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BEYOND THE BIOLOGICAL PERSPECTIVE OF THE ROAD/FAUNA CONFLICT: VERTEBRATES IN THE DECISION MAKING OF SPANISH MOTORWAY OPERATING COMPANIES

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ABSTRACT

Apart from safety issues, most scientific literature on the road/wildlife conflict has been focused on the analysis of the impacts of roads on animal populations. However, the integration of roads into ecosystems does not follow straightforwardly from such analyses as it depends on interactions between the infrastructure, the management operations and the biological communities in the surroundings. Thus, the involvement of companies that operate motorways is key in designing strategies to the environmental integration. From this perspective, we surveyed companies operating eight motorway sections in Spain (c. 225km in total) in order to identify: i) the types of fauna-related problems they faced, ii) the mitigation measures they take in response, and iii) the importance given to such problems in decision making, both subjectively and in terms of cost. A total of eight questionnaires were answered and six road-kill databases were gathered.

Results show that the perception of wildlife problems and the implementation of mitigation measures varied between motorway sections, the highest-scored problems being road kills (cited in 100% of cases,), effects on the stability of roadslopes (50%), damage to fencing (50%) and carriageway deterioration (12%). Furthermore, the typology and extent of the problems differed significantly depending on the type of landscape crossed, with differences between those affecting motorways crossing urban zones and those seen at motorways in less disturbed areas. Companies adopt several mitigation and management actions that focus on these problems, with costs regarded as nonexistent or low in 62% of cases or moderate in 38%. The effectiveness of such actions is scarcely analyzed. In this regard, 38% of responders considered that the public image of their companies suffers from the road/wildlife conflict and 50% of them think that new mitigation measures should be implemented. In conclusion, and with the caution imposed by the small sample size, the survey shows i) road operating companies show disposition to take measures aimed at diminishing the road/wildlife conflict, and ii) highway management could benefit from improving scientific analyses of the implemented measures. Improved management could thus result from knowledge generated by their own monitoring of the effects of roads on wildlife.

Keywords: concession; corporate social responsibility; highway; management; mitigation

INTRODUCTION

The environmental integration of transport infrastructures has comprised one of the principal environmental challenges of recent decades. Under a growth model in which socio-economic growth is linked to infrastructure development, environmental integration is fundamental to guaranteeing sustainability (Saavedra 2010). Minimising the environmental impacts associated with transport infrastructures has thus been a shared preoccupation for legislators, conservationists and scientist's alike (Lawrence 2003, Zaragoza 2005). Such concern has reached the management levels of companies involved with transport infrastructures, who are beginning to recognise that corporate social responsibility (CSR) is not just a necessity but is also an investment that has economic returns (Ambec and Lanoie 2008, Saavedra 2010). Scientific analyses of the environmental impacts associated with transport infrastructures have been increasing against this background, and in parallel with the development of environmental regulations. Thus, a number of studies have investigated the effects of roads on different environmental components (Forman and Alexander 1998, Spellerberg 1998, Coffin 2000, Trombulak and Frissell 2000, Seiler 2001).

The effects of roads and their use on the fauna of their surroundings are among the environmental impacts that have generated most interest. Negative effects predominate, notably (i) increased mortality from road-kill, (ii) fragmentation/isolation of populations, and (iii) habitat destruction or alteration. Nevertheless, several species have been shown to select the vicinity of roads for refuge, feeding or as

green corridors for their movements (Bennett 1991, Frey and Conover 2006, Sabino-Marqués and Mira 2011), with potential consequences, both positive and negative, for the rest of their communities.

A range of measures is currently taken during the design and construction phases with a view to reduce the negative impacts of roads (e.g. Otero 1999, MMA 2006). Nevertheless, minimisation of environmental impacts needs to cover the entire lifetime of the infrastructure but current environmental management guidelines hardly take effects on fauna into account (Zaragoza 2005, AEC 2007). In fact, the management and maintenance measures carried out by companies and public entities responsible for operating roads are key to achieving their appropriate environmental integration, given that roads and motorways are permanent landscape features (Loro *et al.* 2010).

In keeping with trends observed in all productive sectors, road management companies may be expected to increase their concern for the impacts that their infrastructures have on fauna and to take these into account in their management procedures, even though some economic costs will be incurred (Saavedra 2010). CSR aspires to address the current and future demands of society and its ethical values, over and above current legal requirements. The concerns of modern management thus broaden beyond purely economic interests that are of maximum benefit to shareholders to address those of all stakeholders including, in this case, road users, local inhabitants, NGOs and society in general (McWilliams and Siegel 2001, Garriga and Melé 2004, McWilliams *et al.* 2006). Such concerns are in fact a form of future investment, given that they can generate positive returns in the forms of improved public image, economic benefits, easier access to market finance and lower risks of accusations of environmental damage (Orlitzky *et al.* 2003, Becker-Olsen *et al.* 2006, Mackey *et al.* 2007, Godfrey *et al.* 2009). All this being so, companies are increasingly including social objectives in their decision taking, in a bottom-up process in which individual managers play a key role in activities scaling up from day to day problem solving to corporate behaviour (Hemingway and MacLagan 2004).

Nevertheless, we currently do not know the perspective that operators have of the problems that arise from fauna/motorway interactions, despite their being the principal stakeholders in motorway management. Specifically, we are interested in knowing more about the problems operators encounter in their daily management, what mitigation measures are taken, how effective these measures are and how ready the operators themselves are to invest in improving such measures as part of a strategy of corporate social responsibility. Such information is fundamental for achieving adequate environmental integration of infrastructures and for planning and implementing sustainable solutions for a society that requires extensive road networks.

The objective of this study was to know, from the operators' viewpoint, the problems associated with the local fauna that arise from motorway operation and the effectiveness of the mitigation measures taken. We also attempt to analyse the importance operators give to problems both from quantitative: i.e. economic, and qualitative points of view, and whether there is a positive interest among managers in including faunal protection as part of the responsibility that motorway operators have to society at large.

MATERIAL AND METHODS

A questionnaire was sent to the operators of eight motorway sections in Spain, totalling some 225km (Figure 1). General characteristics of the studied motorway sections (length, traffic, the year the road was constructed and landscape types) are reported in Table 1. It was specifically addressed to personnel responsible for addressing the problems caused by fauna in those sections: environmental technicians, heads of conservation operations, directors of operations and heads of highway administration.

The questionnaire comprised 33 questions and up to 89 items requiring responses, the maximum number arising where replies and evaluations were given to all possible problem types raised. The five sections of the questionnaire respectively gathered data and evaluations on (see Annex I for further details):

i) General information on the motorway section.

ii) The typology, description and magnitude of the problems caused by fauna during motorway operation.

iii) Mitigation measures employed and an evaluation of their success.

iv) Evaluation of economic and public image costs to operators arising from fauna-related problems.

v) Respondent-related information.

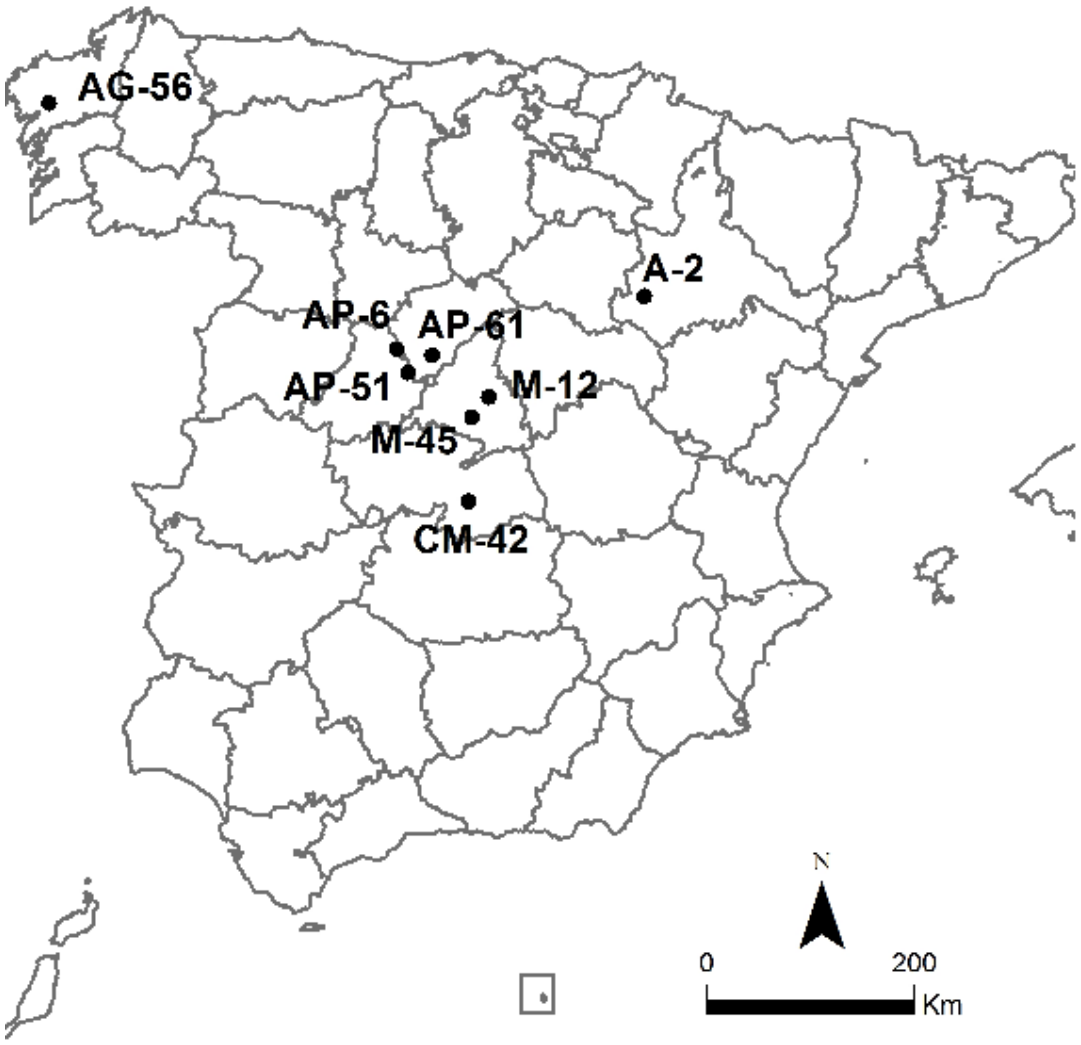

Figure 1. Location of the motorway sections analysed in the Iberian Peninsula.

Descriptive and quantitative information on the different problems confronted was sought throughout the questionnaire. An evaluation was also performed about the perceived importance of the problems, the effectiveness of mitigation measures taken, associated costs and effects on the public image of the operators. Such evaluations involved quantitative assessments by operators on a 0–10 scale or qualitative ones with four categories (nil/low/medium/high) or six categories (nil/very low/low/medium/high/very high).

A total of eight questionnaires were answered (one by motorway section) and six road-kill databases were received.

ANALYTICAL METHODS

The information obtained was summarized as percentage responses to the different questions (Appendix 1). We opted for this type of reporting despite the small sample size (N=8) in order to make the reading easier, though caution must be paid to the interpretation of detected tendencies in this pilot study. Furthermore, testing has been restricted to main issues to avoid data overanalysis. A summary index was also generated by adding the rankings on the 0-10 scale that operators assigned to each problem type (road-kill, instability of road slopes, damage to fences, damage to carriageways, others) in order to have an overall indicator of the gravity of the problems that affect each motorway section.

The general trends in responses were depicted through two multivariate approaches. In order to collate information on the problems caused by fauna and to detect whether a particular typology of problems exists among motorways, a classification of the evaluations

received was completed by means of tree clustering (single linkage) based on the Manhattan distances (Gauch 1982) calculated between the different motorway sections. A subsequent comparison of the global evaluation of the problems generated by fauna for the two main groups raised by the classification, was done with a Mann-Whitney U test (Sokal and Rohlf 1995). This analysis was complemented with road-kill data from operators that record such information, transformed into proportions of each taxon and summarised in search of general patterns by a non-metric Multidimensional Scaling (MDS) on a Manhattan matrix of distances (Kruskal 1964).The MDS was solved in two dimensions in order to get an acceptable fit (stress value <0.01, Zuur *et al.* 2007). To determine which taxa were contributing most to the detected general patterns, Spearman correlations were performed between the position of observations on the dimensions and variables in the input matrix (taxa proportions). These correlations were carried out only for species appearing in at least 4 road kill databases.

Spearman correlations were used to explore the relationships between the perceived gravity of problems reported by the operators and their corporate image concerns, the expenses to address the problems and the need to develop or apply additional measures. Significance levels were fixed at $p<0.05$ and probabilities associated with these correlations were corrected by means of a sequential Bonferroni correction for multiple testing (Rice 1989). All analyses were carried out with Statistica 8.0 software (StatSoft 2007).

RESULTS

THE MAGNITUDE OF FAUNA-RELATED PROBLEMS

The fauna-related problems that were most often cited by operators were road-kill (100% of respondents), undermining of verges by rabbit burrows (50%) and damage to perimeter fencing (50%). Less often mentioned were damage to the carriageway (12.5%) and incursion of domestic animals via junctions (12.5%). In terms of relative importance, road-kills and undermining of embankments were the problems of most concern due to their extent and implications.

Road-kill

Faunal road-kill constituted the principal problem for operators, having repercussions both for road users and the operating companies themselves. Accidents resulting from the presence of animals on the carriageway occurred in 75% of the motorway sections, with a mean incidence of 0.20 km^{-1} $year^{-1}$ (S.E. 0.07). Operators considered that the principal repercussions were for road users (mean evaluation score 6, S.D. 3.78), although operators themselves were also somewhat concerned about the impact on corporate image and associated costs (score 3.6, S.D. 3.62). Nevertheless, none of the accidents on the study sections resulted in personal injuries and there were no cases in which road users made official complaints or formal protests against operators.

Table I. General characteristics of the studied motorway sections
Tabela I. *Características gerais dos fragmentos de autoestrada escolhidos para o estudo.*

Motorway section	Length (Km)	ADT*	Year	Landscape type (%)		
				Urban	Agrarian	Semi-natural: main plant communities
A-2 Alcolea-Calatayud	93.30	15400	1991	1	35	64: xerophilous scrub, pine forests, dry pastures
AG-56 Santiago-Brión	12.50	16467	2008	15	30	55: oak woods, mesophilous scrubs
AP-51 Villacastín-Ávila	22.95	6500	2002	3	25	72: holm oak forest, *Cistus* scrub
AP-6 Villacastín-Adanero	29.54	15000	1972	5	85	10: holm oak forest, *Cistus* scrub
AP-61 San Rafael-Segovia	28.03	6000	2003	8	0	92: holm oak and ash forest, scrub, meadows
CM-42 Toledo-Consuegra	52.20	8690	2005	1	64	35: dry pastures, *Cistus* scrub, holm oak forest
M-12 Accesos Barajas	9.35	19200	2005	75	10	15: dry pastures
M-45 Leganés-Getafe	8.30	79000	2002	75	20	5: dry pastures, *Retama* scrub

*Average Daily Traffic (vehicles day^{-1})

The concern over incursions of animals on to the carriageway was reflected in 75% of the sections being subject to some form of monitoring and recording of such events. Nevertheless, the resulting databases differed considerably between companies in the level of detail recorded. Mean road-kill frequency was 2.48 km^{-1} $year^{-1}$(SE 1.20), according to monitoring results. Appraisals of the frequency of road-kills for each species and season are given in Table II. These show that, according to operators, the most frequently killed species are dogs (*Canis familiaris*), foxes (*Vulpes vulpes*), cats (*Felis* sp.) and wild boars (*Sus scrofa*). Also such problems occur year-round although some species show marked seasonality in occurrence: for example, wild boars are more frequently killed in autumn and winter. In addition, 87.5% of respondents stated that there are few or no road-kills of protected species and the remaining 12.5% were unaware of the frequency of these.

Undermining of embankments and damage to fencing

The proliferation of rabbits in the surroundings of infrastructures was the second most important problem although only half the sections were affected. This problem was most evident at roadcuts (roadslopes constructed by excavation) with 100% of motorways reporting the problem and junctions (25%) and it occurred in sections flanked by crops or dense vegetation, and mainly in spring. The main concerns of operators linked to this cause were as much the costs that they incurred (mean score 7.5, S.D. 5.00) as the damage done to crops in adjacent properties (score 6.0, S.D. 2.00). There was much less concern for road-user safety (score 0.8, S.D. 1.5) associated with this problem.

MOTORWAY CLASSIFICATION ACCORDING TO PROBLEMS CAUSED BY FAUNA

The classification analysis shows that the motorway sections fall into two broad categories according to their fauna-related problems, with some intermediate cases (Figure 2). Motorways that cross more forested areas that are richer in large vertebrates (e.g. AP-51 and AP-61,Table 1) show a broader range of problems (road-kill, damage to fencing and the carriageway) and these are relatively more serious, with a mean evaluation score (28.3, S.D 5.77)

Table II. Levels of concern revealed by questionnaires to motorway managers regarding road-kill, according to species and seasons. Data are the proportion of managers that reported issues with each species, and the sums of seasonal scores assigned to each of these.

Tabela II. *Nível de preocupação revelado pelos inquéritos aos gestores de autoestradas dos atropelamentos de fauna entre espécies e estações. Os dados correspondem á proporção de gestores que declaram problemas com cada espécie, e a soma de pontuações sazonais concedida a cada uma.*

ANIMAL SPECIES	% SECTIONS	SPRING	SUMMER	AUTUMN	WINTER
Birds	25.0	10	12	9	6
Oryctolagus cuniculus	12.5	8	12	8	8
Lepus europaeus	12.5	1	9	8	6
Erinaceus europaeus	12.5	0	0	1	0
Felis sp.	50.0	14	10	10	3
Genetta genetta	12.5	0	0	0	9
Mustela sp.	12.5	0	8	7	0
Lutra lutra	12.5	7	0	0	0
Meles meles	25.0	14	0	0	0
Vulpes vulpes	62.5	18	15	21	25
Canis familiaris	87.5	24	14	20	16
Sus scrofa	37.5	1	1	16	16
Capreolus capreolus	12.5	5	0	3	3
Seasonal importance (%)	**-**	**27.0**	**21.4**	**27.2**	**24.3**

significantly higher than for the other roads (Mann-Whitney test, z = 2.31, p = 0.021). Conversely, motorways that cross less fauna-rich landscapes or that have more of an urban character (the M-12 and M-45 would be the most extreme cases) almost exclusively report problems with road-kill and these are of less gravity (score 4.8, S.D. 3.03). Some variation due to specific problems, for example the ingress of domestic animals via junctions on the AG-56, is superimposed on this pattern.

The ordination of motorway sections according to the species most often recovered from the carriageways, by means of the two-dimensional MDS (Figure 3), proved satisfactory (Kruskal stress<0.001) and shows considerable variability among the sections. Taking into account that acceptable fit is considered if stress<0.1, the fit of the Manhattan distances approach was acceptable. Spearman correlations ($p<0.05$) showed fox and wild boar (left) *vs.* dog (right) being discriminant species in the first ordination axis, and cat (upper part) in second axis.

The AP-6, AP-61 and AP-51, with wild boar road-kills ranging from 11% to 29%, appear in the lower left quadrant: the first two roads also show a greater percentage of medium-sized carnivore road-kills. In contrast, the AG-56 and M-45, in the right half of the ordination plot, are characterised by the high percentages of road-kills of cats and dogs (between 94% and 100% of the road-kills of both species). The CM-42 stands out for the high frequency of hares *Lepus europaeus* (35%) and fox road-kills occurred on all except the M-45.

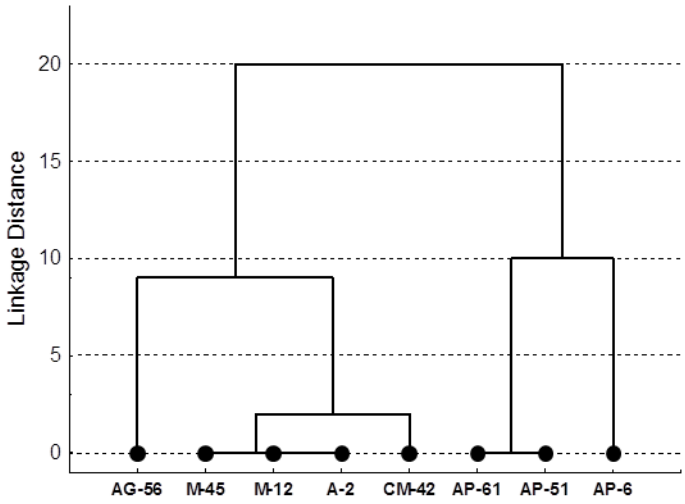

Figure 2. Result of classification of motorway sections according to the seriousness of different types of problems caused by fauna vehicle interaction, according to managers' opinion. The classification tree is based on Manhattan distances between cases and was constructed by means of single linkage procedures.
Figura 2. *Resultado da classificação dos fragmentos das autoestradas em estudo segundo a gravidade dos diferentes tipos de problemas gerados pela fauna segundo a opinião dos gestores. A árvore de classificação está baseada nas distancias de Manhattan entre observações e está construído usando procedimentos do single linkage.*

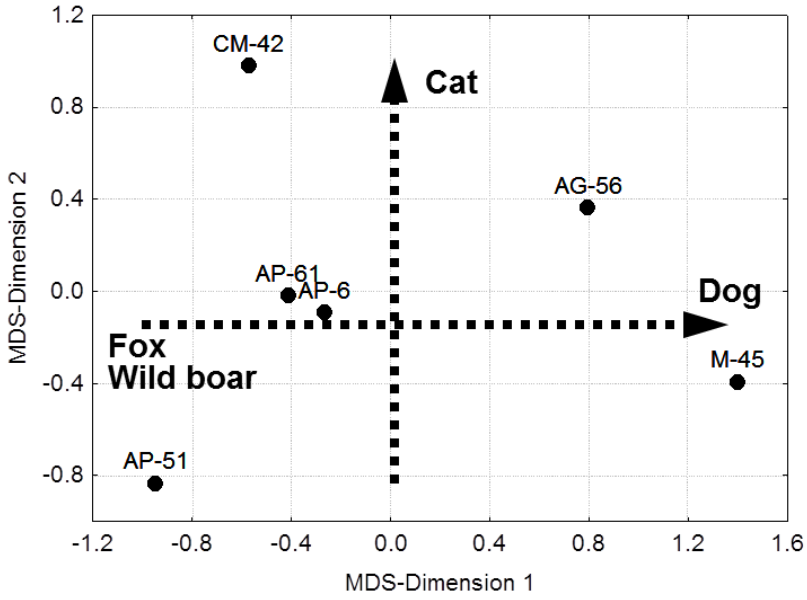

Figure 3. Result of Multidimensional Scaling (MDS) of the studied motorway sections as a function of road-kill species according to road-kill databases of management companies. The scaling is based on Manhattan distances between cases.
Figura 3. *Resultado do Multidimensional Scaling (MDS) dos fragmentos das autoestradas em estudo em função das espécies atropeladas segundo as bases de dados de atropelamento das empresas gestoras. A escala está baseada nas distâncias de Manhattan entre observações.*

MITIGATION METHODS EMPLOYED AND EVALUATION OF THEIR SUCCESS.

The principal adopted measures are perimeter fencing (100%, reinforced below ground in 25% of cases), faunal passages (62.5%), ramps and escape gates (25%), removal of burrows (25%), specific signalling (12.5%) and mowing verges and plant clearing to discourage animals (12.5%). In general, the only indicator of the effectiveness of these measures was recording of tracks in faunal passages (in 50% of sections, none of them complemented with automatic cameras) and nothing was known regarding the effectiveness of other measures. Despite this, some 37.5% of respondents thought it was necessary to introduce or develop new solutions, whereas 62.5% considered these to be largely or totally unnecessary.

ECONOMIC VALUATION OF THE PROBLEMS

In general, operators do not keep specific accountings of costs arising from measures taken to address problems caused by fauna. Nevertheless, some 37.5% regarded these to be moderate, a further 37.5% assessed them as low and 25% reported no costs. The principal costs mentioned were:

- Material costs of maintaining, operating and inspecting ramps and escape gates (62.5%).
- Material costs of maintaining, operating and inspecting faunal passages (50%).
- Operating and monitoring costs of dealing with rabbit burrows (25%).
- Material costs of maintaining, operating and inspecting signalling (12.5%).

When asked what percentage of maintenance costs is represented by fauna-related spending, some 37.5% of respondents did not know and a further 37.5% thought that these were negligible or nil. The remaining 25% put the mean annual percentage cost at 2.0-0.5% of the maintenance budget of the motorway stretch.

CORPORATE RESPONSIBILITY RELATED TO INFRASTRUCTURE IMPACTS ON FAUNA

Some 37.5% of respondents regarded fauna-related problems as a worry in general terms and a very considerable concern in relation to corporate image. However, 62.5% considered damage to corporate image to be low or non-existent.

The responses show coherence, in the form of significant positive correlations, between levels of concern, costs and readiness to adopt new mitigation measures. In the first place it was shown that concern about the potential effects on corporate image was greater among operators of the motorway sections that had the most fauna-related problems and that they scored these highly (Spearman $r = 0.909$; $n = 8$; $p = 0.002$). In accordance with this, expenses intended to address problems with fauna were also scored most highly for these types of sections ($r = 0.779$; $n = 8$; $p = 0.023$).

At the same time, those operators that were most concerned about effects on corporate image accorded most importance to adopting new and/or more intensive mitigation measures ($r = 0.898$; $n = 8$; $p = 0.002$) and scored the costs incurred by their sections more highly than did those respondents that were less concerned by corporate image effects ($r = 0.833$; $n = 8$; $p = 0.010$).

DISCUSSION

The results show that fauna cause some degree of concern to motorway operators, particularly regarding the problem of animals gaining access to the road and the consequent risk of accidents. In addition, operators are disposed to go beyond merely reacting to the problems that they currently encounter to take a proactive and broader view of their social responsibilities. The small sample size demands caution but we may conclude that there exists a basis among motorway operators for achieving a better integration of the faunal element into their decision making processes.

In the first instance it has been possible to detect that there are two extreme categories of motorways regarding the range of problems that confront their operators. One is represented by sections of a more urban or suburban character, in which the number and seriousness of problems is lower and very much centred on road-kill. Given the environment in which they appear, the killed animals, essentially cats and dogs, are of minimal conservation concern, although they may cause social distress and pose certain risk of accidents (DGT 2004). Problems associated with the presence of livestock within the infrastructure also arise in some of these sections. The opposite extreme arises with motorways that cross fauna-rich landscapes, especially where there are dense ungulate

populations (wild boar, but also deer in other areas, Colino 2011), which experience more diverse problems that may be more serious. In such sections collisions with large mammals are the greatest concern although a broad range of species is involved, some of them of high conservation interest: such as mid-sized carnivores including *Genetta genetta*, *Meles meles* and *Mustela* spp. Other types of problems are more evident in sections of this type and they include infrastructure maintenance problems such as damage to fencing, the carriageway and other structures.

In general, this analysis shows that operators give priority attention to road-kill and its potential risks. This is a relatively constant concern year-round, according to the views of respondents, although with some seasonal variation according to species, as shown by the systematic analyses of animal-vehicle collisions: for example, collisions with wild boar are known to concentrate in autumn and winter (Colino 2011). This concern accords with the seriousness with which road-kill is viewed internationally and with the social attention that it has received in recent decades (Forman and Alexander 1998, Coffin 2000), and to a certain extent it points to the readiness of operators to consider the wider impacts of their activities (Garriga and Melé 2004, McWilliams *et al.* 2006). Thus most operators maintain computerised records of road-kill, in anticipation of the national regulation which will oblige the creation of such databases for future infrastructures (MMARM 2008). At the same time, motorway operators showed greater concern over the effect of this problem on external stakeholders, the road users, than on the company itself, even though in no case have they had to deal with accidents due to fauna that involved human casualties, or with complaints from road users, notable mortality of protected species or protests from NGOs. Their concern may thus be seen as having an ethical character (Hemingway and Maclagan 2004, Saavedra 2010) and not solely justified by objectives of direct economic benefit (McWilliams and Siegel 2001, Makey *et al.* 2007).

Another concern of operators is the deterioration that various motorway structures suffer as a result of faunal activity and the implied maintenance costs. A case in point is the activity of rabbits on the roadside banks which may trigger their erosion (Benet *et al.* 2011) and threaten their stability. Perimeter fences are also often damaged. These fences play an important role in reducing road-kill of certain species (Clevenger *et al.* 2001), but their effectiveness depends as much on design features such as subterranean reinforcement as on adequate maintenance.

These concerns together have budgetary implications relating to mitigation measures, as it is acknowledged by the operators of the most problematic sections. In addition to maintaining databases and removing carcases there are maintenance tasks which are mainly structure-related and routine in nature, as well as others that are specifically directed at resolving fauna-related problems. The first group includes fence repair and maintenance of faunal passages, escape gates and signalling. These tasks are similar to those carried out on all structural elements of motorways: involving bridges, drainage, lighting etc., and thus operators include them as a matter of course without any particular difficulty (AEC 2007). In contrast, such tasks as removing rabbit burrows or managing verges to discourage animals are specifically related to problems of faunal origin and it might be expected that operators would see themselves as strongly inconvenienced by the need to carry them out. Nevertheless, most responders thought that mitigation measures associated with fauna incurred negligible or no costs, and even those that quantified these expenses estimated them at little more than 1% of annual maintenance budgets. It may thus be concluded that currently such costs are readily assumable by operator companies.

In this regard, attention should perhaps be given to the fact that all ongoing mitigation measures focus on primary effects of fauna and none of them deal with indirect effects or those involving adjacent properties. This indicates to some extent that the operating companies' economic objectives are the primary concern and that secondary attention is given to social repercussions. It is a characteristic of a management style that still gives little attention to corporate social responsibility (Garriga and Melé 2004, Makey *et al.* 2007) and it highlights that this aspect is as yet poorly developed in this business sector (e.g. Zaragoza 2005, AEC 2007).

Nevertheless, the enquiries supply evidence that there exists some foundation for developing management actions focusing on stronger commitment to CSR. In the first place, operators are aware that those on the receiving end of certain negative aspects of the fauna/motorway interaction are stakeholders other than the

company itself. Also, some operators (fewer than 40%) thought that corporate image might be negatively affected. Finally, the willingness to invest greater efforts in developing new and/or more intensive mitigation measures points to companies being open to suggestions received from the scientific world or from their own research and development departments. All these factors may be seen as positive for the adoption of CSR strategies that are more active and focused on reducing the impacts of motorways on fauna (McWilliams *et al.* 2006, Ambec and Lanoie 2008, Saavedra 2010). This is reinforced by what was previously indicated regarding the costs of the mitigation measures that are currently in place in these infrastructures.

Finally, it is necessary to emphasise that the enquiries have revealed ample scope for improving management in this field. It has been shown that most mitigation measures are not monitored at all, so that it remains unknown how effective they are or how they may be optimised (Glista *et al.* 2009). Also, some of the initiatives that are put in place, such as recording road-kill, are carried out haphazardly and the information obtained is not adequately used. Motorway operation would thus benefit from a rigorous scientific analysis of measures taken so far, and from the establishment of adaptive management procedures that take advantage of the knowledge acquired from the own monitoring of the effects of the infrastructures on fauna (Riley *et al.* 2003).

CONCLUSION

Our results manifest that some road operating companies are well disposed to adopting measures that will reduce potential conflicts between roads and fauna, within a climate that is relatively favourable for the development of strategies that attend to their corporate social responsibility. Nevertheless, we have identified some shortcomings in current procedures, notably the lack of formal evaluation of the effectiveness of implemented mitigation measures.

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APPENDIX 1

Summary of the structure and content of the questionnaire given to the motorway managers.
Conteúdos gerais do inquérito realizado aos gestores das autoestradas.

Survey sections and included variables

I) General features of the motorway
Concessionary company
Location
Year opened to traffic·
Length
Average Daily Traffic

II) Analysis of the problems associated with wildlife
Type and relative importance of the problems: presence and qualitative evaluation
Species involved and seasonality: presence and qualitative evaluation. Database if existent
Location of the problem: kilometer post, characteristics of the right of way
Affected stakeholders and degree of effect: type of effect, qualitative evaluation

III) Analysis of mitigation measures
Type and location of mitigation measures: presence and description
Monitoring and evaluation of measure success: presence, description and qualitative evaluation

IV) Assessment of direct and indirect costs
Quantitative and qualitative assessment of the economic costs
Qualitative evaluation of effects on corporate public image

V) Information about the respondent
Awareness and perception of the problems, potential solutions
General information (age, sex, position)

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