Title

EFFECTIVENESS OF MITIGATION MEASURES TO REDUCE ROAD MORTALITY IN THE NETHERLANDS: BADGER MELES MELES

Authors
Bekker, Hans (G.J.)
Dekker, Jasja (J.A.)

Publication Date
2009-09-13

Peer reviewed

EFFECTIVENESS OF MITIGATION MEASURES TO REDUCE ROAD MORTALITY IN THE NETHERLANDS: BADGER *MELES MELES*

Hans (G.J.) Bekker (hans.bekker@rws.nl) Centre for Transport and Navigation, Rijkswaterstaat. Pb 5044 2600 GA Delft, the Netherlands (corresponding author)
Jasja (J.A.) Dekker (jasja.dekker@zoogdiervereniging.nl) Dutch Mammal Society. Arnhem, the Netherlands

Parts of this paper are based at the article that will be published in *Lutra*, the scientific magazine of the Dutch Mammal Society: "Badger *Meles meles* road mortality in the Netherlands: victim characteristics and effects of mitigation measures" (Jasja J.A. Dekker & Hans G.J. Bekker; 2009)

Abstract

In the 1900's, the badger population of the Netherlands was estimated to count 2500 to 3000 setts with over 4000 individuals. Between then and the 1960's, the number declined drastically and stayed low until the mid-1980's with about 400 setts in the whole of the Netherlands. In the 1980's a high percentage of the population, locally up to 25%, was killed yearly by road traffic. For this reason the Dutch government implemented mitigation measures such as fauna tunnels and fences. It was easy to monitor the use of such measures. By census we know that the population increased to around 5000 individuals in 2006. But were these "badger tunnels" effective: did the number of traffic victims at these tunnels decrease?

To answer this question we analyzed data on badger traffic victims gathered by NGO "Das & Boom" and the Center for Transport and Navigation (Rijkswaterstaat) between 1990 and 2006. First, we determined the distribution of victims over motorways, provincial roads and local roads. In absolute terms, most victims were reported from local roads. However, relative to the length of road in the range of the badger, most victims occur at provincial roads.

Second, we tested whether taking mitigating measures resulted in a decrease of traffic victims. Realization of fauna tunnels resulted in a small but significant decrease in the local number of victims, but effects varied from site to site: at most sites, the number of victims was lower, but at some the number of victims was higher after implementation of the measure. Analysis on a local scale should provide a clearer picture of the effect of mitigation measures on badger mortality.

Such a study was done in the area 'Eindegooi' where the increase of the population of badgers is spectacular. It appears that the increase is related to a package of measures taken in that area.

The challenge for conservation now lies in minimizing victim numbers at local roads. As badger victims occur over a huge length of local roads, mitigation will be difficult. Still, a number of measures are feasible, for example locally designed tunnels and fences, decreasing speed limits or closing roads for through traffic, especially at 'black spots' with high numbers of victims.

Keywords: badger, road mortality, de-fragmentation measures, traffic victims, wildlife passage, road ecology, effectiveness

Introduction

Between 1900 and the 1960's, the number of badgers declined drastically (Van Wijngaarden & Van de Peppel 1964) and stayed until the mid-1980's (Van Wijngaarden et al. 1971, Wiertz & Vink 1986), with about 400 setts in the whole of the Netherlands. In the 1900's, the badger population of the Netherlands was estimated to be 2500 to 3000 setts with over 4000 individuals.

A number of causes for this decline have been suggested (Van Wijngaarden & Van de Peppel 1964, Wiertz & Vink 1986, Van Apeldoorn et al. 1995): hunting and poaching, disturbance and destruction of setts, habitat loss, and pollution, isolation of metapopulations and hampered migration, and traffic. In the 1980's, it became clear that a high percentage of the population was killed by traffic: locally up to 25% (Bekker & Canters 1997, Broekhuizen et al. 1994, Van Apeldoorn et al. 1995).

In 1990 at national level both nature policy in the Nature Policy Plan (Ministerie van Landbouw, Natuur en Visserij 1990) and transport policy in the Second Transport Structure Plan (Ministerie van Verkeer en Waterstaat 1990) underlined the necessity to halt further habitat- and population fragmentation by roads and to diminish existing fragmentation. These combined governmental policies paved the way for de-fragmentation programs and actions (Bekker & Canters 1997).

In the 1990s and 2000s, the distribution and population size of the badger has strongly increased (Wiertz 1992, Van Moll 2005, Witte et al. 2008) (figure 1). This increase may be attributed to the resolving of most of the assumed causes of decline, such compensation of damage to crops (between €13.000 and €71.000 yearly; Faunafonds 2006) and contracting management scheme agreements with farmers with setts on their land (with approximately 500 farmers in 2001-2005, Faunafonds 2006), the decrease in PCBs and heavy metals (except in floodplains, Van den Brink & Ma 1998), raising and translocation of orphaned or threatened badgers (see Van Moll 2005) and the countering of habitat loss and implementing of large mitigation measures at problem points in the major roads.

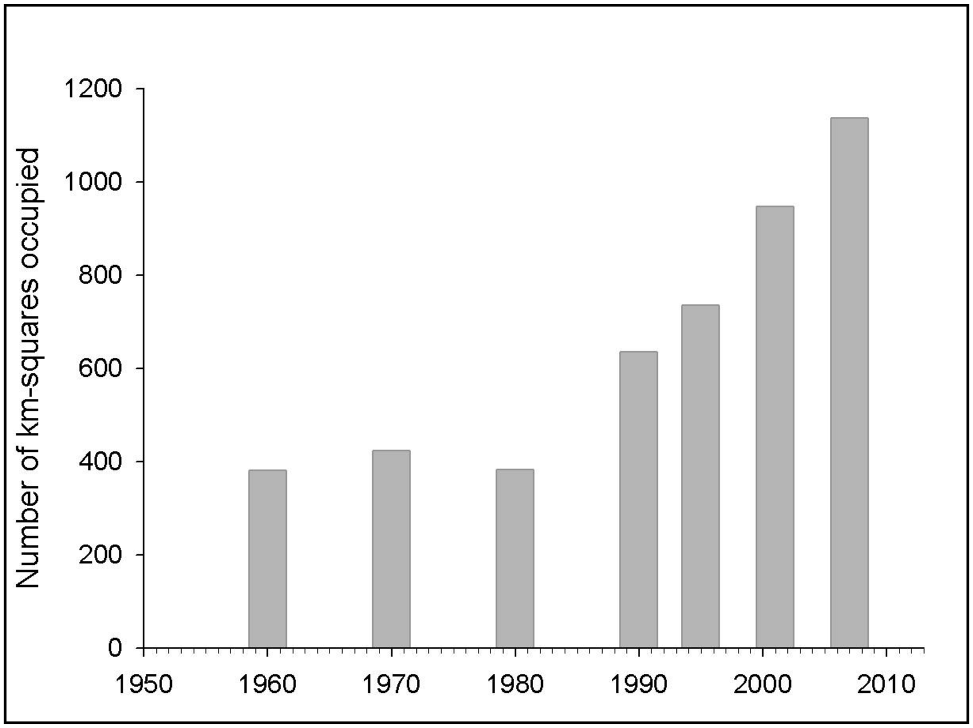


Figure 1. Number of 1km x 1km squares in the Netherlands, occupied by the badger from census. Sources: Van Wijngaarden & Van de Peppel (1964); Van Wijngaarden, Van Laar & Trommel (1971); Wiertz & Vink (1986), Wiertz (1991); Van Moll (2005) and Witte et al. (2008).

The most used mitigation measures aimed at badgers are tunnels under roads, combined with fencing (Kruidering et al. 2004) (figure 2). These tunnels are known to be used by badgers (Maaskamp 1983, Derckx 1986, Van Dinther 1994, Bekker & Canters 1997, Brandjes et al. 2002).

However, it has not been reported what part (in terms of percentage, age and sex) of the population is killed by traffic, or if there is a difference between road types, nor has it been tested whether implementation of tunnels actually decreases mortality. With this knowledge, conservation and mitigation measures can be optimally implemented, using them at certain road types, certain times of the year of certain parts of badger range, using badgers as a model species for other terrestrial mammals.

In this paper, we present and analyse data on badger traffic victims gathered by NGO "Das & Boom" (Bekker & Canters 1997, Vereniging Das & Boom 1990-2006) and the Centre for Transport and Navigation. First, we determine the national distribution of victims over motorways, provincial roads and local roads. Secondly, again at national spatial scale, we test whether taking mitigating measures resulted in a decrease of traffic victims.

Thirdly, we "zoom in" to a local situation, to provide the insight of these measures at the local badger population.

Figure 2. New badger tunnel.

Methods

Censuses, traffic victims, mitigation measures and roadmaps

The datasets of badger victims and of the mitigation measures taken were not gathered specifically for the goal of this study. The NGO Das & Boom and Rijkswaterstaat gathered the data on traffic victims. Victims were generally found by the public, by inspectors of Rijkswaterstaat or by a network of volunteers, and reported to Das & Boom. The location in coordinates with 10 meters precision, road name, date, road type and road manager were then documented. The dataset covers the period from 1 January 1990 until 31 December 2006.

The changes in badger range and number of the last 40 years has been well documented by the badger censuses: using systematic surveys, all suitable badger habitats were checked for inhabited setts in 1960 (Van Wijngaarden & Van de Peppel 1964), 1970 (Van Wijngaarden et al. 1971), 1980 (Wiertz & Vink 1986), and 1990, Wiertz (1992), 1995, 2000 (Van Moll 2005) and 2007 (Witte et al. 2008) (figure 1). We assume that the 2007 census represents the range of 2006 well. The ranges and estimates of the population size are used in this paper to correct for the increase in numbers and range that occurred during the study period.

The Centre for Transport and Navigation, Delft, provided spatial data of the complete Dutch road grid and the spatial data of the mitigation measures for motorways (database Wegensnip; Rijkswaterstaat 2007). Das & Boom provided the data for the provincial and local roads. This dataset contained the type of mitigation measure, location, road type and year of construction.

Distribution of victims

First, we report the number of victims per year. Then, we summarize the number of victims of the period 1990-2006 per month.

We separately analyze victims that were reported outside the known range for the years for which we have census. Badgers are considered to be outside the known range when they are reported on a location farther than two kilometres from the known range, as two kilometres is the maximum distance resident badgers move away from their setts in the Netherlands (Van Wijngaarden & Van de Peppel 1964, Wansink 1995) and elsewhere in western Europe (Neal & Cheeseman 1993, Palphramand et al. 2007).

Next, to correct for effects of population growth and increasing distribution on victim numbers, we express the number of recorded victim as a percentage of the population. We do this by dividing the number of victims by population size for the years a census was done. Following the approach from Wiertz & Vink (1986) we assume that there is usually one sett per km^2, and that 3.2 badgers inhabit one sett. So, to calculate which percentage of the population the recorded victims constitute, we divide the number of badger victims by the number of populated km^2 x 3.2 badgers km^{-2} x 100%.

Road types

In the analyses, we distinguish three road types: motorways (major roads), provincial (county) roads and local (municipal) roads. These roads have different speed limits of respectively 120 or 100 km $hour^{-1}$, 100 or 80 km $hour^{-1}$ and 50 to 30 km $hour^{-1}$, and different traffic density.

Traffic victims and road maps were entered in a GIS, and each victim was attributed to the nearest road. To gain insight in the effect of road type on number of traffic victims, we first calculated the absolute number of traffic victims per road type. There are much kilometers of more municipality roads than there are county or major roads, so it is likely that more victims will fall on these roads than on the other types. To correct for this, we also calculated the number of victims per kilometre of road that lie within the known distribution of badgers, for the years when a census was done.

Effect of mitigation measures

We tested the effect of mitigation measures on badger mortality by comparing the number of victims around the place of the road with a mitigation measure with and without the measure, i.e. before and after implementation. We used 2 kilometres of road on both sides of the mitigation measure, as this is the maximum range a badger moves from it's sett in the Netherlands (Van Wijngaarden & Van de Peppel 1964): we assume that the victim number on roads further from the mitigation measure than this maximum range of movement from the sett are not 'influenced' by this measure.

When testing the effect of mitigation measures, the recent increase in numbers and the expansion of the range of badgers could be a confounding factor: a road can show more victims after the implementation of a mitigation measure if badgers were absent in the area in the years before the implementation and present in the years after. To correct for this, we select only those mitigation measures that were in the distribution area of the badger in the census of 1990. These locations could have had badger victims over the whole period.

First, we compare the number of victims at these locations in the two years before the implementation with the number of victims in the two years after the implementation.

Next, we test the effect of mitigation measures on the number of victims using a Generalized Linear Model (McCullagh & Nelder 1983) approach. Sampling units are 2 kilometre stretches of road surrounding the measure taken. The number of victims per year at these stretches is modelled as a function of the presence-absence of the measure. We used a hierarchical design, with number of victims and presence of measures per year nested in locations. Because the data follows a Poisson-distribution with inflated zeros, we use a Poisson-distributed error term and a log-link function.

At the sites selected for our analyses, i.e. where victims were reported between 1990 and 2006, the number of mitigation measures increased: in 2006, 138 locations with mitigation measures existed, but in 1990 only 11 of these were in place. To correct the bias caused by changing numbers of mitigation measures over years, we select the year in which the number of locations with mitigation measures in present and mitigation measures absent is almost equal: 1998. To further correct for effects of population growth and range expansion we only used those stretches of road surrounding mitigation measures where a victim occurred at least once in the period of 1990-2006.

All statistical analyses were done in statistical package R (R Development core team 2006).

<u>Results</u>

Distribution of victims

The number of badger recorded as victims of traffic shows a steady rise over the period from 1960 to 1990, but stabilizes in the 2000's (figure 3). Of course, these numbers are the minimal number of victims: not all animals that are found are reported, and not all animals hit by cars are found.

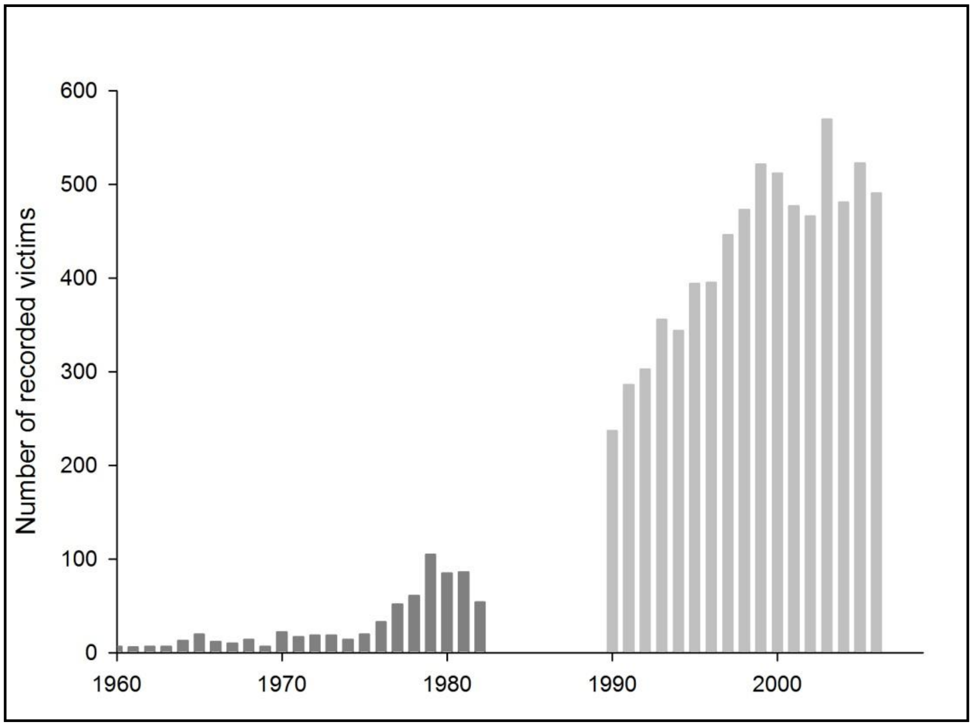


Figure 3. The number of recorded badger traffic victims in the period of 1960-1982 and 1990-2006. Dark grey: data from Wiertz & Vink (1989). Light grey: data from Das & Boom and Centre for Transport and Navigation. No data is available from 1983-1989.

Of the 7279 badger victims reported from 1990 until 2006, trains killed 142 animals. Another 140 victims in the dataset were badgers that had drowned in canals. These animals were not included in the analysis of the effect of mitigation measures on mortality.

The distribution of victims over the Netherlands generally follows the range of badgers, although some victims occur far outside the distribution (figures 4a and 4b). For example, in 1995 45 victims were found outside the known badger range.

In 1990, the recorded badger traffic victims are estimated to be 12% of the estimated Dutch badger population. In 1995, the estimated percentage of the population that is killed by traffic was higher than in 1990: 18%. In the 2000's, the estimated percentage declined again: 17% of the population was killed in 2001, and 13% in 2006 (figure 5).

Road types

In absolute terms, most victims fall at local roads, then at provincial roads and least at motorways (figure 6a). When corrected for the length of each road type in the distribution area of badgers in the Netherlands, a different pattern emerges: the lowest number of victims per kilometre of road occurs at local roads, and the most on provincial roads (figure 6b).

Effect of mitigation measures

We compared the number of victims two years before and 2 years after mitigation measures were taken in the badger range. At 56 measures, the same number of victims occurred before and after mitigation measures were implemented: zero victims. At 31 measures, more victims were found after than before measures were implemented. At 40 measures, fewer victims were found after the measure was implemented.

The generalised linear model shows that mitigation measures taken within the range of badgers resulted in a decrease of the number of traffic victims (table 1).

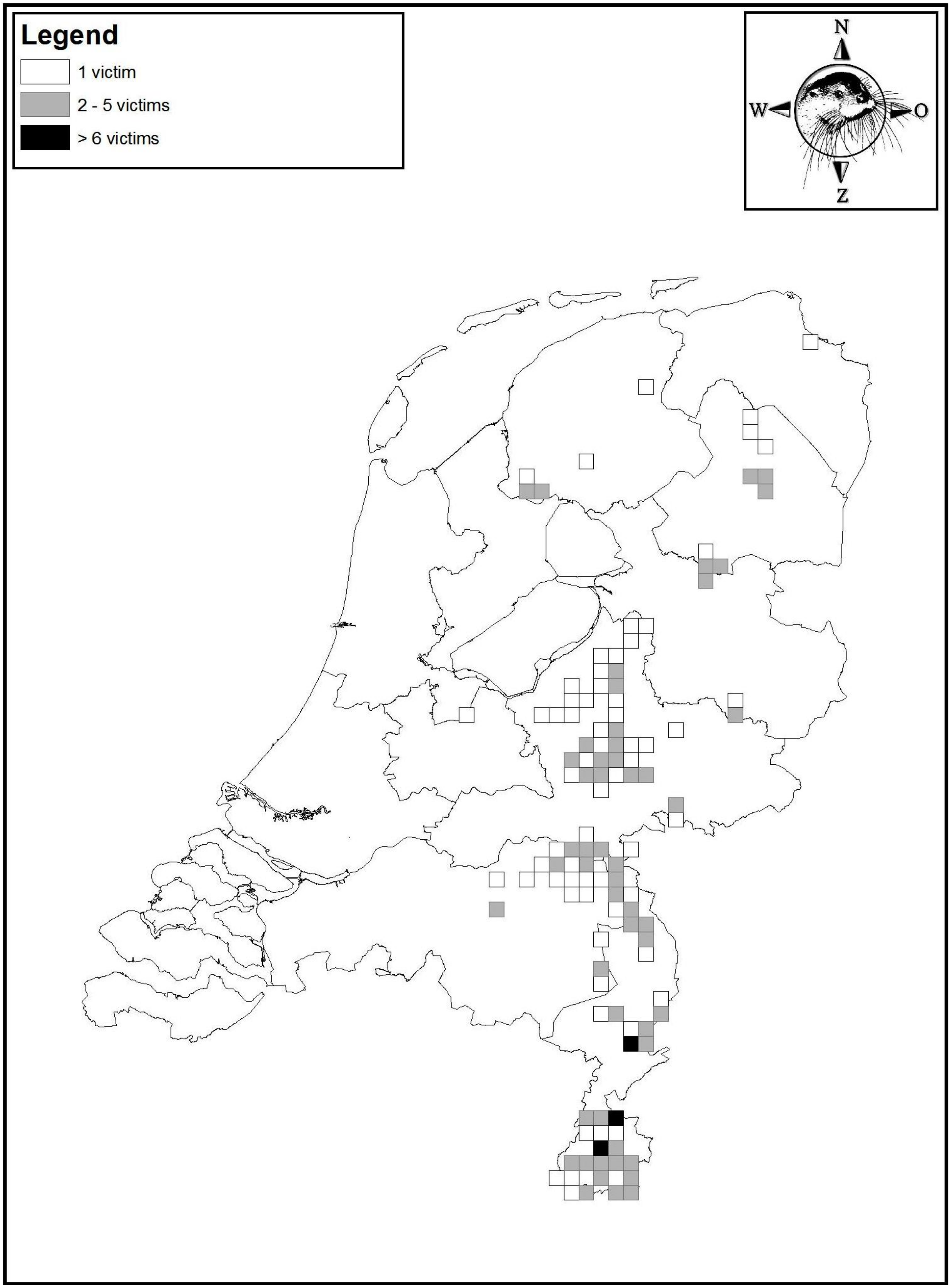


Figure 4a. Distribution of victims in 1990.

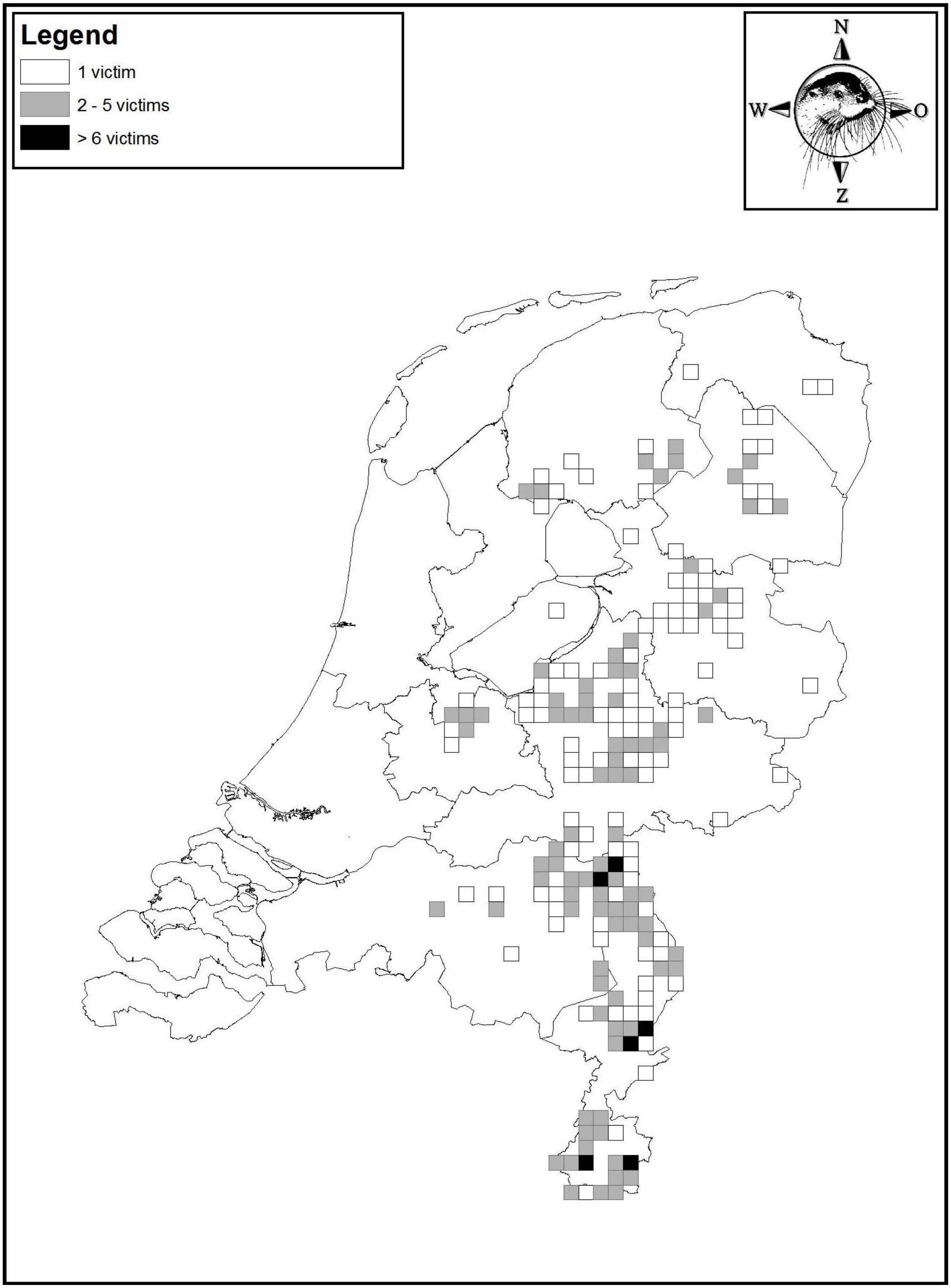


Figure 4b. Distribution of victims in 2006.

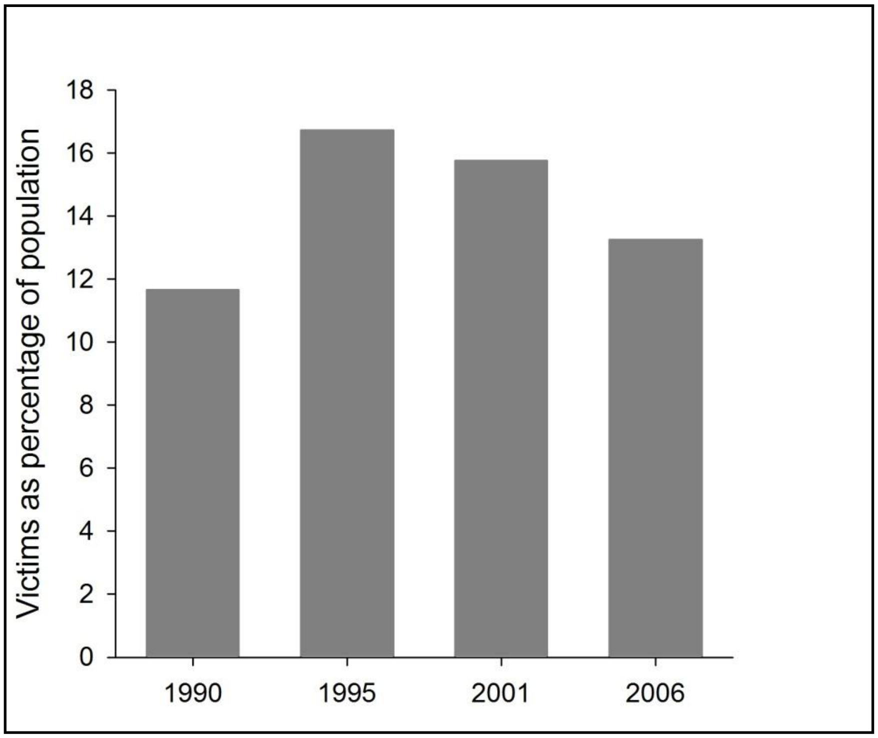
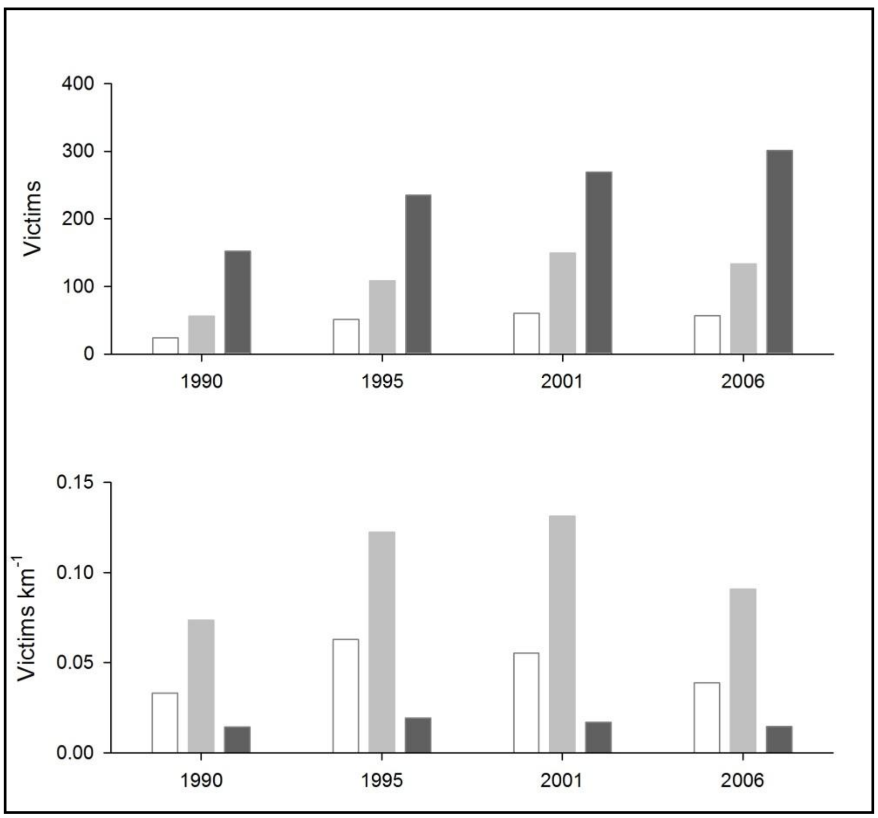


Figure 5. Estimate of the percentage of the Dutch badger population that is killed by traffic for census years.



Figures 6a and 6b. a) Absolute number of victims per road type. b) Number of victims per road type, divided by the total length of that road type in the badger's range. White: motorways, light grey: provincial roads, dark grey: local roads.

Coefficients of the Model	Estimate	Std. Error	z value	*p*
Site: absent	-1.128e-03	8.402e-05	-13.431	<0.001
Site: present	-1.173e-03	8.759e-05	-13.388	<0.001
Residual degrees of freedom: 1969; Null deviance: 2604.4 on 1971 degrees of freedom; Residual deviance: 2394.2 on 1969 degrees of freedom.				

Table 1. Output of GLM analyses. We modelled the number of victims at a site as a function of presence of mitigation measure as a factor, nested within sites.

Discussion

Victims

We estimate that at least between 12% and 18% of the Dutch badger population was killed yearly in the period 1990-2006. These percentages are an absolute minimum: possibly, not all victims that are found are reported. Animals that are hit by cars but not killed directly and move themselves away from the roadside will not be found. Also, the amount of juveniles that became orphans and subsequently died is of course not included in our estimates. This does not take into account losses of litters: Broekhuizen *et al* (1994) estimated that yearly at least 10% of all litters were lost because lactating females were killed at roads.

Road type

Most victims occurred on local roads. This is hardly surprising: this type of roads simply constitutes the most length in the range. This also makes it the hardest road type to manage for decreases in traffic victims. The number of victims per km of road is highest on the provincial roads. What's more, this number increased over the study period. We attribute this to the ease of access for wildlife on provincial roads and to the openness of major roads. In the Netherlands, major roads must be lined with an obstacle free zone of ten meters (Dienst Verkeerskunde 1992; Adviesdienst Verkeer en Vervoer 2006). This makes traffic more visible for wildlife and vice versa. In the south of the UK, most victims occurred on smaller roads as well, and much fewer on motorways (Clarke *et al*. 1998).

Policy-wise, management aimed at lowering numbers of badger traffic victims should be aimed primarily to the provincial roads: here, the number of victims per km of road is highest. The number of victims on the provincial roads and local roads could be lowered with management measures such as implementation and maintenance of road mitigation measures (Kruidering et al. 2005), lowering of speed limits, or by closing off certain stretches of roads (Jaarsma et al. 2007) during the night and/or in sensitive periods. To be most effective, measures should be planned at relevant landscape elements (ditches, tree lines, etc.), following a landscape-oriented approach (Kruidering et al. 2005).

Effect of mitigation measures

Mitigation measures have an effect on victim numbers at many locations: analyses of the full dataset showed fewer victims after mitigation measures were taken, and after implementation of measures there were fewer or equal numbers of victims at a number of sites. However, at other sites there were similar or more victims. These ambiguous results show that it is difficult to get full understanding when analyzing the effects of mitigation measures on victim numbers at a national scale only.

Aside from this, in these analyses there are some confounding factors. In our approach, the effects of the implementation of mitigation measures may have been obscured by the growth and expansion of the badger population in the Netherlands during the study period.

Van Apeldoorn et al (2006) and Vink et al. (2008) analyse a local, well-studied situation. This will give more insight in the effects of the measures on badger mortality. See Box 1.

<u>Box 1</u>; based at Vink, H.J., R.C. Van Apeldoorn, R.C. , G.J. Bekker, 2008.

For 24 years data on badger (Meles meles) and sett numbers were collected by direct observation of a local population in Eindegooi, in the provinces of Utrecht and Noord-Holland, the Netherlands. The population shows periods of slow but also exponential growth and spatial dynamics show colonization of the entire study area.

The expansion of the species throughout the area realised during the period of growth, which offset an increase in population density. At the same time the number of cars on all types of roads in the area also increased, but this did not result in higher traffic mortality, indirectly showing the positive effect of the protection measures that were taken. This is also illustrated by the fact that dead badgers were no longer found at locations where measures had been taken.

Analysis of the population dynamics in relation to de-fragmentation measures involving roads that were taken in the area suggests a positive contribution of tunnels and other measures. At low densities and during periods of slow growth these measures can increase the lifetime of reproducing individuals and help badgers to safely disperse and colonize new habitat patches. Their positive effect on the population is illustrated by a more or less constant individual chance to be killed by cars in spite of the increasing number of cars on motorways and provincial roads that dissect the study area.

Conclusion

In the Netherlands most victims fell on municipal roads, but when expressed per kilometre of road, most victims fell on county roads. Implementing mitigation measures resulted in a lower number of victims. There are several factors affecting the populations of Dutch badgers, so it is hard to say if only road management caused the recent increase of badgers in the Netherlands, but it is clear that mitigation measures decrease mortality in the Dutch badger. And, as has been argued by other authors, (Janssen 1997; Vereniging Das & Boom 2002; Ouden & Piepers 2006), it is important that these mitigation measures remain operational.

Most traffic victims are reported from provincial roads (in absolute numbers), and from local roads (in relative numbers). The victims occur over a huge length of these roads, especially in the case of local roads, making mitigation of their impact difficult. Still, some measures are feasible, for example decreasing speed limits or closing roads for through traffic (Jaarsma et al. 2007).

As traffic victims, badgers could be seen as a model species for all mustelids, and other terrestrial mammals. Implementation of more specific mitigation measures such as tunnels and fences require knowledge of the local badger population and of their spatial behaviour, for maximum effectiveness.

The dataset that was gathered by Das & Boom and the Centre for Transport and Navigation is a unique dataset. The dataset allows an in depth analyses of traffic victims and the possibly complex effects of road mortality on badger population dynamics. For example, mathematical models indicate that an increase of life expectancy of badgers will result in more females in the age of highest reproductive success, and therefore in a relatively big increase in the population (Seiler et al. 2003). However, this proposed mechanism has not been tested in the field. The challenge now lies in testing whether the decrease in mortality brought about by mitigation measures, together with the decrease in habitat fragmentation, indeed translates into positive effects on the population?

Acknowledgements

The authors would like to thank Sil Westra of the Dutch Mammal Society for the GIS-analyses. Gerard Müskens gave useful suggestions for the analyses.

References

Adviesdienst Verkeer en Vervoer (ed.) 2006. Nieuwe Ontwerprichtlijn Autosnelwegen (NOA). Adviesdienst Verkeer en Vervoer, Rijkswaterstaat, Rotterdam, the Netherlands.

Bekker G.J. & K.J. Canters 1997. The continuing story of badgers and their tunnels. In: K.J. Canters, A. Piepers & D. Hendriks-Heersma (eds.). Proceedings of the international conference: Habitat fragmentation, infrastructure and the role of ecological engineering. Maastricht/Den Haag, the Netherlands: 344-353. DWW publication: P-DWW-97-046, Delft, the Netherlands.

Brandjes, G.J., R. Van Eekelen, K. Krijgsveld, K. & G.F.J. Smit 2002. Het gebruik van faunabuizen onder rijkswegen; resultaten van literatuur- en veldonderzoek. DWW-Ontsnipperingsreeks deel 43. Rapport nr DWW-2002-123, Rijkswaterstaat, Dienst Weg- en Waterbouwkunde, Delft, the Netherlands.

Broekhuizen, S., G.J.D.M. Müskens, & J. Sandifort, J. 1994. Invloed van sterfte door verkeer op de voortplanting bij dassen. IBN-rapport 055. Instituut voor Bos- en Natuuronderzoek, Wageningen, the Netherlands.

Clarke, G.P., P.C.L. White & S. Harris 1998. Effects of roads on badger *Meles meles* populations in south-west England. Biological Conservation 86: 117-124.

Derckx, H. 1986. Ervaringen met dassenvoorzieningen bij Rijksweg 73, tracé Teerschdijk-Maasbrug. Lutra 29(1): 67-75

Dienst Verkeerskunde (ed.) 1992. Richtlijnen voor het ontwerp van autosnelwegen (ROA). Dienst Verkeerskunde, Rijkswaterstaat, Rotterdam, the Netherlands.

Faunafonds 2006. Jaarverslag Faunafonds 2006. Faunafonds, Dordrecht.

Jaarsma, C.F., F. Van Langevelde, J.M. Baveco, M. Van Eupen & J. Arisz 2007. Model for rural transportation planning considering simulating mobility and traffic kills in the badger *Meles meles.* Ecological Informatics 2: 73-82.

Janssen, A.A.W., H.J.R. Lenders, & S.E.W. Leuven 1997. Technical state and maintenance of underpasses for badgers in the Netherlands. In: K.J. Canters, A. Piepers & D. Hendriks-Heersma (eds.). Proceedings of the international conference: Habitat fragmentation, infrastructure and the role of ecological engineering. Maastricht/Den Haag, the Netherlands 17-21 September 1995: 362-366. DWW publication: P-DWW-97-046, Delft, the Netherlands.

Kruidering A.M., G. Veenbaas, R. Kleijberg, G. Koot, Y. Rosloot & E. Van Jaarsveld 2005. Leidraad Faunavoorzieningen bij Wegen. Dienst Weg- en Waterbouwkunde, Rijkswaterstaat, Delft, the Netherlands.

Neal, E. & C. Cheeseman 1996. Badgers. T & AD Poyser Natural History, London, UK.

Maaskamp, F. 1983. Het gebruik van een duiker door dassen als onderdoorgang van een weg. Huid en Haar 2: 163-165.

McCullagh, P. & J.A. Nelder 1983. Generalized linear models. Chapmann and Hall, London, UK.

Ministerie van Landbouw, Natuur en Visserij, 1990. Natuurbeleidsplan. Tweede Kamer der Staten-Generaal, 's-Gravenhage, the Netherlands.

Palphramand, K.L., G. Newton-Cross & P.C.L. White 2007. Spatial organization and behaviour of badgers (*Meles meles*) in a moderate-density population. Behavioural Ecology and Sociobiology 61:401–413

R Development Core Team 2006. R: A Language and Environment for Statistical Computing,. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org

Seiler, A., J.O. Helldin, & T. Eckersten 2003. Road mortality in Swedish Badgers. Effect on population. In: A. Seiler. The toll of the automobile: Wildlife and roads in Sweden. Silvestria 295. Ph.D. thesis. Department for Conservation Biology, Swedish University of Argricultural Sciences, Uppsala, Sweden.

Rijkswaterstaat 2007. Database Wegensnip. Rijkswaterstaat, Ministerie voor Verkeer en Waterstaat, Delft, the Netherlands.

Van Apeldoorn R.C., H. Houweling & G. Veenbaas 1995. Mitigerende maatregelen voor de das; een methode voor probleemdetectie en evaluatie van voorzieningen. Landschap 12 (5): 5-12.

Van Apeldoorn R.C., J. Vink & T. Matyáštík 2006. Dynamics of a local badger (*Meles meles*) population in the Netherlands over the years 1983 – 2001. Mammalian Biology 71: 25 – 38.

Van Dinther, B. 1994. Gebruik van dassentunnels door dassen en andere dieren. Rapport 324. Werkgroep Dieroecologie, Katholieke Universiteit Nijmegen, Nijmegen, the Netherlands.

Van Moll, G. 2005. Distribution of the badger (*Meles meles* L.) in the Netherlands, changes between 1995 and 2001. Lutra 48(1): 3-34.

Van Wijngaarden, A. & J. Van de Peppel, 1964. The badger, *Meles meles* (L.) in the Netherlands. Lutra 6(1-2): 1-60.

Van Wijngaarden, A., V. Van Laar & M.D.M. Trommel 1971. De verspreiding van de Nederlandse zoogdieren. Lutra 13 (1-3): 1-41.

Vereniging Das & Boom, 1990-2006. Verkeersslachtoffers onder dassen in Nederland. Vereniging Das & Boom, Beek-Ubbergen, the Netherlands.

Vink, H.J., R.C. Van Apeldoorn, R.C. , G.J. Bekker, *2008*. Defragmentation measures and the increase of the local badger (*Meles meles*) population at Eindegooi? Lutra 51(2).

Wansink, D. 1995. Kansen voor de Gooise Das. Een onderzoek naar populatieontwikkeling, het habitatgebruik en het dieet van een dassenpopulatie bij Hollandse Rading. Rapport nr. P-UB-95-08. Wetenschapswinkel Biologie, Utrecht, the Netherlands.

Wiertz, J. & H. Vink 1986. The present status of the badger *Meles meles* (L, 1758) in The Netherlands. Lutra 29(1): 21-53.

Wiertz, J. 1992. De Nederlandse dassenpopulatie anno 1990. Lutra 35(2): 75-89.

Witte, R.H., D. Bekker, J.J.A. Dekker, C. Achterberg & M. Moonen 2008. Inhaalslag VerspreidingsOnderzoek Nederlandse Zoogdieren (VONZ) 2007. Rapport 2008.01. Zoogdiervereniging VZZ, Arnhem, the Netherlands.