FACTORS AFFECTING SMALL LIVESTOCK PREDATION IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA

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Abstract

Small livestock farmers in South Africa suffer from increasing losses due to predation. Predation losses increased to such an extent that small livestock farming in not viable any more in certain small livestock producing areas. The objective of this study is to determine the predation losses due to predators and identifying the variables that influences the occurrence and level of predation. This can help to develop management systems to reduce predation losses. The black-backed jackal and the caracal are two important medium-sized predators species among the South African wildlife, but they have a negative impact on the livestock industry in South Africa, especially among sheep and goats. The Western Cape Province of South Africa incurred losses in 2010 up to R 104 980 967 ($ 1 165 663). The physical monetary value attached to predation in this study was only the direct cost of predation and do not include indirect cost of controlling damage-causing animals. It was hypothesised that the variables affecting the occurrence of predation and the variables that affected the level of predation was not the same. Therefore, it was necessary to use the Probit and Truncated regression models. The information collected in this study showed that predation is a serious problem for the South African small livestock sector. This study does not answer all questions on predation, but provides valuable information in understanding the magnitude or extent of predation and some of the factors influencing predation on farms.

Keywords: predation, small livestock, South Africa

1. Introduction

Predation on livestock can be a problem for farmers and producers across the world. For example, coyotes kill sheep (Conner, Jaeger, Weller, McCullough, 1998) and goats (Windberg, 1997) in parts of the USA and Canada (Dorance, Roy, 1976). Wolverines kill sheep and domestic reindeer in Norway (Landa, 1999). Farmers have been protecting their stock for hundreds of years, by fencing and kraaling their stock to prevent the risk of predation losses. The black-backed jackal (*Canis mesomelas*) and the caracal (*Caracal caracal*) are important medium size predator species among the South African wildlife, although having a negative impact on the livestock industry in South Africa, especially small stock like sheep and goats (Hall-Martin, Botha, 1980). Although the diet of the black-backed jackal and the caracal normally consists of smaller mammals, they prey on small stock. (Hall-Martin, Botha, 1980; Rowe-Rowe, 1983; Moolman, 1984).

Despite the wide distribution ranges of the black-backed jackal and caracal (Cillie, 1997). Little information is available about their current distribution and their impact on the local small stock industry. However some studies have been done to estimate the problem, the National Woolgrowers Organisation (NWGA) estimated a loss of 8% (2.8 million head of small stock, 2007) of stock per year. Losses to predation are not the only economic losses, there are additional costs in

preventing predation (Arnold, 2001). The decision of how to manage these predators involves the allocation of scarce resources in the midst of competing needs. Economic analysis is therefore a useful tool to aid such decisions (Moberly, White, Webbon, Baker, Harris, 2003)

The primary objective of this study is to quantify the economic loss due to predation on small stock in the Western Cape Province (WCP) of South Africa. The secondary objectives are to determine the influence of management aspects on predation. These aspects include, different ways to control damage-causing animals and management aspects. Management include time of lambing, flock size, lambing months and breeds.

Opportunity cost is an important factor that must be taken in consideration from an economic point of view. The question basically arise, to what level are farmers able and willing to pay for predator control, and the benefits will be and what will the optimum level be of control. Opportunity costs can be divided into direct and indirect costs. The direct costs focuses on the prevention methods. Which include hunting, traps and fences etc., where a fiscal amount of money can be attached. While indirect costs imply, the time a famer has to spend on implementing certain management aspects. Management aspects consist of certain lambing practices, count of stock or the time it takes to control damage causing animals. Indirect costs are however difficult to calculate and will not be estimated in this paper.

2. Procedures

Economics is often experienced as the discipline that measures things in monetary units, while other disciplines use physical units. This view is to simplistic and even in appropriate, economics is not concerned principally with money but with making rational choices and decisions in the allocation of scarce resources amongst competing alternatives. The conceptual models underlying economic analyses include three major components: people, products and resources (Mclnerney, 1987; Otte, et al., 2001). Economic analysis is therefore a useful tool to aid decision-making (Moberly, et al., 2003). A basic criterion for determining whether predator control is an appropriate management action is whether the benefit of carrying out control exceeds the cost and this should be determined before a control program is instigated in order to prevent unnecessary or uneconomic control actions (Caugheley, Sinclair, 1994; Moberly, 2002).

The profit of a small stock farmer is a function of the number of lambs born and lamb losses between birth and weaning, amongst other factors. Losses are made up of predation losses as well as to other causes. It can be assumed that a farmer aims to minimise lamb losses to predators as far as possible (Moberly, 2002; Skonhoft, 2005). Therefore the cost of livestock mortality should take into account both the loss, or reduction in output, and the expenditure on extra inputs, including control and prevention costs (Mclnerney et al., 1992). There are several ways of valuing the costs of stock mortality. One approach is to use the output loss, the loss as "finished products" or the value of the animal when it is lost (Mclnerney, 1987; Moberly, 2002). The value is difficult to estimate if the animal is not at a point of sale, as to if a "finished product" is lost. Losses is determent according to Otte et al. (2002) and Mclnerney et al. (1992) as the total cost (C), the loss of the animal (L), plus the direct and indirect expenditure cost and control expenditure (E). This estimates the total cost to farmers based on the market price of finished an animal multiplied by the number of losses, as explined in equation (1).

$$C = L + E \quad (1)$$

A farmer has to choose a strategy, what level of pest control or preventive measure to use before the economic impact of the pest is known. If there is uncertainty about what level of pest attack will occur, but the probability of any particular level of attack occurring is known, the expected outcome of alternative strategies can be determined. Preventive or control methods consist of control methods (lethal and non-lethal) and managerial aspects. Lethal methods kill the predator and the non-lethal methods are a mean of reducing predation without killing the predator. These methods include lamping with rifles, shooting by day, hunting with dogs, snares, traps poisoning and the non-lethal methods include kraaling of small stock or indoor housing, sheep herder, bells, guard dogs, King Collers (Arnold, 2001; Moberly, 2002; van Deventer, 2008).

3. Data collection

A questionnaire was developed to obtain relevant information on predation on farms in the WCP of South Africa. This questionnaire was designed for short telephonic interviews with farmers in the WCP. Data collection took place over a period of two years, which included two lambing seasons or farmers who used three lambing seasons in two years. The questionnaire includes questions on farm recourses and flock size, farm location, losses of livestock due to predators, topography, surrounding land uses, predator control (lethal and non-lethal) and managerial aspects for two calendar years (2006 and 2007). Management questions were asked to identify whether certain management practices can lead to a reduction in losses due to predators. The management questions on certain farming practices included; how often does a farmer count his stock, lambing location and identification of small stock.

In April 2008 telephonic interviews was held with farmers in the Western Cape Province (WCP) of South Africa. The WCP host a very diverse agricultural sector, include wine producing areas, field crop production and small stock production in the Karoo. This study is part of an greater study that focus on the five mayor small stock producing provinces of South Africa (Free state, Northern Cape, Eastern Cape, Western Cape and Mpumalanga), in which a total of 1 500 farmers was interviewed in these five provinces. According to the methods used by De Vos et al. (2000) a stratified random sample was selected to draw a sample of farmers. In the WCP 187 farmers was interviewed. The sample of farmers was drawn according to the percentage that each of the different magistrates districts of the WCP contributed to the total small stock numbers (sheep and goat) of the WCP. Nationally the WCP contributed 11% of the commercial small stock numbers of the five major small stock producing provinces in South Africa (DOA, 2006).

4. Methodology

The methodology used consists of quantification of predation losses to set a fiscal economic value to predation losses in the WCP. Furthermore to further investigate factors influencing predation on farms in the WCP.

4.1. Quantification of predation cost in the WCP

The primary objective of this study is to quantify the economic loss due to damage-causing animals in the WCP. Quantification is done by multiplying the market price of an animal by the number of animals lost within a province, however this is difficult when this animal is not at a point of sale. The National Wool Growers' Association valued one unit (animal lost) in earlier

estimates at R 600, this was a very low estimate for a unit lost. Stock theft Forum is valuing one small stock (sheep) unit at R1 200, and one small stock (goat) unit at R1 400. By using the value used by stock theft Forum an over estimation is possible. For the purpose of this study a value was used of R600 for one unit (sheep and goat) younger than six months and a value of R1 000 for one unit (sheep and goat) older than six months. However, this only illustrates the direct cost of predation for the WCP and does not reflect the indirect cost of preventing predation on a farm. The cost of prevention includes the cost of a professional hunter, fencing (jackal proof and electrical) and management input, just to name a few. Although some of these methods is a once-off expense, the methods are very expensive and therefore not a viable option to all farmers. Other methods like poison and the use of professional hunters or the farmer hunting himself represent a continuous cost to farmers.

4.2. Model specification

The secondary objective of this study is to determine the influence of management aspects on predation. A hypothesis was made that the variables influencing the occurrence of predation and variables influencing the level of predation is not the same.

In this study the model on factors influencing predation consist of two factors, whether or not predation will occur or not and if predation occurs what level of predation will occur. An important factor that must be taken in consideration is the fact that a small number of farmers incurred no losses on their farms (over 90% of farmers incurred losses). According to Aramyn, Lansink, Verstegen (2007) excluding observation with zero predation can lead to the sample being bias and biased regression parameters. It is however important to include these observations in the regression, because it is possible that no predation occurred during the two year when data was collected or management and control methods (lethal and non-lethal) is of that nature that no predation occurs. Therefore it is important to include these observations when estimating factors influencing predation.

The Tobit regression model is frequently used when dealing with zero observations (Tobin, 1958; Gujarati, 2003; Aramyn et al., 2007). A problem occurs that the Tobit model is very restrictive, according to Aramyn et al., (2007). For example, any variable that increases the probability that predation will occur increases the level of predation on a farm. The Cragg's model is an alternative for the Tobit model and allows one set of parameters to determine the probability that predation will occur and the second set of parameters to determine the level of predation. In the Tobit regression model, a variable that increases the probability of predation will also have a higher influence on the level of predation (Lin & Schmidt, 1984) cited in Katchove and Miranda (2004) and Jordaan and Grové (2010). Thus, the same variables will influence the probability that predation will occur and the level of predation, therefore the Tobit regression model alone would be insufficient in some cases.

According to Katchove and Miranda (2004) the Tobit model arises when the, occurrence of predation (weather or not predation will occur on a farm), is represented by the Probit model in Equation 2.

$$P(\alpha_i = 0) = \Phi\left(-\frac{\beta_\alpha^{'} x_i}{\sigma}\right) \tag{2}$$

The level of predation on a farm, is represented by the Truncated regression model in Equation 3.

$$f(\alpha_i : \alpha_i > 0) = \frac{f(\alpha_i)}{P(\alpha_i > 0)} = \frac{\frac{1}{\sigma}\Phi\left(\frac{\alpha_i - \beta_\alpha^{'} x_i}{\sigma}\right)}{\Phi\left(\frac{\beta_\alpha^{'} x_i}{\sigma}\right)} \quad (3)$$

The variables influencing the probability that predation will occur on a farm is modelled by the Pobit regression model. The dependent variable takes the form of a dummy variable, coded zero for no losses and one if predation incurs on a farm. The variables influencing the level of predation on a farm is modelled by the Truncated regression model. The dependent variable takes the form of a continuous variable, where the reported losses to predators is divided by the total number of ewes/does and lambs/kids on a farm.

According to the hypotheses made, that the variables influencing the probability that predation will occur or not and variables influencing the level of predation is not the same variables.

The Cragg model suggests the assumption that the same variable influences both the probability that predation will occurs as well as the level of predation on a specific farm. In other words the Cragg model is the tool adopted for testing the Tobit model against the alternative two-step model. Cragg's test is based on a comparison between the likelihood ratios (Lin & Schmidt, 1984; Conte & Vivarelli, 2007). The Cragg's model with a log-likelihood function is illustrated in Equation 4 as given by Katchove and Miranda (2004) and furthermore explained by Lin and Schmidt (1984); Zhang *et al.* (2006) and Conte and Vivarelli (2007). The log-likelihood in Cragg's model is a sum of the log-likelihood of the Probit model (the first two terms) and the log-likelihood of the Truncated regression model (the second two terms).

$$\ln L = \sum_{c_i=0} \ln \Phi(-\gamma' z_i) + \sum_{\alpha_i>0} \left\{ \ln \Phi(\gamma' z_i) + \ln \left[\frac{1}{\sigma} \Phi\left(\frac{\alpha_i - \beta_\alpha^{'} x_i}{\sigma} \right) \right] - \ln \Phi\left(\frac{\beta_\alpha^{'} x_i}{\sigma} \right) \right\} .... \quad (4)$$

All the regression models regarding the analyses on data on predation were done by using NLOGIT 4.0 statistical software.

4.3. Hypothesised variables

A summery of hypothesised variables, a short description of variables and the expected signs influencing predation in the WCP is shown in Table 1. The variables in Table 1, can be divided into two groups, management variables and control variables (lethal and non-lethal). It is hypothesised the management will have a negative sign in regression models, it is believed that a higher level of management will reduce predation on a farm (McAdoo, 2000). Management aspects will include time of lambing, flock size, breeds, lambing intervals, counting of small stock, identification of small stock and lambing months.

A positive sign is expected with all control methods including lethal and non-lethal methods. Lethal methods include hunting, poisons and gin traps. Non-lethal methods include electric fences, jackal-proof fencing, bells, King Collars and guarding dogs. According to De Waal (2009) the unnecessary killing of predators will lead to increase in predation in that specific area. Non-lethal methods will only reduce the level of predation and will not stop the occurrence of predation on a farm.

Table 1. Variables influencing predation and direction of influence

Variable	Description	Expected sign
Farming size	Continuous variable, area of farm in hectares	-
Lambing interval	Dummy variables, coded 1 for farms with 8 or 12 month lambing interval, 0 otherwise	-
Lambing months	Dummy variables, coded 1 for farms with lambing seasons in March-April or August-September or March-April and August-September or year round, 0 otherwise	-
Production ewes/does	Continuous variable, number of ewes/does	-
Counting of small stock	Continuous variable, times per months farmers counts small stock	-
Identification of small stock	Dummy variables, coded 1 for identification of small stock, 0 otherwise	-
Combination of two or more non-lethal control methods	Dummy variables, coded 1 for using more than 2 non-lethal control methods, 0 otherwise	+/-
Predator control carried out (including lethal and non-lethal)	Dummy variables, coded 1 for farms where predators were killed by various control measures, 0 otherwise	+
Believed foundation of predation problem	Dummy variables, coded 1 for different sounding practices that contributes to predation on farms (farmers view point), 0 otherwise	+

5. Results

This section will consist of the direct cost to predation in the WCP, was a fiscal amount will be put on predation. in section 5.2 factors influencing predation are shown and discussed.

5.1. The cost of predation in the WCP

Although predation losses are relatively low for the whole province there are some areas within the province that experience very high losses due to predation. These areas mostly include the Central Karoo where small stock farming is the main agricultural activity. A loss of 6.1% was associated with lambs between zero and six months and 0.1% for animals older than six months. The direct cost of predation in the WCP added up to R 104 980 967 as explained in Table 2. Farmers in these areas have high indirect costs in preventing predation on their farms, costs that include professional hunters, electrical fences and management practices.

Table 2. The cost of predation in the WCP

		Number of small stock	Average predation losses (%)	Losses due to predators	Cost per unit (R)	Cost of predation
Sheep	< 6 months	2 564 250	6.1%	156 419	600	93 851 550
	> 6 months	2 564 250	0.1%	2 564	1 000	2 564 250
Goats	< 6 months	227 797	6.1%	13 896	600	8 337 370
	> 6 months	227 797	0.1%	228	1 000	227 797
Total		2 792 047		173 107		104 980 967

5.2. Factors associated with predation losses in the WC province

Different variables that were included into the regression models are shown in Table 3. Variables were kept the same between the two model specifications to test the Cragg's model specifications. The variables were selected at a statistically significant level of 15% significant level. The Cragg's model had a significant P value (P = 0.000; CHISQ = 43.312); according to the Cragg's model it was necessary to use the Probit and Truncated models to analyse data on predation in the WCP.

In the Probit model a number of variables are significant in modelling the occurrence of predation in the WCP. These variables are mostly associated with managerial aspects such as number of ewes on a farm and counting of small stock. A negative coefficient was expected for all managerial aspects, meaning the more intensive the management, the loses the occurrence of predation. In the WCP a higher level of management is associated with larger small stock numbers on a farm (Probit, P = 0.005). Therefore, a higher level of management on a farm will have a tendency to a reduction in predation losses. Regular counting of small stock was not founded to be significant in the Probit model, although having a negative impact on predation. In the WCP agriculture practices are to a great extent diversified, making it difficult for farmers to manage all of there farming enterprises and to do effective predation management.

A great deal of success is associated with control methods in the WCP. Although control methods reduce the level of predation (Truncated), some of these methods will also influence the occurrence of predation on a farm (Probit). This can be attributed to the fact that a specific method or farming action can be highly effective in a specific region at a certain point in time. The use of bells, gin traps and jackal-proof fencing can be seen as an example of very effective control methods, which will have an influence on the occurrence of predation on a farm. Kraaling small stock (Truncated, P = 0.081) at night was founded significant in effecting the level of predation on a farm. A negative coefficient was expected. The reason being that kraaling at night is not significant in the occurrence of predation and the positive coefficient in the Truncated model is due to the fact that damage-causing animals adapt themselves to infiltrate in closed areas and cause major losses, where fences are not up to standard, according to some farmers in the WCP. Hunting by using a professional hunter in the WCP influence on the level of predation, due to the fact that damage-causing animal control is only practised in small parts of the WCP makes it very difficult to control effective predation management.

A high level of success is experienced when non-lethal methods are used in combination or in rotation with one another (Probit, P = 0.050), mainly due to the adaptability of predators.

Table 3. Output of the Probit and Truncated regression models for the WC province

Variables	Probit		Truncated	
	Coefficient	P value	Coefficient	P value
Constant	0.458	0.015	-0.127	0.050
Number of ewes	-0.000	0.005	-0.296	0.807
Counting of small stock	-0.013	0.630	-0.002	0.592
Hunting (by professional hunter)	-0.022	0.957	0.083	0.047
Combination of non-lethal methods	-1.100	0.050	-0.057	0.264
Bells	1.125	0.013	0.06	0.279
Jackal-proof fencing	1.386	0.000	0.052	0.448
Kraaling small stock at night	0.026	0.966	0.117	0.081
Gin traps	0.594	0.069	0.100	0.011

6. Conclusion and recommendations

Predation on small stock by black-backed jackal and caracal is a growing problem in the WCP and in South Africa. Problem-causing animals are responsible for large losses in small stock in the WCP. Direct losses in the WCP added up to R104 980 967 this only included direct cost of predation. Indirect cost of predation is difficult to calculate, control methods differ immensely between production regions. A number of these methods is a once-off payment and usually are tremendously expensive and therefore not accessible to all farmers.

A hypothesis was made that variables that influenced the occurrence of predation and variables that influenced the level of predation was not the same, thus it was necessary to use the Probit and Truncated regression models. An assumption was made the factors influencing the occurrence of predation are usually associated with management aspects and normally will be negatively correlated with predation losses. Variables affecting the level of predation can be seen as factors reducing the level of predation. These factors will usually include non-lethal and lethal methods. Mon-lethal control methods generally do not stop predation, but will reduce the level of predation on a farm. However, where a great deal of success is associated with a curtain prevention method, mostly control methods, this variable will be significant in effecting the occurrence of predation on a farm and at a specific point in time.

The WCP is a very diverse agricultural sector, which include wine producing areas, field crop production and small stock production in the Karoo and southern parts of the province. Due to the fact of the very diverse agricultural sector in the WCP predation losses fluctuate immensely in the province and makes predator control very difficult.

There can be no uncertainty regarding the fact that predation in South Africa is a serious problem for the South African small livestock sector and there is no indication that the problem of predation is subsiding. This study will not answer all questions on predation, but is a step forward in understanding the magnitude of predation and factors influencing predation on farms. The information collected can be used in addition to evaluate smaller areas intensively to deal with predation problems and develop strategies accordingly.

Due to the fact that these two predator species are so abundantly and widely found in South Africa, it makes effective management of problem-causing animals fairly difficult. The results of this study indicated that a higher level of management would lead to a reduction in predation losses. However, a higher level of management is not always financially or physically possible on every farm. These management aspects compete with the same resources on a farm and make it very difficult to implement. Due to the adaptability of these problem-causing animals, mostly black-backed jackal, management aspects must be diversified to have an efficient impact on predator management programs. A farmer has to decide for himself what level of predation is acceptable and what level of control would be sufficient, so that the cost do not exceed the benefit of predator control. As previously said, not all farmers have the ability to effectively control problem-causing animals, mainly due to a lack of resources. On the other hand, this is a major problem for farmers within areas experiencing high losses due to predation. That is why it is necessary for a nation-wide strategy in controlling problem-causing animals.

Government intervention will assist tremendously in implementing a coordinated national strategy in controlling problem-causing animals. The primary responsibility of controlling problem-causing animals will still be in the hands of the farmers. Government intervention can help to make recourses available to farmers in efficiently controlling problem-causing animals.

7. References

Aramyan L.H., Oude Lansink G.J.M., Verstegen A.A.M., 2007. Factors underlying the investment decision in energy-saving systems in Dutch horticulture. Business Economics, Wageningen Univesity, Hollandseweg 1, 6706 KN Wageningen, The Nederlands.

Arnold M.B., 2001. Wildlife integration for livelihood diversification project (working paper 6). Department for international development.

Caughley G., Sinclair A.R.E., 1994. Wildlife Ecology and Management. Blackwell Scientific, Boston, MA.

Cillie B., 1997. Die soogdiergids van Suid Afrika. Briza publikasies.

Conner M.M., Jaeger M.M., Weller T.J., McCullough D.R., 1998. Effect of coyote removal on sheep depredation in northern California. Journal of Wildlife Management, 62, 690-699.

Conte A., Vivarelli M., 2007. R&D and embodied technological change. The role of firm size and sector belonging. Max Planck Institute of Economics, Jena, Germany.

De Vos A.S., Strydom H., Fouche C.B., Delport C.L.S., 2002. Research at Grass Roots: For the Social Sciences and Human Service Professions, (Eds) Second Edition. Van Schalk Publishers.

De Waal H.O., 2009. Recent advances in co-ordinated predator management in South Africa. African Large Predator Research Unit, Department of Animal, Wildlife and Grassland Science (70). University of the Free State, Bloemfontein .

Dorrance M.J., Roy L.D., 1976. Predation losses of domestic sheep in Alaberta. Journal of range Management, 29, 457-460.

Hall-Martin A.J., Botha B.P., 1980. A note on feeding habits, ectopapasites and measurements of the black-backed jackal *Canis Mesomelas* from Addo Elephant National Park. Department of Research and Information, National Parks Board of Trustees.

Jordaan H., Grove B., 2010. Factors affecting forward pricing behaviour: Implecations of alternative regression model specifications. Department of Agricultural Economics, of the Free State, South Africa.

Katchova A.L., Miranda M.J., 2004. Two-step econometric estimation of farm characteristics affecting marketing contract decisions. American Agricultural Economics Association.

Landa A., Fudvangen K., Swenson J.E., Roskaft E., 1999. Factors associated with wolverine Gulo gulo predation on domestic sheep. The Journal of Applied Ecology, Vol 36, No. 6. pp. 963-973.

Lin T., Schmidt P., 1984. A test of the Tobit specification against an alternative suggested by Cragg. The Review of Economis and Statisties, Vol. 66. No. 1. pp. 174-177.

Mclnerney J.P., 1987. An economist's approach to estimating disease losses. Disease in Farm Livestock. Economics and Policy, K. S. & J.P. (Eds.), pp. 35-60.

Mclnerney J.P., Howe K.S., Schepers J.A., 1992. A framework for the economic analysis of disease in farm livestock. Preventive Veterinary Medicine 13, 137-154.

Moberly R.L., 2002. The cost of fox predation to agriculture in Britain. PhD Thesis, Environment Department, University of York.

Moberly R.L., White P.C.L., Webbon C.C., Baker P.J., Harris S., 2003. Modelling the cost of fox predation and preventive measures on sheep farms in Britain. Enviromment Department, University of York, York Y010 5DD, UK.

Moolman L.C., 1984. n Vergelyking van die voedingsgewoontes van die rooikat *Felis caracal* dinne en buite die bergkwagga nasionale park. Departement Dierkunde, Universiteit van Pretoria.

National Department of Agriculture of South Africa, 2006. Abstracts for Agriculture in South Africa. www.nda.agric.za.

Otte M.J., Chilonda P., 2002. Animal health economics. Livestock information, Sector Analysis and Policy Branch, Animal Production and Health Division (AGA), FAO, Rome, Italy.

Rowe-Rowe D.T., 1983. Black- backed jackal diet in relation to food availability in the Natal Drakensberg. Natal Parks, Game and Fish Preservation Board.

Skonhoft A., 2005. The costs and benefits of animal predation: An analysis of Scandinavian wolf re-colonization. Department of Economics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway.

Tobin J., 1958. Estimation of relationships for limited dependent variables. Econometrica, Vol. 26(1), pp. 24.36.

van Deventer J., 2008. Die holistiese benadering tot roofdierbestuur. Resolbing Human-Wildlife Conflict. Prevention is better than cure.

Windberg L.A., Knowlton F.F., Ebbert S.M., Kelly B.T., 1997. Aspects of coyote predation on Angora goats. Journal of Range Management, 50, 226-230.

Zhang, F., Chung, C.L. & Lin, B (2006). Modelling fresh organic produce consumption: A generalized double-hurdle model approach. U.S. Department of Agriculture.