

CHARACTERIZATION OF ROAD ACCIDENTS IN ISRAEL INVOLVING LARGE MAMMALS

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ABSTRACT

This report is the first attempt to evaluate the magnitude of car accidents involving terrestrial mammals in Israel. With the cooperation of the Israeli insurance companies, we identified 351 accidents that involved mammals from 1995 through 1999. Since only accidents that resulted in human injuries were retrievable, this data set underestimates the full scope of the phenomenon. The annual number of accidents increased twofold during the survey period, indicating that the problem is constantly on the rise. Most accidents took place in northern Israel during the evening and nighttime hours, between 18:00–01:00. Cattle (*Bos taurus*) and other domestic ungulates, such as horses (*Equus caballus*), camels (*Camelus dromedarius*), and donkeys (*Equus* sp.), constitute the most serious threat to drivers, accounting for approximately 80% of the accidents. Wildlife, primarily wild boar (*Sus scrofa*), accounted for less than 8% of the accidents. During the study period, 566 injuries to humans and five fatalities were recorded. The total annual damage from these accidents is approximately NIS 3,002,274. (NIS 4 = ~\$1 at the time). This is only a fraction of the overall damage because data on accidents with mammals that only involved property damage were not available. The fact that wildlife plays a minor role in car accidents in Israel is probably a result of the extinction and/or low densities of large wild mammals, especially ungulates (excluding gazelles, *Gazella* spp., and ibex, *Capra ibex*). Our data suggest that proper cattle handling and fencing could significantly reduce human casualties and economic loss. However, it is recommended that fencing be constructed to accommodate sufficient wildlife passages.

INTRODUCTION

Road expansion worldwide and the associated increase in traffic volume have led to potential human–wildlife conflicts, causing thousands of human casualties and multibillion-dollar damage costs annually. For example, in the United States alone more than 1 million automobile accidents with deer result in 211 fatalities, 29,000 injuries, and \$1.1 billion in vehicle repair costs annually. In contrast, in the U.S., there are only 12–16 fatalities from vertebrate attacks (including poisonous snakes) a year (Conover et

al., 1995). Similarly, in Europe (excluding Russia), more than half a million car accidents with ungulates result in 300 fatalities, approximately 30,000 injuries, and ca. \$1 billion in property damage annually (Groot Bruinderink and Hazebroek, 1996).

On the other side of the picture, wildlife too (vertebrates and invertebrates) can be severely affected by roadkill losses and habitat modifications (see Forman and Alexander, 1998; Trombulak and Frissell, 2000, for recent reviews). Not only are small animals generally killed instantly when hit by a car, but so too are most (92%) larger animals, such as white-tailed deer (*Odocoileus virginianus*; 25–180 kg) (Allen and McCullough, 1976). In recent decades, roadkills have surpassed hunting as the leading cause of terrestrial vertebrate mortality by direct human activity (Forman and Alexander, 1998). In addition, probably the most severe negative effect of traffic and road systems on wildlife is the division of animal populations into small isolated sub-populations, i.e., habitat fragmentation. The number of animals in small populations tends to fluctuate more widely, resulting in higher extinction rates. Habitat fragmentation and barriers may also alter the population's genetic structure and prevent recolonization (Forman and Alexander, 1998; Trombulak and Frissell, 2000).

Most data on animal road-kill come from North America and Western Europe (e.g., Lavsund and Sandegren, 1991; Evink et al., 1999; Finder et al., 1999, but see Drews, 1995). This study aims to examine, for the first time, car accidents involving East Mediterranean fauna. Characterizing the phenomenon of car accidents involving terrestrial mammals is the first necessary step in the effort to reduce human casualties, economic loss, and mammal (both wild and domestic) mortality. In Israel, road density has increased rapidly, adding to the potential risk of animal–traffic conflicts. In 1999, 1,730,000 registered vehicles utilized 16,115 km of roads in Israel, i.e., 107 vehicles/km (Israel Central Bureau of Statistics, 2000).

Animal–transportation conflicts have been studied extensively in the Western world (e.g., Evink et al., 1999). However, this subject has not been considered seriously in Israel, despite the thorough local research conducted on another aspect of traffic–wildlife conflict—that of avian–aircraft collisions (Leshem and Rosenboim, 1998, and references therein). Recently, following the construction of the Trans-Israel Highway (a 300-km, eight-lane road), the subject has drawn special attention (Bachi, 2000). In her review, Bachi (2000) lists various sources (not published in the scientific literature) indicating that road–animal conflicts in Israel may indeed be severely affecting various animal groups, including amphibians, reptiles, birds, and mammals.

METHODS

Lacking regular and systematic documentation of mammal roadkills (both wild and domestic), we resorted to using insurance company records to track the incidents. Naturally, this database is limited to cases in which human casualties were compensated. In Israel, the traffic police and the insurance companies record car accidents involving animals only when passengers are hurt. Only one agency, Avner (Motor Vehicle Accident Victims Insurance Assn., Ltd.), deals with traffic-related deaths and injuries

(people may be insured for property damage with other primary insurance companies). First, we searched Avner's database covering the years 1995–1999. Since the database does not hold full details of the accidents, each accident file was cross-examined with the original file at the primary insurance company. For each accident, we retrieved the following details: date, time, location, number and type of injuries, mammal species involved, and value of property and personal injury compensation. The details were not always fully available (see relevant sample sizes in the results). The police database provided by the research division of the traffic police was also cross-examined. There were few cases in which fraud was suspected.

DATA ANALYSIS

A linear correlation was used to analyze annual associations between accidents and traffic volume. One-way ANOVA was used to identify monthly trends of car accidents with mammals. All statistical analyses were performed with 'Statistica' software for Windows (StatSoft Inc., Tulsa, OK, U.S.A.).

RESULTS

CASUALTIES

During the period 1995–1999, we identified 351 accidents in which mammal-related car accidents caused human casualties: 536 slight to moderate injuries, 30 serious injuries, and five fatalities. On average, this equals one death and 113 injuries for every 70 animal-related car accidents each year.

MAMMALS INVOLVED

Of the total of 351 mammal-related car accidents, the species could be identified in 226 of them. Domestic ungulates accounted for most of the accidents (Table 1). Cattle (*Bos taurus*) were hit most and were involved in nearly half of the car accidents. Horses (*Equus caballus*) accounted for nearly 20% of the accidents, followed by other large domestic ungulates, such as donkeys and camels (Table 1). Pets (cats and dogs) were responsible for 10% of the accidents. It is possible that some of the pets in rural areas were actually misidentified wild carnivores, especially the golden jackal (*Canis aureus*), which is frequently killed on rural roads (Inbar and Shanas, unpublished). Due to their small size, pets impose small direct-hit impact. Casualties following incidents with pets often occur as a result of drivers trying to avoid hitting the animal. Wildlife accounted for 8% of the accidents. The most common wild mammal involved in accidents was the wild boar (*Sus scrofa*). In three accidents, mountain gazelles (*Gazella gazella*) were involved (Table 1).

TEMPORAL TRENDS

The annual number of reported car accidents involving mammals increased more than twofold between 1995 and 1999 (Fig. 1). These numbers correlate with the total number of vehicles in Israel ($r = 0.97$, $n = 5$, $p < 0.01$), but not with the overall number of

Table 1
Mammal species involved in car accidents in Israel between 1995 and 1999. Only accidents with human casualties are included

Animal	Number of incidents	Proportion
Cattle, <i>Bos taurus</i>	103	0.45
Horse, <i>Equus caballus</i>	43	0.19
Donkey, <i>Equus</i> sp.	27	0.12
Camel, <i>Camelus dromedarius</i>	8	0.03
Goat, <i>Capra aegagrus</i>	3	0.01
Dog, <i>Canis familiaris</i>	21	0.09
Cat, <i>Felis</i> sp.	3	0.01
Wild boar, <i>Sus scrofa</i>	14	0.06
Mountain gazelle, <i>Gazella gazella</i>	3	0.01
Red Fox, <i>Vulpes vulpes</i>	1	0.004
Total	226	
Total domestic ungulates	184	0.814
Total pets	24	0.106
Total wildlife	18	0.08

accidents on Israel's roads ($r = 0.18$, $n = 5$, NS, Fig. 1). Thus, unlike the 1999 overall reduction in car accidents in Israel, the number of accidents with mammals is constantly increasing. On a monthly basis, the mean number of accidents significantly increased between 1995 and 1999 (one-way ANOVA, $F_{4,55} = 4.18$, $p < 0.001$). For example, the monthly mean (\pm SE) for 1999 was 8.7 ± 1.3 , which was more than twice the 1995 mean of 3.6 ± 0.9 . Annually, mean monthly accidents peaked twice, once in the summer and again in the winter. The lowest accident rate occurred in March–April and September, although the trend was not statistically significant (one-way ANOVA, $F_{11,48} = 0.58$, NS, Fig. 2).

More than 60% of the accidents occurred in the evening and nighttime hours between 18:00 and 01:00 (Fig. 3). All accidents with wild boar and red fox occurred during the nighttime hours, while all accidents with mountain gazelle (*Gazella gazella*) took place during the daytime.

LOCATION

The areas posing the highest risk of severe collision with mammals are found in northern Israel (Fig. 4). Most of the accidents (70%) took place in the Galilee and the Golan Heights, mainly (but not only) with cattle. Camels pose a serious danger to motorists in the south (the Negev and the Arava Valley to Elat), and donkeys are a major problem in the West Bank (Judea and Samaria). Accidents with wild boar primarily occurred in the Galilee and the Golan Heights. Two of the three collisions with mountain gazelles occurred in the Golan Heights (see Fig. 4). Small pets are the most frequently hit mammals in urban areas, such as Tel Aviv and vicinity.

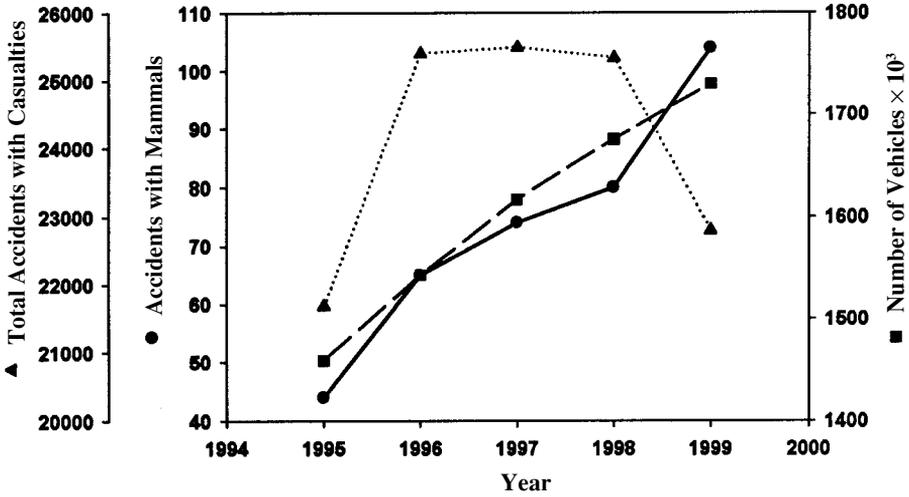


Fig. 1. Trends in total and mammal-related car accidents (with casualties; n = 351) and vehicle numbers in Israel between 1995 and 1999. Data on total accidents and vehicles are from the Israel Central Bureau of Statistics (2000).

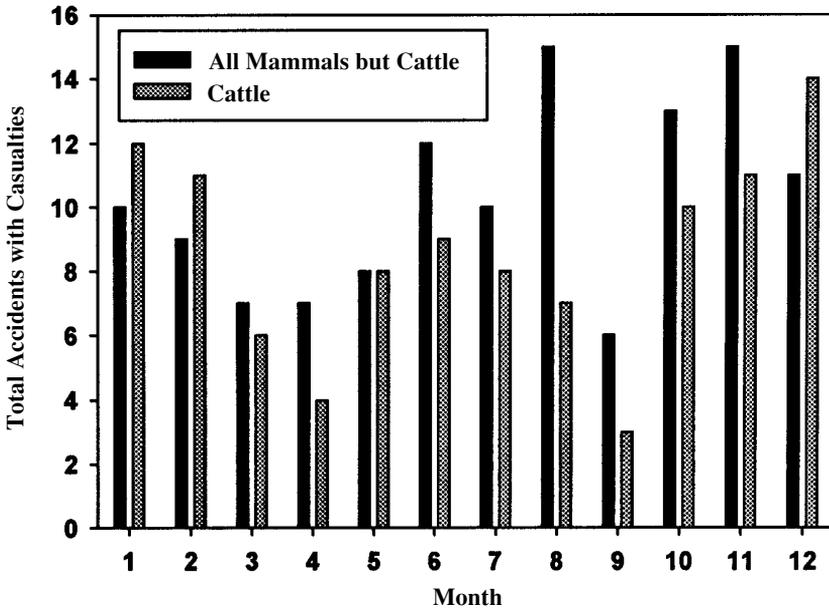


Fig. 2. Temporal trends in mammal-related car accidents between 1995 and 1999 (n = 226 accidents). The correlation between monthly accidents of cattle and all other animals is not significant, $r = 0.52$, $n = 12$, $p = 0.08$.

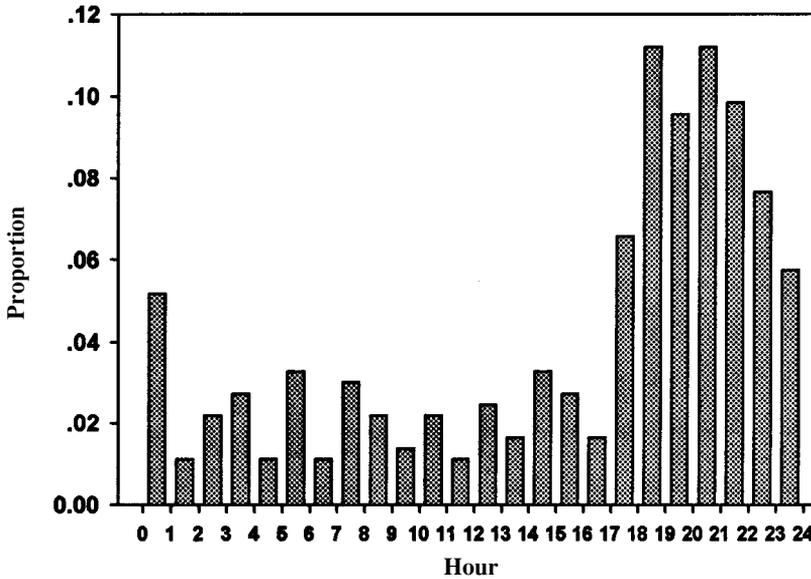
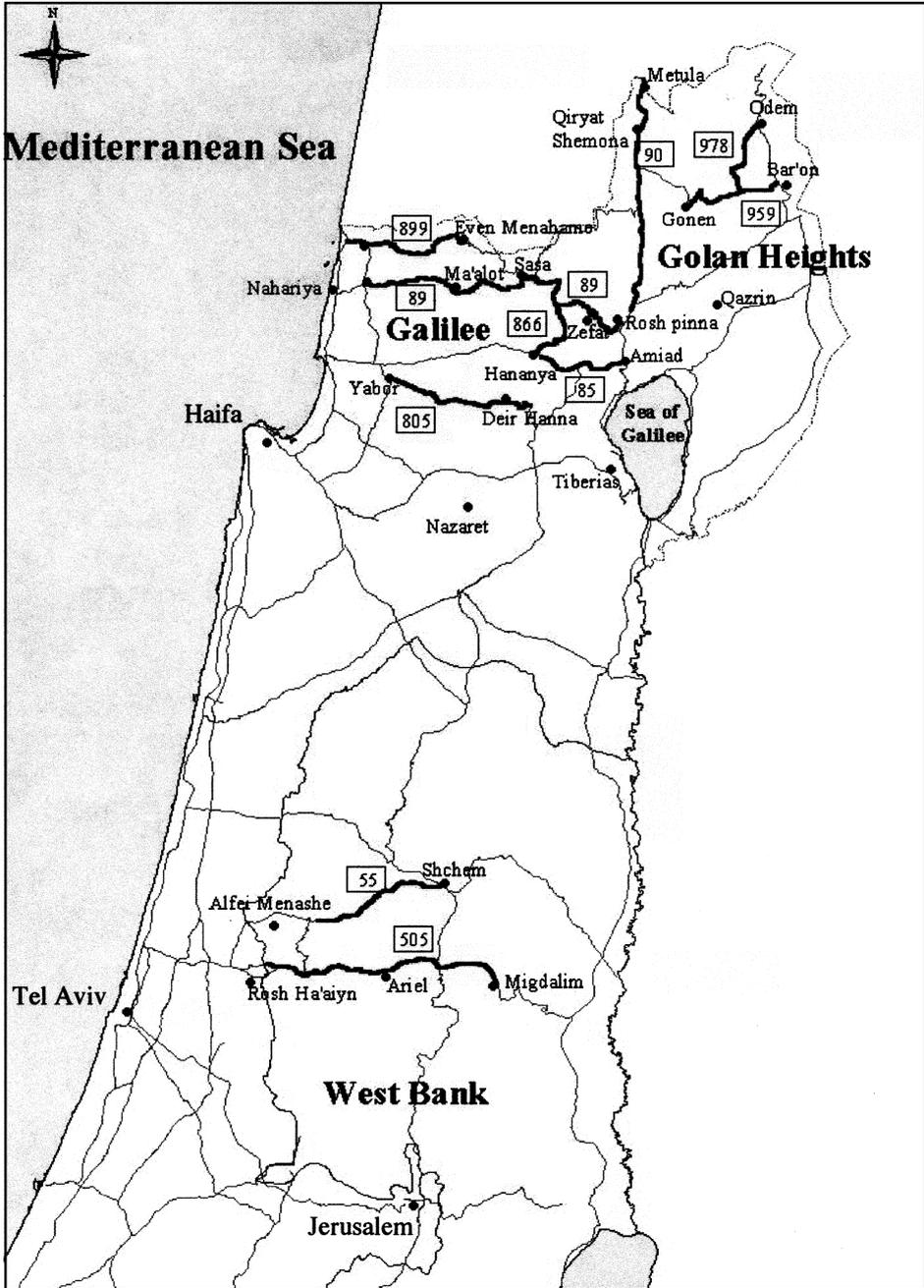


Fig. 3. Distribution of accidents in which animals were involved between 1995 and 1999 (n = 351).

ECONOMIC LOSS

The only accurate data on financial damage were available from cases involving compensation for personal injury. From 1995 to 1999, the insurance company paid NIS 10,435,897 (\$2.6 million, \$1 = ~NIS 4). Data on property damage in accidents with human casualties were scattered and in some cases unretrievable. The average property damage was NIS 13,036 per accident. Thus, we estimate that the total property damage for the 351 accidents during 1995–1999 was NIS 4,575,385. The overall annual damage from these accidents is approximately NIS 3,002,274. Wildlife accounted for 8% of the accidents, translating to NIS 240,181 in financial damage.

Fig. 4 (*facing page*). A map of north and central Israel illustrating sites mentioned in the text. The roads listed below (and highlighted on the map) are the top ten roads with mammal-related car accidents involving human casualties between 1995 and 1999. These roads should be considered as indicators for risky regions rather than as specific risky routes: Golan Heights—Rd. 959 from Gonen Jct. to Bar' on Jct.; Rd. 978 from HaShiryon Jct. to Odem Jct.; Upper Galilee—Rd. 89 from Kabri Jct. to Rosh Pinna Jct.; Rd. 90 from Mahanayim to Metula; Rd. 866 from Hananya Jct. to Meron Jct.; Rd. 899 from Misrafot Jct. to Even Menahame; Lower Galilee—Rd. 85 from Halaftha Jct. to Amiad Jct.; Rd. 805 from Yavor Jct. to Deir Hanna Jct.; Samaria—Rd. 55 between Km Post 8–42; Rd. 505 between Km Post 19–58.



This is obviously an underestimate of the overall damage since we do not have records on accidents involving mammals that ended only in property damage or the value of the loss of a domestic mammal.

DISCUSSION

Domestic ungulates pose a serious threat to motorists along the roads of Israel. Unlike the recent overall reduction in car accidents, the number of animal-related accidents with casualties has increased constantly and sharply (Fig. 1). Clearly, accidents with casualties cannot serve as an indication of the total number of mammals killed by vehicles. Most accidents took place in the Upper Galilee and Golan Heights during the early evening hours.

The number of accidents is affected by multiple driver- and animal-related factors (Inbar and Mayer, 1999). Driver-related factors include traffic volume (vehicles/time), speed, road width, and braking distance (influenced by road structure and weather). Animal-related factors include specific traits, such as time of activity, movement patterns, food distribution, and breeding behavior (e.g., Carbaugh et al., 1975; Case, 1978; Fahrig et al., 1995; Inbar and Mayer, 1999). Therefore, because we could not standardize the mammal-car accident data for road length, traffic volume, and mammal density, the data on specific roads can only serve as an indicator for risk areas. These areas are found in the Golan Heights, Upper Galilee, and Samaria (Fig. 4).

We found that most accidents happened during the evening and early nighttime hours (Fig. 3), probably because the roads are not only very busy at this time, but the drivers' ability to avoid accidents is also limited because of the dark, and both domestic and wild mammals are still relatively active at these hours. Later at night, the number of accidents was found to decrease, probably as a result of lower traffic volume and reduced activity of domestic ungulates. The relatively improved visual conditions during daylight hours apparently are conducive to a lower number of accidents.

Our finding that most accidents were caused by domestic mammals (i.e., cattle in the Galilee, camels in the Negev) may have practical implications for accident prevention. Cattle owners or road builders in designated areas (Fig. 4) should be obliged to fence the livestock plots, preventing access of cattle to the roads. However, fencing should be constructed to accommodate proper wildlife passages. Furthermore, special attention should be paid to livestock handling during the evening hours. Similarly, camel owners should keep their herds away from Negev roads.

In Europe and North America, large (over 30 kg) wild mammals, usually ungulates, are more frequently involved in car accidents (Conover et al., 1995; Putman, 1997). The minor role of wildlife in car accidents in Israel reflects the poor status of such large wild mammals, especially ungulates. Several large mammals from northern Israel became extinct during the past two centuries, including the Syrian bear (*Ursus arctos*), roe deer (*Capreolus capreolus*), and fallow deer (*Dama dama*) (Yom-Tov and Mendelsohn, 1988). Of all wild mammals in Europe and North America, deer are the most frequently involved in collisions with vehicles (Conover et al., 1995; Groot Bruinderink and

Hazebroek, 1996; Finder et al., 1999). Thus, any reintroduction of deer into Israel (Saltz, 1996) should consider their potential encounters with traffic once large populations are established. Similarly, the reintroduced wild ass (*Equus hemionus*) may have the potential to create a serious conflict with traffic in the Negev Desert.

Animals of the size of mountain gazelles (20–30 kg) and Nubian ibex (*Capra ibex*; 20–50 kg) have the potential to be frequently involved in serious accidents. Clearly, the two gazelle species in Israel, the northern (*G. gazella*) and the southern (*G. dorcas*) gazelles, are only rarely involved in car accidents (three cases of the former during the period under study). Gazelles are not listed among the most frequent wildlife road-kill losses (Israel Nature and Parks Authority records, cited in Bachi, 2000). This may be attributable to the fact that gazelles are primarily diurnal and therefore have a reduced potential of collisions with cars. In addition, gazelles learn quickly about potential threats (Mendelssohn and Yom-Tov, 1999a) and may avoid fast-moving vehicles and road areas. Likewise, the Nubian ibex was not involved in any serious accident during the period under study and is not listed as a frequent wildlife road-kill loss (Israel Nature and Parks Authority records, cited in Bachi, 2000). This is probably because ibexes are diurnal and inhabit steep cliffs in remote areas, such as the Judean Desert and the Negev highlands, where the traffic volume is low. On the other hand, wild boars are frequently involved in car accidents, apparently a result of their wide distribution, which has been extended during the last century due to human activity and increased density (Mendelssohn and Yom-Tov, 1999b). Their primarily nocturnal activity pattern, high mobility (Mendelssohn and Yom-Tov, 1999a), and large size (>50 kg) add to their car collision potential.

The fact that domestic ungulates (cattle) are the mammals most frequently involved in severe car accidents in Israel makes the problem easier to address. Proper legislation and meticulous cattle handling and fencing in the northern rural areas (as with camels in the south) should minimize the problem. Most road-kill animals do not cause accidents with human casualties or property damage, primarily because of their small size. Nevertheless, most of these accidents are fatal for the terrestrial vertebrates (mammals, birds, reptiles, amphibians) and invertebrates themselves. Taking into account the direct hits, habitat destruction, and fragmentation by roads, with the rapid urban and road expansion in Israel, traffic could become one of the major threats to the unique local fauna. Thus, roadside fencing should be constructed with sufficient and efficient wildlife passages in mind.

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