Small carnivores, big database – inferring possible small carnivore distribution and population trends in Israel from over 30 years of recorded sightings

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Abstract

The Israel Nature and Parks Authority (INPA) has been recording wildlife observations over many years in an open-access database. Given the time scale and number of observations, these can provide insight into trends in spatial distribution and some populations and communities of local species. This study discusses the possible implications of patterns in small carnivore sightings in Israel from 1980 to 2010. The records suggest that some changes affected all species similarly, whilst others had different, sometimes opposite, effects on different species. Records for all five species have been decreasing in the southern deserts of Israel, although in other regions the relative number of sightings of Egyptian Mongoose *Herpestes ichneumon* has been increasing over time, while those for Ratel *Mellivora capensis*, Stone Marten *Martes foina* and Marbled Polecat *Vormela peregusna* have been decreasing. The relative number of sightings of Eurasian Badger *Meles meles* has fluctuated over time, but shows no obvious trend. Spatial data also suggest that the distributions of the two already regionally threatened species, Ratel and Marbled Polecat, are decreasing and that the species need, possibly immediately, conservation attention. Distributions of the other species seem stable, perhaps suggesting that their situation, for now, is secure. Additional data exist in other sources in Israel; their comparison with the present dataset and the use of more analytical tools could test the suggestions of this study.

Keywords: *Herpestes ichneumon*, Israel Nature and Parks Authority (INPA), *Martes foina*, *Meles meles*, *Mellivora capensis*, *Vormela peregusna*

טורפים קטנים, מאגר מידע גדול – ניתוח מגמות אפשריות בתפוצת ואוכלוסיית הטורפים הקטנים בישראל מתוך למעלה מ-30 שנים של תצפיות מתועדות

תקציר

רשות הטבע והגנים בישראל מתעדת תצפיות בבעלי חיים וצמחים במשך שנים רבות במאגר מידע הזמין לציבור. בהתחשב במשך הזמן ומספר התצפיות, יכולים הנתונים במאגר זה לספק תובנות לגבי מגמות בתפוצה ובמספר מדדי אוכלוסייה וחברה של מינים מקומיים. מחקר זה דן במשמעויות אפשריות של מגמות בתצפיות בטורפים קטנים בישראל משנת 1980 ועד 2010. הנתונים מציעים שכמה שינויים השפיעו על כל המינים באורח דומה בזמן שלאחרים הייתה השפעה שונה, לעיתים הפוכה, על מינים שונים. מספר התצפיות בכל המינים נמצא במגמת ירידה במדבריות הדרום בזמן שבאזורים אחרים מספר התצפיות היחסי בנמייה *Herpestes ichneumon* עלה לאורך הזמן בעוד שאלו בגירית הדבש *Mellivora capensis*, בדלק *Martes foina* ובסמור *Vormela peregusna* ירדו. מספר התצפיות היחסי בגירית המצויה *Meles meles* השתנה לאורך הזמן אך לא הראה כל מגמה ברורה. הנתונים המרחביים מציעים כי תחום התפוצה ו/או גודל האוכלוסייה של שני המינים המקומיים שכבר נמצאים בסכנת הכחדה, גירית הדבש והסמור, מצטמצמים ושמינים אלו זקוקים למאמצי שימור, ייתכן שבאופן מיידי. תפוצת שאר המינים נראית יציבה, דבר שעשוי להצביע על כך שלפחות בזמן זה הם עדיין אינם תחת איום. נתונים נוספים נמצאים במאגרים נוספים בישראל – השוואה של אלו עם מאגר הנתונים המוצג כאן ושימוש בכלים מחקריים נוספים יכולים לשמש בעתיד בכדי לבחון את ההצעות המועלות במחקר זה.

מילות מפתח: רשות הטבע והגנים, נמייה, דלק, גירית הדבש, גירית מצויה, סמור

Introduction

Despite the relatively rapid changes in habitats sometimes caused by anthropogenic factors in much of the world, responses of the biological systems can lag behind; and many environmental changes are themselves ongoing. Therefore, understanding the specific factors that underlie biological responses may require observations over long periods of time. Such observations are often non-existent or are limited to the small regions typically covered by specific studies, which hinders interpretation of changes. In Israel, the Israel Nature and Parks Authority (INPA), the governmental authority responsible for nature conservation, has been recording observations of Israeli wildlife for several decades, observations that may help detect and possibly later explain various trends and changes in biological parameters over the respective, long, time period. These data have been collected mainly by INPA staff and include information at various levels of detail per record, with the basic being date and location (including coordinates) of the observation. Data collection has been enhanced in recent years since palm-top computers were distributed among rangers. This started in 2008 in one region and all regions were so covered by 2010. These data are stored as a free access dataset (ww2.bgbm.org/natureinfo) that can be queried by observations of specific species or lists of species in particular regions.

Israel has a relatively rich fauna and flora of diverse origins (e.g. Ethiopian, Saharan, Oriental and Palaearctic), and a mosaic of eco-regions, from Alpine to extreme desert, condensed in a small area (Tchernov & Yom-Tov 1988). These environmental and faunal characteristics, coupled with the large INPA dataset, can make the country a model for studying the spatial response of species to various direct and indirect human influences on habitats. This article reviews trends in the distribution of non-lutrine small carnivores in Israel, as reflected from observations in the INPA dataset. The analysis covers Egyptian Mongoose *Herpestes ichneumon*, Ratel *Mellivora capensis*, Eurasian Badger *Meles meles* (*M. canescens*, sensu del Cerro *et al.* 2010), Marbled Polecat *Vormela peregusna* and Stone Marten *Martes foina*. These species represent African, Palaeotropical and Palaearctic species, small- to medium-sized species, species occupying various habitats and with diverse feeding ecologies, and species with varying commensal tendencies. Eurasian Otter *Lutra lutra* also inhabits Israel but was not included in this analysis: its aquatic lifestyle exposes it to pressures different from those faced by non-aquatic species, and its population is surveyed annually by the Society for the Protection of Nature Israel. It thus deserves a separate discussion. Common Genet *Genetta genetta* was sometimes mentioned to live in Israel (e.g. Aharoni 1930), but the reports, all from long ago, have been disputed and suggested to be either incorrectly located or, if genuinely from Israel, referring to Marbled Polecat (Kock 1983). This conclusion is strongly supported by the lack of Common Genet records in Israel in recent decades. Similarly, Tristram (1888) wrote that Least Weasel *Mustela nivalis* occurred around Mount Tabor, but this species has never been found otherwise in Israel and Tristram's (1888) record, for which no specimen is known, is thus assumed to be in error.

Two of the analysed species, Marbled Polecat and Ratel, are recognised as threatened in Israel (Vulnerable and Endangered, respectively) mainly through anthropogenic factors (Dolev & Perevolotsky 2002). The same species are believed to have decreasing global populations (Begg *et al*. 2008, Tikhonov *et al*. 2008), although only Marbled Polecat is globally threatened (as Vulnerable; Tikhonov *et al*. 2008). The other species are not categorised as threatened, in Israel or globally, and are believed to show stable population sizes globally (not assessed locally in Israel). Since the anthropogenic factors in Israel are not species-specific, review of long-term observations on the presence of small carnivores may help to determine the responses of each species to different changes in the environment or human-inflicted threat and to explain the trends that are presented by each species.

Methods

Analysed data

A total of 3,308 records of small carnivore (all in Mustelidae and Herpestidae) sightings was retrieved from the INPA database. These records come from all regions of Israel, with Israel defined in the INPA database as the former British Mandatorial Palestine (i.e. including Samaria and Judea regions) and the Golan Heights, and the time period 1980 to the end of 2010. The 349 records of Eurasian Otter were excluded from the analysis (see Introduction). Four records of other species were discarded because their coordinates lay far outside Israel (e.g. middle of the Mediterranean Sea), presumably as a result of mistyping. Another record was removed because the date (1909) could not be confirmed. Hence, 2,954 records were analysed.

Data quality

The sightings in the database were collected mainly by INPA rangers and scientists, but also by other researchers and field staff from other institutions, conservation organisations or academia. All observers are experienced in identifying the various species (sightings reported by lay people are not recorded) and, therefore, the records analysed are believed generally reliable. Data collection has been incidental to other activities and, thus, reporting rates and efforts of the rangers are unlikely to be similar in all regions; observers will differ in their reliability in identifying the subject animals; and there may be errors in recording exact positions of observation. But these factors are unlikely to produce long-term directional trends, especially given the large total number of records and the large difference in numbers of records per species. For each species, spatially outlying records are discussed below in more detail, to assess the possibility of their inaccuracy.

Scope of analysis

Data were collected incidentally to other activities, with sampling effort varying between regions and time periods. They cannot provide precise information about abundance of taxa. However, several factors suggest that the analysis can provide insights on long-term trends: small carnivores in Israel are not observed particularly often (see previous paragraph for number of sightings over 31 years); their natural history and thus detectability is not expected to change over time; many observers contributed to the database; and there were many observations for most species throughout the duration of the database. Artificial biases of the sampling, such as change with time in relative spread of observer effort across habitats, regions and times of day and night, or bias for or against specific species, need to be carefully considered and are mentioned where they may explain certain observations. Nonetheless, these factors are not expected to have consistent, gradual trends, so are unlikely to cause apparent long-term trends in distribution or relative number of sightings for different species.

Data interpretation and analysis

Sighting locations were transferred to KML format using the Excel to KML tool by Earth Point (http://www.earthpoint.us/ExcelToKml.aspx). This allowed the superposition of record locations data onto Google Earth map for interpretation of the species distributions.

For testing significance of changes in the relative number of sightings for the various species the Pearson product-moment correlation coefficient (r) was used. Arcsine transformation was used on the proportion data of the number of sightings in each species from the total number of sightings in all species and significance was tested using the Student's T distribution with two degrees of freedom. The sample size was seven, with six time periods of five years (1980–1984, 1985–1989, 1990–1994, 1995–1999, 2000–2004, 2005–2009) and 2010 treated separately. The data were grouped because of the low number of sightings for some species in single years and because of the potentially larger effect of differing sampling efforts if data from single years would be treated. Year 2010 was included in the analysis because of the large number of sightings in this year, which add important data, but treated separately in order to keep the rest of the 5-year groups, which cover continuously the rest of the study period, comparable, if needed. Because relative, rather than absolute, numbers are compared, the fact that time spans in this group differ does not compromise the statistical analysis.

Geography

The names of the various regions used in this article (Fig. 1) reflect a commonly used geographical division based on topography and habitat types. A further, gross, sub-division to north, central and south of Israel is here made, with the north including regions 1–7 and 10a in Fig. 1, the south including regions 20 and 21, and the central, the remainder.

The geographical borders mentioned in this study do not necessarily reflect any recognised or proclaimed international or other geopolitical borders or the political views of the author.

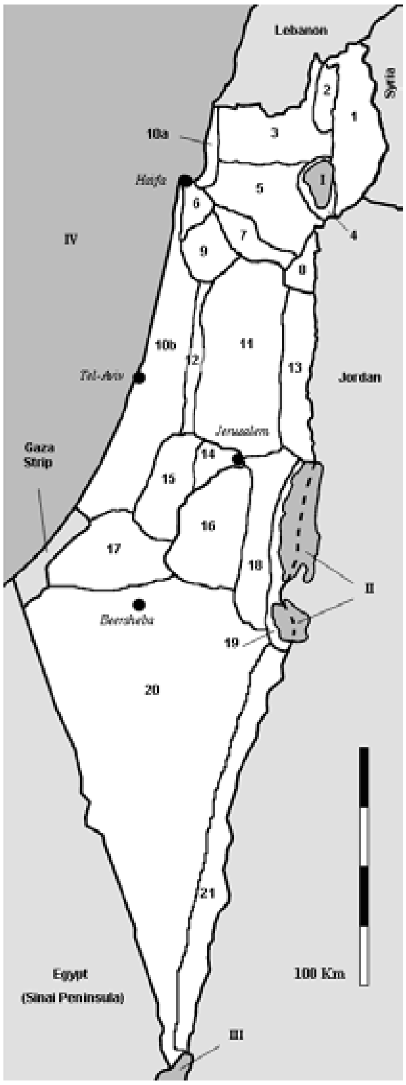

Fig. 1. Israel (white) showing geographical regions used in the text: 1) Golan Heights; 2) Hula Valley; 3) Upper Galilee; 4) Sea of Galilee lowlands; 5) Lower Galilee; 6) Carmel Mountain; 7) Jezre'el Valley; 8) Beit-She'an Valley; 9) Menash'e Highlands; 10) Coastal Plain (a-northern; b-central and southern); 11) Samaria Mountains; 12) Samaria Foothills; 13) Jordan Valley; 14) Jerusalem Mountains; 15) Judean Lowlands; 16) Judea Mountains; 17) Lakhish Region; 18) Judea Desert; 19) Dead Sea Valley; 20) Negev; 21) Arava. Countries and regions not included in this study are coloured light grey. Lakes and seas are coloured dark grey: I) the Sea of Galilee; II) the Dead Sea; III) the Red Sea; IV) the Mediterranean Sea.

Individual species patterns and trends

Table 1 summarises the number of sightings of each species in the INPA database over the review period.

Ratel *Mellivora capensis*

The INPA database holds few (33) Ratel sightings, but these come from all regions of Israel. This small number hinders determination of the species's distribution. Originally, Ilani (1979) suggested that the Ratel's distribution in Israel is fragmented and consists of four discrete populations: a) in the northern Coastal Plain and the western slopes of the Upper and Lower Galilee; b) in the Hula Valley and bordering mountain slopes of the Golan Heights and eastern Upper Galilee; c) the Judean Lowlands and Lakhish Region; and d) the northern Arava Valley. However, several sightings since the 1980s come from between these suggested ranges: the central Coastal Plain, central and western Negev, the Jordan Valley, and the higher areas of the Galilee and Golan Heights. These sightings, although few, suggest at least some contact between the proposed sub-populations, even if rare. The alternative, of growing sub-populations with expanding ranges, seems unlikely because of the continuously decreasing number of sightings. From 1980 to 1984 there were 13 sightings, which came from various areas of the country. The number of sightings for each 5-year term decreased steadily, dropping to just a single in 2005–2009 (and none in 2010). Ilani (1979) estimated the population size to be 45–85 animals in Israel. Given the varying sampling effort over the study period the number of sightings is not necessarily directly proportional to the population size (see Methods), but, nonetheless, the steady decline in number of sightings is a strong indication that the population is most probably declining. Since the population was already suggested to be small before the study period (Ilani 1979) the species might be more threatened in Israel than is currently considered (Endangered; Dolev & Perevolotsky 2002), quite possibly on the brink of extinction, and requires strong and immediate action to protect it. Even local, incidental events, such as a malicious, indiscriminate poisoning by a single farmer, could have a devastating effect of what seems to be a very small remnant Ratel population in Israel.

The decreasing and small number of sightings obscures biogeographical trends. Sightings from 1980 until 1989 came from all regions of Israel. During 1990–1999 all sightings

Table 1. The number of recorded sightings of each species of small carnivore* in Israel recorded in the INPA database for each species in each 5-year period 1980–2009, and in 2010.

Species	Ratel *Mellivora capensis*	Marbled Polecat *Vormela peregusna*	Stone Marten *Martes foina*	Eurasian Badger *Meles meles*	Egyptian Mongoose *Herpestes ichneumon*	Total
Period						
1980–1984	13	52	59	85	61	270
1985–1989	9	71	140	227	259	706
1990–1994	6	11	57	92	61	227
1995–1999	2	16	94	118	192	422
2000–2004	2	10	60	137	129	338
2005–2009	1	15	71	176	393	656
2010	0	3	11	71	250	335
Total	33	178	492	906	1,345	2,954

*excluding Eurasian Otter *Lutra lutra*.

came from the adjacent regions of the Judean Lowlands, the Lakhish Region, the southern Coastal Plain and the western Negev. But in 2000–2010, all sightings in the INPA database came from northern parts. Yet, sightings are so scarce that it is impossible to rule out that small numbers persist in other regions but have not, by chance, been recorded recently by INPA. This may be supported by four 2006–2009 sightings recorded in a different source (Society for the Protection of Nature in Israel) that come from various regions: Negev Desert, Judean Mountains and the Galilee.

Marbled Polecat *Vormela peregusna*
The distribution of Marbled Polecat in Israel shows relatively high affinity with open habitats, including intensively cultivated areas. Most observations come from the central part of the country, which encompasses areas such as the Coastal Plain, the Samaria Foothills and Judean Lowlands and the Lakhish Region. Where not built on, these areas are mostly intensively cultivated; natural habitats are mainly open or semi-open. In the north, Marbled Polecat is also more often found in cultivated areas such as the Jezre'el, Beit-She'an or Hula valleys, with relatively few observations from the higher elevations of the Upper Galilee and Golan Heights. This affinity with open habitats including cultivated areas often brings Polecats near human settlements and there are several records from the vicinity of large cities, such as Rehovot, Rishon-Le'Zion and Herzliya, in the heavily urbanised centre of Israel, with one record coming from an agricultural enclave in the heart of the largest metropolitan area in Israel, just outside Tel-Aviv. Nevertheless, whilst most records come from mainly open habitats in the mild-climate regions of Israel, there are isolated records from other regions, with most of them reliable (experienced observers, animals in hand). There is one record from within the city of Jerusalem, two more from the Samaria Mountains and another from the Hebron area, all areas of higher elevation, cooler climate and with less intense traditional agriculture or no agriculture at all. There are also records from arid, warmer areas, such as the central part of the Jordan Valley and the northern and central Negev (near Beersheba and Kibbutz Retamim, respectively), which all offer green paths (seasonal streams) and patchy cultivated areas for Polecats to move along or forage in. However, the scarcity of observations from these areas suggests that the mountainous regions of central Israel, as well as the arid regions that border the more populated and cultivated areas, are marginal areas for Polecats, supporting either small or temporary populations. This pattern, based on 178 records, contradicts suggestions that Marbled Polecat is mainly a desert and steppe species (Tikhonov *et al*. 2008, Wilson & Mittermeier 2009), even though in some countries in the Levant some sightings support this suggestion (e.g. Nader 1991, Saleh & Basuony 1998). Generally in Israel, Polecats seem to prefer agricultural areas. When found in natural habitats, only a handful of sightings come from desert areas (with none more recent than 1991) and more, but still relatively few, come from the steppe climate regions of the southern Judean Lowlands and the Lakhish Region.

The locations of Polecat sightings have shifted gradually towards the cooler north of the country (Fig. 2). Between 1980 and 1994, the southernmost records in the INPA database came from as far south as Kibbutz Retamim (latitude about 31°03'20"N) with other observations coming from the agricultural areas in the north-western Negev. Reports from the southern, arid regions also came from other sources during the 1970s and 1980s (see Dolev & Perevolotsky 2002). However, between 1995 and 2004, the southernmost observation was already from a northern location (latitude 31°32'02.4"N), with some more observations coming from slightly more to the north (just north of the Gaza Strip), and from 2005 onwards the southernmost observation was from near the city of Rehovot (about 31°51'30"N), a total shift of over 80 km north. Furthermore, despite overall many more sightings recorded in the centre of Israel than the north, this trend reversed after 1999 and since 2000 more sightings are recorded from the northern part of Israel.

This apparent northward shift in distribution by Marbled Polecat may, however, not reflect changing habitat preferences, but human activities. It is too difficult to distinguish between the possible effects of the several factors that may contribute to the pattern, to be sure of its cause(s). One major factor seems to be the increase in synanthropic species such as Golden Jackal *Canis aureus* and Red Fox *Vulpes vulpes*. These species have been the main beneficiaries among mammals from the increase of available garbage near human settlements in Israel (Yom-Tov & Mendelssohn 1988) and already have been suggested to contribute to the extinction or the shift in distribution of desert species in Israel (Sand Cat *Felis margarita* and Sand Fox *Vulpes rueppellii*, respectively; Dolev & Perevolotsky 2002). These species might out-compete Polecats for prey or even prey directly on the smaller Polecats. A second factor might be the foreign labourers, coming to Israel for agricultural work, who brought their customary hunting practices to the country and in some areas caused and may still cause pressure on local wildlife. Hunting was concentrated, measured by numbers of traps found, in the north-western Negev, the Lakhish Region and the central Coastal Plain and Samaria Foothills among other areas (Yom-Tov 2003), areas that overlap with Marbled Polecat distribution. Although Polecats were not directly observed among the species caught, other small carnivores (Egyptian Mongoose, Eurasian Badger and Eurasian Otter) were; and many small species (rodents, birds, reptiles and amphibians) were either actively hunted or caught as by-catch (Yom-Tov 2003). So, it is fair to assume that Marbled Polecats would also be either targeted or caught by mistake. A third, possibly major, factor might be the domestic/feral cat *Felis* population in the country. These cats in Israel predate wildlife, including endangered species (Brickner-Braun *et al*. 2007). Therefore, cats could possibly out-compete the Marbled Polecat for food given their similar diets or even prey on Polecats directly given the usually larger size of the cats. This factor, if indeed real, is also expected to influence more significantly the smaller or isolated Polecat populations in marginal areas or the Polecat populations in the centre of Israel, which harbours a much more dense human and, hence, feral cat populations.

Other factors, such as more frequent series of drought years in Israel (1989–1991, 1999–2001, 2004–2011), changes in agricultural practices in some regions, such as the increase in citrus-fruit growing in the north-western Negev or increase in greenhouse agriculture instead of open land, and increasing habitat fragmentation due to road construction and heavier traffic, may also contribute to the northward shift in Polecat distribution in Israel. Regardless of the specific cause, the spe-

Fig. 2. Changes in the reported distribution of Marbled Polecat *Vormela peregusna* in Israel over 1980–2010, based on records obtained from the INPA database. The distribution area that includes all sighting locations for the time period, excepting the southernmost sighting (a black circle), is coloured dark grey (left) 1980–1994, (centre) 1995–2004 and (right) 2005–2010.

cies should be monitored closely: the results here of decreasing distribution, coupled with its overall decreasing relative rate of recording (see 'Community trends'), support its classification as threatened; given the rate of these changes, an updated assessment might be warranted.

Stone Marten *Martes foina*
Stone Marten is a temperate Palaearctic species, which in its entire distribution range occupies habitats ranging from forests to rocky and semi-open areas, including near human settlements, up to an elevation of 4,000 m (Wilson & Mittermeier 2009). However, in Mediterranean ecosystems the species uses various kinds of wooded areas more than cultivated or urban areas (Santos & Santos-Reis 2009, Pereira *et al*. 2012). This study suggests that in Israel, the species shows this latter pattern. Early records (1980–1984) came from two separate regions – northern Israel, mainly from the Upper Galilee and Golan Heights regions, and from the Jerusalem Mountains. These regions are characterised by mostly rural settlements separated by dense or semi-open areas of natural Mediterranean woodland or planted pine *Pinus* forests, whence came most observations. However, the disjunct pattern was possibly a sampling artefact, because in the next decade (1985–1994) reports from the Samaria Mountains, which connect the Jerusalem area to the Jezre'el Valley and Lower Galilee, accumulated. This area had no or very little INPA presence before that time, reflecting its different geopolitical status. Similar to the Upper Galilee or Jerusalem Mountains, it is also characterised by mostly rural settlements but, unlike in the latter two, these are separated by a more open habitat (of anthropogenic origin) or by areas of traditional agriculture. Nevertheless, vegetation, even if lower, less dense or of different species composition, is still found in the region and can offer shelter to Martens.

The later period, between 1995 and 2010, showed a relative stability in the area of distribution, but two trends are worth mentioning: Stone Marten appearance in the western and southern slopes of the Carmel Mountain, and a relative reduction in sightings in the Jerusalem and Samaria Mountains. These might be artefacts of sampling effort, but genuine change is possible. The south-western area of the Carmel Mountain had a series of large forest fires (>50 ha) during the 1980s (Tessler *et al*. 2010), which could explain the lack of sightings from the region in that decade and in the early 1990s. These fires however brought changes in forestry management protocols in the region: focus on natural recovery of native vegetation, planting of native Mediterranean woodland species, active reduction of mono-species pine forest that had been planted in the past, and the limiting of its re-growth (Harpaz 1992). More natural forest supports more diverse, local fauna, so its recovery probably would benefit species such as Martens (Ashkenazi 2004). The decrease in sightings in the Jerusalem Mountains might also relate to forest fires, since the region suffered a series of large ones (>50 ha) in the 1990s and early 2000s (Tessler *et al*. 2010). The decrease in sightings in the Samaria Mountains might reflect a change in the geopolitical situation, which saw areas transferred to civil jurisdiction, including environmental issues, of the Palestinian Authority in the years following the Oslo Accords that were signed between Israel and the Palestinians, and thus INPA presence in Samaria decreased significantly.

Overall, the 492 Marten sightings suggest a distribution covering all Israel's mountainous regions in the Mediterranean climate zone, from sea-level to the highest elevation of over 2,000 m of Mt Hermon, the northernmost point of the Golan Heights. The distribution also shows that the Marten keeps true to its origin as a temperate or colder climate species, with more sightings coming from cooler regions of the Upper Galilee, Golan Heights and the Jerusalem area, and fewer from warmer areas such as the Lower Galilee or the Carmel. It is difficult to determine, however, if the populations in the warmer areas are viable or represent temporary activity of individuals dispersing to the edges of the cooler areas or between the two main distribution areas. The sightings also suggest that Martens avoid urban areas but do approach and even enter small settlements, with observations including animals entering houses and needing to be removed by INPA rangers. Two reported sightings from the eastern slopes of the Samaria Mountains, a semi-arid region with only low vegetation along seasonal streams and sparsely distributed settlements, are inconsistent with the range suggested by the rest of the records. These sightings are from or near vegetated areas (a stream canyon; an agricultural area) and may be explained by dispersal along green routes, but the distance from all other observations and the atypical surrounding area (relative to otherwise reported and observed Stone Marten habitat) suggest that these sightings may be transients or misidentifications. The absolute number of Marten sightings in each 5-year period ranges from 57 to 140 and has no apparent trend. And given that the distribution is stable, possibly slightly expanding, Stone Marten conservation status in Israel is probably secure.

Eurasian Badger *Meles meles*

Eurasian Badger is the second-most sighted small carnivore species in Israel with 906 records in the INPA database. This is somewhat surprising for an animal that prefers continuous or fragmented wooded habitats in Mediterranean ecosystems (Remonti *et al.* 2006, Santos & Beier 2008, Lara-Romero *et al.* 2012) and is at the edge of its range: Israel is its southernmost distribution (Kranz *et al.* 2008, Wilson & Mittermeier 2009). Furthermore, the sightings cover all regions of Israel, including desert regions. Overall, most sightings (about 500) indeed come from the north, which is generally less urbanised, with more areas of natural, wooded habitats and cooler climate. However, close to 400 sightings come from the central parts of Israel, which are on average lower in elevation and warmer, with denser human population and mostly open habitats, often cultivated. Indeed, in some of the 5-year periods there were more sightings from the centre than from the north. Eurasian Badger has also been recorded in arid regions, such as the Jordan Valley all the way south to the Dead Sea and the northern and western Negev, where it is associated with agricultural areas. The southernmost observation comes from the central Arava, a very arid region with isolated settlements and adjacent patches of cultivated areas. This record is over 90 km from the nearest other record, but it was made by INPA's Chief Veterinarian and is, therefore, presumed reliable. This sighting, and others from the southern deserts, suggest that Eurasian Badger can disperse over large tracts of arid land between patches of suitable habitats.

The study period probably had only relatively small changes in Eurasian Badger distribution. The only major trend is the decrease and eventual cessation of sightings from desert areas, with the last recorded sighting in the south in 1995. Possible reasons for this, such as competition with synanthropic species and poaching by foreign labourers, were discussed in detail under Marbled Polecat. Other regions of Israel provided sightings throughout the study period, although there have been fluctuations in numbers or density of observations in some regions. The Hula Valley and its flanking eastern Upper Galilee and Golan Heights mountains, and the western slopes of the Jerusalem Mountains, showed the most stable, and the Lakhish Region the sparsest and most fluctuating, sighting abundance. The two former regions resemble described preferred Badger habitat, with intense agriculture, wealth of water courses and partially wooded areas (Hula Valley and flanking mountains) or relatively densely wooded areas with patches of poultry-rearing areas and cultivated land (Jerusalem Mountains), while the latter (Lakhish Region) is a drier, warmer, open area of mainly cultivated land with only relatively small and fragmented patches of wooded areas.

Absolute numbers of Eurasian Badger sightings have fluctuated, ranging from 85 to 227 in different 5-year terms, with no evident trend. Therefore, despite the lack of recorded sightings from desert areas in the last 15 years of the analysis period (1996–2010), overall the Eurasian Badger population in Israel is probably secure.

Egyptian Mongoose *Herpestes ichneumon*

The Egyptian Mongoose is by far the most commonly sighted small carnivore in Israel, with 1,345 sightings in the INPA database. These sightings are highly unevenly distributed. In other regions it is commonly associated with riparian habitats amid open or low-vegetation areas (Palomares & Delibes 1993, Cavallini & Palomares 2008, Matos *et al.* 2009, Wilson & Mittermeier 2009) and these habitats boast the most records in Israel as well. In Israel, which is a dry country with relatively few natural water bodies, many sightings come from anthropogenic wetland habitats. Most Egyptian Mongooses were sighted in the Hula Valley, the Beit-She'an Valley and the central Coastal Plain. These regions have many water courses (natural or human-manipulated) and aquaculture ponds that would resemble preferred mongoose habitat. Other sightings, although less dense, come from along water courses such as the Jordan River or the continuously or seasonally flowing streams of the Coastal Plain, and from near some man-made water reservoirs such as the Nitzanim Lake. In areas that cannot directly be associated with wetland habitats, the Galilee, Golan Heights, Jerusalem Mountains and Lakhish Regions, sightings are fewer. Here it is possible that mongooses have been using anthropogenic food sources such as open rubbish dumps or discarded animal carcases (mainly from the poultry industry). Also, it is probable that the animal never strayed far from small, local springs, ponds and reservoirs or other small-scale water bodies. Further support for the connection between mongooses and wetlands in Israel is the rarity of sightings from desert areas. Of the 1,345 sightings, only two came from desert habitats not beside wetland habitats, one each from the southern Judean Desert and the northern Arava; both in 1988, from highly experienced observers. This rarity does not seem to be because of heat intolerance. Mongooses inhabit some of the hotter areas of Israel such as the southern Jordan Valley and the Dead Sea Valley: in these, a river (Jordan Valley) or a string of near-shore freshwater springs (Dead Sea) may provide favourable habitat and also a corridor for dispersal between agricultural areas. However, without such habitats, Egyptian Mongoose may not be able to establish a population or possibly even disperse regularly. Some may manage to travel along stream-beds (perhaps after seasonal floods; no direct evidence for this) and maybe survive as individuals or small, isolated populations for short periods.

The high affinity of Egyptian Mongoose for wetlands, and that most of these habitats in Israel are, at least to some degree, manipulated by humans including control over water flows, prevented major changes in its distribution. Sightings have been recorded from all the Mongoose's major distribution areas throughout the study period. There were some fluctuations in marginal, less suitable areas with fewer records, such as the Lakhish Region or the cultivated areas of the north-western Negev.

The number of Mongoose sightings in Israel has fluctuated significantly, from 61 to 393 per 5-year period, but showed no consistent trend. Between 2000–2004 and 2005–2009 the number of sightings more than tripled (129 to 393). This might represent a start of an ongoing increase, as in 2010 alone 250 sightings were recorded. The significance of this possible trend is discussed below in relation to number of sightings of other species.

Community trends

The sightings in the INPA database also reflect trends that are not unique to a single species, but seem to be common to several species, sometimes to all.

Record disappearance from the southern deserts of Israel

All species analysed excepting Stone Marten were recorded from the south of Israel (the Negev and Arava regions). The absolute number of the sightings from the south and the proportion that these sightings constitute of the total sightings for each species are different, but a common trend to all was that towards the end of the study period the number of sightings in desert areas in the south decreased. The proportion of the sightings from the southern deserts fluctuated in the first half of the study period, ranging from 0.74% to 1.76%, and later decreased to 0.24%; since 2000 there are no observations from the southern deserts. This trend is clear, although not quite statistically significant (N = 7, r = -0.709, t = -2.248, p = 0.074).

Two major factors that could have been responsible for this trend, increased numbers of synanthropic species and poaching by foreign labourers, were discussed above in detail under Marbled Polecat. They are likely to have had their strongest effect on small, localised and fragmented populations, such as those of the small carnivores in the southern deserts. Although artificial sampling biases might have also contributed to the periodic changes, especially the fluctuations in the early part of the study period, it is unlikely that artificial biases alone would produce zero observations over 17 years: the last recorded small carnivore sighting was from 1995. Therefore, it is strongly suggested here that populations of small carnivores in the southern deserts decreased significantly over the study period.

Changes in the proportion of individual species records

The total numbers of sightings for all species together and for most individual species over the study period varied, with no obvious trend (Table 1). However the proportion of total sightings per species (Fig. 3) did change: proportions of Stone Marten, Marbled Polecat and Ratel sightings among the total decreased significantly (Stone Marten, n = 7, r = -0.817, t = -3.169, P = 0.025; Marbled Polecat, n = 7, r = -0.871, t = -3.967, P = 0.011; Ratel, n = 7, r = -0.829, t = -3.316, P = 0.021) while Egyptian Mongoose increased (n = 7, r = 0.891, t = -4.379, P = 0.007). Eurasian Badger was the only species to show no significant trend in the proportion of sightings.

Over the study period, sampling effort and rate of reporting have changed. In recent years, for example, INPA field staff use palm-top computers enabling immediate reporting of sightings. This new technology has brought a major increase in the number of reports (335 small carnivore sightings in 2010 alone versus a highest total of 706 sightings in any previous 5-year period, that of 1985–1989). Surveys that are held periodically, focusing on either broad groups (e.g. carnivores, mammals) or regions, scientific studies, and changes in personnel may also affect numbers of reports. Therefore, the absolute number of sightings cannot indicate the abundance of individual species or small carnivores in general. Also, the relative difference among the numbers of sightings for the studied species in a given point of time cannot indicate the true relative difference among their numbers or abundance, since differences in natural biology or morphology make species vary in their detectability. For example, Egyptian Mongoose is the only diurnal species among the five studied and, therefore, more sightings of this species are expected, relative to its numbers, than of the four nocturnal species.

Nonetheless, I suggest that the observed change in relative encounter rates over time (above) does reflect true changes in the abundance of the species relative to each other. Although the artificial factors mentioned above and others mentioned earlier might bias the observations of a single species in a spe-

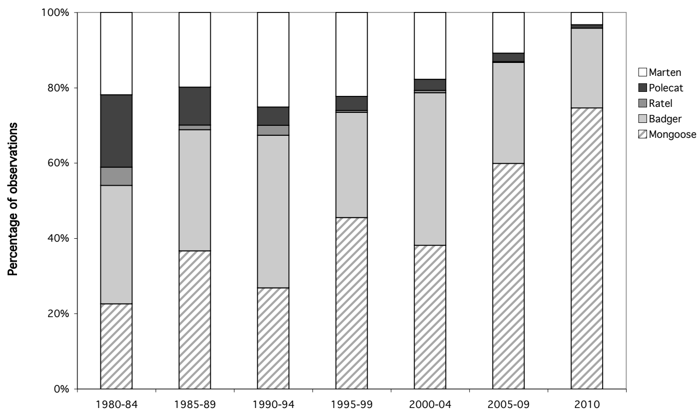

Fig. 3. The percentage of the total number of sightings in Israel contributed by each species of small carnivore, excluding Eurasian Otter *Lutra lutra*, to the INPA database in each 5-year period, and in 2010.

cific time period, I suggest that since these are either limited in time (e.g. a survey), not expected to change over time (e.g. natural biology or detectability) or not expected to show a consistent, gradual, directional trend (e.g. inclination to report an observation in a specific species, i.e., a report bias), they cannot be responsible for the statistically significant, long-term, gradual change in the relative number of sightings in the different species.

This suggested change in relative abundance in itself still does not make it possible to conclude whether the proportions of sightings of individual species changed because Egyptian Mongoose became more common and numbers of other species remained stable or because other species decreased but Mongoose populations remained stable. Nonetheless, coupling this observed change with other data, such as the decreasing distribution area of Marbled Polecat, decreased number of observations in the centre of Israel of Stone Marten, and sharp decrease in sightings of Ratel, suggests that the populations of these three species are declining, which, at least partly, may explain their lessening relative encounter rate. A second factor that may contribute to the observed change in relative encounter rate may be the gradual improvement in the condition of water bodies in Israel. The re-flooding of parts of the Hula Valley, developments to wetland protected areas, a Governmental programme to reconstruct riparian habitats, and tightening regulations on water pollution (e.g. Bar Or 2004, Ministry of Environmental Protection 2004, 2007, 2010) may have favoured Egyptian Mongoose, which shows the highest affinity for wetlands, and, hence, increased its relative abundance over other species. It is difficult to estimate how important these factors have been, if they work synergistically or separately or whether other factors, such as indiscriminate poisonings by farmers, have been responsible for the reported changes in relative numbers of sightings and, suggestively, in the relative abundance.

In sum, these statistically significant changes over the study period suggest quite strongly that Egyptian Mongoose has been becoming relatively more common than the rest of the small carnivore species in Israel.

Conclusions

More than 30 years of recording sightings of small carnivores in Israel show that, at least partly, anthropogenic factors influence small carnivore distribution and relative abundance. Furthermore, circumstantial connections can be suggested between specific factors and trends in the analysed data. Some factors seem to influence all species, while others may influence a single species, depending on its biology and habitat preferences. Increased abundance of synanthropic species and poaching by foreign labourers plausibly negatively affected all small carnivore species, and may be responsible for the lack of recorded sightings in the southern deserts during the last two decades. On the other hand, increased availability and quality of riparian and wetland habitats due to human activities may have benefited mainly Egyptian Mongoose and forest fires possibly had a direct negative, but ultimately positive, effect on Stone Marten. Since individual factors influence different species or have opposite affects on different species, a change in the relative number of sightings, which is suggested to represent relative abundance, is apparent. Ratel and Marbled Polecat seem to be decreasing in numbers and/or distribution and their regional conservation status may need to be re-assessed; Stone Marten and Eurasian Badger show relative stability; and Egyptian Mongoose is becoming more common, at least relative to all other species.

This study has used the information from only one database for which, moreover, there has been no way to assess the reliability of species identifications. Further analysis and study of absolute numbers of small carnivore species in Israel, analysing data from additional databases, specimen collections and other sources and investigation of factors with unknown differential effect such as poisoning, should be performed and would add much to the discussion presented here. The national conservation status of Ratel and Marbled Polecat is particularly in need of clarification.

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