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Management of Wildlife-Human Conflicts in Israel: A Wide Variety of Vertebrate Pest Problems in a Difficult and Compact Environment

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Abstract: Although Israel is a small country, it sits at the junction of three continents, and has an especially rich diversity of ecotones and wildlife. In addition, Israel serves as a narrow land-bridge on the major migratory route for millions of birds between Eurasia and Africa. Competing with all this wildlife for living space is a relatively dense human population. Israel is quite conservation-minded with strict wildlife protection laws and very little hunting. All these factors contribute to a situation in which there is much human influence over whatever available habitat is left for wildlife. Consequently, wildlife-human conflicts are common and diverse, but are dealt with mainly with non-lethal methods.

Millions of migratory birds cross through Israel and share Israel's small airspace with the Israeli Air Force (IAF). Israel is especially active in Bird Aircraft Strike Hazard (BASH) issues, which are controlled by a variety of means, including real-time radar information of migratory birds, habitat management, and use of border collies at airfields.

Wildlife in Israel are vectors for human diseases (e.g., leishmaniasis, rabies, and West Nile fever). To prevent rabies epidemics, Israel has recently begun successful use of oral rabies vaccination (ORV) for jackals (*Canis aureus*) and foxes (*Vulpes vulpes*).

Some examples of avian wildlife-agriculture problems include pelicans (*Pelecanus onocrotalus*), night herons (*Nycticorax nycticorax*), and cormorants (*Phalacrocorax carbo* and *P. pygmeus*) in fishponds; bee-eaters (*Merops apiaster*) eating pollinators; Eurasian cranes (*Grus grus*) on winter crops; and various corvids in fruit trees and sunflowers. Some examples of mammalian wildlife-agriculture problems include wolf (*Canis lupus*) and golden jackal (*C. aureus*) depredation of calves and sheep; damage to drip irrigation pipes by canids; wild boar (*Sus scrofa*) in field and fruit crops; fruit bats (*Rousettus aegypticus*) in lychee and other fruit orchards; mongoose (*Herpetes ichneumon*) predation on ostrich chicks; hyrax (*Procavia capensis*), gazelles (*Gazella gazella*), ibex (*Capra ibex*), and porcupine (*Hystrix indica*) damage to fruit and trees in a variety of orchards; and a variety of rodent damage to crops.

Problem resolution at agricultural facilities involves immediate government response and outreach to farmers, a great emphasis on non-lethal preventative measures (such as fencing, pyrotechnics, repellents, and livestock guarding dogs), and active management of wildlife populations (occasionally including culling).

Key Words: Israel, Mediterranean, wildlife-agriculture conflict, wildlife damage, bird migration, Bird Aircraft Strike Hazard (BASH), oral rabies vaccination (ORV), vertebrate pest management, non-lethal methods, rabies, leishmaniasis, West Nile fever, diseases

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INTRODUCTION

Although it is a small country (about 20,000 km²), Israel has a very wide variety of conflicts between wildlife and humans, mainly as wildlife damage to agriculture. Moran and Keidar (1993) listed 61 vertebrate species causing direct and indirect damage to agriculture. Their list included 27 mammal, 32 bird, and 2 reptile species. In the decade since that list was prepared, more species have been identified that could be added (S. Moran, pers. comm.), including Persian fallow deer (*Dama mesopotamica*), which were reintroduced into Israel in the 1990s (Saltz 1996) and are already causing damage in orchards.

In addition to agricultural damage, wildlife contribute to other acute problems in Israel including the spread of human diseases (e.g., rabies) (Nemptov and King 1998), and bird hazards to aircraft (Leshem et al. 1999).

Much work is done in Israel to solve these wildlife-

human conflicts, but little is formally documented, and even less is available in English. This report is an overview of some of the major wildlife-human conflicts in Israel— a review of the biogeography and human factors unique to Israel, and a summary of methods currently employed for resolution of these conflicts.

THE BIOGEOGRAPHY OF ISRAEL IN BRIEF

To understand why Israel has such a wide variety of wildlife-human conflicts, it is necessary to understand the country's unique biogeography. Despite its small size, Israel has an extremely rich biodiversity (Yom-Tov and Tchernov 1988). This is because Israel is at the juncture of three continents— Europe, Asia, and Africa (Figure 1), and of several climatic regions (Gabbay 1997, Frankenberg 1999). For example, 2,780 plant, 96 reptile, 511 bird, and 116 mammal species occur in Israel (Gabbay 1997).

The northern half of Israel is a hilly area character-

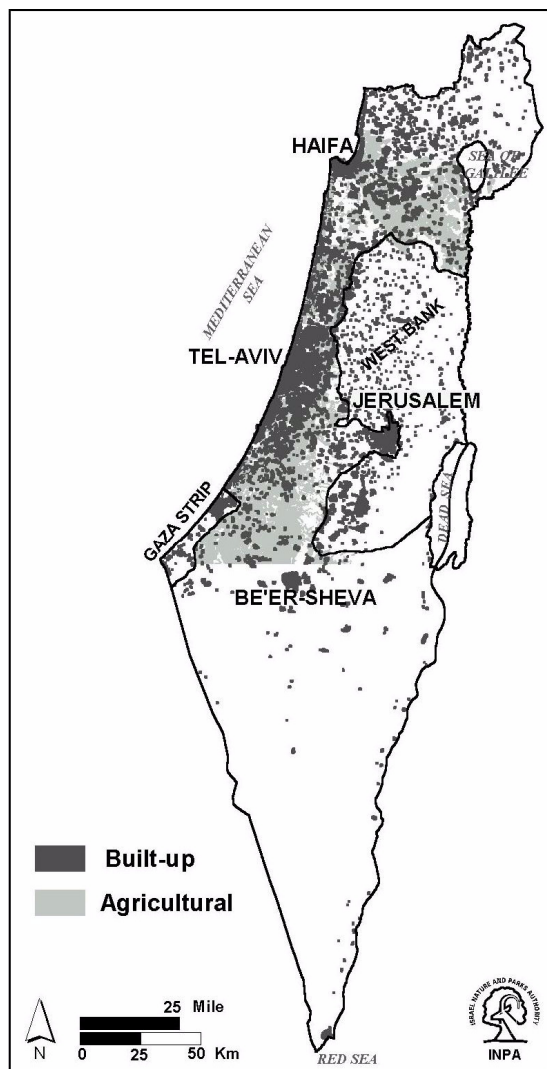


Figure 1. Maps of Israel. (Top) Israel's unique position at the junction of three continents. (Bottom) Land use in Israel is divided mainly between agricultural, built-up, and desert regions.

ized by a Mediterranean climate with hot, rainless summers, and cool winters with up to 900 mm (35 in) annual rainfall. The south of Israel, and most of the eastern rift valley, is an African savanna and desert ecosystem with less than 100 mm (4 in) annual rainfall (Nir 1970). The center of the country is a narrow coastal plain between the West Bank and the Mediterranean Sea with dense human population centers (Figure 1), serving as a transition zone bridging the two major ecotones (Frankenberg 1999).

Israel sits along the long and narrow coastal area between the Mediterranean Sea (to the west) and the deserts (to the east) that have created a major flyway between Eurasia and Africa, utilized by millions of birds migrating annually (Shirihai 1996), similar to the bottleneck of the isthmus of Panama in the New World. About 20% of Israel's land is in declared nature reserves (mostly in desert regions).

THE HUMAN FACTOR

The population of Israel exceeds 6 million, yielding an average density of about 300 persons/km². Population is not distributed evenly, as only a small percentage of the population lives in the southern (desert) areas. In addition, there are some 2.5 million Palestinians in the areas administered by the Palestinian Authority (in the Gaza Strip and the West Bank). If one excludes the sparsely inhabited desert areas, the population density in this region is arguably one of the highest in the world.

Agriculture has existed in this part of the world for at least 10,000 years, and as such the landscape and biota have been under continuous and increasing influence by this practice (especially due to grazing pressure). There is very little land in Israel that can be considered "wilderness" (not under human influence).

Israel is quite conservation-minded and has enacted very strict wildlife protection laws. In addition, Israel has relatively few licensed hunters (about 3,200 or 0.05% of the population), as hunting has never been part of the Jewish tradition (Nemtzov 2001). The consequence of these factors is a high potential for conflict between humans and wildlife.

RESPONSE AND RESOLUTION OF WILDLIFE-AGRICULTURE CONFLICT

Resolution of wildlife-human conflicts in Israel falls under the jurisdiction of the Israel Nature and Parks Authority (INPA), the single government agency responsible for all aspects of wildlife and nature protection, including hunting. The INPA is connected with the Ministry of Environment, not the Ministry of Agriculture. Nevertheless, the INPA emphasizes the importance of cooperation with farmers for successful resolution of wildlife-agriculture conflicts, which leads to better overall conservation of wildlife. The INPA employs a nationwide network of rangers who are in close contact with farmers and are required to provide immediate response to farmers who experience wildlife

damage. Rangers provide information on the reasons for the damage, suggest efficient methods of resolution, and will often assist the farmer in carrying them out. The fast response time and professional approach by the rangers is important to prevent farmers from feeling that they have no alternative but to take the law into their own hands and to employ harmful (and illegal) solutions, such as poisoning wildlife (except for rodents).

INPA policy includes a decided preference for employing non-lethal solutions to wildlife-agricultural conflicts. Yet the rangers have the authority to issue depredation permits on the spot, or to carry out lethal control themselves (trapping and/or shooting) when deemed necessary.

MAJOR WILDLIFE-AGRICULTURE CONFLICTS IN ISRAEL

Damage to Equipment for Low Water-Use Agriculture

Israel is one of the world leaders in the use of technologies for raising crops in arid regions, which are also used in other parts of the world (Werner et al. 1997). One popular method is the use of plastic pipes for drip irrigation, which are used for a wide variety of crops (e.g., fruit orchards, cotton, jojoba, and vegetable crops) (Moran 1981). Another common system is raising crops (vegetables and flowers) covered with polyethylene sheeting over single rows or as temporary small hot-houses. Polyethylene sheeting is also used during sterilization of the soil. Both types of plastic equipment are subject to wildlife damage (mainly at night) by young canids—red foxes (*Vulpes vulpes*), golden jackals (*Canis aureus*), and wolves (*C. lupus*); by porcupines (*Hystrix indica*); and also by birds—Syrian woodpeckers (*Dendrocopos syriacus*), yellow-vented bulbul (*Pycnonotus xanthopygus*), and corvids (*Corvus* spp. and *Garrulus glandarius*). Damaged pipes must be repaired daily to prevent water leaks and low water pressure in the pipes. Plastic sheeting also must be repaired immediately to maintain the microclimate under it. Repairs are labor-intensive and expensive.

Successful prevention of these problems includes the use of repellents, burying the pipes (which is most appropriate for orchards where drip pipes remain in place for years), and occasional shooting and trapping (to reduce local animal populations). Another method used with occasional success is to provide alternatives for problem animals by placing water troughs or chewing bones in the vicinity of the problem area.

One of the more popular repellents in use in Israel is Magen-2003™. This slow-release capsaicin-based product was created by Du-Kedem, Ltd. of Givat Haim, Israel, and found to be a very effective repellent for solving a wide variety of agricultural conflicts with mammals (birds, however, are not deterred by capsaicin). This product is sprayed directly onto drip irrigation pipes (usually as they are being rolled out), or right onto the vegetation in and around passageways that wildlife use to

gain access to the agricultural fields. It can even be sprayed directly onto plants that need protection (such as young trees), as it does no harm to vegetation. Protection lasts for about 2-3 months (since the compound degrades, mainly due to UV light and not by rain), which makes it inappropriate for use on most fruits or vegetables that will be harvested for human consumption.

Because Magen-2003™ uses only food-grade capsaicin (the active compound in hot peppers), it is able to be marketed in Israel as a “spice” and it is not registered as an animal repellent. It is apparently not available for sale outside of Israel at this time.

Livestock Depredation

Calves and sheep are the most common livestock killed by wildlife in Israel, but occasionally domestic fowl (chickens, geese, and ostrich chicks) are killed as well. On rare occasions, predators have killed ungulates held in poorly protected mini-zoos. While wolves and jackals are the main culprits responsible for livestock depredation (Yom-Tov et al. 1995, Nemtzov and King 2001), other species (e.g., mongoose, *Herpetes ichneumon*; wild boar, *Sus scrofa*; leopards, *Panthera pardus*; hyenas, *Hyaena hyaena*; and caracal, *Felis caracal*), occasionally have been responsible.

The most successful solutions to this problem involve the use of night enclosures (mainly for sheep), combined with good fencing (conventional and/or electric) and/or the use of livestock-guarding dogs (LGD) (Nemtzov and King 2001). Although protected by law, wolves and jackals are controlled by shooting (jackals more freely than wolves); poisoning is not permitted. Farmers receive no compensation for losses due to depredation, although they do receive financial assistance to purchase fencing and/or LGD.

Piscivorous Waterfowl in Fishponds

Israel has few wetlands and most of these are exploited for raising fish, mainly in freshwater fishponds. Because of Israel's unique position with respect to migratory birds, these fishponds are especially susceptible to piscivorous waterfowl during migration stopovers. For example, some 75,000 white pelicans (*Pelecanus onocrotalus*) migrate to Africa over this area twice a year (Leshem and Yom-Tov 1996). In addition, tens of thousands of piscivorous waterfowl (e.g., great cormorants, *Phalacrocorax carbo*; and night herons, *Nycticorax nycticorax*) stay and over-winter in Israel. There are also large populations of domestic piscivorous waterfowl (e.g., little egrets, *Egretta garzetta*; grey herons, *Ardea cinerea*; and pygmy cormorants, *Phalacrocorax pygmeus*) that exploit the ponds for food.

The most successful programs to prevent waterfowl damage to fishponds involve regionally coordinated scaring, primarily using pyrotechnics (and only occasionally employing lethal shooting). These programs work because they are based on tracking the flocks of birds in real-time, thus enabling coordinated efforts to scare flocks

of birds from the area by a whole team of workers in a large region (instead of each farm trying to protect only its own ponds). Some fish growers use netting over their ponds, but this is not encouraged by the INPA as a recent study has shown how netting can be harmful to waterfowl when not used correctly (Nemtzov and Olsvig-Whittaker 2001).

Damage in Orchards by Birds and Herbivores

Both migratory and domestic birds damage fruit yields in Israel in a wide variety of orchards (e.g., cherries, apples, peaches, and persimmon) as well as grapes in vineyards. The main domestic culprits are yellow-vented bulbul, various corvids, chukar partridge (*Alectoris chukar*), ring-necked parrot (*Psittacula krameri*), Syrian woodpeckers, and house sparrows (*Passer domesticus*). In addition, Egyptian fruit bats (*Rousettus aegypticus*) damage a variety of fruit crops, especially lychee, dates, bananas, and loquat.

Some of these wildlife species are classified as pests and are controlled by trapping and shooting (e.g., fruit bats, bulbul, and sparrows). Most bird species are protected by Israeli law, but some are shot or trapped under permit (e.g., corvids and woodpeckers). No poisoning is permitted. In spring, migratory birds (e.g., blackcap, *Sylvia attricapilla*) are trapped in mist nets in orchards and released to the north so that they may continue their migration.

Herbivorous (and omnivorous) mammals cause damage to orchards in a variety of ways. Porcupines eat the bark of young trees, and male gazelles (*Gazella gazella*) and fallow deer kill young trees when they rub their horns or antlers on them. Foxes, jackals, wild boar, ibex (*Capra ibex*), and hyrax (*Procavia capensis*) will eat fruit off trees before harvest. Badgers (*Meles meles*) and porcupines damage tree roots by digging. The most effective solutions are proper fencing of the orchard, Magen-2003™ (a capsaicin-based repellent), scaring (gas cannons and pyrotechnics), and hunting (wild boar).

Damage to Field Crops

Both migratory and domestic birds cause damage to field crops in Israel. For example, some 25,000 Eurasian cranes (*Grus grus*) began in the mid-1990s to spend the winter in the Hula Valley of northern Israel instead of continuing their migration to Africa (D. Alon, unpubl. data). This large population caused considerable damage to the winter wheat crop there, and some birds were shot (illegally) in attempts to halt the damage. A cooperative program began in fall 2000 involving local farmers, the INPA, and conservation non-governmental organizations (NGOs) to prevent damage to the crops and to the cranes by providing alternative feeding sites on rented fields in the valley. The project involved establishing 3 alternative feeding sites in the valley that were stocked with a total of about 2 tons of corn kernels per day. Farmers needed only to protect their fields (using pyrotechnics) early in the morning, when cranes begin searching for a place to

feed for the whole day. After the first few days, almost all the cranes learnt to simply stay by the feeding sites all day and night, since these were established next to water so that the birds would not need to leave them to drink or to find a place to spend the night. Funding for the project was covered half by the farmers themselves as an organized assessment of about \$3 per ha, and half by the Ministry of Agriculture, the Ministry of Environment, and various other sources. This cooperative project was considered a huge success by all involved parties. Crop damages in the valley were reduced to nil and the project cost the farmers a fraction of what had been lost in previous years to wildlife damage. In addition, no birds were shot, and eco-tourism to the valley to view the birds increased. In fall 2002, the project will begin its third year.

Many field crops (e.g., wheat, corn, and sunflowers) are damaged by small passerines such as crested lark (*Galerida cristata*) and yellow-vented bulbul, both of which are classified as pests, and by protected bird species such as corvids and ring-necked parrots. A variety of herbivores and omnivores cause damage to field crops, especially wild boar, gazelle, brown hare (*Lepus capensis*), and a number of small rodents. Of these mammals, only wild boar may be hunted. Electric fencing, gas cannon, and pyrotechnics are commonly used with varying degrees of success.

Rodents are controlled in field crops by rodenticides, or by establishing nesting boxes for barn owls (*Tyto alba*) (Kahila et al. 1999). The barn owl method was instituted in Israel some 25 years ago and has gained in popularity over the years as its cost-effectiveness has become more accepted. Owl boxes of a local design are set up on poles in and around the fields to be protected. Barn owls learn to establish themselves in most of the boxes, and eventually they successfully reduce rodent damage in the fields to minor levels. Research has shown that when rodent numbers are reduced, the owls find alternative food but will continue to use the nesting boxes in the fields (Y. Motro, unpublished data).

The barn owl method takes a number of years to establish, and it requires the abolishment of rodenticides in the immediate vicinity to prevent poisoning the owls. Some farmers were reluctant to start using this method because they felt they would suffer from elevated rodent damage until the barn owls were plentiful enough to control them. Experience showed that the method is cost-effective over the long run because the slightly elevated damages in the early years is offset by the money saved each year on rodenticide application.

Rodents in alfalfa fields are sometimes controlled by drowning by slowing the passage of large, mobile irrigation gear over the field and removing the spray heads. This method constitutes a low-cost, environmentally friendly solution while providing safe (non-poisoned) food for raptors and other scavengers. Some farmers in Israel using these methods have been able to

Table 1. The number of rabies cases diagnosed in wildlife in Israel during the years 1995 to 2001 (data courtesy of the Israel Veterinary Service).

Species	Scientific name	No. of cases	Percent
Red fox	<i>Vulpes vulpes</i>	223	69.0
Golden jackal	<i>Canis aureus</i>	15	4.6
Wolf	<i>Canis lupus</i>	8	2.5
Badger	<i>Meles meles</i>	7	2.2
Marbled	<i>Vormela peregusna</i>	1	0.3
Egyptian	<i>Herpestes ichneumon</i>	1	0.3
<i>Total</i>		<i>255</i>	<i>100.0</i>

have their crops certified as “organically-grown” and thus they receive higher compensation for them.

Bees and Beehives

Domestic and migratory bee-eaters (*Merops apiaster* and *M. orientalis*) damage agriculture indirectly by interfering with pollination of a variety of crops, especially melons. Bees do not exit the hives when bee-eaters are around, and those that do are often eaten (thus causing losses to the owner of the beehive).

The most effective solution is changing planting dates of the melons so that pollination does not coincide with bee-eaters’ migration. Other successful solutions are helium balloons and bird effigies, though these work for only a short time. Another successful solution has been to trap bee-eaters in mist nets for release further north, but these birds must be released very quickly as bees will attack and kill trapped bee-eaters. Recent tests to frighten the birds by using remote-controlled model airplanes are encouraging.

WILDLIFE DISEASES AND MAN

Wildlife in Israel have been identified as vectors for a number of human diseases, the 3 most important of which are rabies, leishmaniasis, and West Nile fever.

Rabies

The major reservoir of the rabies virus in Israel is foxes, but the disease has been detected in other species of wildlife (Table 1) and in dogs (Nemtsov and King 1998). After 3 people died of rabies in Israel in 1997-98, a program began for oral rabies vaccination (ORV) of foxes and jackals (Yakobson et al. 1998). The program began on a large scale in early 2000 and has been dramatically successful; there were only 6 reported cases of rabies in Israel in 2001 (3 in dogs and 3 in foxes), as opposed to 32 cases in 2000, and 76 cases in 1999 (data of the Israel Veterinary Service).

Leishmaniasis

Wildlife hosts for leishmania in Israel are fat sand rat (*Psammomys obesus*), Sundevall’s jird (*Meriones crassus*), and probably the short-tailed bandicoot rat (*Nesokia indica*) (Schlein et al. 1984). Control of the

disease is directed mainly at the sandfly vectors, and there are no programs to control the rodent hosts.

West Nile Fever

This disease reached epidemic proportions in Israel in 2000. Serological evidence of exposure to the virus has been found mainly in domestic fowl, but also in a large number of species of wild birds. Despite this, the virus has been isolated from only one species of wild bird, the white stork *Ciconia ciconia* (R. King, pers. comm.). Researchers continue to search for the virus in other species of migrating and domestic birds.

BIRD AIRCRAFT STRIKE HAZARD (BASH)

Two factors combine to make Israel especially susceptible to problems of BASH: Israel’s unique position with respect to migratory birds, and a very active air force with hundreds of military aircraft in combat and training.

These two factors have led to a high risk for bird strikes. The number of bird strikes has been greatly reduced over the past few years due to a number of projects, mainly by the Israel Air Force (IAF) in combination with a variety of Israeli organizations. The major solution involved research on understanding the migration patterns of the birds, which convinced the IAF to enact specific rules to create no-fly zones where and when migratory birds are most likely to occur. In addition, there is a network of radar facilities manned by bird experts that provides real-time information to the IAF on concentrations of birds over Israel. Plans are afoot to expand and link a larger network of BASH radar facilities in the Middle East to assist the air forces of neighboring countries that are friendly with Israel, such as Turkey, Cyprus, Greece, Jordan, and Egypt.

Within IAF airfields, the land around the runways is managed to limit the attractiveness of this habitat to birds by choosing appropriate crops to be planted there. Birds are kept away from the runways by teams of experts who work with pyrotechnics and traps. The IAF has had successful experiments with the use of border collies and remote-controlled model airplanes, and it is expanding the use of these. Ben Gurion International Airport at Tel Aviv experimented with falconry, but it rejected its

continued use due to high costs and limited effectiveness. The airport relies mainly on pyrotechnics, model airplanes, and habitat management.

DISCUSSION

A combination of factors have combined to make Israel especially susceptible to a wide variety of wildlife-human conflicts: high human density, small land area, high level of human encroachment on wilderness areas, a conservation-minded public, strict wildlife protection laws, low level of hunting pressure, and high numbers of migratory birds.

Wildlife protection is enhanced in Israel by employing mainly non-lethal methods and by involving stakeholders in problem resolution. Timely response by government officials to farmers' calls for help keeps destructive control methods (i.e., illegal poisoning) to a minimum. The availability of efficient and cost-effective methods to resolve wildlife-human conflicts can make such tasks easier.

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