Nature Conservation 50: 115–143 (2022)
doi: 10.3897/natureconservation.50.81915
https://natureconservation.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Nature Conservation
Launched to accelerate biodiversity conservation

Dogs, not wolves, most likely to have caused the death of a British tourist in northern Greece

Yorgos Iliopoulos[1], Christos Astaras[2], Eirini Chatzimichail[1]

1 *Callisto Wildlife and Nature Conservation Society, Mitropoleos 123, GR-54621, Thessaloniki, Greece*
2 *Forest Research Institute, ELGO-DIMITRA, GR-57006 Vassilika, Thessaloniki, Greece*

Corresponding author: Yorgos Iliopoulos (yiliop2@gmail.com)

Academic editor: A. Grimm-Seyfarth | Received 9 February 2022 | Accepted 24 September 2022 | Published 20 October 2022

https://zoobank.org/17DA017D-DFA9-46C3-AC60-A581E4D080AF

Citation: Iliopoulos Y, Astaras C, Chatzimichail E (2022) Dogs, not wolves, most likely to have caused the death of a British tourist in northern Greece. Nature Conservation 50: 115–143. https://doi.org/10.3897/natureconservation.50.81915

Abstract

Wolf (*Canis lupus*) populations have recovered and expanded across many parts of the world thanks to conservation efforts, including improved legal status and restoration of their prey. Concurrently, public concerns regarding the risk of wolf attacks on humans and livestock are increasing as wolves occupy human-dominated landscapes. We examined a unique case in Europe allegedly involving wolves in the death of a female British tourist, aged 64, in northern Greece in September 2017. This incident received extensive international media attention and yet many fundamental details of the case area are lacking, including whether local livestock guarding dogs played a role. To assist in resolving the case, we conducted an extensive literature review which documented 13 criteria linked to the risk of either a wolf and/or a dog attacking a human. We also conducted a camera trap survey (October to December 2017) soon after the fatal attack to calculate the activity overlap among humans, dogs and wolves. Sufficient data were available for assessing 11 of the 13 criteria. For the remaining two, the required data were either not analysed (i.e. canid DNA collected from the attack site), not appropriately collected (i.e. DNA from the mouths of suspected dogs) or were collected, but misinterpreted (i.e. the post-consumption patterns of the victim's corpse). Via this combination of evidence, we conclude that this case involved a fatal dog attack. This assertion is supported by evidence such as the: a) high dog-human activity overlap at the attack site which peaked during the attack time as opposed to near zero wolf-human activity overlap at the same time, b) presence of a large pack of unsupervised dogs, c) high ratio of male dogs in the dog pack, d) close vicinity of the attack site to dog owner's property and e) previous documented aggression of these dogs towards humans. The consumption patterns, time scale and location of the victim's remains indicate a posthumous consumption of the corpse possibly by the same dogs and/or by wild scavengers including wolves. A multidisciplinary approach, such as this one, in the assessment of putative wildlife attacks on humans can reduce misidentifications of the responsible species by forensic authorities and, therefore, prevent unfounded decrease in public tolerance for large carnivores.

Copyright *Yorgos Iliopoulos et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Keywords
animal attacks on humans, forensic analysis, large carnivores, livestock guarding dogs, multidisciplinary approach, wolf

Introduction

The wolf (*Canis lupus* L.) has expanded across many parts of the world over the last three decades, thanks to conservation efforts related to its legal protection and restoration of its habitats (Chapron et al. 2014; Cimatti et al. 2021). This recovery of wolf populations, although often heralded as important for restoring ecological processes (Ripple and Beschta 2012; Boyce 2018), is not without risk, including the potential of increasing human-wildlife conflict due to wolf depredation of livestock and game animals (Janeiro-Otero et al. 2020). Moreover, concerns about the risk that wolves pose to human safety are gaining public attention (Linnell et al. 2003), as wolves increasingly occupy human-dominated landscapes (Kuijper et al. 2019).

Despite the fact that there are more than 17,000 wolves in Europe (Boitani 2018) and 75,000 in north America, with presence also in landscapes which are home to millions of people, reports of wolves attacking humans since the early 20th century are rare (Penteriani et al. 2016; Linnell et al. 2021). Wolf attacks resulting in human injuries or fatalities have been reported in published literature, unpublished/historical reports and the media (Linnell et al. 2002; Linnell et al. 2021). In general, wolf attacks on humans can be categorised as: 1) attacks by unhealthy/injured wolves, 2) provoked or defensive attacks and 3) predatory attacks (Linnell et al. 2021). Attacks by unhealthy wolves have been reported mainly in areas with rabies prevalence in wildlife, like India (Isloor et al. 2014), China (Wang et al. 2014), Iran (Gholami et al. 2014), Turkey (Turkmen et al. 2012; Ambarli 2019), Russia (Sidorov et al. 2010), as well as other countries from the Middle East, Eurasia and Asia (Linnell et al. 2021). Provoked wolf attacks on humans are rarer and have involved cases where wolves injured humans in defence of their life, prey or offspring (Linnell et al. 2021). Predatory attacks were mainly reported from areas with low natural wolf prey availability, wolf habituation with anthropogenic food sources, such as livestock, offal remains and garbage, high human density in rural settings and absence of firearms (McNay 2002; Löe and Röskaft 2004; Lescureux and Linnell 2014). Such conditions are mostly found in the Middle East and Asia, including India (Jhala and Sharma 1997; Rajpurohit 1999), Iran (Behdarvand et al. 2014; Behdarvand and Kaboli 2015) and Israel (Linnell et al. 2021). Predatory attacks on humans by healthy wolves have been also reported in Europe and North America in the 20th and 21st century (Linnell et al. 2002; Mc Nay 2002; McNay and Mooney 2005; McNay 2007; Butler et al. 2011; Penteriani et al. 2017; Linnell et al. 2021; Nowak et al. 2021). However, in the last 40 years, since scientific studies on wolves have been carried out, only two people have been killed by wolves in North America, while in western Europe (excluding Russia and some neighbouring countries where rabies is still prevalent), no wolf predatory attack on humans has been verified (Linnell et al. 2021).

As reports of wolf attacks on humans and increased livestock depredation may impede species conservation efforts (Linnell et al. 2021), great care is needed in assessing attacks putatively attributed to the species. Reports of wild predator attacks on humans and livestock – especially when receiving wide media coverage – have the potential to disproportionately decrease public tolerance towards those species, with broader repercussions for wildlife conservation (Kansky and Knight 2014; Hoffmann et al. 2017; Penteriani et al. 2017; Bombieri et al. 2018). Unsubstantiated incidents of human-wolf conflict, in particular involving human injuries or fatalities, can increase public fear of wolves. Fear has been used by individuals or interest groups to promote public dislike for wolves and to reduce the legislative protection afforded to the species (Linnell and Alleau 2015).

We examine here the 2017 case study of an alleged wolf involvement in the fatal attack of a female British tourist, aged 64, in northern Greece, because of the potential ramifications it could have for wolf public perception across Europe, especially given the extensive media attention it received both nationally and internationally (Arbieu et al. 2021). Specifically, we tested the hypothesis that wolves were indeed responsible for the fatality by examining factors associated with: a) wolf and dog attacks on humans reported in literature, b) relying on case-related evidence from official reports and c) our own field investigations, initiated soon after the attack, regarding wolf and dog occurrence and activity patterns at the attack site and adjacent areas. The criteria and assessment protocols proposed and used may help reduce the chance of predator misidentification in future human attack cases.

Case report

According to the official police report to the District Attorney, on 21 September 2017, the victim called her family in Britain at about 17:00 h Greek local time (GMT+2), which was still daylight, to report that she was being "attacked by fierce dogs" along the Petrota-Maroneia section of the E6 European long distance tourist trail in Rhodope Prefecture, northern Greece. Local witnesses, including two Austrian tourists whose written report to WWF Greece was shared to us with their consent, confirmed having seen her one hour earlier (4 pm) leaving Petrota Beach (~ 3.7 km from the attack site) heading on foot towards Maroneia Village along the car-accessible dirt/forest road which is part of the E6 European long-distance hiking trail (Figs 1–2). In response, the fire brigade initiated, that same evening, a missing person search in the area, but returned without success. The next morning (22 September 2017), the search resumed with additional personnel from the local police department, a special search and rescue unit of the fire brigade and local volunteers, continuing through the night and beyond. Eventually, using tracking dogs, some personal belongings (incl. passport, clothing) and bodily remains of the victim were discovered on the morning of 23 September 2017, approximately 36 hours after the initial distress call. The collection of additional remains concluded 72 h following the attack. The remains were dispersed along an approximately 15,000 m^2 area adjacent to the E6 trail/road, 3.7 km from Petrota Beach – or approximately 1 hour of leisure walk (Figs 1–2). According to the official police

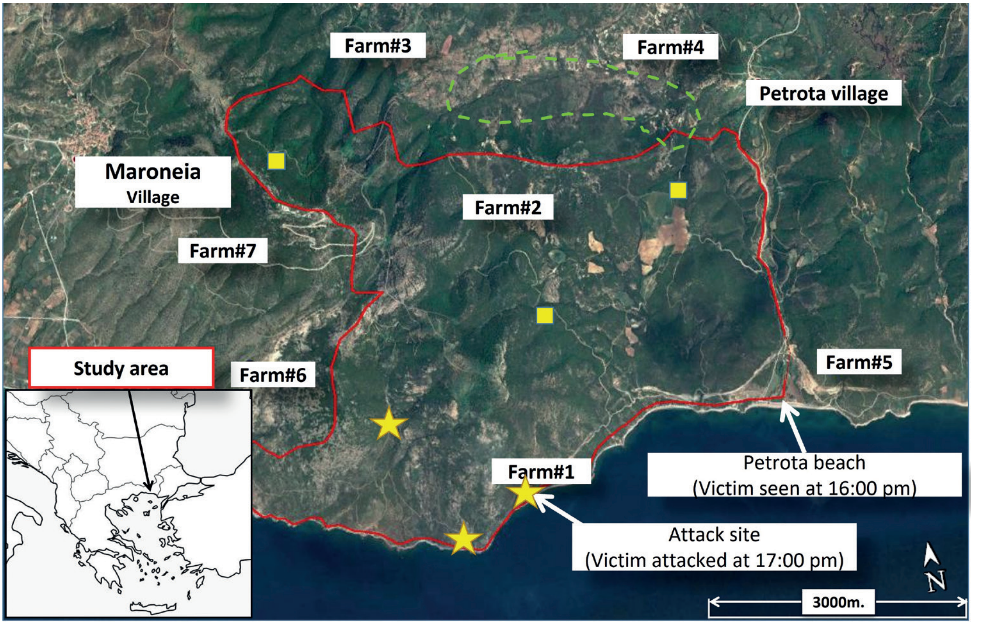

Figure 1. Area delimited by solid line indicates the approximate boundaries of the study area, the dashed line indicates the approximate location of the local wolf pack rendezvous site. Star symbols indicate camera traps deployed at the "Attack area", while closed square symbols indicate location of camera traps deployed in the "Broader area".

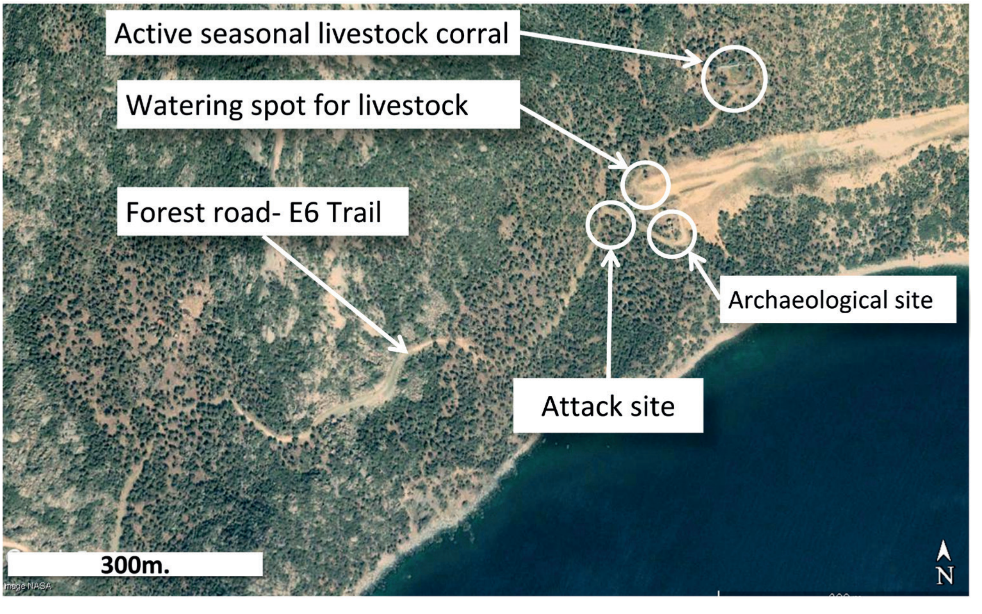

Figure 2. Location of the attack site in relation to a nearby goat herd corral and watering spot.

report, the attack site (60 m a.s.l.) was determined to be approximately 40 m from the forest road, 200 m from an actively used seasonal night-time corral for a 750-strong goat herd and 90 m from the herd's watering troughs (Figs 2–4). The herd was protected by at least ten free-roaming livestock guarding dogs (Figs 5–6).

According to the Coroner's report, the tourist's body was almost completely consumed with only ten bone fragments (parts of skull, lower jaw, femur and tibia) and soft tissue (both lungs, part of the heart and small parts of skin) retrieved by the police. All remains had signs of animal bites and/or consumption. Amongst the retrieved belongings were torn clothing (incl. jacket, trousers, shirt, hat) with traces of dry blood.

Initial national and international media reported stray dogs or livestock guarding dogs as being responsible for the death of the victim (e.g. "The Guardian" 2017, "Express" 2017). However, a 26 September 2017 article in The Times (London) (de Bruxelles and Carassava 2017) cited the Coroner's belief, prior to the completion of the laboratory analysis of remains, that the victim "may have been attacked by other wild animals, like rabid wolves" judging by the state of the victim's remains. This statement, which was widely reproduced by national and international media, contributed to an already ongoing debate on the future of the protection status of wolves in European countries, including a call by the German Federal Ministry of Agriculture, just four days after The Times' article, to regulate their national wolf population by hunting (Heine 2017). Recognising the potential long-term impact of this case on public perceptions of human-wolf interactions in Europe, we initiated this study on 2 October 2017.

Figure 3. The attack site over the E6 trail (forest road passable for vehicles).

Figure 4. Watering spot of the goat herd corral adjacent to the attack site at 90 m, occupied throughout the study duration and until early November 2017 where remains of the victim were also retrieved.

Study area

Our study area extended over 21 km^2 in the Prefecture of Rodope in northern Greece (Fig. 1). It was defined as the area encompassing: (a) the attack site, (b) the grazing area of the goat herd kept at the corral adjacent to the attack site and (c) potential nearby wolf pack home sites (i.e. rendezvous sites) as defined by habitat modelling (Iliopoulos et al. 2014) because wolf presence in the area was unknown at the onset of the study.

Figures 5, 6. Unsupervised livestock guarding dog images from the goat flock occupying the corral adjacent to the attack site.

The study area ranges from 0–612 m a.s.l and is characterised by dense evergreen Mediterranean shrubland dominated by *Quercus coccifera.* Cultivated and abandoned olive groves extend across parts of the lower elevation and coastal areas. In addition to the goat herd that are grazed in this area, there is one more free-ranging livestock herd within the study area and five around the periphery (Fig. 1). The dirt forest road that forms the E6 European long-distance hiking trail traverses the study area parallel to the coast (Figs 2–3).

Methods

Our study was complementary to the on-going police investigation at the time and tasked under a permit issued by the Hellenic Ministry of Environment and Energy with: (a) assessing wolf and dog presence and activity patterns in the study area and (b) providing an expert wildlife opinion on the case. All material (e.g. torn clothes, human bones, animal hair and faeces) collected at the attack site, which could be used to extract genetic material for DNA analysis of the involved predator, were held by the police department and were not accessible for external analysis. Nevertheless, in March 2019, the District Attorney handling the case granted access to the police and coronary-related reports and, hence, we included their findings in our analysis.

Reviewing both canid ecology literature and forensic cases involving large carnivore and dog attacks on humans, we identified a list of criteria and factors either linked to the risk of a human being attacked or useful for distinguishing the responsible predator (Table 1). We then used these criteria to assess our case. This approach was deemed necessary because the full consumption of the victim's corpse and the time it took to locate the victim's remains severely compromised the collection of evidence related to the attack for predator identification, such as size and shape of bite marks, location of injuries to the soft tissue corpse (i.e. Fonseca and Palacios 2012; Fonseca et al. 2015) or analysis of saliva DNA from fresh body wounds collected soon after the attack and prior to any post-mortem consumption (i.e. Caniglia et al. 2013; Caniglia et al. 2016). Furthermore, multi-criteria assessment was also needed due to an additional complication in our case; the inability to determine if the biological samples (hair, faeces) collected at the attack site were from the predator or subsequent scavengers, because it took 36–72 h from the initial distress phone call to locate all the victim's remains. Even though these samples were not ultimately analysed for canid DNA, the interpretation of such analysis would have been problematic since scavenging could have taken place prior to collection. Other authors have also urged to not depend solely on forensic pathologist reports in cases of animal-related human fatalities, but to include ecological and environmental characteristics of the attack as well (i.e. Fegan-Earl 2005; Shields et al. 2009; Fonseca and Palacios 2012).

Table 1. Criteria and factors used in the present study to assist in identifying the species (wolf or dog) most likely to be responsible for the attack.

Criteria and Factors for identification of predator	
Description and Rationale (species applicable) [Source]	**Data collection method**
1. Encounter rate between carnivore and human (Dog, Wolf)	
Probability of an attack increases with increased encounter rate.	camera trapping
[Penteriani et al. 2016; Penteriani et al. 2017; Martin et al. 2018]	

Criteria and Factors for identification of predator	
Description and Rationale (species applicable) [Source]	**Data collection method**
2. Location of attack site in relation to carnivore territory (Dog, Wolf)	
Carnivore aggression towards humans may be escalated closer to certain areas of their territory. Most dog attacks, causing injury or death on humans are connected to their owner's property. Wolves may show aggression to humans close to home-sites and denning areas. [Rubin and Beck 1982; Borchelt et al. 1983; McNay 2002; Patronek et al. 2013; Notari et al. 2020].	police reports, camera trapping, field observations, wolf home-site predictive model
3. Carnivore health / body condition (Dog, Wolf)	
Rabid wolves and dogs attack all mammals, including humans when rabies is endemic with no consumption of the victims [Turkmen et al. 2012; Ambarli 2019]. Rabies in Greece was not present in the country during the study period. Wild carnivores with compromised health (i.e. old age, injury, disease) may be more prone to seek food close to humans or identify humans as prey and attack. [Penteriani et al. 2016; Nowak et al. 2021]. Healthy wolves may also attack and kill humans. [Butler et al 2011; Behdarvand et al 2014; Behdarvand and Kaboli 2015]	national rabies reports, camera trapping and field observations
4. Group size (Dog)	
Dog group size is positively related to the probability of a fatal attack on humans. A single aggressive move towards a human by one dog can trigger the attack of the rest of the pack, escalating the severity of the attack often until the victim is immobilised or dead. [Borchelt et al. 1983; Kneafsey and Condon 1995; Raghavan 2008; Santoro et al. 2011; Patronek et al. 2013]	camera trapping, field observations
5. Dog(s) body size (Dog)	
The presence of large-bodied dogs may be related to more frequent and severe attacks on humans. [Roll and Unshelm 1997; Mikkola et al. 2021]	camera trapping, field observations
6. Number of male dogs (Dog)	
The number of male unneutered dogs present in a group is positively related to the probability of an attack on humans. Most fatal dog attacks on humans involved male dogs. [Shuler et al. 2008; Hsu and Sun 2010; Patronek et al. 2013; Matos et al. 2015; Notari et al. 2020; Mikkola et al. 2021]	camera trapping, field observations
7. Wolf prey availability and wolf habituation (Wolf)	
Low natural prey availability and/or human-related food provision may affect the frequency with which wolves visit human settlements in search of food, leading to fearless behaviour towards humans and may predispose them on predatory attacks in any location of their territories [Sidorovich et al 2003; Heilhecker et al. 2007; Behdarvand and Kaboli 2015; Nowak et al. 2021]	camera trapping, field observations, mapping of human related food resources (i.e. livestock herds)
8. Season of attack related to wolf biological cycle (Wolf)	
Wolf attacks on humans are mostly recorded between May and August [Rajpurohit 1999; Behdarvand and Kaboli 2015]	Police reports
9. Dog socialisation to humans and previous aggression (Dog)	
Lack of, or negative, socialisation and/or previous aggression of dogs to humans may increase probability of a dog attack. [Patronek et al. 2013; Marion et al. 2018; Mikkola et al. 2021]	camera trapping, field observations, witness testimonials
10. Human supervision (Dog)	
Lack of human supervision of free roaming dogs increases the chance of an escalated in severity attack and, therefore, the probability of its being fatal. [Rubin and Beck 1982; Borchelt et al. 1983; Patronek et al. 2013]	camera trapping
11. Bite patterns (Dog, Wolf)	
Location and distribution of bites over the victim's body may reveal species and individuals involved. [Santoro et al. 2011; Fonseca et al. 2015]	police and coroner reports
12. Post-mortem consumption patterns and rates (Dog, Wolf)	
Extent, rate and patterns of post-mortem consumption may be indicative of the carnivore species involved and its group size. Attacks and post-mortem consumption of humans by dogs is not typically driven by hunger, although cases of human corpses being consumed almost completely, even of their owners, have been reported. Dog consumption patterns on human resemble those of wild canids. [Borchelt et al. 1983; Haglund et al. 1989; Rothschild and Schneider 1997; Avis 1999; Wilmers and Stahler 2002; Peterson and Ciucci 2003; Christiansen and Wroe 2007; Steadman and Worne 2007; Buschmann et al. 2011; Fonseca and Palacios 2013; Behdarvand and Kaboli 2015; Fonseca et al. 2015]	police and coroner reports
13. Sampling of genetic material from bites and wounds	
DNA obtained from samples collected from the mortal remains can be used to identify responsible carnivore(s) for the attack and/or post-mortem consumption. [Sundqvist et al. 2007; Caniglia et al. 2013; Harms et al. 2015; Caniglia et al. 2016; Plumer et al. 2018; López-Bao et al. 2017]	coroner and genetic laboratory reports

Data collection

Our field data collection commenced on 2 October 2017, ten days after the body remains of the victim were located and one week after the coroner's interview in "The Times". It concluded two months later (5 December 2017) and after the goat herd and its dogs had left the corral at the attack site (12 November 2017). While a wolf pack's movement pattern can change when the pups start to follow adults away from the den, our eventual data showed this to have taken place in November. Our data collection, therefore, commenced sufficiently close to the incident to contain relevant data about dog and wolf activity in the area at the period of the attack.

While wolves are widely distributed in northern Greece, at the onset of the study, the spatio-temporal presence of wolves proximate to the attack site was not known. We deployed six camera traps (Reconyx RC60, Bushnell HD Trophy Cam) along forest roads and paths to: a) examine the presence of wolves during the study period and their breeding status and population size and b) record whether and to what extent wildlife, livestock, dog and human activities overlapped in time and space. Camera traps have been widely used across the world to examine interspecies interactions, including with humans (e.g. Muhly et al. 2011). With that in mind, we grouped the cameras in two clusters of three cameras each, based on their distance from the site of the attack. One cluster ("Attack area") monitored animal and human activity within the grazing area of the goat herd stationed at the corral adjacent to the attack site. Specifically, one camera was placed on the E6 trail (dirt road) 20 m from the attack site, a second one was placed 600 m to the west and the third 1,600 m to the northwest along a trail/road leading to the E6 trail (Fig. 1). The cameras of the second cluster ("Broader area") were placed at locations closer to and in-between two areas identified as potential wolf pack rendezvous sites (home-sites), based on criteria developed by Iliopoulos et al. (2014) that links water presence, distance from roads, forest cover and human infrastructure (villages) with rendezvous site suitability in Greece. They were 2,100 m, 3,800 m and 4,500 m (Euclidean distance) from the attack site (Fig. 1).

The camera traps use passive infrared sensors to detect heat and movement within a funnel-shaped area in front of the camera (radius ~ 10 metres) and are silent. They were set to record three consecutive images per triggering event (rapid-fire mode) which is known to capture even fast-moving objects (e.g. animals, vehicles). The cameras recorded around the clock, including at night with the use of infrared light which was invisible to mammals (covert type 940 nm "no glow"). The recorded images were time and date stamped. To avoid either theft or vandalism, the cameras were carefully concealed in bushes by an experienced camera-trap user (YI), while maintaining direct line of sight of the road. As this was a study conducted with the specific intent of obtaining information to assist the police investigation, the placement of the camera traps was unknown to the local population. Therefore, the activity data obtained for both humans and animals were unaffected by the presence of the cameras.

Data analysis

For each photographed wolf or dog, we recorded its sex, age (pup, juvenile, adult) and body condition, when possible. In addition, dogs were classified in three categories (livestock guarding, hunting and stray dogs), based on their morphological characteristics and their association or not with livestock herds and human activities (shepherds, hikers, hunters). Especially for livestock guarding dogs (LGDs), we individually identified them, based on their size, coat type and pattern, tail shape and the livestock herd with which they were associated. Furthermore, we classified LGD detections in two categories: supervised (i.e. accompanying herd and/or shepherd) and unsupervised (i.e. moving alone). We categorised human detections into those within vehicles and those on foot or bicycles. The latter group was further divided into researchers (our team – excluded from analysis), recreationists (hikers, hunters, bicyclists) and shepherds.

We considered photographs of a given species or category to be a different detection event when separated by at least one hour. For each camera trap cluster, we calculated the relative abundance index (RAI) of each category of humans and animals mentioned above using the following formula: RAI = n * 100/TD, where n = number of detection events and TD = number of trapping days of the cluster's camera traps.

We estimated the coefficient of activity overlap (Δ), as defined by Ridout and Linkie (2009), between: a) unsupervised LGDs and human - recreationists, b) wolves and human - recreationists and c) unsupervised LGDs and wolves, using the package "overlap" (Meredith and Ridout 2021) in the R statistical package (R Core Team 2019). Δ can take values between 0 (no activity overlap across 24 h) and 1 (perfect overlap). We calculated the confidence intervals of Δ using bootstrapping (n = 1,000). For this analysis, when multiple individuals were captured within a single detection event, each animal was counted individually as per Muhly et al. (2011).

Results

In total, our camera trapping effort was 293 trap days (mean 49 ± 15 SD, n = 6); 120 for the "Attack area" and 173 for the "Broader area" (Table 2). Wolf presence was confirmed via records at all six cameras, consisting of individuals of one reproductive pack (breeding pair and four pups). In addition, we confirmed the presence of golden jackals (*Canis aureus*), which is a potential scavenger for the case study (Table 2). The maximum jackal family group observed was two animals, with most detections recorded in the "Attack area". All jackal detections occurred after dusk and before dawn. The encounter rate of natural wolf prey species was very low, with roe deer (*Capreolus capreolus*) not detected at all and wild boar (*Sus scrofa*) detected only once in the "Broader area" (Table 2). Specifically, considering both the camera trap data and the field observations, we were able to obtain the following information regarding the presence, activity patterns and overlap of wolves, livestock guarding dogs and humans at the two sites.

Table 2. Activity measures for wildlife, livestock guarding dogs and humans at the "Attack area" and "Broader area", based on camera trapping, expressed as relative abundance indexes (RAI's) and sum of all individual detections.

Species / Category	Relative Abundance Index (RAI)		Sum of all individual detections	
	"Attack area"	"Broader area"	"Attack area"	"Broader area"
Wolf	*9*	14	*47*	43
Golden jackal	*32*	5	*47*	10
Wild boar	*0*	0.6	*0*	1
Livestock guarding dogs (LGDs) - Total	*58*	9	*169*	62
LGDs with herd/shepherd	*20*	5	*83*	33
LGDs unsupervised	*38*	6	*86*	29
Hunting dogs	*2.5*	18	*3*	38
Livestock (goats, cattle)	*76.6*	9.25	-	-
Shepherds	*29*	4	*48*	7
Recreationists (hikers, hunters, bicyclists)	*18*	12	*49*	32
Vehicles	189	120	227	207

Vicinity of attack site – "Attack area"

We recorded 11 wolf detection events. All occurred during night-time with the activity pattern of wolves at the "Attack area" peaking at midnight and prior to sunset (Fig. 7, chart a). Until 11 November, wolf detections (n = 4) involved solely the two adults of the pack. By the time the pups, born in spring 2017, appeared in the cameras, the corral adjacent to the attack site was not systematically used by the goat herd.

We recorded 56 detection events of humans, of which 34 were of shepherds. The recreationists (hunters n = 5, hikers/cyclists n = 17) ranged in group size from 1–3 individuals. Most detections were around noon and peaked during afternoon (Fig. 7, chart c).

We recorded 69 LGD detection events and identified in total 11 LGD individuals belonging to the goat herd stationed at the corral adjacent to the attack spot, of which at least eight were males. All but two of the dog pack were of large-bodied breed in good physical condition (Figs 5–6). Activity at the corral (vehicles, shepherds, herd, LGDs) was recorded daily until approximately 12 November, when the herd moved out of the coral. After this date, the presence of the LGDs and its herd was periodic. As of early November, a cattle herd started appearing in the cameras accompanied by two additional LGDs, accounting for six LGD detections only. Hunting dog detections were rare in this site (n = 3). No feral dogs were detected at the "Attack area".

From those 69 LGD detection events, 45 were of "unsupervised dogs" (i.e. without livestock or humans/vehicles recorded at the given camera within 1 h). Supervised LGDs accompanying the goat herd were mostly detected during morning hours (9 am – 12 noon), (Fig. 7, chart e). In contrast, unsupervised LGD activity was multimodal, with most detections occurring either between 9 am -10 am or 4 pm - 7 pm (Fig. 7, chart g). The evening activity of the goat herd LGDs was also corroborated by the field team during the camera trap deployment at the "Attack area". Specifically, at 7 pm (night-time) on 3 October 2017, while the livestock were corralled, the authors (YI, EC) observed and heard the LGDs barking spread out over a radius of several hundred meters from the corral.

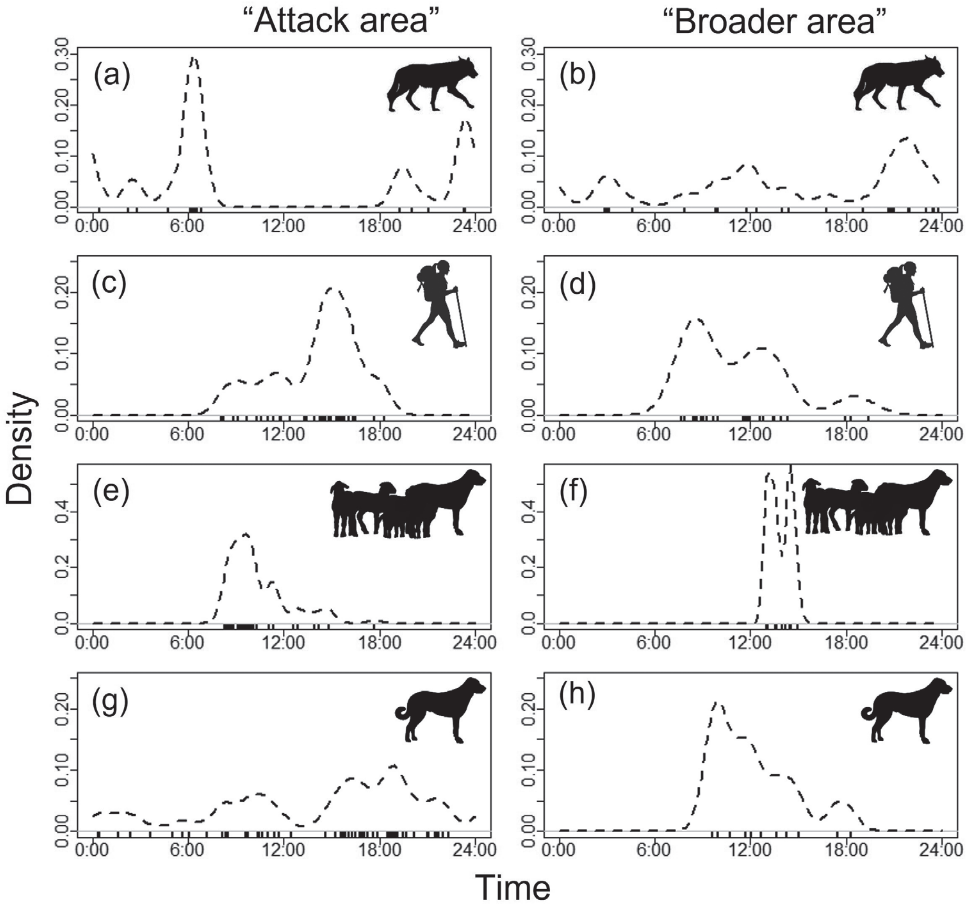

Figure 7. Density plots showing the activity pattern of wolves at (a) "Attack area" (n = 47) and (b) "Broader area" (n = 43), humans (excluding researchers and shepherds) at (c) "Attack area" (n = 49) and (d) "Broader area" (n = 32), supervised large guarding dogs with the herd at (e) "Attack area" (n = 83) and (f) "Broader area" (n = 33) and unsupervised large guarding dogs at (g) "Attack area" (n = 86) and (h) "Broader area" (n = 29). The time of the original observations at the camera traps are displayed as black ticks below the x axes. Sample sizes refer to the sum of all detections (Table 2).

Livestock presence was pervasive throughout the study period. We recorded 92 detection events of the goat herd from the "Attack area" and one cattle herd. In addition, we observed several livestock carcasses in various stages of consumption along the E6 trail. Their cause of death could not be determined in all cases (e.g. disease, disposal, predation).

"Broader area"

The number of detection events of wolves in the "Broader area" was higher than at the "Attack area", (RAI 14 and 9, respectively; Table 2), which is not surprising considering that the camera sites were closer to highly suitable habitat for wolf rendezvous sites.

The actual presence of a rendezvous site was verified by spontaneous pack howling, including pups, heard on October 7 by the field team. The wolf activity pattern in the "Broader area" was cathemeral (i.e. without a particular pattern; Fig. 7, chart b) and resembled the one of unsupervised LGDs at the "Attack area" (Fig. 7, chart g).

Overall human detection events were fewer in the "Broader area", with shepherds being seven times less frequently detected than at the "Attack area" (RAI 4 and 29, respectively). Of the recreationists, most events involved hunters (n = 16), with hikers/cyclists detected only three times. This explains the human activity pattern peaks at 7 am and 2 pm – times when hunters go and return from their trips (Fig. 7, chart d).

The detections of LGDs in the "Broader area" was six-fold lower than at the "Attack area" (RAI 9 and 58, respectively; Table 2), and involved dogs from four neighboring farms (range of distance to cameras 1.4–2.6 km) and not the goat herd corralled next to the attack site. The supervised and unsupervised LGD detections were almost evenly split (9 and 10 detections, respectively). For both LGD categories, the activity pattern was concentrated during daylight hours, peaked around noon and did not differ significantly as in the case of the "Attack area" (Fig. 7, charts g and h). Hunting dogs were seven times more frequently encountered than at the "Attack area" (Table 2). In addition, we detected three suspected feral dogs. Livestock were also seven times less frequently detected than at the "Attack area" (RAI 9.25 and 76.6, respectively; Table 2) and involved primarily cattle and goat herds other than the one at the "Attack area".

Activity overlap

The activity overlap between wolves and humans (hikers, cyclists, hunters) at the "Attack area", where the fatal attack took place, was significantly lower than the overlap between unsupervised LGDs and humans (0.04 vs. 0.55; Table 3). At 5 pm, which is the time of the attack, the probability of wolves encountering humans during our study period was near zero (Fig. 8, chart a). On the contrary, the overlap of unsupervised LGDs and humans was at its peak at that same time (Fig. 8, chart b).

The very low activity overlap between wolves and humans was observed only at the "Attack area" and not in the "Broader area"; the latter of which represents the activity at the broader landscape beyond the immediate vicinity of the attack site (Table 3). Moreover, activity overlap of LGDs by wolves at the "Attack area" was half of that in the "Broader area" during the study period.

Table 3. Activity overlaps (Δ) between humans, wolves and LGD's at the "Attack area" and "Broader area".

Activity overlap pairs	Overlap coefficient Δ (95% CI)	
	"Attack area"	"Broader area"
LGDs (unsupervised) & Humans	**0.55** (0.42–0.68)	**0.72** (0.56–0.89)
Wolves & Humans	**0.04** (0–0.12)	**0.48** (0.32–0.59)
LGDs (unsupervised) & Wolves	**0.22** (0.13–0.30)	**0.42** (0.27–0.58)

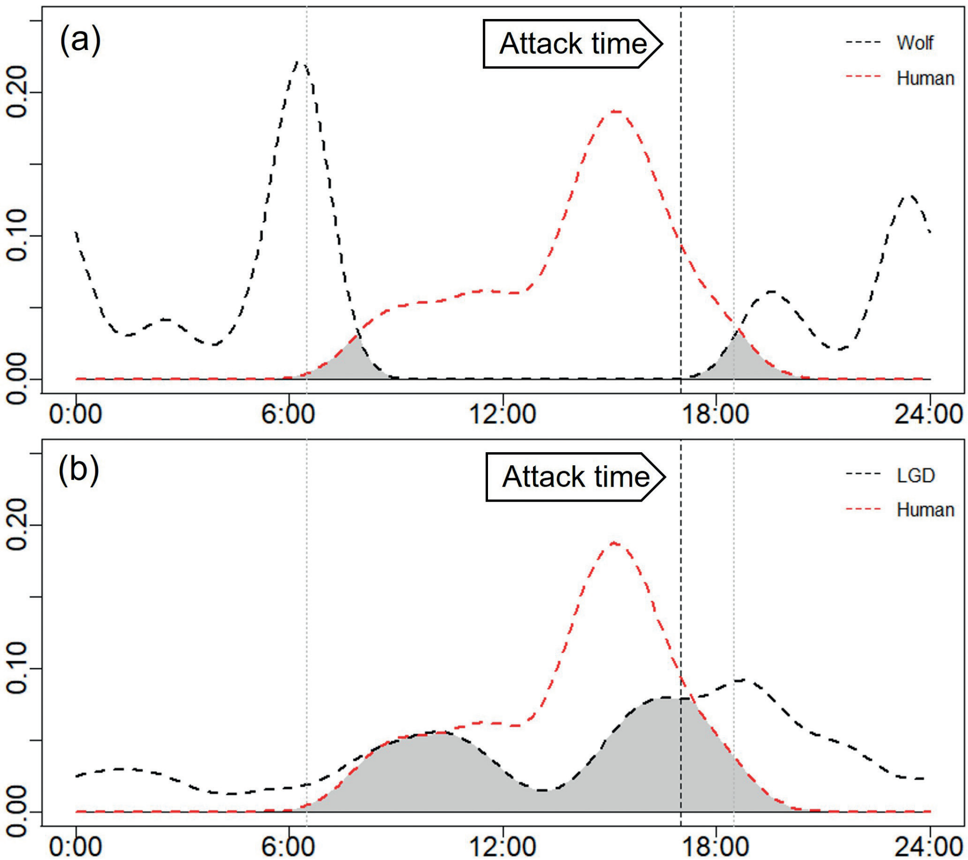

Figure 8. Activity overlap at the "Attack area" of humans ("recreationists" – i.e. hikers, bikers, hunters, excluding researchers and shepherds) and (a) wolves (coefficient of overlap $\Delta = 0.04$) and (b) unsupervised livestock guarding dogs ($\Delta = 0.55$). Sunrise and sunset are marked at their average time for the study period (GMT+2).

Predator criteria and factors assessment

We applied the findings from the camera trapping, activity pattern analysis, field observations and review of official and witness reports to the criteria and factors proposed in Table 1 for the identification of the most likely responsible predator for the attack (Table 4). From the 13 criteria/factors presented, sufficient data for assessing them were available for eleven. For two, the required data were either not analysed (i.e. canid DNA collected from the attack site), not appropriately collected (i.e. DNA from the mouths of suspected dogs) or were misinterpreted (i.e. the post-consumption patterns of the victim's corpse). We do not include in this assessment feral dogs as they were not observed at the "Attack area".

Table 4. Assessment of study findings according to the proposed criteria and factors to the case for the identification of either LGDs or wolves as responsible for the fatal attack considering the study findings (symbols: check (✓) denotes evidence of a factor/criterion pointing at the species' involvement, (X) to lack of evidence, dash (–) not applicable in the current case study and (?) to inconclusive evidence).

Livestock Guarding Dogs	*Wolves*
1. Encounter rate between carnivore and human	
Facts	**Facts**
• LGDs were active around the clock at "Attack area"	• Wolves were detected only at night-time at "Attack area"
• The activity overlaps of unsupervised LGDs and humans (hikers, hunters, cyclists) was high	• The activity overlap of wolves and humans (hikers, hunters, cyclists) was 14 times lower than the corresponding overlap of LGDs.
• At the time of the attack, the activity overlap was at its peak	• At the time of the attack, the activity overlap was practically zero
Assessment	**Assessment**
Probability of LGDs encountering the victim during the time and location of the attack was very high. Criterion is met.	Probability of wolves encountering the victim during the time and location of the attack was very low. The observed differences in the activity pattern of the wolf pack in the two sites (i.e. strictly nocturnal at the attack site, cathemeral near the pack's rendezvous site) is consistent with wolf avoidance of LGDs and human activity, both of which were 6–7 times lower in "Broader area". Criterion is not met.
✓	X
2. Location of attack site in relation to carnivore territory	
Facts	**Facts**
• The attack site is adjacent to the corral of the goat herd guarded by the LGDs. The herd and, therefore, the LGDs were present at the day of the attack and used daily the area throughout our study period • LGDs demonstrated increased territorial defence behaviour and aggression towards non-familiar humans (Witness report + authors' observations)	• The attack site is located, at a distance > 5 km from its rendezvous site/home-site. The wolf pups appear at the "Attack area" only after the pack entered the nomadic phase (Mills et al. 2008) in November, which coincided with the period that the LGDs and the goat herd left the seasonal corral.
Assessment	**Assessment**
LGDs were likely to have reacted towards the victim's presence as an intruder present at the core of their territory. Risk factor applies.	Since the attack location is not a critical area for the protection of the offspring, it is unlikely that wolves would have reacted with aggression for defensive purposes. Risk factor does not apply
✓	X
3. Carnivore health condition	
Facts	**Facts**
• Animals appear healthy and in good physical condition – i.e. no visibly malnourished individuals	• Animals appear healthy and in good physical condition – i.e. no visibly malnourished individuals
• No records of rabies in Greece since 2014	• No cases of rabid wolves in Greece during the 2012–2014 rabies outbreak • No records of rabies in Greece since 2014
Assessment	**Assessment**
The condition of the LGDs observed does not suggest that impaired hunting ability due to physical disability or disease (rabies) would have acted as driver of the attack. Risk factor does not apply.	The condition of the wolves does not suggest that impaired hunting ability due to physical disability or disease (rabies) would have acted as driver of the attack. Risk factor does not apply.
X	X
4. Canid group size	
Facts	**Facts**
• Pack size of eleven LGDs	• Pack size of two adult wolves until 11 Nov.
Assessment	**Assessment**
The LGD pack was able to subdue a human. The pack had many adult animals and, therefore, it is possible that just one of them initiated the attack triggering the rest to escalate it eventually to a fatality. Risk factor applies in analogy to dog pack size.	Wolves were able to physically subdue an adult human. Risk factor applies.
✓	✓

5. Dog(s) body size	
Livestock Guarding Dogs	***Wolves***
Facts • Most LGDs were large-bodied **Assessment** The presence of large-bodied animals in the LGD pack highly increased risk of fatality in the event of an attack is. Risk factor applies.	Not applicable
✓	–
6. Number of male individuals	
Livestock Guarding Dogs	***Wolves***
Facts • At least eight of the eleven LGDs were male. **Assessment** The large number of male dogs in the pack suggests that high levels of intra-group competition may have been present, which in turn is a factor for increased risk of attacks to humans. We were unable to determine whether the male dogs were neutered, but, in general, this is a rare practice for LGDs in Greece. Risk factor applies.	**Facts** • One of the two adult wolves was male. **Assessment** This risk factor refers to LGDs mostly. However, it is worth noting that at this time of the year, adult male wolves have low levels of testosterone as it is not the mating season. Therefore, they probably would not demonstrate levels of interspecies aggression. Risk factor does not apply or is not relevant
✓	–
7. Wolf prey availability and wolf habituation	
Livestock Guarding Dogs	***Wolves***
Not applicable	**Facts** • The natural prey availability (wild boar, roe deer) for wolves in the study area is low. • There is high availability of anthropogenic food sources (livestock, carrion, hunting dogs) in the area at the given season, which wolves can both prey on and scavenge. **Assessment** The wolf pack was likely accustomed to anthropogenic food sources and this could lead to human habituation. While the pack is probably not food stressed, the overall food requirements for the pack were high given the presence of the pups. Risk factor applies.
–	✓
8. Season of attack related to wolf biological cycle	
Livestock Guarding Dogs	***Wolves***
Not applicable	**Facts** Fatal attack happened in late September. **Assessment** Attack was outside the period from May–August where predatory wolf attacks to humans in human dominated landscapes have been more frequent. Risk factor does not apply.
–	**X**
9. Dog socialisation to humans and previous aggression	
Livestock Guarding Dogs	***Wolves***
Facts • Dog group in rural area, raised in a livestock fold. Minimum contact with family members. • Witnesses reported an LGD pack that matches the one at the attack site in terms of size, location and timing, as having demonstrated aggressive behaviour towards people passing by. • Dog aggression demonstrated towards the authors. • Extensive occasions where LGDs roamed unsupervised in the attack site at all hours of the day.	Not applicable
Assessment The above evidence suggests that, as is typical in Greece for LGDs, the pack dogs have not been positively reinforced to human socialisation and that the observed aggressive behaviour towards strangers is the norm and not the exception. Risk factor applies.	Not applicable
✓	–

10. Human supervision	
Livestock Guarding Dogs	***Wolves***
Facts • LGDs roamed unsupervised in the attack site at all hours of the day. • At the time of the attack, the probability of a human (hiker, hunter, cyclist) encountering an unsupervised LGD of the pack was maximum. **Assessment** The probability of the victim encountering the herd's LGDs at a time that they were not effectively supervised by the shepherd, which could have tried to interrupt the escalation of an attack, is high. Risk factor applies.	Not applicable
✓	–
11. Bite patterns	
Livestock guarding dogs	***Wolves***
Facts • The near complete post-mortem consumption of the victim's body means that examination of bite mark patterns inflicted during the attack was impossible. **Assessment** Not possible to assess.	**Facts** • The near complete post-mortem consumption of the victim's body means that examination of bite mark patterns inflicted during the attack was impossible. **Assessment** Not possible to assess.
–	–
12. Post-mortem consumption patterns and rates	
Facts • Near complete consumption of victim's body, disarticulation including decapitation, breaking of skull and large bones, scattering of body remains over a large area. • The above post-mortem consumption occurred within maximum 36 hours.	
Livestock Guarding Dogs	***Wolves***
• Body remains (fragment of skull) retrieved by police at the watering trough of the goat herd, located 70 m from the attack site. • The victim's jacket and underwear were located 50 m from the corral. • Around the clock presence of LGDs at the attack site.	• Wolves had presence in the area during night-time only. • Only two wolves recorded at the "Attack area" until 12 November (1.5 months after the attack)
Assessment Domestic dogs – including breeds smaller than the LGDs observed – are capable of both killing a human and causing the type of extensive and fast post-mortem damaged observed in the case (e.g. Borchelt et al. 1983; Haglund et al. 1989; Fonseca and Palacios 2013; Fonseca et al. 2015). While similar-sized dog breeds to wolves have approximately 25% less powerful bite compared to wolves (Christiansen and Wroe 2007), even medium-sized dogs can break the skull and large bones of a human (e.g. Steadman and Worne 2007; Buschmann et al. 2011). Consumption of a human corpse by dogs can commence immediately after death, if there is trauma and blood (Rothschild and Schneider 1997). Notably, Avis (1999) reported that, in one case, a dog pack killed in one attack two people and consumed them immediately, even though they had been fed earlier by their owner. Therefore, the observed post-mortem consumption pattern and rate of the victim's corpse cannot be used as a criterion for excluding dog involvement in pre-mortem fatal attack, as suggested by the coroner.	**Assessment** Wolves can cause the type of extensive and fast post-mortem damage observed in this case. Since a) only two adult wolves were recorded being active in the area and only at night, b) according to literature, wild wolves which have not fed for many days can consume at most 10 kg of biomass in one meal, following which they need several hours for digestion before feeding again (Wilmers and Stahler 2002; Peterson and Ciucci 2003), c) consumption could be interrupted by the adjacent large LGD pack at the corral and d) the rescue team searching for the victim was active in the area as of the evening of the attack (including during the night), it is questionable whether wolves alone could have achieved the near complete post-mortem consumption observed in one meal. However, translocation of body parts away from the attack site to feed wolf pups cannot be excluded. Similarly, other scavengers recorded at the attack site (jackals, foxes) could have scavenged on the body. Therefore, the observed post-mortem consumption pattern and rate of the victim's corpse cannot be used as a criterion for suggesting wolf involvement in pre-mortem fatal attack.
?	?

13. Sampling of genetic material from bites and wounds	
Facts	
• The police retrieved torn garments (jacket, trousers, shocks, shirt) of the victim with puncture wounds. • Cheek swabs and hair samples were collected by a veterinarian from ten LGDs of the goat herd corralled next to the attack site after sedating them, > 72 h after the attack. • Animal hairs were retrieved on top of bone fragments found at the attack site. • All genetic analysis conducted involved the extraction of human DNA from collected samples. • No attempt to extract carnivore DNA (i.e. from animal hair, possible saliva from garment).	
Livestock Guarding Dogs	***Wolves***
Assessment	**Assessment**
The epithelial DNA obtained from the cheeks of the LGDs using swabs was at best collected no less than 72 h following the attack (pers. comm.). The aim of this analysis was to determine whether the LGDs had bitten or consumed the victim. The established way for using genetic analysis to identify the culprit of an attack (carnivore on humans or livestock) is to collect saliva from the puncture wounds on the victim (or in case of humans, also on his/her clothes), (Sundqvist et al. 2007; Caniglia et al. 2013; Harms et al. 2015; Caniglia et al. 2016; López-Bao et al. 2017; Fabbri et al. 2018; Plumer et al. 2018). This was unfortunately not done in this case, even though the victim's torn clothes were retrieved.	Since no saliva was obtained from the victim's clothes, the genetic analysis was unable to elucidate possible wolf involvement in the attack. For example, in a fatal wolf attack case on a woman in Alaska (Butler et al. 2011), genetic analysis of saliva obtained from both body remains and clothes successfully identified not only the species, but also the number of individuals involved in the attack.
Moreover, the time elapsed from the attack until the swab collection means that any foreign genetic material could have deteriorated in the unstable (warm, humid) condition of the animals' mouths, especially if only biting was involved. According to a recent study that tested exactly this point, it was concluded that hexogen (i.e. victim's) DNA could not be traced in the mouths of dogs after 4 h (Iarussi et al. 2020). So, the absence of human DNA detection in the swab analysis does not absolve the dogs as potential predators or scavengers. Finally, even if human DNA had been detected in the LGDs' mouths, the interpretation of its source would have been problematic – it could have been due to post-mortem consumption and not necessarily the attack phase of the incident.	Therefore, the protocol used was inappropriate and the criterion is not informative.
Therefore, the protocol used was inappropriate and the criterion is not informative.	
–	–

Discussion

Based on the assessment of our findings, there is substantial circumstantial evidence that the fatal attack on the British tourist in Greece on 21 September 2017 could have been caused by the livestock guarding dogs (LGDs) of the goat herd corralled adjacent to the attack site. Our evidence includes high activity overlap between recreationists and unsupervised LGDs (with it peaking at 5 pm, which is the same time as that of the attack), lack of LGD supervision, large LGD pack size, high ratio of males among LGDs, close vicinity of the attack site to the LGDs and the livestock corral, and a record of LGD aggression towards humans as recently as a few days before the attack. Specifically, regarding LGD aggression, apart from the author's own field observations, two Austrian tourists reported seeing a helmet-mounted video of two Belgian bikers who were attacked by seven aggressive dogs on the same section of the trail a couple days before the attack. This was reported as a written statement to WWF-Greece and submitted to the police. It was also shared with us with their consent.

However, there are certain inherent limitations due to the nature of our study which dictate that the LGDs' involvement in the fatal attack is highly probable, but not certain. This includes that our data collection unavoidably occurred after the attack and, therefore, cannot with certainty reflect the exact conditions on the day of the attack. Additionally, the behaviour of the wolves could have changed through time, due to the brief (72 h), but intense human activity near the attack site by search and forensic teams. Therefore, in principle, a wolf attack cannot be excluded despite the very low probability supported by our findings. In terms of posthumous body consumption, our findings suggest that the same dogs and/or wild scavengers, including wolves, could have contributed.

Although our study confirmed the presence of golden jackals in the study area and the coroner's media statements and report suggested the species could be involved in the fatal attack, we did not consider the species as a potential predator in our assessment. We decided this because there is no literature reference of jackals fatally attacking humans anywhere in the world and injury reports are limited to countries where rabies is endemic and human and jackal densities are very high (i.e. India, Akhtar and Chauhan 2009), whilst rabies in Greece is no longer endemic. Moreover, jackals were exclusively nocturnal at the study area and exhibited no overlap with human activity. Finally, the resident jackal family group consisted of just two adults (low density).

Our findings stem from a set of criteria developed to assist, along with standard forensic protocols, the predator identification in cases such as ours (i.e. nearly complete body consumption and delayed location of remains). On the contrary, the coroner's conclusion was based primarily on the post-mortem consumption pattern observed and the lack of human DNA detection in the mouths of the dogs. Importantly, there was no differentiation in the report between the two distinct phases of the incident – the attack and the post-mortem consumption of the body. Recognising these two phases is important, as the species responsible for the fatal attack may not consume (or may not be the only one to consume) the body. Therefore, in that particular case, the post-mortem consumption pattern cannot be used as a criterion for excluding dog responsibility for the fatal attack. Moreover, the reported form and extent of post-mortem consumption can result from dog consumption according to forensic literature (e.g. Borchelt et al. 1983; Haglund et al. 1989; Avis 1999; Steadman and Worne 2007; Buschmann et al. 2011; Fonseca and Palacios 2012; Fonseca et al. 2015).

Regarding the search for human DNA in the dog cheek swabs, the results could not be informative in this specific case. The sampling occurred > 72 h after the attack and, critically, not from a location that would identify the attacker, especially if only bites had been inflicted on the victim. Several forensic publications recommend to sample for predator DNA from the saliva left on the wounds and clothes of the victim, soon after the attack (e.g. Sundqvist et al. 2007; Caniglia et al 2013; Harms et al. 2015; Caniglia et al. 2016; López-Bao et al. 2017; Fabbri et al. 2018; Plumer et al. 2018). Regardless, even if genetic material is collected using swabs from the mouth of suspected animals, a recent study by Iarussi et al. (2020) showed that no traces of hexogen (i.e. the victim's) DNA could be traced in the swab samples after 4 h. Therefore, the absence of human DNA in the dog cheek swabs analysed in our case study is not informative about the involvement or not of the dogs in the attack.

Results from this case study are in line with the main conclusion of Linnell et al. (2021) that human fatalities from healthy wolves in Europe are extremely rare (e.g. non-existent for the period 2015–2018), while rabies remains the most prevalent cause for verified human injuries or deaths from wolves. Rabies is no longer endemic in Greece, at least since 2015 (EFSA 2021), while not a single case of a rabid wolf has been recorded in the country since rabies was first detected in 2012. On the contrary, in 2016 alone, at least 45 human fatalities caused by dogs were recorded in Europe (Sarenbo and Svensson 2020).

We recognise that the rarity of wild carnivore fatal attacks on humans in Europe, especially with such extensive posthumous consumption, complicated efforts to resolve this case. Forensic science literature of similar cases recommends a more interdisciplinary approach to the evaluation of the evidence, which includes also ecological and environmental characteristics of the attack (e.g. Fonseca and Palacios 2012). The value of such a broader approach to the case was recognised by the Police Department, Forest Service and Ministry of the Environment, which expeditiously provided the necessary permits and support for our study. Moreover, the Public Prosecutor's office took into consideration an earlier version of this report, amongst all other information available, prior to bringing the owner of the goat herd to court with the accusation of involuntary manslaughter. After many adjournments of the court, the case verdict was issued on September 23, 2022. The judges concluded that the death was due to attack by the livestock guarding dogs of the goat herd being kept at the time at the temporary coral near the attack site, and found the owner guilty of involuntary manslaughter.

Resolving the case is important for carnivore conservation in Europe, as it received considerable national and international media coverage (Arbieu et al. 2021). The alleged involvement of wolves, despite the lack of concrete evidence to support it, has left a lingering impression to the public regarding the threat that wolves pose to humans, as deduced by the frequent enquiries addressed to the authors regarding the case. Though rare, even alleged wildlife involvement in human attacks have the potential to decrease public tolerance towards these species, which can have broader repercussions on wildlife conservation (Bombieri et al. 2018). Therefore, we consider the detailed description of what transpired in the death of the British tourist to be of value to the broader public, forensic authorities and scientific/wildlife management community.

Our assessment regarding the responsibility of LGDs in the fatal attack is also not without potential negative impacts on large carnivore conservation. LGDs are recognised as an effective and socially acceptable tool for wildlife-human co-existence (Rigg et al. 2011). The case could amplify existing concerns about the broader risk that LGDs may pose to recreationists (Linnell and Lescureux 2015). Therefore, ensuring both adequate livestock protection from large carnivores and public safety is important in areas where nature tourism and extensive livestock raising co-occur, since both activities are important for rural economies. In Greece, a large LGD group size, like the one observed in this case, is common in areas with large carnivores (wolf and brown bear). Moreover, LGDs often need to work independently from the shepherd's supervision to locate and deter predators (Landry et al. 2020).

The location of the seasonal livestock corral next to a tourist trail was a decisive factor in the case, as it greatly increased the chance of the LGDs encountering the victim. In addition, the victim's response to approaching dogs, though unknown, could have contributed to the initiation and escalation of the attack, as documented in similar studies (e.g. Borchelt et al. 1983; Rezac et al. 2015; Reese and Vertalka 2020).

Conclusions

Based on the assessment of our findings, we conclude that there is no concrete evidence that wolves were responsible for the death of the British tourist in the Maroneia-Petrota region, northern Greece. On the contrary, evidence provided by the assessable risk criteria, based on literature review and field observations, suggest an increased probability of a dog attack as a probable cause of death of the British tourist. The court's decision issued around the same time as the acceptance of this article was also in line with our assessment.

There are lessons to be learned from this tragic case study. Risks related to livestock guarding dogs need to be carefully evaluated in areas with frequent tourist activity to avoid human injuries and fatalities. We propose three practical measures to reduce the probability of future LGD attacks on humans. First, all permanent and seasonal livestock corrals in the vicinity of tourist areas (e.g. hiking trails, open-air archaeological sites, mountain lodges) should be mapped, their potential risk to users evaluated including assessment of dog behaviour and, if necessary, relocated. In all cases, warning signs can be added both on site and in hiking maps or applications. Secondly, together with the guidelines provided for encounters with potentially dangerous wildlife (e.g. brown bears; Bombieri et al. 2019), the public should also be informed about best ways of avoiding and handling dangerous LGD encounters. Additionally, in countries where deterrence tools, such as pepper sprays, are not allowed, legal exceptions to their use for animal deterrence in rural areas could be considered.

Finally, a multidisciplinary approach in the assessment of putative wildlife attacks on humans can reduce misidentifications of the responsible species and, therefore, prevent unfounded decrease in public tolerance for large carnivores, which is difficult to achieve and even harder to maintain. To reduce future controversies, police routines should be established that automatically integrate wildlife expertise into such investigations, as well as establishing best practices for the collection of appropriate forensic data.

Acknowledgements

The study was implemented under a research licence from the Hellenic Ministry of Environment (no. 154593/2487). The authors would like to thank the Head of the Rhodope Forest Directorate, M. Gotzaridou for assistance and support during field work, Sapes Police Department for facilitating ongoing research, P. Maragou from WWF Greece for providing access to testimonials from the study area, R.A. Montgomery and three other anonymous reviewers for providing valuable feedback on an earlier version of this manuscript and Callisto Wildlife Society for providing all necessary equipment needed for the research.

References

Akhtar N, Chauhan NPS (2009) Food habitats and human-jackal interaction in Marwahi Forest Division, Bilaspur Chhattisgarh. Indian Forester (October): 1347–1356. https://www.cabdirect.org/globalhealth/abstract/20103013807

Ambarli H (2019) Analysis of wolf–human conflicts: Implications for damage mitigation measures. European Journal of Wildlife Research 65(6): 1–9. https://doi.org/10.1007/s10344-019-1320-4

Arbieu U, Chapron G, Astaras C, Bunnefeld N, Harkins S, Iliopoulos Y, Mehring M, Reinhardt I, Mueller T (2021) News selection and framing: The media as a stakeholder in human-carnivore coexistence. Environmental Research Letters 16(6): 064075. https://doi.org/10.1088/1748-9326/ac05ef

Avis SP (1999) Dog pack attack: Hunting humans. The American Journal of Forensic Medicine and Pathology 20(3): 243–246. https://doi.org/10.1097/00000433-199909000-00005

Behdarvand N, Kaboli M (2015) Characteristics of Gray Wolf Attacks on Humans in an Altered Landscape in the West of Iran. Human Dimensions of Wildlife 20(2): 112–122. https://doi.org/10.1080/10871209.2015.963747

Behdarvand N, Kaboli M, Ahmadi M, Nourani E, Salman Mahini A, Asadi Aghbolaghi M (2014) Spatial risk model and mitigation implications for wolf–human conflict in a highly modified agroecosystem in western Iran. Biological Conservation 177: 156–164. https://doi.org/10.1016/j.biocon.2014.06.024

Boitani L (2018) *Canis lupus* (errata version published in 2019). The IUCN Red List of Threatened Species 2018: e.T3746A144226239. [Accessed on 08 February 2022]

Bombieri G, Nanni V, Delgado M del M, Fedriani JM, López-Bao JV, Pedrini P, Penteriani V (2018) Content Analysis of Media Reports on Predator Attacks on Humans: Toward an Understanding of Human Risk Perception and Predator Acceptance. Bioscience 68(8): 577–584. https://doi.org/10.1093/biosci/biy072

Bombieri G, Naves J, Penteriani V, Selva N, Fernández-Gil A, López-Bao JV, Ambarli H, Bautista C, Bespalova T, Bobrov V, Bolshakov V, Bondarchuk S, Camarra JJ, Chiriac S, Ciucci P, Dutsov A, Dykyy I, Fedriani JM, García-Rodríguez A, Garrote PJ, Gashev S, Groff C, Gutleb B, Haring M, Härkönen S, Huber D, Kaboli M, Kalinkin Y, Karamanlidis AA, Karpin V, Kastrikin V, Khlyap L, Khoetsky P, Kojola I, Kozlow Y, Korolev A, Korytin N, Kozsheechkin V, Krofel M, Kurhinen J, Kuznetsova I, Larin E, Levykh A, Mamontov V, Männil P, Melovski D, Mertzanis Y, Meydus A, Mohammadi A, Norberg H, Palazón S, Pătrașcu LM, Pavlova K, Pedrini P, Quenette PY, Revilla E, Rigg R, Rozhkov Y, Russo LF, Rykov A, Saburova L, Sahlén V, Saveljev AP, Seryodkin IV, Shelekhov A, Shishikin A, Shkvyria M, Sidorovich V, Sopin V, Støen O, Stofik J, Swenson JE, Tirski D, Vasin A, Wabakken P, Yarushina L, Zwijacz-Kozica T, Delgado MM (2019) Brown bear attacks on humans: A worldwide perspective. Scientific Reports 9(1): e8753. https://doi.org/10.1038/s41598-019-44341-w

Borchelt PL, Lockwood R, Beck AM, Voith VL (1983) Attacks by packs of dogs involving predation on human beings. Public Health Reports 98: 57–66. https://www.jstor.org/stable/4627350

Boyce MS (2018) Wolves for Yellowstone: Dynamics in time and space. Journal of Mammalogy 99(5): 1021–1031. https://doi.org/10.1093/jmammal/gyy115

Buschmann C, Solarino B, Püschel K, Czubaiko F, Heinze S, Tsokos M (2011) Post-mortem decapitation by domestic dogs: Three case reports and review of the literature. Forensic Science, Medicine, and Pathology 7(4): 344–349. https://doi.org/10.1007/s12024-011-9233-x

Butler L, Dale B, Beckmen K, Farley S (2011) Findings related to the March 2010 fatal wolf attack near Chignik Lake, Alaska. Wildlife Special Publication, Alaska departement of fish and game, Division of wildlife conservation, USA. https://www.adfg.alaska.gov/static/home/news/pdfs/wolfattackfatality.pdf

Caniglia R, Fabbri E, Mastrogiuseppe L, Randi E (2013) Who is who? Identification of livestock predators using forensic genetic approaches. Forensic Science International. Genetics 7(3): 397–404. https://doi.org/10.1016/j.fsigen.2012.11.001

Caniglia R, Galaverni M, Delogu M, Fabbri E, Musto C, Randi E (2016) Big bad wolf or man's best friend? Unmasking a false wolf aggression on humans. Forensic Science International. Genetics 24: e4–e6. https://doi.org/10.1016/j.fsigen.2016.06.009

Chapron G, Kaczensky P, Linnell JDC, von Arx M, Huber D, Andrén H, López-Bao JV, Adamec M, Álvares F, Anders O, Balčiauskas L, Balys V, Bedő P, Bego F, Blanco JC, Breitenmoser U, Brøseth H, Bufka L, Bunikyte R, Ciucci P, Dutsov A, Engleder T, Fuxjäger C, Groff C, Holmala K, Hoxha B, Iliopoulos Y, Ionescu O, Jeremić J, Jerina K, Kluth G, Knauer F, Kojola I, Kos I, Krofel M, Kubala J, Kunovac S, Kusak J, Kutal M, Liberg O, Majić A, Männil P, Manz R, Marboutin E, Marucco F, Melovski D, Mersini K, Mertzanis Y, Mysłajek RW, Nowak S, Odden J, Ozolins J, Palomero G, Paunović M, Persson J, Potočnik H, Quenette P-Y, Rauer G, Reinhardt I, Rigg R, Ryser A, Salvatori V, Skrbinšek T, Stojanov A, Swenson JE, Szemethy L, Trajçe A, Tsingarska-Sedefcheva E, Váňa M, Veeroja R, Wabakken P, Wölfl M, Wölfl S, Zimmermann F, Zlatanova D, Boitani L (2014) Recovery of large carnivores in Europe's modern human-dominated landscapes. Science 346(6216): 1517–1519. https://doi.org/10.1126/science.1257553

Christiansen P, Wroe S (2007) Bite forces and evolutionary adaptations to feeding ecology in carnivores. Ecology 88(2): 347–358. https://doi.org/10.1890/0012-9658(2007)88[347:BFAEAT]2.0.CO;2

Cimatti M, Ranc N, Benítez-López A, Maiorano L, Boitani L, Cagnacci F, Čengić M, Ciucci P, Huijbregts MAJ, Krofel M, López-Bao JV, Selva N, Andren H, Bautista C, Ćirović D, Hemmingmoore H, Reinhardt I, Marenče M, Mertzanis Y, Pedrotti L, Trbojević I, Zetterberg A, Zwijacz-Kozica T, Santini L (2021) Large carnivore expansion in Europe is associated with human population density and land cover changes. Diversity & Distributions 27(4): 602–617. https://doi.org/10.1111/ddi.13219

de Bruxelles S, Carassava A (2017) Wolves blamed for death of mauled British tourist Celia Hollingworth. The Times. https://www.thetimes.co.uk/article/wolves-blamed-for-british-tourist-s-death-x708crgcp [Assesed February 8, 2021]

EFSA [European Food Safety Authority and European Centre for Disease Prevention and Control] (2021) The European Union One Health 2019 Zoonoses Report. EFSA Journal 19(2): e06406 [286 pp]. https://doi.org/10.2903/j.efsa.2021.6406

"Express" (2017) Horror over British woman mauled to death by pack of wild dogs in Greece. https://www.express.co.uk/news/world/858874/Dog-Attack-Greece-Celia-Hollingworth [Accessed February 8, 2022]

Fabbri E, Velli E, D'Amico F, Galaverni M, Mastrogiuseppe L, Mattucci F, Caniglia R (2018) From predation to management: monitoring wolf distribution and understanding depredationpatterns from attacks on livestock. Hystrix, the Italian Journal of Mammalogy 29: 101–110. https://doi.org/10.4404/HYSTRIX-00070-2018

Fegan-Earl AW (2005) Animal attacks and injuries. Fatal and non-fatal. In: Byard R, Corey T, Henderson C, Payne-James J (Eds) Encyclopedia of forensic and legal medicine, Vol. 1, 1st edn. Oxford, UK, 68–71. https://doi.org/10.1016/B0-12-369399-3/00013-6

Fonseca GM, Palacios R (2012) An unusual case of predation: Dog pack or cougar attack? Journal of Forensic Sciences 58(1): 224–227. https://doi.org/10.1111/j.1556-4029.2012.02281.x

Fonseca GM, Mora E, Lucena J, Cantin M (2015) Forensic studies of dog attacks on humans: A focus on bite mark analysis. Research and Reports in Forensic Medical Science 5: 39–51. https://doi.org/10.2147/RRFMS.S92068

Gholami A, Fayaz A, Farahtaj F (2014) Rabies in Iran: Past, Present and Future. Journal of Medical Microbiology and Infectious Diseases 2(1): 1–10. http://jommid.pasteur.ac.ir/article-1-49-en.html

Haglund WD, Reay DT, Swindler DR (1989) Canid Scavenging/Disarticulation Sequence of Human Remains in the Pacific Northwest. Journal of Forensic Sciences 34(3): e12679J. https://doi.org/10.1520/JFS12679J

Haidt A, Gawryś R, Szewczyk M (2021) Human Decision-Making as a Key Factor in the Risk of Wolf–Dog Interactions during Outdoor Activities. Animals 11(9): 2497. https://doi.org/10.3390/ani11092497

Harms V, Nowak C, Carl S, Muñoz-Fuentes V (2015) Experimental evaluation of genetic predator identification from saliva traces on wildlife kills. Journal of Mammalogy 96(1): 138–143. https://doi.org/10.1093/jmammal/gyu014

Heilhecker E, Thiel RP, Wayne H (2007) Wolf, *Canis lupus*, behavior in areas of frequent human activity. Canadian Field Naturalist 121(3): 256–260. https://doi.org/10.22621/cfn.v121i3.472

Heine H (2017) Streit um Wölfe: Landwirtschaftsminister will Abschuss erleichtern. Der Tagesspiegel. https://www.tagesspiegel.de/berlin/streit-um-woelfe-landwirtschaftsminister-will-abschuss-erleichtern/20400392.html [Accessed February 8, 2022]

Hoffmann CF, Montgomery RA, Jepson PR (2017) Examining the effect of billboards in shaping the great wolf debate of the American West. Human Dimensions of Wildlife 22(3): 267–281. https://doi.org/10.1080/10871209.2017.1314059

Hsu Y, Sun L (2010) Factors associated with aggressive responses in pet dogs. Applied Animal Behaviour Science 123(3–4): 108–123. https://doi.org/10.1016/j.applanim.2010.01.013

Iarussi F, Cipolloni L, Bertozzi G, Sasso L, Ferrara M, Salerno M, Rubino GTR, Maglietta F, Dinisi A, Albano D, Iarussi V, Pomara C, Sessa F (2020) Dog-bite-related attacks: A new forensic approach. Forensic Science International 310: 110254. https://doi.org/10.1016/j.forsciint.2020.110254

Iliopoulos Y, Youlatos D, Sgardelis S (2014) Wolf pack rendezvous site selection in Greece is mainly affected by anthropogenic landscape features. European Journal of Wildlife Research 60(1): 23–34. https://doi.org/10.1007/s10344-013-0746-3

Isloor S, Marissen WM, Veeresh BH, Nithinprabhu K, Kuzmin IV, Rupprecht CE, Satyanarayana ML, Deepti BR, Sharada R, Neelufer MS, Yathiraj S, Abdul Rahman S (2014) First Case Report of Rabies in a Wolf (*Canis lupus pallipes*) from India. Journal of Veterinary Medical Research 001: 1–6.

Janeiro-Otero A, Newsome TM, Van Eeden LM, Ripple WJ, Dormann CF (2020) Grey wolf (*Canis lupus*) predation on livestock in relation to prey availability. Biological Conservation 243: 108433. https://doi.org/10.1016/j.biocon.2020.108433

Jhala YV, Sharma DK (1997) Child-lifting by wolves in eastern Uttar Pradesh, India. Journal of Wildlife Research 2: 94–101. https://ci.nii.ac.jp/naid/10026778633/ [Accessed August 7, 2021]

Kansky R, Knight AT (2014) Key factors driving attitudes towards large mammals in conflict with humans. Biological Conservation 179: 93–105. https://doi.org/10.1016/j.biocon.2014.09.008

Kneafsey B, Condon KC (1995) Severe dog-bite injuries, introducing the concept of pack attack: A literature review and seven case reports. Injury 26(1): 37–41. https://doi.org/10.1016/0020-1383(95)90550-H

Kuijper DPJ, Churski M, Trouwborst A, Heurich M, Smit C, Kerley GIH, Cromsigt JPGM (2019) Keep the wolf from the door: How to conserve wolves in Europe's human-dominated landscapes? Biological Conservation 235: 102–111. https://doi.org/10.1016/j.biocon.2019.04.004

Landry JM, Borelli JL, Drouilly M (2020) Interactions between livestock guarding dogs and wolves in the southern French Alps. Journal of Vertebrate Biology 69(3): 20078 [1–18]. https://doi.org/10.25225/jvb.20078

Lescureux N, Linnell JDC (2014) Review. Biological Conservation Complete 171: 232–245. https://doi.org/10.1016/j.biocon.2014.01.032

Linnell JDC, Alleau J (2015) Predators that kill humans: Myth, reality, context and the politics of wolf attacks on people. Problematic Wildlife: A Cross-Disciplinary Approach, 357–371. https://doi.org/10.1007/978-3-319-22246-2_17

Linnell JDC, Lescureux N (2015) Livestock guarding dogs – cultural heritage icons with a new relevance for mitigating conservation conflicts. Norwegian Institute for Nature Research, Trondheim.

Linnell JDC, Andersen R, Andersone Z, Balciauskas L, Blanco JC, Boitani L, Brainerd S, Beitenmoser U, Kojola I, Liberg O, Løe J, Okarma H, Pedersen HC, Promberger C, Sand H, Solberg EJ, Valdmann H, Wabakken P (2002) The fear of wolves: A review of wolfs attacks on humans. NINA Oppdragsmelding 731, Norsk institutt for naturforskning NINA.

Linnell JDC, Solberg EJ, Brainerd S, Liberg O, Sand H, Wabakken P, Kojola I (2003) Is the Fear of Wolves Justified? A Fennoscandian Perspective. Acta Zoologica Lituanica 13(1): 34–40. https://doi.org/10.1080/13921657.2003.10512541

Linnell JDC, Kovtun E, Rouart I (2021) Wolf attacks on humans: an update for 2002–2020. NINA Report 1944, Norwegian Institute for Nature Research.

Löe J, Röskaft E (2004) Large carnivores and human safety: A review. Ambio 33(6): 283–288. https://doi.org/10.1579/0044-7447-33.6.283

López-Bao JV, Frank J, Svensson L, Åkesson M, Langefors Å (2017) Building public trust in compensation programs through accuracy assessments of damage verification protocols. Biological Conservation 213: 36–41. https://doi.org/10.1016/j.biocon.2017.06.033

Marion M, Béata C, Sarcey G, Delfante S, Marlois N (2018) Study of aggressiveness in livestock-guarding dogs based on rearing method. Journal of Veterinary Behavior 25: 14–16. https://doi.org/10.1016/j.jveb.2018.03.001

Martin HW, Mech LD, Fieberg J, Metz MC, Macnulty DR, Stahler DR, Smith DW (2018) Factors affecting gray wolf (*Canis lupus*) encounter rate with elk (*Cervus elaphus*) in Yellowstone National Park. Canadian Journal of Zoology 96(9): 1032–1042. https://doi.org/10.1139/cjz-2017-0220

Matos RE, Jakuba T, Mino I, Fejsakova M, Demeova A, Kottferova J (2015) Characteristics and risk factors of dog aggression in the Slovak Republic. Veterinární Medicína 60(8): 432–445. https://doi.org/10.17221/8418-VETMED

McNay ME (2002) Wolf-Human Interactions in Alaska and Canada: A Review of the Case History. Wildlife Society Bulletin 30: 831–843. https://www.jstor.org/stable/3784237

McNay ME (2007) A Review of Evidence and Findings Related to the Death of Kenton Carnegie on 8 November 2005 Near Points North, Saskatchewan. Alaska Department of Fish and Game, Fairbanks, Alaska.

McNay ME, Mooney PW (2005) Attempted Predation of a Child by a Gray Wolf, near Icy Bay, Alaska. Canadian Field Naturalist 119(2): 197–201. https://doi.org/10.22621/cfn.v119i2.106

Meredith M, Ridout M (2021) Overview of the overlap package: https://cran.r-project.org/web/packages/overlap/vignettes/overlap.pdf [Accessed August 8, 2021]

Mikkola S, Salonen M, Puurunen J, Hakanen E, Sulkama S, Araujo C, Lohi H (2021) Aggressive behaviour is affected by demographic, environmental and behavioural factors in purebred dogs. Scientific Reports 11: 1–10. https://doi.org/10.1038/s41598-021-88793-5

Mills KJ, Patterson BR, Murray DL (2008) Direct Estimation of Early Survival and Movements in Eastern Wolf Pups. The Journal of Wildlife Management 72(4): 949–954. https://doi.org/10.2193/2006-457

Muhly TB, Semeniuk C, Massolo A, Hickman L, Musiani M (2011) Human activity helps prey win the predator-prey space race. PLoS ONE 6(3): e17050. https://doi.org/10.1371/journal.pone.0017050

Notari L, Cannas S, Di Sotto YA, Palestrini C (2020) A retrospective analysis of dog–dog and dog–human cases of aggression in Northern Italy. Animals 10(9): 1–17. https://doi.org/10.3390/ani10091662

Nowak S, Szewczyk M, Tomczak P, Całus I, Figura M, Mysłajek RW (2021) Social and environmental factors influencing contemporary cases of wolf aggression towards people in Poland. European Journal of Wildlife Research 67(4): 69. https://doi.org/10.1007/s10344-020-01455-1

Patronek GJ, Sacks JJ, Delise KM, Cleary DV, Marder AR (2013) Co-occurrence of potentially preventable factors in 256 dog bite-related fatalities in the United States (2000–2009). Journal of the American Veterinary Medical Association 243(12): 1726–1736. https://doi.org/10.2460/javma.243.12.1726

Penteriani V, Delgado M del M, Pinchera F, Naves J, Fernández-Gil A, Kojola I, Härkönen S, Norberg H, Frank J, Fedriani JM, Sahlén V, Støen O-G, Swenson JE, Wabakken P, Pellegrini M, Herrero S, López-Bao JV (2016) Human behaviour can trigger large carnivore attacks in developed countries. Scientific Reports 6: 1–8. https://doi.org/10.1038/srep20552

Penteriani V, Bombieri G, Fedriani JM, López-Bao JV, Garrote PJ, Russo LF, Delgado M del M (2017) Humans as Prey: Coping with Large Carnivore Attacks using a Predator-Prey Interaction Perspective. Human-Wildlife Interactions 11: 10. https://doi.org/https://doi.org/10.26077/dpyb-q611

Peterson RO, Ciucci P (2003) The wolf as a carnivore. In: Mech LD, Boitani L (Eds) Wolves: behaviour, ecology and conservation. The University of Chicago Press, Chicago, USA, 161–191.

Plumer L, Talvi T, Männil P, Saarma U (2018) Assessing the roles of wolves and dogs in livestock predation with suggestions for mitigating human–wildlife conflict and conservation of wolves. Conservation Genetics 19(3): 665–672. https://doi.org/10.1007/s10592-017-1045-4

R Core Team (2019). A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna.

Raghavan M (2008) Fatal dog attacks in Canada, 1990–2007. The Canadian Veterinary Journal 49: 577. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2387261/ [Accessed August 8, 2021]

Rajpurohit KS (1999) Child lifting: Wolves in Hazaribagh, India. Ambio 28: 162–166.

Reese LA, Vertalka JJ (2020) Understanding Dog Bites: The Important Role of Human Behavior. Journal of Applied Animal Welfare Science 24(4): 331–346. https://doi.org/10.1080/10888705.2020.1790371

Rezac P, Rezac K, Slama P (2015) Human behavior preceding dog bites to the face. Veterinary Journal 206(3): 284–288. https://doi.org/10.1016/j.tvjl.2015.10.021

Ridout MS, Linkie M (2009) Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural Biological & Environmental Statistics 14(3): 322–337. https://doi.org/10.1198/jabes.2009.08038

Rigg R, Find'o S, Wechselberger M, Gorman ML, Sillero-Zubiri C, Macdonald DW (2011) Mitigating carnivore–livestock conflict in Europe: Lessons from Slovakia. Oryx 45(2): 272–280. https://doi.org/10.1017/S0030605310000074

Ripple WJ, Beschta RL (2012) Trophic cascades in Yellowstone: The first 15 years after wolf reintroduction. Biological Conservation 145(1): 205–213. https://doi.org/10.1016/j.biocon.2011.11.005

Roll A, Unshelm J (1997) Aggressive conflicts amongst dogs and factors affecting them. Applied Animal Behaviour Science 52(3–4): 229–242. https://doi.org/10.1016/S0168-1591(96)01125-2

Rothschild MA, Schneider V (1997) On the temporal onset of postmortem animal scavenging "Motivation" of the animal. Forensic Science International 89(1–2): 57–64. https://doi.org/10.1016/S0379-0738(97)00112-6

Rubin HD, Beck AM (1982) Ecological behavior of free-ranging urban pet dogs. Applied Animal Ethology 8(1–2): 161–168. https://doi.org/10.1016/0304-3762(82)90141-9

Santoro V, Smaldone G, Lozito P, Smaldone M, Introna F (2011) A forensic approach to fatal dog attacks. A case study and review of the literature. Forensic Science International 206(1–3): e37–e42. https://doi.org/10.1016/j.forsciint.2010.07.026

Sarenbo S, Svensson PA (2020) Bitten or struck by dog: A rising number of fatalities in Europe, 1995–2016. Forensic Science International 18: 110592. https://doi.org/10.1016/j.forsciint.2020.110592

Shields LBE, Bernstein ML, Hunsaker JC, Stewart DM (2009) Dog bite-related fatalities: A 15-year review of Kentucky medical examiner cases. The American Journal of Forensic Medicine and Pathology 30(3): 223–230. https://doi.org/10.1097/PAF.0b013e3181a5e558

Shuler CM, DeBess EE, Lapidus JA, Hedberg K (2008) Canine and human factors related to dog bite injuries. Journal of the American Veterinary Medical Association 232(4): 542–546. https://doi.org/10.2460/javma.232.4.542

Sidorov GN, Sidorova DG, Poleshchuk EM (2010) Rabies of wild mammals in Russia at the turn of the 20th and 21st centuries. Biology Bulletin of the Russian Academy of Sciences 37(7): 684–694. https://doi.org/10.1134/S1062359010070034

Sidorovich VE, Tikhomirova LL, Jędrzejewska B (2003) Wolf Canis lupus numbers, diet and damage to livestock in relation to hunting and ungulate abundance in northeastern Belarus during 1990–2000. Wildlife Biology 9(2): 103–111. https://doi.org/10.2981/wlb.2003.032

Steadman DW, Worne H (2007) Canine scavenging of human remains in an indoor setting. Forensic Science International 173(1): 78–82. https://doi.org/10.1016/j.forsciint.2006.11.011

Sundqvist A-K, Ellegren H, Vilà C (2007) Wolf or dog? Genetic identification of predators from saliva collected around bite wounds on prey. Conservation Genetics 9: 1275–1279. https://doi.org/10.1007/s10592-007-9454-4

"The Guardian" (2017) British woman mauled to death by wild dogs in Greece is named. https://www.theguardian.com/uk-news/2017/sep/25/british-woman-mauled-death-wild-dogs-greece-named [Accessed February 8, 2022]

Turkmen S, Sahin A, Gunaydn M, Tatli O, Karaca Y, Turedi S, Gunduz A (2012) A Wild Wolf Attack and Its Unfortunate Outcome: Rabies and Death. Wilderness & Environmental Medicine 23(3): 248–250. https://doi.org/10.1016/j.wem.2012.03.009

Wang L, Tang Q, Liang G (2014) Rabies and rabies virus in wildlife in mainland China, 1990–2013. International Journal of Infectious Diseases 25: 122–129. https://doi.org/10.1016/j.ijid.2014.04.016

Wilmers CC, Stahler DR (2002) Constraints on active-consumption rates in gray wolves, coyotes, and grizzly bears. Canadian Journal of Zoology 80(7): 1256–1261. https://doi.org/10.1139/z02-112