case was even above the Arctic Circle.

Expected numbers in the Netherlands

The average density in the Balkans varies between 1 and 10 territorial packs/100 km^2, with the highest density being 50/100 km^2 (Selimovic et al., 2011; Šálek et al., 2014; Krofel et al., 2023). The wide variation in numbers in the Balkans can be explained by differences in waste processing (Krofel et al., 2023). Organic waste is an important source of food for golden jackals in Eastern Europe and the carrying capacity of an area increases in accordance with the availability of waste. The areas also differ in terms of the amount of forest cover. Areas with a high level of forest cover form the main habitat for wolves, making them less suitable for golden jackals.

The trend in numbers over time is not easy to estimate for the Netherlands. It could take decades before a stage of exponential growth is reached, as was the case in Slovenia (Krofel et al., 2023). It took 60 years for the population to start to grow after the initial establishment and a further 30 years before golden jackals became prevalent. Stoyanov (2012) estimates the speed of growth in an area where there is hunting to be 13% per year for the population in Bulgaria based on the figures for game hunting.

Wennink et al. (2019) have conducted a habitat suitability analysis (HSA) for the golden jackal in the Netherlands. The basic principles they set for this were 1: food is not a limiting factor for the species, 2:

urban areas are not used as a resting place, but are used for foraging at night, 3: the territory of a family group in a highly suitable area is 6 km^2 and in suitable habitat is 12 km^2, 4: although roads serve as barriers, they are not insurmountable and 5: the presence of wolves in an area make that area unsuitable for golden jackals because of predation by wolves.

Modelling was used to determine what constitutes suitable habitat and how many family groups it could support. In the highly suitable habitats in the Netherlands, 150 family groups could live. In suitable habitats, there could be a further 1,200 family groups. Combined with the remaining habitat, the Netherlands could accommodate approximately 1,450 family groups. However, if the habitat suitable for wolves is deducted from that, the remaining habitat for golden jackals could accommodate around 800 family groups (Figure 3.2.1; Wennink et al., 2019). The suitable habitat for wolves was identified by modelling in Lelieveld (2012). According to the authors, the parameters used for the model were conservative, which means numbers could be higher.

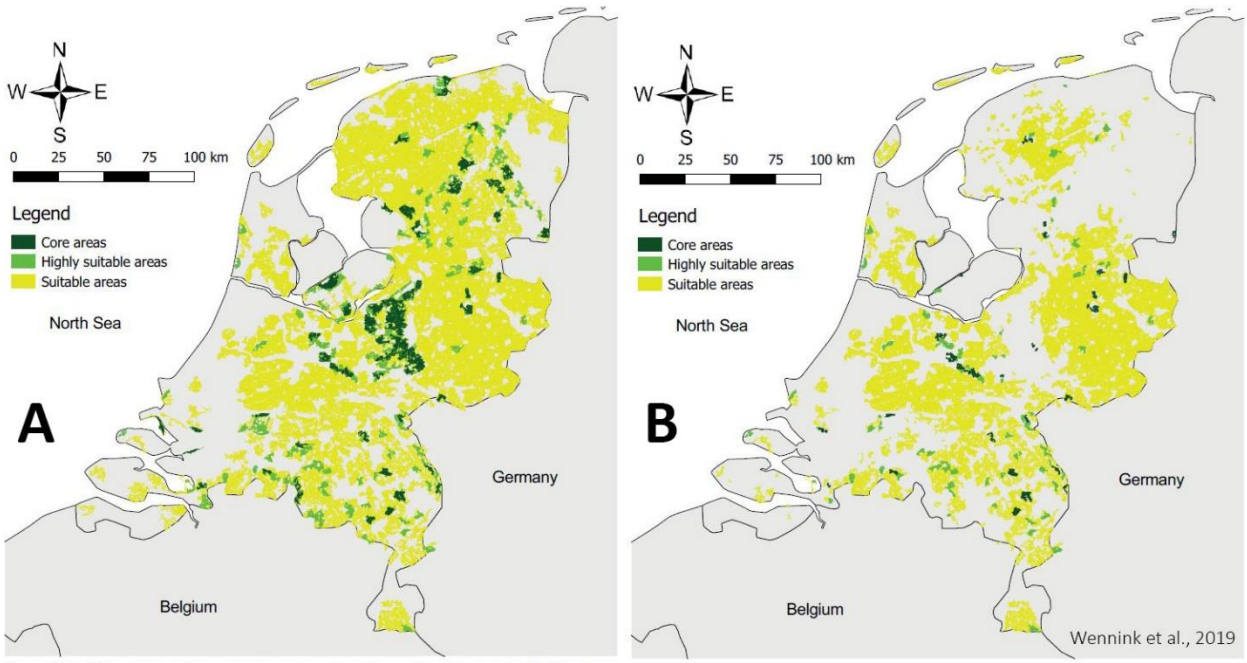

Figure 3.2.1 *Potentially suitable habitat for the golden jackal in the Netherlands, according to modelling in Wennink et al. (2019). The area in green shows the most suitable habitat, divided into the core area in dark green and highly suitable habitat in green. The remaining suitable habitat is shown in yellow. On the left (A) are the model results without the influence of the wolf, on the right (B) is the potential suitable habitat for golden jackals, including the influence of the wolf if wolves have occupied the habitat deemed suitable.*

3.3 Is it possible to draw any conclusions about the average size of a golden jackal territory in the Netherlands?

In Europe, few studies have been conducted on the size of territories (home range). The limited information available would suggest that home range sizes are very variable (Fenton et al., 2021; Frangini et al., 2022), just like the available data on densities (see 3.2). A GPS tagging study involving six golden jackals in Serbia and Hungary showed that the average home range size was 11.2 km^2, with significant differences between individuals of 1.3-32.5 km^2 (90% Kernel; Fenton et al., 2021). Core areas in the home range that were used frequently were often smaller and in many cases less than 3 km^2. During the day, they preferred areas rich in cover and there was only limited movement (300 m/6 hours), with human activity/buildings being avoided. At night-time, larger distances were covered of 1 km/6 hours in more open, agricultural areas close to built-up areas. In Greece, based on three tagged animals with a VHF transmitter, a home range of 2.2 to 15 km^2 was identified (Giannatos, 2005, cited in Fenton et al., 2021). Frangini et al. (2022) identified a

home range size in Italy that matches the study by Fenton et al. (2021). Based on one individual with a VHF transmitter and seven GPS-tagged animals, a home range size was identified for the VHF animal of 0.18 and 1.01 km^2 (50% and 95% MCP). For the GPS animals, an average home range was calculated of 3.24 and 31.22 km^2 (50% and 95% Kernel), with a minimum of 2.22 and a maximum of 135.92 km^2. The animal with the largest home range was a young female that was probably in the dispersal phase. Csányi et al. (2023) report a home range size of 5.8-10.2 km^2 (95% Kernel) for the three GPS tagged animals in Hungary. Wennink et al. (2019) assume that a territory of a family group in a highly suitable area is 6 km^2 and 12 km^2 in a suitable habitat. Differences in home range sizes of settled animals can be explained based on the individual situation of the animals being monitored. Some of the individuals monitored preferred to forage close to urban areas whereas other animals avoided these areas. The limited information from the study area in Italy and Eastern Europe would therefore not appear to lend itself to simple extrapolation to the situation in the Netherlands. Home range sizes of golden jackals are generally highly variable and depend on multiple factors, such as the supply of food and presence of hiding places (Graf & Hatlauf, 2021). The difference in landscape configuration, the supply of food in competition with other carnivores (fox, wolf, etc.) between the Netherlands and the areas referred to above, combined with the golden jackal's high level of ecological plasticity makes it difficult to draw any clear conclusions about the expected average size of a territory in the Netherlands.

Photo 3.3.1 *Golden jackal in Romania (Photo: Han Bouwmeester).*

4 Legal status, monitoring and favourable conservation status

This chapter looks at the legal status of the golden jackal in Europe and the requirements for ensuring a favourable conservation status for the species. This also involves the question of whether hybridisation of the golden jackal with other species may occur, what factors play a role in this and what consequences this has for policy and management. In order to determine the favourable conservation status, monitoring data needs to be collected. For this reason, a global overview of monitoring methods is also presented.

4.1 What is the legal protected status of the golden jackal in Europe?

In recent decades, the golden jackal has independently extended its range. This increasing range is not the consequences of human action (introduction), golden jackals cannot be regarded as (invasive) exotic species and must be regarded as indigenous when countries are (re-)colonised (Trouwborst et al., 2015). The golden jackal is an Annex V Habitat Directive species (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). This designation within the European Union limits the freedom of national governments to determine policy with regard to the species. Annex V status means that member states must ensure that species are maintained in a favourable conservation status. If this favourable conservation status is threatened as a result of certain actions, such as hunting, additional measures will be required. The species is not subject to strict protection in accordance with the Habitat Directive and there is no designation of Natura 2000 areas. Every six years, EU member states must report on the Conservation Status of Annex V species (Article 17, Council Directive 92/43/EEC, 1992).

In addition, the golden jackal is covered by the basic regime of the Bern Convention and is not considered to be an Appendix II or III species (endangered or vulnerable species). This therefore concerns the general protection of species and their habitats. This convention serves as guidance for countries outside the European Union.

Table 4.1.1 provides an overview of the conservation status of the golden jackal in Europe. Interestingly, this national status varies. In several countries, the golden jackal enjoys no protection and killing the animals is not prohibited or regulated. The species is also hunted in some countries. This is permissible for HD Annex V species, taking account of the favourable conservation status (and its monitoring). There is a lack of clarity with regard to the implementation of laws and regulations concerning golden jackals in Europe for many countries where the species is emerging as a newcomer, even within a single country, such as Austria, where policy varies by province (Hatlauf et al., 2021). In Austria, depending on the province, the species is either strictly protected, hunting is permitted in certain periods or hunting is permitted all year round. The status described by Hatlauf in 2021 has since changed in several provinces, with year-round hunting increasingly becoming the norm (Hatlauf pers. info.). Another good example is Estonia, where the species was initially classified as an invasive species before this was later overturned (Männil & Ranc, 2022). Liechtenstein, on the other hand, accorded the species protected status before it even appeared (Hatlauf et al., 2021). In the Netherlands, the golden jackal is not subject to any protection in accordance with the Environment and Planning Act. This would require an amendment to the Living Environment (Activities) Decree, Article 11.54, Annex IX.

Table 4.1.1 *Legal protected status of the golden jackal in Europe (Trouwborst et al., 2015; Hatlauf et al., 2021; Kojola et al., 2023; https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000649682; J. Linnell pers. info.; K. Olsen pers. info.).*

Country	National status	HD	Bern
Albania	Protected	-	Basic protection
Belarus	Unprotected	–	Basic protection
Bosnia-Herzegovina	Hunted	–	Basic protection
Bulgaria	Hunted	Annex V	Basic protection
Denmark	Unprotected	Annex V	Basic protection
Germany	Protected	Annex V	Basic protection
Estonia	Unprotected	Annex V	Basic protection
Finland	Protected	Annex V	Basic protection
France	Unprotected	Annex V	Basic protection
Greece	Unprotected	Annex V	Basic protection
Hungary	Hunted	Annex V	Basic protection
Italy	Protected	Annex V	Basic protection
Kosovo	Hunted	–	–
Croatia	Hunted	Annex V	Basic protection
Latvia	Hunted	Annex V	Basic protection
Liechtenstein	Protected	-	Basic protection
Lithuania	Hunted	Annex V	Basic protection
Moldavia	?	–	Basic protection
Montenegro	Hunted	–	Basic protection
The Netherlands	Unprotected	Annex V	Basic protection
North Macedonia	Protected	–	Basic protection
Norway	Protected	-	Basic protection
Ukraine	Hunted	–	Basic protection
Austria	Variable	Annex V	Basic protection
Poland	Protected	Annex V	Basic protection
Romania	Hunted	Annex V	Basic protection
Serbia	Hunted	–	Basic protection
Slovenia	Hunted	Annex V	Basic protection
Slovakia	Hunted	Annex V	Basic protection
Czech Republic	Unprotected	Annex V	Basic protection
Turkey	Variable	–	Basic protection
Switzerland	Protected	–	Basic protection

- = not applicable; ? = unknown; variable = differs according to area/province.

4.2 What is the likelihood of hybridisation of golden jackals?

The golden jackal and other closely related canids, such as wolves, coyotes and dogs can interbreed and produce (fertile) hybrids. Based on genetic research on wolves in Bulgaria, Moura et al. (2014) found evidence of several cases of hybridisation between wolves and golden jackals. The North American Coyote *Canis latrans* has also been successfully crossed with the Golden Jackal experimentally (Alderton, 2004). Recently, incidental hybridisation has been demonstrated for golden jackal-dog. Galov et al. (2015) studied three canids from Croatia that were probably golden jackal-dog hybrids based on phenotype characteristics. Genetic research showed that hybridisation can indeed happen. One female was a first-generation dog-golden jackal hybrid, one juvenile male was a dog backcross and one male was a golden hybrid backcross. The latter two cases therefore indicate that golden jackal-dog hybrids can produce fertile offspring.

Factors that increase the chance of hybridisation

For the above example, factors that increase the likelihood of hybridisation are the lifestyle of the golden jackal in Croatia (close to human habitation) and the culling of golden jackals during the reproductive season, which causes social bonds to be broken and the remaining golden jackal sets off in search of a different mate (Trouwborst et al., 2015). In addition, many dogs run around freely in Croatia and there are a lot of strays. The fact that golden jackals and dogs differ genetically and so far only three hybrids have been identified would suggest that hybridisation probably plays no significant role in established populations, something which applies generally to carnivores (Tensen & Fischer, 2023). The same probably also applies in the Netherlands, but, in the early phase of establishment, hybridisation may potentially lead to such a mixing of genes that this affects a species' ability to adapt to its environment. In addition to this threat to the species, the opposite can also be the case, where species become genetically enriched and have new potential for adaptation as a result (Tensen & Fischer, 2023). We recommend that potential risks of negative effects of hybridisation be prevented, especially in the establishment phase. It would seem that it is mainly male animals that appear in the early phase of colonisation. At this stage, the chance of unnoticed hybridisation is minimal. Only when the first females arrive, will the chance of (unnoticed) hybridisation increase. Böcker et al. (2022) have reported a golden jackal that spent months with a family of foxes, was included as part of the family and brought food. They suggest that, in this case, the golden jackal benefited psychologically from inclusion in the fox family. This behaviour suggests that there is the chance of hybridisation in the early phase of establishment on the edge of the distribution area. In cases where hybridisation can be demonstrated, removal (with an environmental permit) is permitted in accordance with the Habitat Directive and the Bern Convention (Trouwborst et al., 2015). This same policy is also applied to wolf-dog hybrids based on Recommendation 173 of the Council of Europe (2014); for comparison with the wolf, see also C5.3 in Jansman et al. (2021).

4.3 Monitoring golden jackals

Depending on the purpose of the monitoring, there are various methods available for monitoring golden jackals (Photo 4.3.1). According to the European monitoring standard, monitoring can be done based on culling data, using acoustic monitoring, wildlife cameras, tagging and genetic monitoring of dead animals and prey (Hatlauf & Böcker, 2021). It is recommended that these models followed in Europe should be applied in order to ensure compatible data. The trend in population development can be monitored based on culling data in countries where the species is hunted (Stoyanov, 2012; Szabó et al., 2007). A non-invasive method that is often used in countries where the species is not hunted is acoustic monitoring. This involves howl recordings that are actively provoked or registered passively (Giannatos et al., 2005; Szabó et al., 2007; Šálek et al., 2014; Graf & Hatlauf, 2021; Krofel et al., 2023). Passive monitoring, in which recorders are used to record vocalisations of golden jackals, is often applied in terrain that is difficult to access. Active monitoring is better applied in situations where the terrain is easily accessible. In this process, sound recordings are played for several seconds, there is monitoring for a period of several minutes, possibly with the procedure being repeated, in order to listen for any response. This method can be used to monitor trends of territorial animals and the composition of different packs. The monitoring of population development using wildlife cameras can provide an insight into distribution, trends in numbers and behaviour (Hatlauf & Böcker, 2021; Martin-Garcia et al., 2023).

Tagging is a research method that is not considered to be standard monitoring, but a research technique that mainly provides ecological information (Hatlauf & Böcker, 2021). This method requires jackals to be captured and tagged using a VHF or GPS system. It can be used to determine the use of terrain and territorial size and to monitor dispersal. In order for the results to apply more generally, sufficient numbers of animals with a spread of genders and ages need to be tagged since information is merely anecdotal for low numbers.

One potential method for systematic monitoring in Europe that is not yet applied to any great extent could be genetic monitoring, such as that applied for the wolf (Hatlauf & Böcker, 2021). Analysis of (parts of) golden jackals found dead and samples from prey (swabs from bite injuries) urine or droppings, oestrus blood or hairs left on sharp objects (e.g. barbed wire) can cast light on the number of packs, mating pairs, individual animals and provide information about the area from which dispersing animals have come. For dispersing animals, this is conditional on the existence of cross-border partnerships in which genetic data can

be shared. In addition, hybrid golden jackals can be detected (Jansman et al., 2021). As part of the CEwolf consortium, of which the Netherlands is a part, golden jackals are regularly found in the monitoring of wolves as 'bycatch'. In addition to identifying the species, animals are also issued with a unique serial number that can be tracked (see also C3.1).). It is recommended that active monitoring (actively searching for DNA traces, especially faeces and/or placing camera traps) be used in areas with permanent golden jackal activity, such as the area around the Lauwersmeer lake. Passive monitoring based on separate observations (sightings, photographs, etc.) can mainly be of relevance in the early phase of establishment. In principle, this can involve joining a platform, such as the NDFF or the Wolf Reporting Point, to enable observations to be validated.

At the instructions of the government (IPO, 2023), many autopsies have been carried out on golden jackals by WENR in collaboration with the Dutch Wildlife Health Centre (DWHC, Utrecht), including extensive veterinary screening for viruses, bacteria and parasites (Photo 3.3. 1). In addition, extensive research is carried out into the cause of death, age, gender, stomach contents, reproductive status and condition.

Photo 4.3.1 *Compilation of golden jackal monitoring methods in Austria. A: acoustic monitoring. B: camera traps. C: tracks. D: autopsy on dead animals (Photos: Jennifer Hatlauf).*

4.4 Under what conditions will the golden jackal population have a favourable conservation status?

In terms of size, populations can develop from vulnerably small to the ecological carrying capacity. Ecological carrying capacity can be defined as the maximum population size of a species based on the naturally available food supply. In other words, the maximum number of individuals of a particular species that can live in a given area. The carrying capacity of a given area is determined primarily by the size and quality of the habitat for the species concerned (Groot Bruinderink et al., 1999). For example, the carrying capacity of an area that has an abundant supply of food is higher than that of an area of a comparable size where less food is available. For golden jackals, the carrying capacity of an area is determined by factors such as (1) the

presence of prey, (2) the presence of parasites and pathogens, (3) the presence of other large predators which compete for food or leave uneaten prey or which predate directly (such as wolves), and (4) climatic conditions (including the amount of precipitation, temperature, snowfall and snow density) (Kramer et al., 2017). Under natural conditions – i.e. in the absence of population management – carrying capacity will remain more or less stable over time. Population sizes can, however, rise slightly in favourable years and fall back again as a result of disease, competition or food scarcity. In Central Europe, some of these factors are influenced or determined by humans, such as prey density and anthropogenic mortality through the (managed) hunting of hares, rabbits, aquatic birds and ungulates. Climate – and climatic change – is another factor that plays a role in determining the carrying capacity of an area.

The golden jackal habitat suitability analysis for the Netherlands (Wennink et al., 2019) shows that this species is extremely flexible in the types of habitat where it can survive (C3.2; Figure 3.2.1). If the presence of wolves is discounted from the model, there would be space in the Netherlands for approximately 1,432-1,476 family groups (Figure 3.2.1 A). If the habitat suitable for them has been occupied by wolves, that share of the potentially suitable habitat for golden jackals no longer applies. The area remaining, see Figure 3.2.1 B, would then provide space for 781-851 family groups.

It is unclear how large a golden jackal population would need to be in order to be ecologically viable. In order to assess what is an ecologically viable population, this report uses the definition of favourable conservation status. Favourable conservation status can be interpreted as a situation in which a population of wild animals has a low marginal probability of extinction over a 100-year period based on its population size, the condition of its habitat and genetic diversity (Evans & Arvela, 2011; ter Harmsel et al. (2022). The conservation status of a Habitat Directive species is deemed to be favourable if:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats;
- the natural distribution area of the species is neither being reduced nor is likely to be reduced for the foreseeable future;
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis;

However, the way in which this is achieved in practice is left to EU member states to decide. Reinhardt et al. (2016) consider favourable conservation status for wolves to depend not only on numbers but also on their distribution and their access to suitable habitat, so that they can also find their own niche in the ecosystem. Chapter 5.10 of Jansman et al. (2021) examines the subject in more detail for wolves. For golden jackals, no information was found relating to the favourable conservation status criteria for the golden jackal. Hatlauf (pers. info.) has also confirmed that they have no information about this either. If the situation for wolves is applied, this would mean that an ecologically viable population would need to consist of around 1,000 pairs or family groups. If the habitat suitability analysis by Wennink et al. (2019) provides an accurate estimate of the number of potential family groups, there will be at least room for around 751-851 family groups in the Netherlands. Since it is likely that there will be mixing with surrounding countries, this would therefore mean that the Netherlands is capable of supporting an ecologically viable population.

Currently, the prevalence of golden jackals in the Netherlands and surrounding countries remains very sporadic. In summary, it is recommended that developments be effectively monitored and an assessment made as to whether adjustments need to be made to the expectations suggested by modelling. In view of the trend among such species as coyote (Flores, 2016), the possibility that golden jackals start to exploit the human environment to a greater extent cannot be ruled out.

5 Behaviour and the relationship between golden jackals and humans

This chapter provides an assessment of the potential interactions between golden jackals and human interests. What behaviour do golden jackals exhibit, how flexible are they in their behaviour and what repercussions does this have for their relationship with humans? There is also the question of how a problem golden jackal should be defined and what damage can be expected to livestock, pets and traffic.

5.1 What changes can be expected in golden jackals' behaviour as a consequence of the species' adaptation to a landscape dominated by humans?

Like most *Canidae*, golden jackals are intelligent predatory animals that are highly opportunistic and flexible in their survival. This is underscored by the wide variation in types of habitat and key sources of food in the species' area of distribution. In landscapes transformed by humans, natural selection will favour individuals that respond to anthropogenic disruption by an increase in fitness (Bulmer, 2015). Natural selection affects individual behavioural characteristics, such as wariness and boldness and/or behavioural plasticity, enabling individuals to adapt to changes in their environment. Risk aversion is probably also passed on via the parents, as a result of which young who are raised in a human habitat may possibly be better able to deal with the many human stimuli and risks while still having the ability to exploit the opportunities (food). Roads, for example, present a risk of vehicle strikes for golden jackals, but can also be used to cover large distances efficiently whilst also serving as a source of food thanks to the presence of roadkill. Jansman et al. (2021) includes a detailed examination of the behavioural mechanism involved when wolves adapt to a human-dominated cultivated landscape. It is plausible to suggest that this could also apply to golden jackals. One important difference is the fact that a golden jackal is considerably smaller than a wolf and therefore a less powerful predator that also represents a lower risk of injury to humans and especially farm animals and pets.

In human-dominated cultivated landscapes, it is possible that natural selection will occur in individuals that are less wary: the warier individuals are more likely to avoid this type of landscape, move elsewhere or fail to survive (Linnell et al. 2021). There is also variation among those individuals that are more tolerant of humans: some golden jackals accept human activity but avoid humans when possible, while others are not deterred by human activity and may therefore be seen by humans at times. Bold behaviour is not problematic in itself, provided it is not accompanied by undesirable behaviours that could be regarded as problematic. The landscape of Belgium and the Netherlands is, perhaps like nowhere else, characterised by extensive human presence and fragmentation by roads (Jaeger et al., 2011). If golden jackals appear here, they will inevitably observe the presence of people or human activities to the full. As long as they do not actively seek out and approach humans up close, this behaviour should be regarded as normal and low risk. There are also golden jackals that pass through areas of human habitation, possibly in search of food and largely ignore humans when they do so (Bulmer, 2015; Fenton et al., 2021). This behaviour is not abnormal and poses no intrinsic risk to humans. Nevertheless, it is essential that golden jackals continue to see humans as potential predators which tolerate golden jackals nearby to some extent.

One important component of animal behaviour is not genetically determined, but is learned and subsequently reinforced by positive or negative experiences ('behavioural conditioning'). The first year of life is when new behaviours can be acquired easily (Langenhof & Komdeur, 2018). In addition, young golden jackals that are learning to fend for themselves rarely make effective hunters, and this makes them more prone to experimental, atypical behaviours in an attempt to get food. As is the case with wolves (Jansman et al, 2021), this behaviour may be intensified if the parents die prematurely. It is important to prevent young golden jackals from associating humans with easy access to food or ceasing to view humans as a potential danger, and thus becoming positively conditioned to humans. Most of the recent negative interactions between wolves or coyotes and humans are attributable to this scenario (Linnell et al., 2002; 2021; Flores,

2016; Reinhardt et al., 2020; Nowak et al., 2021). Strong habituation and positive conditioning can also occur when humans deliberately approach 'rendezvous sites' (e.g. to take photographs).

In general, golden jackals avoid human environments, especially by day, but they may use the same areas at night to gather food. In Asia and south-east Europe, leftover food and dead animals are dumped in the direct living environment of humans more frequently than in the Netherlands, where the collection and processing of waste and carcasses is effectively regulated. Scavengers, such as foxes and golden jackals, can specifically target that waste and seek out a resting place at a close distance from humans in order to then go foraging in the urban area at night. This may target the waste directly, but may also focus on rodents, such as mice and rats that are also attracted by the waste. Research in such areas as Greece has also shown that golden jackals prefer to forage in urban areas in groups, possibly as an adaptation to the increased risk. In that context, the group provides greater safety (Bulmer, 2015). In the Dutch situation, the development of this behaviour would seem less likely in view of the waste-processing methods.

For now, golden jackals appear to be keeping their distance from humans. To what extent they will increasingly begin seeking out the human environment remains to be seen. In parts of southern and eastern Europe where agricultural areas are increasingly being rewilded, more natural habitat for golden jackals is emerging. In the Dutch living environment, the pressure on the use of land is intensive. It is possible that flora and fauna will increasingly start seeking out the human living environment either opportunistically or by necessity, something that can already be seen in foxes, wild boars and peregrine falcons in urban areas. The North American coyote is also becoming increasingly common in cities. According to Flores (2016), this is because coyotes have never been truly wilderness animals, but have always lived in close proximity to humans. This is largely due to the fact that the coyote's diet consists mainly of mice and rats, species that also thrive in the human environment. The urban coyote quickly became a phenomenon, not only in south-west America, but also in other large urban areas in the US. Since measures were taken to eradicate stray urban dogs, a competitor has disappeared, making it easier for coyotes to fill that niche. The fact that this has not been without incident is examined in C5.3 and C5.4. The extent to which golden jackals will follow coyotes in increasingly seeking out the urban environment remains to be seen, but can certainly not be ruled out.

5.2 What is a problem golden jackal and do they exist?

When there are conflicts between nature and humans, this is more likely to involve a problem situation than a problem animal. For a golden jackal, killing a sheep is normal behaviour, but for the owner and the sheep, this constitutes a problem. A problem golden jackal would be one that systematically causes nuisance or damage. In principle, this is still natural behaviour from the golden jackal's perspective, but from a human perspective, problem situations can arise. Attacks on farm animals can be expected to be less significant in number because golden jackals, with an average weight of around 6-15 kg (Table 2.1.1), are less capable of killing livestock than wolves that weigh around 35-45 kg. The likelihood of a problem golden jackal emerging would seem to be small in view of the fact that no targeted attacks on humans are to be expected (see C5.3). Any problematic situations that may be expected are mainly possible in the case of habituation or conditioning in the process of foraging (see C5.1). As in the case of wolves, golden jackals that could constitute a problem are individuals that demonstrate excessively bold behaviour towards humans and therefore form a risk of bites, those specialising in pet or farm animals or those that repeatedly attack properly protected livestock.

5.3 Golden jackal attacks on humans: what experiences have there been in Europe?

There have been no known attacks by golden jackals on humans in Europe (Rutkowski et al., 2015). Rabid animals have the potential to bite humans. In Zagreb Anti Rabies Clinic, 18,094 patients were recorded who had been bitten by various animals from 1995 to 2014, two cases of which involved a golden jackal (<0.01%; Vodopija et al., 2016). One of these cases was via hunting dogs that had killed a rabid golden

jackal and a second case involved a tourist who had suffered a graze in France and later reported to the clinic. The bite force of a golden jackal is 165 N and comparable to that of the red fox (164 N) but many times less than that of a wolf (593 N) (Huber et al., 2005). This means that golden jackals do not represent any real danger of lethal bite injuries to humans, even in the case of rabid animals.

To gauge the risk of attacks on humans, it could be helpful to look at the coyote (Flores, 2016). Prevalent in North America, the coyote is a similar size, but can also be slightly heavier. This species occurs increasingly in urban areas and there have been several incidents with humans and pets. On 26 August 1981, a three-year-old toddler was killed by a coyote attack in Los Angeles. The toddler had escaped supervision and run into the yard. This was the first human victim of a coyote ever recorded. In October 2009, a 19-year-old woman was bitten to death by two coyotes in a national park. It remains unclear what exactly happened here and why, and there has even been speculation that this involved hybrids between wolf, coyote or dog, which may exhibit different behaviour. In any case, it is considered to be a rare incident. Between 1960 and 2006, almost 70 people were bitten by coyotes. In many cases, ill-advised behaviour (feeding/chasing away) on the part of humans was a contributing factor. Of 175 coyotes studied in Chicago, five showed relatively bold behaviour. They specialised in hunting pets or did not shy away from humans. Of 260 tagged coyotes in Chicago and Los Angeles, not one exhibited aggressive behaviour towards humans. Since golden jackals tend to be warier than coyotes (Hatlauf, pers. info.) and have yet to become established in European urban areas, the chance of incidents would appear to be small.

5.4 Golden jackal attacks on farm animals and pets: what experiences have there been in Europe?

Agonistic interactions between golden jackals and dogs can occur when golden jackals and stray dogs meet each other (Roženko & Volokh, 2010). Frequent attacks on dogs by golden jackals would appear unlikely. Dogs are mainly predated by large carnivores, such as leopards, wolves and bears (Gompper, 2021). This predation by large carnivores appears limited and incidental in most cases. In view of the size and bite force of the golden jackal, which is comparable to that of the red fox, there does not seem to be too great a likelihood of predation of dogs, although one pack of golden jackals was observed attacking a dog on the floodplains of the Dniester river in Ukraine (Roženko & Volokh, 2010). Domestic cats, dogs and poultry do occur in the diet, but this is mainly as a result of consuming carrion (Lanzki et al., 2016). The opposite situation, where (hunting) dogs kill a golden jackal, appears to be more likely (Gompper, 2021; Vodopija et al., 2016).

The predation of farm animals mainly involves (the young of) goats and sheep, which is considered to be a growing problem in Austria (Hatlauf, pers. info.). In Estonia, where there is an established population along the coast, there have so far been no reports of predation of pets and poultry (Männil & Ranc, 2022). However, in the period 2016-2022, there were known cases of (suspected) predation of on average 22 sheep/year, mainly lambs. Since there is no compensation scheme for sheep in Estonia, this may be an underestimate, or an overestimate if golden jackals eat carrion. The predation of sheep has also been reported in Germany, Denmark, the Netherlands, Greece and Italy (Hatlauf et al., 2021; Giannatos et al., 2005; own data BIJ12/WENR). However, farm animals in Europe are often eaten in the form of carrion (see C2.2), so it can be expected that any damage will occur only very occasionally. Any such case could involve an individual specialising in farm animals or pets. The golden jackal GG010m identified via DNA research may have been one such example. This animal was identified at various locations close to dead sheep, and in three specific cases in Germany, the conclusion was drawn that the sheep were killed by GG010m (LANUV 2023).

The closely related coyote can serve as an example of specialisation focusing on pets (Flores, 2016). In the city, coyotes usually eat mice, rats, urban birds, such as geese and ducks as well as plants, fruit, carrion and dog and cat food. Because of the mutual competition, small dogs or cats are occasionally killed. Around 1 to 2% of the diet is made up of small pets.

5.5 What are the possible consequences of the presence of golden jackals in the Netherlands for traffic safety?

Traffic represents an important cause of death for golden jackals (Photo 5.5.1). In Bulgaria, 3.6% of the mortality in the population is caused by traffic (Stoyanov, 2012). Between 2018-2021, 34 traffic victims were reported in Italy in a population of around 150 animals in 2020 (Frangini et al., 2022). Based on a modelling study, they concluded that the risk of collisions was the highest in areas with good habitat quality and connectivity, a fragmented landscape and long motorways. The study area in Italy covers approximately 1.7 km of road/km^2. This would suggest that the risk of collisions involving golden jackals is real. In the Netherlands, there are almost twice as many paved roads as in the study area in Italy, with around 3.4 km of road/km^2 (Statistics Netherlands, 2018), which would probably make the chance of collisions higher here. In view of the golden jackal's weight at around 6-14 kg and its shoulder height of 40-50 cm, the impact of the collision with a vehicle would be relatively low (Grimmberger & Rudloff, 2009).

As a result of golden jackals' hunting instinct, the number of collisions involving ungulates, such as roe deer, red deer, fallow deer and wild boar, could increase when animals take flight and cross a road. However, golden jackals mainly consume slaughterhouse waste or carcasses (carrion) from ungulates (see C2.2). Packs can sometimes demonstrate active hunting behaviour, pursuing the young of wild boars and wounded ungulates (Lanzki et al., 2016; Lange et al., 2021). The active hunting of ungulates by golden jackals does not seem to occur on any great scale and any instances are very occasional. Any (significant) increase in the number of collisions involving ungulates would therefore not be expected. In the event of the permanent establishment of golden jackals, we recommend that research be conducted on this.

Most of the (wild) ungulates consumed by golden jackals are eaten in the form of carrion. In landscapes dominated by humans, many ungulates are killed in traffic. On the one hand, this mortality is beneficial for golden jackals, because they can benefit from the food supply in the form of carrion (Tsunoda & Masauki, 2020). On the other hand, this can result in a higher likelihood of collisions involving golden jackals.

Photo 5.5.1 *Traffic is an important cause of death for golden jackals (Photo: Marielle van Uitert).*

6 Damage and management

This chapter explores the question of whether golden jackals can cause damage to human interests, whether action is required to combat this and if so how.

6.1 Do golden jackals cause damage to human interests and how can that be managed?

Damage to human interests could occur as a result of attacks on farm animals and pets, attacks on people and the transmission to humans of zoonoses. Attacks on humans seem unlikely and significant damage to farm animals or pets is not to be expected (see C5).

6.1.1 Zoonoses

Golden jackals can be carriers of a range of zoonoses (pathogens that pass from animals to humans) and the worldwide list includes more than 190 species (Gherman & Mihalca 2017; Veronesi et al., 2023). Most of these are pathogens that are also passed on by dogs and (domestic) cats. In Europe, this concerns a large number of species groups such as protists (unicellular microorganisms), trematodes (flatworms), cestodes (tapeworms), nematodes (roundworms, eelworms) and invertebrates (mites, lice). Leishmania, Echinococcus, nematodes, Toxocara and Trichinella would appear to be the most important zoonoses. In the case of Leishmania (a unicellular parasite), transmission is via drain flies (from the Psychodidae family; moth flies), which do not (yet) occur in the Netherlands and this disease would therefore not currently appear relevant. Most of the zoonoses also occur in red foxes (Table 6.1.1), which would therefore not suggest any additional risk should golden jackals become established in the Netherlands. As far as is known, golden jackals are less likely to carry mites (mange). In addition, most zoonoses have low to moderate prevalence in golden jackals in Europe compared to other canids (wolf, fox, raccoon dog; Veronesi et al., 2023). They could therefore represent a minor additional source of infection for humans. However, the significant dispersal distance could increase the risk of the importation and transmission of zoonoses that do not yet occur here (Cunze & Klimpel, 2022). For example, they can be regarded as a natural reservoir for Trichinella in the Balkans and their long dispersal distance could potentially introduce the parasite in countries where Trichinella is not yet prevalent (Veronesi et al., 2023).

Rabies hardly ever occurs in Europe now but could in principle reach the Netherlands from Eastern Europe via dispersing golden jackals (Musto et al., 2022). In recent years, rabies has been largely eradicated in Europe through the large-scale use of oral vaccine campaigns using carrion bait. This could also be used to keep golden jackals free of rabies. One area of concern with regard to oral vaccination programmes is the fact that golden jackals may consume a lot of carrion, making it more difficult to vaccinate other target species that can carry rabies (fox) if there is competition for the carrion bait.

Table 6.1.1 *Zoonoses in the red fox and golden jackal (Veronesi et al., 2023).*

Zoonosis	Red fox	Golden jackal
Giardia spp.	X	
Leishmania spp.	X	X
Babesia spp.	X	X
Hepatozoon spp.	X	X
Toxoplasma gondii	X	
Cryptosporidium spp.	X	
Cytauxzoon spp.		
Alaria alata	X	X
Echinococcus spp.	X	X
Taenia spp.	X	X
Mesocestoides spp.	X	X
Angiostrongylus spp.	X	X
Dirofilaria spp.	X	X
Trichinella spp.	X	X
Capillaria spp.	X	X
Thelazia callipaeda	X	X
Spirocera spp.	X	X

6.1.2 Management options for golden jackals

1. Prevention

Depending on the situation, preventive measures can be taken against the predation of farm animals (Photo 6.1.2.1). Many of the applicable methods are similar to those used to combat wolves and foxes (BIJ12 website[7]; Jansman et al., 2021; The predation management forum, 2016). The use of livestock guard dogs, donkeys or alpacas is an option. Wire fencing can form an effective barrier (for jackals in Africa: height ≥1.2 m, gap openings < 75 mm; The predation management forum, 2016). Prevention of damage to farm animals is more difficult to achieve with golden jackals than it is with wolves if electric fencing is used (Hatlauf, pers. info.). When applying electric fencing around livestock, the bottom wire has to be lower than it generally is for wolves, which is difficult to achieve. Golden jackals are smaller and can more easily get under the wires. In South Africa, wide PVC collars or metal wire collars are used around the neck of sheep to protect them. This technique is also less effective on golden jackals because they sometimes use a different method of killing than biting the throat (Shivik 2006; The predation management forum, 2016). Management by means of culling can be a solution if it concerns a problem individual or pack. When national protected status has been regulated, management by means of culling can be more easily applied if the favourable conservation status has been reached. It is not a good option because of the golden jackal's high reproduction capacity, which makes it difficult to maintain levels at zero and thereby prevent attacks on livestock (see below).

[7] https://www.bij12.nl/onderwerpen/faunazaken/diersoorten/wolf/schade-voorkomen/ (seen on 11 December 2023)

Photo 6.1.2.1 *Experimental fencing for farmed goats with a red fox (small) and golden jackal (large) silhouette for reference purposes. Experiments are being conducted in Austria to identify which protection is most suitable for preventing predation by golden jackals (Photo: Jennifer Hatlauf).*

2. Removal of problem animals

In the event of a pack or individual golden jackal causing systematic damage, the option of removing the animal or animals (with an environmental permit) by shooting or capture may be considered. This would also apply in the event of unexpected negative effects on rare species or ecosystems. Drive hunting for culling purposes, with or without dogs. and the use of carron bait are appropriate methods in Bulgaria (Stoyanov, 2012). In the European Union, the eradication of a problem animal is permitted for HD Annex V species if due account is taken of the (monitoring of) the population's favourable conservation status (see C4.4). This will be a possibility for the Netherlands when national protected status has been regulated.

Mass culling of golden jackals takes place in Bulgaria, where around half of the population is shot every year (Stoyanov, 2012). This results in a relatively young population, with only 5-10% of animals exceeding three years in age. The population continues to grow in spite of culling. One disadvantage of permitting culling is that the species is seen as undesirable, increasing the risk of illegal persecution. In Greece, persecution through culling and poisoning led to a fall in the population between 1970 and 2000, both in numbers and distribution, resulting in failure to achieve favourable conservation status (Giannatos et al., 2005; Trouwborst et al., 2015). The population has grown again in the last two decades (Karamanlides et al., 2023).

6.2 What experiences have there been with the culling of golden jackals and what effect does this have on golden jackal pack behaviour?

It is possible that culling has an impact on the behaviour and reproductive strategy of golden jackals (Pecorella et al., 2023). Although canids generally form monogamous territorial mating pairs, cases have also been observed of polyandry, mating of the dominant alpha male with non-dominant females, and communal locations for raising young. In Eastern Europe in particular, there is regular culling of golden jackals (see Table 4.1.1). In view of the species' high reproductive potential, this does not result in a rapid fall in the size or spread of the population (Stoyanov 2012; Hatlauf, pers. info.). The very intensively persecuted coyote in North America has also been seen to have a highly resilient population (Flores, 2016). In the absence of large carnivores (top-down regulation), the abundance of medium-sized predators is

regulated by the food supply (bottom-up regulation). For golden jackals in general, it has been shown that the quantity of food has an impact on numbers, speed of reproduction, survival, dispersal and use of space (Lanszki et al., 2018b). However, very little is so far known about the species' reproductive biology and how a range of factors influence this in Europe (Pecorella et al., 2023). One of these factors could be that culling results in a relative increase in the supply of food for the remaining animals, which could reduce juvenile mortality. There has been recent anecdotal evidence suggesting that if the mother/alpha female is culled, the vacant position in the pack is rapidly filled (Csányi et al., 2023). This suggests that reproduction can be re-initiated rapidly following the loss of a parent.

It is not clear to what extent the behaviour of golden jackals or packs changes as a result of management by means of culling. Expectations are that this already wary species will become even less visible.

6.3 What effect does fauna management and hunting of other species in the Netherlands have on the golden jackal?

As opportunist predators, golden jackals can eat rabbits, hares, wood pigeons, wild ducks and pheasants (hunted species) as well as (although mainly in the form of carrion) ungulates, such as roe deer, deer and boar, of species that are subject to fauna management (see C2.2). This may also apply to other species subject to some kind of management, such as geese and muskrats. Whether fauna management and hunting have an impact on the population dynamic of golden jackals depends on several factors. Firstly, it needs to be known whether and how many prey animals that are hunted or managed species golden jackals would need per year, and therefore what demand the prey animal populations would need to meet. Secondly, an accurate picture of the prey animal population in terms of numbers, composition and dynamics is required. Thirdly, there would need to be information concerning how much of the prey animal population is eradicated annually by means of management. For wolves, this theme has already been covered in Jansman et al. (2021, C7.5). This will also apply in broad outline to golden jackals.

There has so far been no research conducted into the choice of diet of golden jackals in the Netherlands. Hares and rabbits constitute only a limited percentage of the diet in Europe, but this may vary locally. Although ungulates are occasionally eaten, this is usually in the form of carrion (C2.2). Knowledge concerning the numbers, composition and dynamics of hunted and managed species does exist with regard to distribution and trends, but there is a lack of solid data on actual numbers, composition and population dynamics (Groot Bruinderink & Van der Grift, 2015; Van der Grift., 2018). Some species are showing a negative trend and are included on the national or regional red list (e.g. rabbit and hare). In the case of red deer, wild boar and fallow deer, there is zero tolerance in large parts of the country. All wild ungulates are subject to some form of fauna management, with around 40-80% of the population being culled annually (see www.faunabeheereenheid.nl for fauna management plans). In summary, hunting and fauna management could in theory have a negative impact on golden jackals in terms of numbers and distribution area. On the other hand, culled animals (or their remains) are left behind after hunting and food used as bait during culling can also be used. This constitutes a very useful source of food for golden jackals, increasing its carrying capacity.

Further research into the diet of golden jackals in the Netherlands is therefore to be recommended. The arrival of golden jackals in the Netherlands means that it is important to take this predator into account when it comes to the hunting and management of animals. If hunted and managed species constitute a significant part of golden jackals' diets, it is recommended that current management plans are re-evaluated in order to take account of expected predation by golden jackals when determining numbers of animals to be culled. This is also the recommendation made in the guidance document on large predators drafted for the Council of Europe by the Large Carnivore Initiative Europe (LCIE) (Linnell et al., 2008). That document states that it is very important that the presence of larger predators is taken into account when deciding on culling quotas for ungulate management.

7 Discussion & recommendations

The arrival of the golden jackal in the Netherlands means the addition of a new predator. Interestingly, this is not the case of a return (as far as is known, the species has never occurred here in the past) or reintroduction (as in the case of the otter), but spontaneous expansion of the distribution area. An illustrative example of this kind of spontaneous expansion can be seen in the establishment of the great egret (*Ardea alba*) which has been observed in the Netherlands for several decades. This is natural behaviour and part of the evolutionary flexibility of species, in which adaptation is a core value. Because of the significant dynamics in the European habitat (land readjustment and use) and climate (change), this adaptation to changing conditions is essential for the survival of species. One form of adaptation is to extend or shift the habitat/range, and the golden jackal is an example of this.

Biodiversity is under pressure in the Netherlands. Historically, the larger wild animals in general, and potentially dangerous or problematic predators in particular, have disappeared from our living environment. For the larger mammal species (> 10kg) that still occur, there are generally fauna management plans in place to manage numbers and distribution. In ecological terms, there is increasing understanding of the importance of complete ecosystems, in which the trophic levels (hierarchical positions of species in a food web) are well represented and the ecosystems are therefore also resilient as a result (Estes et al., 2012). A recent article looked in greater detail at the significant degradation of megafauna in Europe since the last interglacial period and the role of humans in influencing this process (Davoli et al., 2023). One of its conclusions is that the functional heterogeneity of ecosystems is reduced as a result of the disappearance of many species. They therefore also recommend ambitious policy with regard to the reinstatement of megafauna communities in order to strengthen the functioning of ecosystems. Although the arrival of the golden jackal as a medium-sized predator will not replace the role of such disappeared species as the Eurasian cave lion, brown bear, hyena, leopard or lynx, the species will – if it manages to sustain and spread further – form an additional chain in the ecosystem. Future research will need to ultimately show what the influence of the species will be on ecosystems. Because of its flexible foraging strategy, there may be potentially (local) positive effects of the golden jackal, but (local) negative effects on species and ecosystems could also occur. Because the species is a predator with a dominant proportion of carrion in its diet, it cannot be ruled out that it will play a role in mitigating the spread of diseases and zoonoses. It is equally impossible to predict the impact on human interests (damage). It is also unclear where and in what numbers golden jackals are likely to occur in the short and medium term in the Netherlands. This report provides an initial assessment of these aspects based on the information currently available.

Since the species did not previously occur in the Netherlands and since there are currently very small numbers of golden jackals in the Netherlands and surrounding countries, much still remains unclear. It is therefore also to be recommended that developments in and around the Netherlands continue to be monitored effectively and for the species' protected status to be enshrined in legislation. This report includes several recommendations on each theme.

In broad outline, these are as follows:

- Establishing the legal status and therefore the protected status of the species in the Netherlands.
- Monitoring developments in terms of number and distribution area. It is recommended that active monitoring (actively searching for DNA traces, especially faeces and/or placing camera traps) be used in areas with permanent golden jackal activity. Passive monitoring based on separate observations (sightings, photographs, etc.) can mainly be of relevance in the early phase of establishment. In principle, this can involve joining a platform, such as the NDFF or the Wolf Reporting Point, to enable observations to be validated.
- Being alert to hybridisation based on genetic monitoring, especially in established solitary female individuals. We recommend that potential risks of negative effects of hybridisation be prevented, especially in the establishment phase.
- Carrying out research into the diet and use of terrain of this species in the Netherlands.

- Monitoring the risks of vehicle collisions involving the species itself, but also involving prey animals responding to the presence of this species.
- Monitoring damage to farm animals and pets and, in the event that the extent of damage leads to societal debate, initiating research into damage prevention.

Bibliography

Alderton, D. 2004. Foxes, Wolves & Wild Dogs of the World. Cassell Illustrated, London.

Alvares, F., Bogdanowicz, W., Campbell, L. A. D., Godinho, R., Hatlauf, J., Jhala Y. V., Kitchener, A.C., Koepfli, K.P., Krofel, M., Senn, H., Sillero-Zubiri, C., Viranta, S. & Werhahn, G. 2019. Old World Canis spp. with taxonomic ambiguity: Workshop conclusions and recommendations. IUCN Canis Specialist Group.

Arnold, J., Humer, A., Heltai, M., Murariu, D., Spassov, N. & Hacklaender, K. 2012. Current status and distribution of golden jackals Canis aureus in Europe. Mammal Review, *42*(1): 1-11.

Bij12. Goudjakhals. https://www.bij12.nl/onderwerpen/faunazaken/diersoorten/goudjakhals/ accessed on 27-3-2023

Böcker, F., Weber, H. & Collet, S. 2022. First documentation of golden jackal (Canis aureus) reproduction in Germany. Mammal Research https://doi.org/10.1007/s13364-022-00666-y

Böcker, F., Weber, H., Arnold, J., Collet, S. & Hatlauf, J. 2022. Potential effect of intraspecific isolation: observations of a Golden jackal (Canis aureus) and red foxes (Vulpes vulpes) living in sociopositive relation. In: Heltai, M. (ed.). 3rd international jackal symposium, 2-4 November 2022, Gödöllo, Hungary. Abstract book.

Bošković, I., Šperanda, M., Florijančić, T., Šprem, N., Ozimec, S., Degmečić, D., & Jelkić, D. 2013. Dietary habits of the golden jackal (Canis aureus L.) in the Eastern Croatia. Agriculturae Conspectus Scientificus, 78(3): 245-248.

Bulmer, L. 2015. The impact of anthropogenic disturbance on the behaviour and ecology of the golden jackal (Canis aureus). Doctoral dissertation, Thesis, The University of York, York, United Kingdom.

Statistics Netherlands (CBS): www.cbs.nl/nl-nl/visualisaties/verkeer-en-vervoer/vervoermiddelen-en-infrastructuur/wegen in 2018

Ćirović, D., Penezić, A. & Krofel, M. 2016. Jackals as cleaners: Ecosystem services provided by a mesocarnivore in human-dominated landscapes. Biological Conservation, 199: 51-55.

Csányi, E., Lanszki, J., Heltai, M., Pölös, M., Schally, G. & Sándor, G. 2023. The First Evidence of A Monogamous Golden Jackal's Adaptive Response to Partner Loss. Applied Animal Behaviour Science, 106095.

Cunze, S. & Klimpel, S. 2022. From the Balkan towards Western Europe: Range expansion of the golden jackal (Canis aureus)—A climatic niche modeling approach. Ecology and Evolution, 12(7), e9141.

Davoli, M., Monsarrat, S., Pedersen, R. Ø., Scussolini, P., Karger, D. N., Normand, S. & Svenning, J.C. 2023. Megafauna diversity and functional declines in Europe from the Last Interglacial to the present. *Global Ecology and Biogeography*, 00: 1–14. https://doi.org/10.1111/geb.13778

Estes, J., J. Terborgh, J. Brashares, M. Power & J. Berger 2011. Trophic downgrading of planet Earth. Science 333: 301-306.

Evans D. & Arvela M. 2011. Assessment and reporting under Article 17 of the Habitats Directive. Explanatory Notes en Guidelines for the period 2007-2012.

Fenton, S., Moorcroft, P.R., Ćirović, D. Lanszki, J., Heltai, M., Cagnacci, F., Breck, S., Bogdanović, N., Pantelić, I., Ács, K. & Ranc, N. 2021. Movement, space-use and resource preferences of European golden jackals in human-dominated landscapes: insights from a telemetry study. Mammalian Biology 101: 619–630. https://doi.org/10.1007/s42991-021-00109-2

Frangini, L., Franchini, M., Stokel, G., Madinelli, A., Pesaro, S., Saimon, F., & Filacorda, S. 2022. First telemetry data on golden jackal (Canis aureus) in Italy: insights on the species' spatial ecology. In XII Congresso Italiano di Teriologia.

Galov A., Fabbri, E., Caniglia, R., Arbanasić, H., Lapalombella, S., Florijančić, T., Bošković, I., Galaverni, M. & Randi, E. 2015. First evidence of hybridization between golden jackal (Canis aureus) and domestic dog (Canis familiaris) as revealed by genetic markers. R. Soc. open sci. 2: 150450. http://dx.doi.org/10.1098/rsos.150450

Gherman, C.M. & Mihalca, A.D. 2017. A synoptic overview of golden jackal parasites reveals high diversity of species. Parasites Vectors 10, 419. https://doi.org/10.1186/s13071-017-2329-8

Giannatos, G., Marinos, Y., Maragou, P. & Catsadorakis, G. 2005. The status of the golden jackal (Canis aureus L.) in Greece. Belgian Journal of Zoology, 135(2), 145.

Gompper, M.E. 2021. Adding Nuance to Our Understanding of Dog–Wildlife Interactions and the Need for Management. Integrative and Comparative Biology 61(1): 93–102. https://doi.org/10.1093/icb/icab049

Graf, L. & Hatlauf, J. 2021. Distance estimation of howling golden jackals (Canis aureus) using relative sound level. Mammal Research 66: 567–572. https://doi.org/10.1007/s13364-021-00587-2

Grimmberger, E. & Rudloff, K. 2009. Atlas der Säugetiere Europas, Nordafrikas und Vorderasiens. Natur und Tier Verlag, Münster.

Groot Bruinderink, G. & E. van der Grift 2015. Populatiebeheer van wilde hoefdieren: nog niet goed op orde. Vakblad Natuur bos landschap, December 2015.

Groot Bruinderink, G.W.T.A., J.M. Baveco, K. Kramer, A.T. Kuiters, D.R. Lammertsma & S. Wijdeven 1999. Dynamische interacties tussen hoefdieren en vegetatie in de Oostvaardersplassen. IBN-Rapport nr 436, Wageningen.

Hatlauf, J. 2021. Biologie des Goldschakals. Goldschakalprojekt Österreich: https://www.goldschakal.at/biologie/ accessed on 15-11-2023

Hatlauf, J. & Böcker, F. 2021. Empfehlungen zur Dokumentation und Beurteilung von Hinweisen des Goldschakals (Canis aureus) in Europa. BOKU-Berichte zur Wildtierforschung und Wildbewirtschaftung 26. Hrsg: Institut für Wildbiologie und Jagdwirtschaft (IWJ) Universität für Bodenkultur Wien.

Hatlauf, J., Bayer, K., Trouwborst, A. & Hackländer, K. 2021. New rules or old concepts? The golden jackal (Canis aureus) and its legal status in Central Europe. European Journal of Wildlife Research 67(25). https://doi.org/10.1007/s10344-020-01454-2

Hoffmann, M., Arnold, J., Duckworth, J.W., Jhala, Y., Kamler, J.F. & Krofel, M. 2018. Canis aureus. The IUCN Red List of Threatened Species 2018: e.T118264161A46194820. http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T118264161A46194820.en

Huber, D.R., Eason, T.G., Hueter, R.E. & Motta, P.J. 2005. Analysis of the bite force and mechanical design of the feeding mechanism of the durophagous horn shark Heterodontus francisci. Journal of Experimental Biology, 208(18): 3553-3571.

IPO 2023: Interprovinciaal Wolvenplan *addendum*. IPO-WOlvenwerkgroep.

Jaeger, J.A.G., Soukup, T., Madriñán, L.F., Schwick, C. & Kienast, F. 2011. Landscape fragmentation in Europe. Joint EEA-FOEN report. Copenhagen, Denmark: EEA.

Jansman, H.A.H., J. Mergeay, E.A. van der Grift, G.A. de Groot, D.R. Lammertsma, K. Van Den Berge, F.G.W.A. Ottburg, J. Gouwy, R. Schuiling, T. van der Veken & C. Nowak 2021. *De wolf terug in Nederland; Een factfinding study.* Wageningen, Wageningen Environmental Research, Report 3107.

Juškaitis, R. 2023. Dormice (Gliridae) in the Diets of Predators in Europe: A Review Broadening Understanding of Dormouse Ecology. Diversity 15(1): 52. https://doi.org/10.3390/d15010052

Kaczensky, P., Ranc, N., Hatlauf, J., Payne, J.C. et al. 2024. Large carnivore distribution maps and population updates 2017 – 2022/23. Report to the European Comission under contract N° 09.0201/2023/907799/SER/ENV.D.3 "Support for Coexistence with Large Carnivores", "B.4 Update of the distribution maps". IUCN/SSC Large Carnivore Initiative for Europe (LCIE) and Istituto di Ecologia Applicata (IEA).

Karamanlidis, A.A., de Gabriel Hernando, M., Avgerinou, M., Bogdanowicz, W., Galanis, K., Kalogeropoulou, S., Krambokoukis, L., Panagiotopoulos, N. & Taklis, C. 2023. Rapid expansion of the golden jackal in Greece: research, management and conservation priorities. Endangered Species Research, 51: 1-13.

Koepfli, K.P., Pollinger, J., Godinho, R., Robinson, J., Lea, A., Hendricks, S., Rena M. Schweizer, R.M., Thalmann, O., Silva, P., Fan, Z., Yurchenko, A.A., Dobrynin, P., Makunin A., Cahill, J. A., Shapiro, B., Álvares, F., Brito, J. C., Geffen, E., Leonward, J.A., Helgen, K.M., Johnson, W.E., O'Brien, S.J., Van Valkenburgh, B. & Wayne, R.K. 2015. Genome-wide evidence reveals that African and Eurasian golden jackals are distinct species. Current Biology, 25(16): 2158–2165. doi:10.1016/j.cub.2015.06.060

Kojola, I., Henttonen, H., Heikkinen, S., & Ranc, N. 2023. Golden jackal expansion in northernmost Europe: records in Finland. Mammalian Biology: 1-5.

Kramer, K., Cornelissen, P., Groot Bruinderink, G.W.T.A., Kuiters, L., Lammertsma, D., Vulink, J.Th., Van Wieren, S.E. & Prins, H.H.T. 2017. Effects of weather variability and geese on population dynamics of large herbivores creating opportunities for wood-pasture cycles. A modelling approach: 109-124. In: Cornelissen, P. (ed.) 2017. Large herbivores as a driving force of woodland-grassland cycles: The mutual interactions between the population dynamics of large herbivores and vegetation development in a eutrophic wetland. PhD thesis. Wageningen University, Wageningen.

Krofel, M., Berce, M., Berce, T. Kryštufek, B., Lamut, S., Tarman, J. & Fležar, U. 2023. New mesocarnivore at the doorstep of Central Europe: historic development of golden jackal (Canis aureus) population in Slovenia. Mammal Research 68: 329–339. https://doi.org/10.1007/s13364-023-00686-2

Krofel, M., G. Giannatos, D. Ćirović, S. Stoyanov & Newsome, T.M. 2017. Golden jackal expansion in Europe: a case of mesopredator release triggered by continent-wide wolf persecution? Hystrix, the Italian Journal of Mammalogy 28: 9-15.

Krofel, M., Hatlauf, J., Bogdanowicz, W., Campbell, L.A.D., Godinho, R., Jhala, Y. V., Kitchener A.C., Koepfli K.P., Moehlman, P., Senn, H., Sillero-Zubiri, C., Viranta, S., Werhahn, G. & Alvares, F. 2021. Towards resolving taxonomic uncertainties in wolf, dog and jackal lineages of Africa, Eurasia and Australasia. Journal of Zoology, 316: 155–168. https://doi.org/10.1111/jzo.12946

La Haye, M.J.J., van Kats, R.J.M., Müskens, G.J.D.M. Hallmann, C.A. & Jongejans, E. 2020. Predation and survival in reintroduced populations of the Common hamster Cricetus cricetus in the Netherlands. Mammalian Biology 100: 569–579. https://doi.org/10.1007/s42991-020-00063-5

Lammertsma, D. R., Villing, N., & Jansman, H. A. H. (2024). *De komst van de goudjakhals (Canis aureus) naar Nederland: Een factfinding study*. (Rapport / Wageningen Environmental Research; No. 3228). Wageningen Environmental Research. https://doi.org/10.18174/648788

Lange, P.N.A.M.J.G., Lelieveld, G. & de Knegt, H.J. 2021. Diet composition of the golden jackal Canis aureus in south-east Europe –a review. Mammal Review 51: 207-213.

Langenhof, M. R., & J. Komdeur 2018: Why and how the early-life environment affects development of coping behaviours. Behavioral Ecology and Sociobiology 72(3): 1-32. DOI:10.1007/s00265-018-2452-3

Lanszki, J., Hayward, M. W., & Nagyapáti, N. 2018b. Feeding responses of the golden jackal after reduction of anthropogenic food subsidies. PLoS One, 13(12), e0208727.

Lanszki, J., Heltai, M. & Szabó, L. 2006. Feeding habits and trophic niche overlap between sympatric golden jackal (Canis aureus) and red fox (Vulpes vulpes) in the Pannonian ecoregion (Hungary). Canadian Journal of Zoology. 84(11): 1647-1656. https://doi.org/10.1139/z06-147

Lanszki, J., Kurys, A., Szabó, L., Nagyapáti, N., Porter, L. B., & Heltai, M. 2016. Diet composition of the golden jackal and the sympatric red fox in an agricultural area (Hungary). Folia Zoologica, 65(4): 310-322.

Lanszki, J., Schally, G., Heltai, M. & Ranc, N. 2018. Golden jackal expansion in Europe: First telemetry evidence of a natal dispersal. Mammalian Biology 88: 81–84. https://doi.org/10.1016/j.mambio.2017.11.011

LANUV 2023. https://naturschutz.ruhr/lanuv-erstmals-ein-goldschakal-in-nrw-nachgewiesen accessed on 17-11-2023

Lelieveld, G. 2012. Room for wolf comeback in the Netherlands. A spatial analysis on the possibilities of settlement of wolves from European populations in the Netherlands. MSc Ecology, Vrije Universiteit, Amsterdam.

Linnell J.D.C., Salvatori V. & Boitani L. 2008. Guidelines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe report prepared for the European Commission (contract 070501/2005/424162/MAR/B2).

Linnell, J.D.C., Kovtun, E. & Rouart, I. 2021. Wolf attacks on humans: an update for 2002–2020. NINA Report 1944 Norwegian Institute for Nature Research.

Linnell, J.D.C., Løe, J., Okarma, H., Blancos, J.C., Andersone, Z., Valdmann, H., Balciauskas, L., Promberger, C., Brainerd, S., Wabakken, P., Kojola, I., Andersen, R., Liberg, O., Sand, H., Solberg, E.J., Pedersen, H.C., Boitani, L. & Breitenmoser, U. 2002. The fear of wolves: a review of wolf attacks on humans. Norwegian Institute for Nature Research Oppdragsmelding, 731: 1-65.

MacCracken, J.G. & Hansen, R.M. 1987. Coyote Feeding Strategies in Southeastern Idaho: Optimal Foraging by an Opportunistic Predator? The Journal of Wildlife Management, 51(2): 278–285. https://doi.org/10.2307/3801003

Männil, P. & Ranc, N. 2022. Golden jackal (Canis aureus) in Estonia: development of a thriving population in the boreal ecoregion. Mammal Research 67: 245–250. https://doi.org/10.1007/s13364-021-00615-1

Martin-Garcia, S., Cortazar-Chinarro, M., Rodríguez-Recio, M., Jiménez, J., Höglund, J. & Virgós, E. 2023. Comparing minimum number of individuals and abundance from non-invasive DNA sampling and camera trapping in the red fox (Vulpes vulpes). Biodiversity and Conservation 32: 1977–1998. https://doi.org/10.1007/s10531-023-02586-y

Miller, B., Dugebly, B., Foreman, D., Martinez del Río, C., Noss, R., Phillips, M.K., Soulé, M., Terborgh, J. & Willcox, L. 2001. The importance of large carnivores to healthy ecosystems. Endangered Species update 18: 202-210.

Moehlman, P.D. & Hayssen, V. 2018. Canis aureus (Carnivore: Canidae). Mammalian Species 50(957): 14-25.

Moura, A.E., Tsingarska, E., Dąbrowski, M.J. Czarnomska, S.D., Bogumiła Jędrzejewska, B. & Pilot, M. 2014. Unregulated hunting and genetic recovery from a severe population decline: the cautionary case of Bulgarian wolves. Conservation Genetics 15: 405–417. https://doi.org/10.1007/s10592-013-0547-y

Musto, C., J. Cerri, E. Manieri Sentimenti & Delogu, M. 2022. Evaluation of limiting factors of Oral Rabies Vaccinations (ORV) in wild canids, evidence from a field trial in Central Italy. Hystrix, the Italian Journal of Mammalogy https://doi:10.4404/hystrix–00517-2021

Nowak S., Szewczyk M., Tomczak P., Całus I., Figura M. & Mysłajek R.W. 2021. Social and environmental factors influencing contemporary cases of wolf aggression towards people in Poland. European Journal of Wildlife Research 67: 69. 10.1007/s10344-020-01455-1

Reinhardt, I, Kaczensky, P., Frank, J., Knauer, F. & Kluth G. 2020. How to deal with bold wolves. 10.19217/skr577

Reinhardt, I. & G. Kluth 2016. Abwanderungs- und Raumnutzungsverhalteen von Wólfen (Canis lupus) in Deutschland. Natur und Landschaft 91(6): 262-271.

Roženko, N. & Volokh, A. 2010. The golden jackal (Canis aureus L., 1758) as a new species in the fauna of Ukraine.

Rueness, E.K., Asmyhr, M.G., Sillero-Zubiri, C., Macdonald, D.W., Bekele, A., Atickem & A., Stenseth, N.C. 2011. The Cryptic African Wolf: Canis aureus lupaster Is Not a Golden Jackal and Is Not Endemic to Egypt. PLoS ONE 6(1): e16385. https://doi.org/10.1371/journal.pone.0016385

Rutkowski, R., Krofel, M., Giannatos, G., Ćirović, D., Männil, P., Volokh, A.M., Lanszki, J., Heltai, M., Szabó, L., Banea, O.C., Yavruyan, E., Hayrapetyan, V., Kopaliani, N., Miliou, A., Tryfonopoulos, G.A., Lymberakis, P., Penezić, A., Pakeltytė, G., Suchecka, E. & Bogdanowicz, W. 2015. A European Concern? Genetic Structure and Expansion of Golden Jackals (Canis aureus) in Europe and the Caucasus. PLoS ONE 10(11): e0141236. https://doi.org/10.1371/journal.pone.0141236

Šálek, M., Červinka, J., Banea, O.C., Krofel, M., Ćirović, D., Selanec, I., Penezić, A., Grill, S. & Riegert, J. 2014. Population densities and habitat use of the golden jackal (Canis aureus) in farmlands across the Balkan Peninsula. European Journal of Wildlife Research 60: 193–200. https://doi.org/10.1007/s10344-013-0765-0

Selimovic, A., Schöll, E.M., Bosseler, L. & Hatlauf, J. 2011. Habitat use of golden jackals (Canis aureus) in riverine areas of northern Bosnia and Herzegovina. European Journal of Wildlife Research 67:14. https://doi.org/10.1007/s10344-021-01457-7

Sheldon, E.L., Feit, B., Feit, A. & Letnic, M. 2023. Negative frequency dependent prey selection by two canid predators and its implications for the conservation of a threatened rodent in arid Australia. Biodiversity and Conservation 32: 1671–1686 https://doi.org/10.1007/s10531-023-02570-6

Shivik, J. 2006. Tools for the Edge; What's new for conserving carnivores. Bioscience 56: 253-259.

Sillero-Zubiri, C., Hoffmann, M. & Macdonald, D.W. 2004. Canids: Foxes, wolves, jackals and dogs. Status survey and conservation action plan. IUCN/SSC Canid Specialist Group, Gland, Switzerland.

Spassov, N. and Acosta-Pankov, I. 2019. Dispersal history of the golden jackal (Canis aureus moreoticus Geoffroy, 1835) in Europe and possible causes of its recent population explosion. Biodiversity Data Journal 7: e34825. https://doi.org/10.3897/BDJ.7.e34825

Stoyanov, S. 2012. Golden jackal (Canis aureus) in Bulgaria. Current status, distribution, demography and diet. International symposium on hunting. Modern aspects of sustainable management of game population. Zemun-Belgrade, Serbia 22-24 June 2012.

Stoyanov, S. 2020. Cranial variability and differentiation among golden jackals (Canis aureus) in Europe, Asia Minor and Africa. ZooKeys 917: 141–164. https://doi.org/10.3897/zookeys.917.39449

Stronen, A. V., Konec, M., Boljte, B., Bošković, I., Gačić, D., Galov, A., M. Heltai, M., Jelenčič,M, Kljun, F., Kos, I., Kovačič, T., Lanszki, J., Pintur, K., Pokorny, B., Skrbinšek, T., Suchentrunk, F., Szabó, L., Šprem, N., Tomljanović, K. & Potočnik, H. 2021. Population genetic structure in a rapidly expanding mesocarnivore: golden jackals in the Dinaric-Pannonian region. Global Ecology and Conservation 28, e01707. https://doi.org/10.1016/j.gecco.2021.e01707

Szabó, L., Heltai, M., Lanszki, J. & Szűcs, E. 2007. An indigenous predator, the golden jackal (Canis aureus L., 1758) spreading like an invasive species in Hungary. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca 63: 1-6.

Tensen, L. & Fischer, K. 2023. Evaluating hybrid speciation and swamping in wild carnivores with a decision-tree approach. Conservation Biology, online ahead of print. https://doi.org/10.1111/cobi.14197

ter Harmsel, R., Bijlsma, R.-J., van der Grift, E., Villing, N., van Eupen, M., Biersteker, L., & Los, S. 2022. Staat van instandhouding haas en konijn. (Rapport / Wageningen Environmental Research; No. 3153). Wageningen Environmental Research. https://doi.org/10.18174/564404

The predation management forum 2016. Predation management manual. The farmers one-stop guide to identifying and managing predators. Agri Connect (Pty) Ltd.

Torretta, E., Riboldi, L., Costa, E., Delfoco, C., Frignani, E. & Meriggi, A. 2021. Niche partitioning between sympatric wild canids: the case of the golden jackal (Canis aureus) and the red fox (Vulpes vulpes) in north-eastern Italy. BMC Ecology and Evolution 21, 129. https://doi.org/10.1186/s12862-021-01860-3

Trouwborst, A., Krofel, M. & Linell, J.D.C. 2015. Legal implications of range expansions in a terrestrial carnivore: the case of the golden jackal (Canis aureus) in Europe. Biodiversity Conservation 24: 2593

Tsunoda, H. 2022. Niche overlaps and partitioning between Eurasian golden jackal Canis aureus and sympatric red fox Vulpes vulpes. In Proceedings of the Zoological Society 75(2): 143-151. New Delhi: Springer India.

Tsunoda, H. & Saito, M.U. 2020. Variations in the trophic niches of the golden jackal *Canis aureus* across the Eurasian continent associated with biogeographic and anthropogenic factors. Journal of Vertebrate Biology, 69(4): 1-13.

Van der Grift, E. 2018: Faunabeheer: Waar is de wetenschap? Vakblad Natuur bos landschap, november 2018: 4-7.

Veronesi, F., Deak, G., & Diakou, A. 2023. Wild Mesocarnivores as Reservoirs of Endoparasites Causing Important Zoonoses and Emerging Bridging Infections across Europe. Pathogens 12(2): 178. https://doi.org/10.3390/pathogens12020178

Vlasseva, A., Chassovnikarova, T., Mitkovska, V. & Dimitrov, H. 2020. Compensatory increase of the reproductive capacity of the red fox Vulpes vulpes (L., 1758) in sympatric coexistence with the golden jackal Canis aureus L., 1758. Acta Zoologica Bulgarica 15: 217-222.

Vodopija, R., Racz, A. & Pahor, Đ. 2016. The incidence of jackal bites and injuries in the Zagreb anti rabies clinic during the 1995-2014 period. Acta Clinica Croatica, 55(1): 151-155.

Wennink, J., Lelieveld, G., de Knegt, H.J. & Klees, D.J.C. 2019. Habitat Suitability Analysis for the golden jackal (Canis aureus) in the Netherlands. Lutra 62(1): 13-29.

Wilson, D.F. & Mittermeier, R.A. (Eds.) 2009. Handbook of the mammals of the world. Volume 1: Carnivores. Lynx Edicions, Barcelona.

WUR 2016. Eerste goudjakhals gezien in Nederland. https://www.wur.nl/nl/nieuws/Eerste-goudjakhals-gezien-in-Nederland.htm. Accessed on 27-3-2023.

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