

https://dspace.org/

The barn owl as a control agent for rat populations in semi-urban habitats

Meyer, Sharon

2008-07-16T08:55:09Z
http://hdl.handle.net/10539/5067

Downloaded from a DSpace repository. https://dspace.org/

The Barn Owl as a Control Agent for Rat Populations in Semi-Urban Habitats

Sharon Meyer

A dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science

Johannesburg, 2008

DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted for the degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

_____

Sharon Meyer

_____ day of _____ 2008

ABSTRACT

The project to release barn owls in semi-urban areas within Sebokeng was initiated when the Gauteng Department of Health received complaints from Sebokeng residents about the increase in black house rats *Rattus rattus*. This project was designed to investigate the efficacy of using owls as biological control agents of rats at three schools in Sebokeng, and to inform learners at these schools about barn owls, in light of the learners' strong sense of their culture and the associated beliefs and superstitions. There were two aims to the project. Firstly, to assess whether and how released barn owls impact on rat populations in the vicinity of the schools. Secondly, to provide environmental education to previously disadvantaged communities, and to assess how experiential group work using Outcomes Based Education (OBE) teaching changes the attitudes of learners towards owls.

Owl boxes with two owlets each were established at two schools (SPS 1and SPS 3); another school (SPS 2) had a resident breeding barn owl pair. A fourth school, SPS 4, was used as a control and no owls were released here. Snap trapping of rats took place at these schools and SPS 4 to assess the impact of owls on rat populations. Trapping took place before owls were present and after they were released at the release sites. At SPS 1 and SPS 3, the percentage of rats caught per trap night decreased by 41 and 51% respectively after owls were released. At SPS 4, 34% more rats per trap night were caught than at SPS 2 (owls always present). In addition, the rats caught were smaller and showed a distinct male bias, potentially indicating a shift in behaviour and/or changes in demography.

The environmental education part assessed the change in knowledge and perception of selected learners. Questionnaires were completed by the learners before the start of the environmental education as well as after the owl release programme started, where applicable. Learners at SPS 1 and SPS 3, who were required to feed and monitor the owlets before their release, showed significant changes in their perception, beliefs and enthusiasm for the owls. Learners at SPS 2 were well informed about owls, while those at SPS 4 harboured misgivings for and a lack of knowledge about owls.

This study indicated that barn owls are suitable biological control agents for rats in the semi-rural areas. The success of the release programme was achieved by active participation of learners and environmental education, highlighting the benefits of a multidisciplinary approach in the programme.

ACKNOWLEDGEMENTS

I would like to thank the National Research Foundation for providing financial support for this project over a three-year period. This assistance is greatly appreciated and was one of many factors that made this research possible.

Jonathan Haw of Ecosolutions cc has been involved in raptor research for many years and has initiated several similar owl release projects in various study sites across the country. He was instrumental in the initiation of this project in particular, and used his network of resources to source the orphaned barn owls, construct the owl boxes, and obtain day old chicks to feed the owls for the first month of their release. I would like to thank Mr Haw for the valuable information and experience he provided over the first 3 months of this study.

Mrs Makobela (SPS 1), Mr Hlahlani (SPS 3) and Mr Luthuli (SPS 2) are the teachers who participated in the project and assisted me in the organisation and management of the owl working groups. They assisted tremendously in the day-to-day rat trapping, control of learners (and owls), as well as the community awareness campaign. They are all very dedicated and hardworking teachers who are overcoming unbelievable obstacles to educate the learners of their schools. I have huge respect for their knowledge and their daily struggle against the challenges that teaching in Sebokeng presents.

The three owl working groups from SPS 1, SPS 3 and SPS 2 made the project worthwhile. I would like to thank Lucky specifically for catching and skinning a large rat for me. It was very thoughtful, if a bit smelly. Charlotte was enthusiastic and independently managed the owl monitoring programme at SPS 1. Sibusiso undertook his own research and always had important questions about the owls and the rat control. All the learners were wonderful to work with and their eagerness to help and learn had me looking forward to my trips to Sebokeng. Thank you to the kids who assisted me with the bicycle pump when I had a flat tire!

Mrs Lyn Meyer assisted me with the environmental education component of the study and explained the OBE principles to me, which was vital to the methodologies selected for the group work with the Sebokeng learners. Mrs Meyer provided reading material on OBE and group learning.

Prof Neville Pillay has provided constant support and advice over the long and tedious writing-up process. He has assisted wherever possible to keep me focused on the task ahead, despite my frequent lapses. In addition, Prof Pillay contributed by helping with the statistical analyses for the snap trapping data and the environmental education questionnaires.

Prof. Pillay made all the resources at his disposal available to me and was always helpful and positive about the project, against all odds. I do not think any other supervisor would have lived through the ordeal.

I would like to thank Cymbian Enviro-Social Consulting for supporting me during the writing up of this report and assisting me financially when funds ran out and the project didn't. I would like to thank Mr Warren Kok in particular for encouraging me to present this study at the 2006 International Association for Impact Assessments Conference (and paying for my attendance at the conference). Thanks to Mr Riaan van der Merwe for producing the map.

Thank you to Alistair Douglas for his assistance in reviewing draft reports and editing graphs. His support was invaluable through the compilation of the final research report!

Thanks to Pick 'n Pay for sponsoring lunch for the owl groups on our trip to the Johannesburg Zoo in 2005.

List of Figures

Figure 2.1. Location of the SPS 1, SPS 3, SPS 2 and SPS 4 in Sebokeng 17
Figure 2.2. Charlotte inspects the resident breeding pair of barn owls at Seeiso 19
Figure 2.3. Owl box being set up at SPS 3 21
Figure 2. 4. Proportion of rats per trap night for each school when owls were absent and present at the sites 27
Figure 2.5. Sex ratio, expressed as a percentage of males, of rats trapped at four primary schools where owls were present and/or absent. 28
Figure 2.6. Mean (+SE) head-body length of the rats trapped at all four schools when owls were present and/or absent. 28
Figure 2.7. Mean (+SE) mass of the rats trapped at the four schools when owls were absent and when owls were present. 29
Figure 3.1. The questionnaire completed by learners at participating schools 51

List of Tables

Table 2.1: Snap-trapping sessions at the two control schools (SPS 2 and SPS 4) and the two release schools (SPS 1 and SPS 3) over the duration of the owl release programme. *23*
Table 2.2: Rat numbers trapped at each school over time. *26*
Table 3.1. The responses about owls of learners from four primary schools in Sebokeng. Questionnaires were provided to the same set of learners before and after owls were released in SPS 1and SPS 3. Statistics = GLZ analyses; for each question, the first row of the statistics indicates learners responses when owls were present and absent, and the second row compares responses by different schools. Number of learners in each school is given in brackets. *53*

.

Table of Contents

ABSTRACT iii
CHAPTER 1. INTRODUCTION 1
1.1 Rationale and motivation for study 1
1.2 Invasive alien species and biological control 3
1.2.1 Examples of biological control studies 3
1.2.1.1 Falcons as control agents of pigeons 3
1.2.1.2 European Rabbit 4
1.3 Biology and pest status of *Rattus spp.* 4
1.3.1 Rats as predators and scavengers of conservation species 5
1.3.2 Rats affecting crop production 5
1.3.3 Rodent-borne Disease 6
1.3.3.1 Bubonic Plague 6
1.3.3.2 Salmonellosis 7
1.3.3.3 Leptospirosis 7
1.3.3.4 Seoul Virus 7
1.3.3.5 Murine Typhus 7
1.3.3.6 Rat Bite Fever 7
1.3.3.7 Trichinosis 8
1.3.4 Rodent control methods 8
1.3.5 Barn owls as biological control agents of rat populations 9
1.4 Barn Owl Biology 10
1.5 Environmental education 11
1.6 Objectives/outcomes 13
1.7 Outline of the dissertation 14
CHAPTER 2. BIOLOGICAL CONTROL OF RAT POPULATIONS BY BARN OWLS 15
2.1 Introduction 15
2.1.1 Biological control of rats 15
2.2 Materials and Methods 16
2.2.1 Study Site 16
2.2.2 Study subjects 18
2.2.3 Owl release 19
2.2.4 Rat trapping 21
2.2.5 Owl pellet analysis 24
2.2.6 Data analysis 24
2.3 Results 25
2.3.1 Owl Release Programme 25
2.3.2 Biological Control of Rats 25
2.3.3 Owl pellets 29
2.4 Discussion 29
2.4.1. Owl Release Programme 29
2.4.1.1. Location of the release sites 30
2.4.1.2. Environmental education and community awareness 30
2.4.1.3. Extensive available prey base and secure nest sites 31
2.4.1.4. Resident owls in vicinity of release sites 31
2.4.2 Biological control of rats 32
2.4.3 Owl predation on rats 35
2.4.4 Conclusion 36

CHAPTER 3. ENVIRONMENTAL EDUCATION 37
3.1. Introduction 37
3.1.1. Environmental Education 37
3.1.2. OBE as a tool for Environmental Education 38
3.1.3. Conceptual Change Theory 40
3.1.4. Other Environmental Education Tools 41
3.1.5. How the Sebokeng environmental education objectives were reached 41
3.1.6. The Revised National Curriculum Statement critical outcomes 43
3.1.7. Curriculum Structure under RNCS 44
3.2. Methods and Materials 44
3.2.1. Study Site 44
3.2.2. Initial Teacher and Learner Awareness 45
3.2.3. OBE as a tool for Knowledge Transfer 46
3.2.4. Subjects 46
3.2.5. Owl release 48
3.2.6. Rat trapping 48
3.2.7. Community Awareness Campaign 49
3.2.8. Evaluation of learners 49
3.2.9. Data analysis 50
3.3. Results 52
3.4. Discussion 54
3.4.1. Conclusion 55
3.4.1.1. Environmental Education Theory 57
CHAPTER 4. CONCLUSIONS 58
4.1. Owl release programme 58
4.1.1 Owls as rat control agents 58
4.1.2. Measuring the efficacy of the control agent 59
4.2 The Environmental Education Programme 60
4.3 Multidisciplinary approach 61
4.4 Future Studies 62
4.4.1 Owls as biological control agents 62
4.4.2. Environmental Education in previously disadvantaged South African communities 64
5 REFERENCES 65
APPENDIX 1. RAT POISON AND THE POTENTIAL THREAT TO HUMAN LIFE 74

CHAPTER 1. INTRODUCTION

1.1 Rationale and motivation for study

The project to release barn owls in semi-urban areas was initiated when the Department of Health received complaints from communities living in Sebokeng (Haw, pers com., 2004). Sebokeng residents and people from surrounding townships have experienced an increase in black house rat (*Rattus rattus)* activity, including damage to stored food, defecation by rats within households, as well as rat bites to children. The increase in rat activity in the Sebokeng and surrounding areas may be attributed to a decrease in predators, as well as an increase in readily available foraging and nesting sites (Haw, pers com., 2004).

In response to the increase in rat activity, the owl release programme was initiated at three primary schools within the Sebokeng Township, with a fourth school utilised as a control site. The programme was aimed at assessing whether the presence of predators at various study sites within this semi-urban area would impact on rat population numbers. The schools selected as study sites were known to have large rat populations and had experienced rat related damage to property in the kitchens and storerooms; damage to stored foods as well as evidence of rat activity (defecation and urination) in the school kitchens and storerooms (Makobela, pers com., 2004). The three participating schools (SPS 1, SPS 2 and SPS 3) and the control school (SPS 4) are located within 20km of each other in the SPS 1 and Evaton residential areas of Sebokeng, Gauteng Province.

One of the implications of introducing owls into a predominantly black African community is the cultural lore pertaining to these predatory birds (Makobela, pers com., 2004). Due to their nocturnal habits and silent flight, owls have achieved mythological status globally (Marcot, 2000). In many African cultures, owls are symbols of death or omens related to evil and sorcery (Puckree *et al.*, 2002). In Southern Africa, in particular, the owl is a symbol of foreboding, is often seen as evil or malevolent, and is killed out of fear and superstition (Makobela, pers com, 2005). In traditional medicines, owl parts are used to ward off spirits, cast spells and cure diseases. Sangomas often pay for dead owls to use for medicines and other spiritual cures. In particular, sangomas use powdered owl parts as a treatment for hearing disorders (Andrade & Ross, 2005).

I believe that, in order for sustainable management of rat populations, it is important that communities in South Africa appreciate the ecological importance of owls and how these nocturnal birds of prey can actually be useful within residential settlements. The benefits of having owls within semi-urban areas must be highlighted for the communities involved in this study, since the success of the release programme depends on the owls being accepted by local residents. Reduced rodent damage to property and the reduced risk of rodent-borne disease may provide a basis for further local interest in the released owls. Therefore, it is vital to the owl release programme that the residents of Sebokeng are made aware of the potential benefits of the owls for rodent control.

With the introduction of Outcomes Based Education (OBE), a more interactive method of teaching is encouraged, whereby learners are involved in the learning experience rather than being passive recipients (Vygotsky, 1978; John-Steiner, 1985; Rogoff, 1990; Meyer, 1998, 2000). With this in mind, an interactive approach to teaching the biology, behaviour and environmental value of the barn owl to primary school learners in the Sebokeng area can be accomplished through the owl release programme (Brown, *et al*., 1989). OBE principles were utilised as tools for the environmental education process.

In this study, a multi-disciplinary approach is adopted, incorporating both biological control and environmental education aspects in the research (Lary *et al*., 1997). This approach is important for modern science as it incorporates human interaction with the research project (Wicklein & Schell, 1995). The environmental education ensures that solutions to the problem are practical for use by local residents. In addition, local knowledge and experience are identified and incorporated into the study, which is guided by the scientific process. This provides a more "user-friendly" resolution to the problem, which has been developed in liaison with the people most affected by the rat activity. This ensures that the solution recommended is more easily adopted by the community in question, as they have participated in the process and have observed the research and results thereof (Cheek, 1992).

Due to the dual approach, there are two main aims for the project:

1. To assess the effect of the owl presence on invasive alien rat populations at three semi-urban primary schools.
2. To initiate environmental education on owl biology and their usefulness in controlling rat populations for the learners at the three primary schools (SPS 1, SPS 2 and SPS 3) in Sebokeng.

1.2 Invasive alien species and biological control

Invasive alien species are those introduced deliberately or unintentionally outside of their natural habitats where they have the ability to establish themselves and out-compete indigenous species and take over the new environments (Rejmanek & Richardson, 1996). It has been suggested that invasive alien species succeed in the new environment primarily because they do not have any natural enemies (Callaway & Aschehoug, 2000). The problems associated with invasive aliens are experienced globally in many different ecosystems. In terrestrial habitats, plants, mammals and insects comprise the most common types of invasive alien species (UNEP, 2000).

The threat to biodiversity due to invasive alien species is considered second only to that of habitat loss (Wittenberg & Cock, 2001). Therefore, invasive alien species are a serious impediment to conservation and the sustainable use of global, regional and local biodiversity, with significant undesirable impacts on the goods and services provided by ecosystems (Weeden *et al.*, 2006).

Biological control, which involves the suppression of one organism by another (Cook & Baker, 1983), is a process used for the eradication and/or control of invasive alien species. Agents of biological control most commonly utilised are pathogens, parasites, and insects (Zimmer, 2001). The biological control agent should preferably be an indigenous species or dependent on the target alien species for survival, since this will negate the risk that the control agent may, over time, become an invasive alien species itself (Weeden *et al.*, 2006).

1.2.1 Examples of biological control studies

1.2.1.1 Falcons as control agents of pigeons

In South Africa, various initiatives have been introduced to find a biological control agent for pigeon infestations on buildings. In 2001, Eskom introduced Lanner falcons to Megawatt Park roof to control pigeons breeding on the roof of the building. The presence of the pigeons resulted in pigeon feathers, mites and faeces entering the building through the conditioning system (Michael, pers com., 2001). The existence of a large number of pigeons nesting and roosting near the air conditioning vent had caused an increase in illness in Megawatt Park staff (Nelson, pers com., 2001).

The introduction of a pair of Lanner Falcon to Megawatt Park roof in Sinninghill, Johannesburg, was initiated by Jonathan Haw and the Eskom Enterprises Technology Services International Research Division (Naidoo, pers com., 2001). After approximately 6 months of Lanner falcon presence on Megawatt Park roof, the number of pigeons utilising the roof for nesting and roosting had dropped by approximately 20% (Haw, pers com., 2002). It was found that Lanner falcons are excellent predators of pigeons and provide effective deterrent and control agents for pigeon populations in urban areas (Haw, pers com., 2002).

1.2.1.2 European Rabbit

In Australia, European rabbits were introduced in 1788, but the current infestation appears to have originated with the release of 24 wild rabbits in 1859 (Wheeler & King, 1985). Without natural predators, rabbits have caused enormous habitat damage (Wheeler & King, 1985), have been blamed for the extinction of many native animals (Griffin & Friedel, 1985), and have caused millions of dollars of damage to agriculture (Faqan *et al.*, 2002).

Releasing rabbit-borne diseases has proven somewhat successful in controlling rabbits. In 1950, myxomatosis was deliberately released into the rabbit population which caused populations to drop from an estimated 600 million to about 100 million (Kovaliski, 1998). Myxomatosis is a severe viral disease that decimated the wild rabbit population when it arrived in Britain 50 years ago (Pech & Hood, 1998). Genetic resistance in the remaining rabbits allowed the population to recover to 200-300 million by 1991 (Twigg *et al.*, 1998). The Commonwealth Scientific and Industrial Research Organization (CSIRO) scientists released rabbit calicivirus (Rabbit Hemorrhagic Disease or RHD) in 1996, but the efficacy of this virus was not as successful as myxomatosis (Twigg *et al.*, 1998).

1.3 Biology and pest status of *Rattus spp*.

Two alien rat species occur in South Africa, namely the brown house rat, *Rattus norvegicus*, and the black house rat, *Rattus rattus*, (De Graaff, 1981). Both of these species are said to have originated in India and other Indo-Malayan countries, and arrived in America, Europe and Africa by ship (Innes, 1990; Komen, 2002).

Adult black rats are medium-sized rodents, weighing up to 280g and measuring about 200 mm in length, excluding the tail (De Graaff, 1981). Black rats usually live in

trees or in the upper storeys of buildings (Komen, 2002). In contrast, brown rats are larger (up to 485g and 200-250mm long; De Graaff, 1981). They live within walls, under floors, in garbage bins and dumps and sometimes in the ground (Kemp, 1987).

Rats are mostly nocturnal (Innes, 1990; Kemp, 1987). They breed all year round, and have a high reproductive potential: under normal conditions, females have between 3 and 7 litters per year, with a litter size of 6-22 pups. Young are weaned at 3-4 weeks, and sexual maturity is reached at about 80 days (Komen, 2002).

1.3.1 Rats as predators and scavengers of conservation species

Rats are omnivorous, feeding on a wide range of plant and animal foods, such as snails, beetles, spiders, moths, stick insects and cicadas and the fruit of many different plants (Innes 1990). They also prey on the eggs and young of forest birds (Innes *et al.*, 1999). In the recovery programme for the endangered Rarotonga flycatcher or kakerori, *Pomarea dimidiata*, Robertson *et al.* (1994) identified house rats as the most important predator affecting the breeding success of this species. Several cases are known where predation on seabirds can be reliably attributed to house rats, including sooty terns, *Sterna fuscata*, in the Seychelles (Feare, 1979), Bonin petrels, *Pterodroma hypoleuca*, in Hawaii (Grant *et al.*, 1981), Galapagos dark-rumped petrels, *Pterodroma phaeopygia*, in the Galapagos Islands (Harris, 1970), and white-tailed tropicbirds, *Phaethon lepturus*, in Bermuda (Gross, 1912).

1.3.2 Rats affecting crop production

Rats, particularly the brown house rat *R. norvegicus*, are responsible for the damage of crops around the world (Wood & Fee, 2002; Meek *et al.*, 2003). For example, in Asia, pre-harvest losses of rice crops to rat damage are estimated at between 5 and 10% of the total harvest, which equates to approximately 30 to 60 million tonnes of rice, enough to feed 180 million people for a year (CSIRO Sustainable Ecosystems, 2003). In Malaysia, the loss of palm oil plantation production to rat damage is estimated at 5 to 10% of the total crop, when rat populations within palm oil plantations reach 100-600 individuals per hectare (Wood & Fee, 2002). Records from south-east Asia indicate that rodents attack other crops, including coconut, cocoa, and sugar cane (Wood & Fee, 2002).

The Bayers homepage (www.bayers.co.za) states that in South Africa, rats damage growing crops such as rice, maize, sugar cane, coconut and cocoa plantations. Rats feed on and contaminate stored food through urination and defecation. In addition, rodents

cause damage to property through gnawing and burrowing which is especially prevalent on electricity cables and water supply pipes.

1.3.3 Rodent-borne Disease

Rats are also notorious for spreading rodent-borne diseases, the most well-known of which is bubonic plague (Mills & Childs, 1998), although several other modern diseases are also transmitted by rats (Gratz, 1999). An article from an IOL news website dated February 10, 2003, warned that the risk of rodent-borne diseases is on the increase in urban areas in Australia. Similar risks of epidemic diseases carried by rodents have been reported in other countries, including South Africa (National Department of Health, unpublished data). An article printed in Natal Mercury, published on 09 February 2004, examined the risks associated with rats in urban areas and described the increasing rat populations in the KwaZulu-Natal cities, and in South Africa generally (Bolowana, 2004). The article discussed the potential for rodent-borne disease within the urban area.

1.3.3.1 Bubonic Plague

Bubonic Plague is recorded to have killed approximately 30 000 people in London and an estimated 80 000 in Milan in an outbreak during the Middle Ages. This outbreak eliminated 25% of the European population of the time. A more recent outbreak has been reported in Namibia where Bubonic Plague has spread through 21 villages in the rural Ohangwena region (the Namibian, 1999).

Bubonic Plague is carried by fleas that live on rats. The bacterium *Pasteurella petis* is carried by the flea and affects the digestive system of the flea, causing them to regurgitate blood while feeding. This releases the bacterium into the host blood stream (Keeling & Gilligan, 2000). Gubler (1998) has indicated that the risk of an outbreak of Bubonic Plague in modern cities is significant, and very much related to changes in climate, sewage and water reticulation and general cleanliness of the living conditions worldwide.

1.3.3.2 Salmonellosis

Salmonellosis ranks as one of the most widespread animal-borne diseases worldwide. Human cases of food poisoning caused by Salmonella occurs when rodents defecate or urinate on food, eating utensils, kitchen counters and other areas associated with human food and food preparation. The symptoms of Salmonella poisoning is acute gastroenteritis, abdominal cramps, anorexia, diarrhea, headaches, high fever and vomiting (Blaser, 1996).

1.3.3.3 Leptospirosis

Leptospirosis, also known as Weil's disease, is caused by the bacterial spirochete *Leptospira icterohaemorrhagicae*. It is transmitted among rats and mice to humans via contact with infected rat urine. The bacteria enter the blood stream through scratches on the skin, via mucous membranes or the conjunctivae when rubbing eyes.

1.3.3.4 Seoul Virus

Seoul Virus is a strain of Hantavirus and is transmitted through contact with rat faeces or urine. Seoul Virus causes hemorrhagic fever with renal syndrome and the mortality rate is less than 1% of all victims.

1.3.3.5 Murine Typhus

Flea borne typhus is caused by Rickettsia typhi and is associated with rats. the bacteria is transmitted to humans through infected flea faecal material that is rubbed into a wound or mucous membrane.

1.3.3.6 Rat Bite Fever

Rat Bite or Haverhill Fever is caused by infection of the bacteria *Streptobacillus moniliformis*. The bacteria is transmitted from rat to humans through secretions of mouth, nose or eyes. The fatality rate for untreated cases can be as high as 10%. Secondary infection and tetanus can also evolve if the wound is not disinfected.

1.3.3.7 Trichinosis

This is caused by the nematode *Trichina spiralis*, which lives within the muscles of domestic rodents. Pigs, dogs and cats acquire *T. spiralis* by eating infected rats or eating infected rat faeces. Humans may become infected by eating rare pork meat.

1.3.4 Rodent control methods

Current rodent control relies on poisons (Jackson & Ashton, 1992; De'Ath *et al.*, 1997). Rat poisons or rodenticides rely on anticoagulants such as coumatetralyl as the active ingredient (Bayer website, 2004). These anticoagulants are dangerous to all animals or humans who may ingest them as they eat through the stomach lining and cause extensive internal haemorrhaging.

The use of rodenticides and other baiting techniques impact on rodent numbers but, as illustrated by the ongoing supply and demand of rodenticides, these methods do not provide a long term control mechanism (Haw, *pers com.*, 2001). Rat poisons are reported to have negative effects on people (Appendix 1) and wildlife (Lipton & Klass, 1984; Babcock *et al.*, 1993). Rodenticides are usually not species-specific poisons and often kill non-target animals (Shore *et al.*, 1999). A report from the Poison Working Group (PWG) in Namibia highlighted the impact of rat poisons on wildlife, reporting that in one incident five lappet-faced vultures were killed by irresponsible use of rodent poisons (Komen, 2002). Poisons are also known to have been ingested accidentally by small children (Kogan, 1998).

Due to the various health and safety risks associated with rat poisons, as well as for environmental conservation purposes, there has been a shift to other methods of managing rat infestations (Aplin *et al.*, 2003). For example, in West Java, 49% of farmers stopped using endosulfan plus sump oil (a popular rodenticide treatment in the area), due to the success and effectiveness of a cheaper, environmentally sustainable 'integrated rodent management system', which promotes methods of control such as trap-barrier systems, reduced width of irrigation banks to less than 30cm (preventing nesting by rats), and increased general hygiene around villages and gardens (CSIRO, 2003).

Trapping of rats has also been carried out in attempts to control populations. Trapping is usually done with baited snap traps. This method is also not target specific and other small rodents may be killed (CSIRO, 2003; Aplin *et al.*, 2003). The efficacy of

pitfall traps, barrier methods and bait success are being studied in Asian countries, such as Vietnam (Aplin *et al.,* 2003).

Other methods of controlling rats include reducing reproductive output by immuno-compromising rats with viral particles, which attack reproductive cells (sperm or egg cells; Chambers, 1997).

In Australia various vermin species, including rats and rabbits, were controlled in specific areas through barrier fencing (Moseby & Read, 2006). However, barrier fencing is only useful where particular areas or infrastructure need securing. Moreover, vermin species often overcome the barrier fencing through gnawing of the fence or digging under the fence (Wheeler & King, 1985).

Another rat control method utilises a high intensity ultrasonic sound generator, which produces bursts of ultrasonic frequency, which is an auditory irritant to the rats (Weinberg, 1986). Thus, the generator dissuades rats from entering a specific building or area.

Finally, the use of biological control agents has been proposed as a method for controlling rat populations. In many instances, urban residents have employed domesticated cats as rat control agents (Blackwell *et al.*, 2003). However, domestic cats are not indigenous to many parts of the world and may cause other problems when introduced to an area where they cannot be controlled.

1.3.5 Barn owls as biological control agents of rat populations

The use of barn owls, *Tyto alba*, in the control of rodents has been very successful in the palm groves of Malaysia (Wood & Fee, 2002), significantly reducing rodent damage to palms (Duckett, 1991). In addition to this reduction, the Malaysian project established that barn owls could raise at least two broods per annum (Wood & Fee, 2002).

The November 2003 issue of The Rodent Research Newsletter published by Community Ecology highlighted different methods of rodent population control, specifically with respect to crop damage (CSIRO, 2003). In Caulvery Delta, India, barn owls have been evaluated for rodent pest management and results of pellet analysis indicated that 78% of the prey base of these owls was made up of rodent species (CSIRO, 2003).

Meek *et al.* (2003) carried out a 21-year study on barn owl release in lowland southern England. They reported that barn owls are adapted to living in close proximity to human habitation, and that the released barn owls were able to establish breeding

populations within the agricultural areas. This may be due to the fact that barn owls are widespread in most habitats and can adapt to various living conditions in which suitable rodent populations exist.

1.4 Barn Owl Biology

The barn owl has a wide distribution and can be found on all continents (besides Antarctica) and on most islands (Konig *et al.*, 1999). Its preferred habitat is open woodland or grassland, where they nest in tree hollows, in buildings and even in wells and tall structures like windmills (Kemp, 1987).

Barn owls are common birds of prey resident in semi-urban areas in South Africa (Barnes, 2000). They specialise in hunting small ground mammals, and the vast majority of their food consists of small rodents (Yom-Tov & Wool, 1997). A study in Chile indicated that small mammals formed the greatest proportion (76%) of the diet of barn owls, which predated on only four species, of which the leaf-eared mouse, *Phyllotis darwini*, represented 62% of the total prey species identified (Carmona *et al*.; 2006). However, studies have shown that barn owls are opportunistic hunters and will switch between prey species according to their availability (Tores *et al.*, 2005). This may mean that the owls will prey on other small animals such as lizards if these animals are available when the preferred rodent prey base is scarce.

Barn owls are highly adapted to nocturnal hunting. They possess morphological characteristics which permit silent flight: the wings have a velvety “pile” on the feather surface, and the leading edges of the wing feathers have a fringe, or fine comb, which deadens the sound of the wing beats (Feduccia, 1999). The silent flight does not alert the prey and also aids hearing (Hoffman, 1997). Another adaptation for hunting at night, even in total darkness, is their highly sensitive hearing. This is made possible by having ear openings positioned at slightly different heights on the head. The ear openings are set at different angles, and covered by a flexible ruff made up of short, densely webbed feathers, which frames the face, turning it into a dish-like reflector for sound. In this way the barn owl is provided with very directional hearing (von Campenhausen & Wagner, 2006; Coles & Guppy, 1988; Payne, 1971). They can pinpoint the source of a sound from several metres away.

Barn owls will fly as much as 5 to 7 km away from their nests to forage and do not often hunt in the immediate vicinity of their nesting site. This is apparently to divert

attention away from their young by not drawing attention to themselves near their nesting sites (Marti, 1992).

The majority of barn owls nest in tree hollows up to 20 metres high, and not less than 2 metres above ground to reduce the risks of predation of eggs and hatchlings (Bachynski & Harris, 2002). Barn owls will also nest in old buildings, caves and well shafts. They breed at any time during the year, depending on food supply. Between 3 and 6 eggs are laid at 2-day intervals, and are incubated for 30-34 days (Martinez & Lopez, 1999).

In a good year, a pair may breed more than twice, and they are known to produce up to 3 broods per year, depending on the availability of prey (J. Haw, pers com, 2004). Rodent outbreaks cause barn owl numbers to increase proportionally to the available rodent prey-base (Kalman, 1993). They have been known to produce between 25 and 30 chicks in one breeding season in response to high numbers of rodent prey (Andries *et al.*, 1994).

Chicks are covered in white down and brooded for about 2 weeks. Jonathan Haw (pers com, 2004) has observed that a breeding pair in semi-urban South Africa was capable of bringing more than 50 rats to their young each night during brooding.

Barn owls cache extra food, particularly during the breeding season. However, under normal conditions, an owl will bring an average of 6-10 rats a night for feeding the young, depending on the number of young in the nest (Marti, 1992). Owlets usually fledge by 50 to 55 days, but they can remain in the nest between 30 to 80 days, depending on the number of eggs and the time interval between hatching of the chicks (Trapp, 2003). Thereafter, they will remain in the vicinity of the nest for a week or so to acquire hunting skills and then rapidly disperse from the nest area (Martinez & Lopez, 1999; Wilson *et al.*, 1986). Barn owls are able to breed at about 10 months of age (Kemp, 1987).

1.5 Environmental education

Environmental education has become an integral and vital part of schooling all over the world, but particularly in Third World countries (Rickinson, 2001). In South Africa, the need for environmental education lies mainly in communities that are previously disadvantaged, such as those in Sebokeng. These communities have not been afforded the opportunity to learn about the environment as other communities have (Kunzmann & Dericioglu; 1983). This is largely due to illiteracy, no access to television

or radio, and isolation from conservation organisations and facilities such as National Parks, zoos and rehabilitation centres (Dillon, 2003).

As a result of a poor understanding of environmental issues in predominantly third world countries, the United Nations Environmental Programme (UNEP) was launched in the early-1970s. The UNEP described environmental education as: "... the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among men, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behaviour about issues concerning environmental quality" (International Union for the Conservation of Nature, UNEP, 2000, pg 2).

The 1977, Tbilisi Conference on implementation of environmental education introduced five directive principles that defined environmental education:

- A lifelong process that occurs at all levels of education.
- An integration of environment, human interactions and political processes, together with socio-economic issues.
- The development of attitudes and value systems which lead to socio-economic improvement through environmental conservation.
- Developing an individual's understanding and skills to address social, economic and environmental issues.
- The holistic and preferably interdisciplinary approach to experiential learning in natural, built and social environments.

In South Africa, environmental education has been initiated through various programmes. Two examples are mentioned below.

1. The Southern African Development Community (SADC) Environment and Land Management Sector (ELMS) initiated a support programme for environmental education in the Southern African region in 1993 (SADC website, updated 2007). The programme comprised of various components aimed at improving the resources, networking, training and policy relating to environmental education in the SADC region.
2. The South African National Botanical Institute (SANBI) has launched its "Greening the Nation" campaign which aims at utilising environmental education to improve sustainable living, a healthy environment, the conservation of natural

resources, environmental protection and stewardship and responsible development within South African communities (SANBI, 2007).

With the international and local drive toward sustainable development and responsible custodianship of natural resources, the importance of environmental education is becoming more significant (Tbilisi Conference Proceedings, 1977). This is particularly important in previously disadvantaged communities where poor living conditions, few resources and a general lack of technical knowledge do not facilitate communities to efficiently address initiatives for environmental conservation practices (UNEP, 2000).

The barn owl release programme incorporates the principles proposed by UNEP in order to involve communities in an experiential environmental study. The learners, teachers and community at large had the opportunity to participate in the project and could evaluate the success of the programme through first hand observation. The success of the environmental education component of the owl release programme relied heavily on community awareness and the visible impact of owls on the rat infestation in Sebokeng.

1.6 Objectives/outcomes

There are two parts to this study. The first part relates to the biological control of rat populations and includes three objectives.

1. To release orphaned barn owls into three primary schools in semi-urban Sebokeng, southern Gauteng.
2. To study the impact of the barn owl presence on rodent population size and demography by conducting rodent trapping.
3. To identify the prey species preferred by barn owls through analysis of their pellets.

The second component of the research is to provide environmental education to the learners at three participating schools. The learners were then encouraged to transfer this information onto families and friends living in close proximity to the owl release sites.

There are five objectives of the environmental education study.

1 Introduce learners to an ecocentric view of owls and their niche in the food chain, while not dismissing their cultural beliefs.

2 Encourage learners to investigate scientific thinking and to gain an understanding of the value of conservation efforts.

3 Facilitate processes whereby learners understand the importance of owls in the natural ecosystem.

4 Encourage group work by learners to produce a specific deliverable, e.g. a monitoring programme. This method utilises outcomes based education principles as tools for environmental education.

5 Ensure that learners become involved in a community awareness programme that facilitates the participation of the community in the owl release programme.

1.7 Outline of the dissertation

My dissertation comprises four chapters, including an introduction and a final discussion, and two experimental chapters (owl release and rat population dynamics, and environmental education). The experimental chapters include appropriate introduction, materials and methods, results and discussion sections. Due to the nature of this layout, there is some overlap of information in the chapters. The tables and figures are numbered in sequence and listed in the relevant reference tables prior to the main table of contents. One reference section is provided for at the end of the entire dissertation. There is one appendix.

CHAPTER 2. BIOLOGICAL CONTROL OF RAT POPULATIONS BY BARN OWLS

2.1 Introduction

2.1.1 Biological control of rats

Biological control has become a preferred method of pest management in recent years (Wittenberg & Cock, 2000). However, the control agent must be carefully selected in order to provide the required pest management while having no long term impact on the indigenous habitat or ecosystem (Weeden *et al.,* 2006).

Various methods of biological control have been investigated for the brown house rat, *Rattus norvegicus*. In Hawaii and the Caribbean islands, the small Indian mongoose, *Herpestes auropunctatus*, was very effective in controlling populations of *R. norvegicus*. However, the mongoose also impacted on various indigenous snake species in the new habitat through predation on eggs and juvenile snakes (Pimentel *et al.*, 2000). This provides a warning for the irresponsible implementation of biological control.

In Malaysia, experimental research has been undertaken using the barn owl, *Tyto alba*, as a control agent (Meek *et al.*, 2003; Wood & Fee, 2003). Results have been positive, and because the barn owl is an indigenous predator of these regions and preys predominantly on rats and other rodents, no impact to the ecosystem or indigenous species has been observed (Beauchamp & Raid, 1997).

There were three aims of the biological control component of this study.

1 To release orphaned barn owls into three primary schools in semi-urban Sebokeng, southern Gauteng, and establish whether they take up residency;
2 Study the impact of the barn owl presence on rodent population size and demography (sex ratio and size) by conducting rodent trapping.
3 Identify the prey species preferred by barn owls through analysis of their pellets.

2.2 Materials and Methods

2.2.1 Study Site

The study site was within the semi-urban area surrounding Sebokeng in southern Gauteng, including SPS 1 and Evaton townships. The Sebokeng-Sasolburg area had a large rat population and experienced various rat related damage to property (Makobela, pers com, 2005). The site was selected for its semi-urban characteristics, the general lack of predatory birds in the area, and the large rat populations.

Three schools in this suburban area, SPS 1, SPS 2 and SPS 3, were identified as release sites for barn owls (Figure 2.1). SPS 2 and SPS 3 were situated about 500m from each other, and SPS 1 was about 1km from the other two schools. SPS 4, the control school, was about 20km from the other three schools (see Figure 2.1). The SPS 4 was selected as the control site because it was situated far away from the other schools and, presumably, would have not been affected by the owls at other three schools.

SPS 1, SPS 2 and SPS 4 have a main brick structure with additional prefabricated classrooms. SPS 3 contains all prefabricated structures. Existing school buildings were used for the owl release and the owl boxes were placed on roofs at SPS 1 and SPS 3. SPS 2 had a resident pair of breeding barn owls and so no additional owls were added to this site, but the resident barn owls were monitored throughout the study.

Houses surrounding the four schools were small brick structures near SPS 1 and SPS 4 and corrugated iron make-shift homes were predominant in the area around SPS 3. The roads were all dirt and litter was a perennial problem along the roads within Bophelong and Evaton. The dumping of domestic waste provides foraging and nesting opportunities for rats and may have attracted rat habitation.

There was open veld close to the schools (within 500m of each school grounds) and this may have also encouraged rat infestations due to availability of nesting material and providing dispersal opportunities (Bennet, 1990). In addition, the three schools selected for owl release were within 200m of at least one waste dump. There was no waste dump in close proximity to SPS 4, but the school had a vacant plot next to it, which provided suitable habitat for rats. Confirmation of rat activity at all four schools was provided by observation of rats by local residents, school teachers and learners, and from the occurrence of rat faeces and evidence of rat damage.

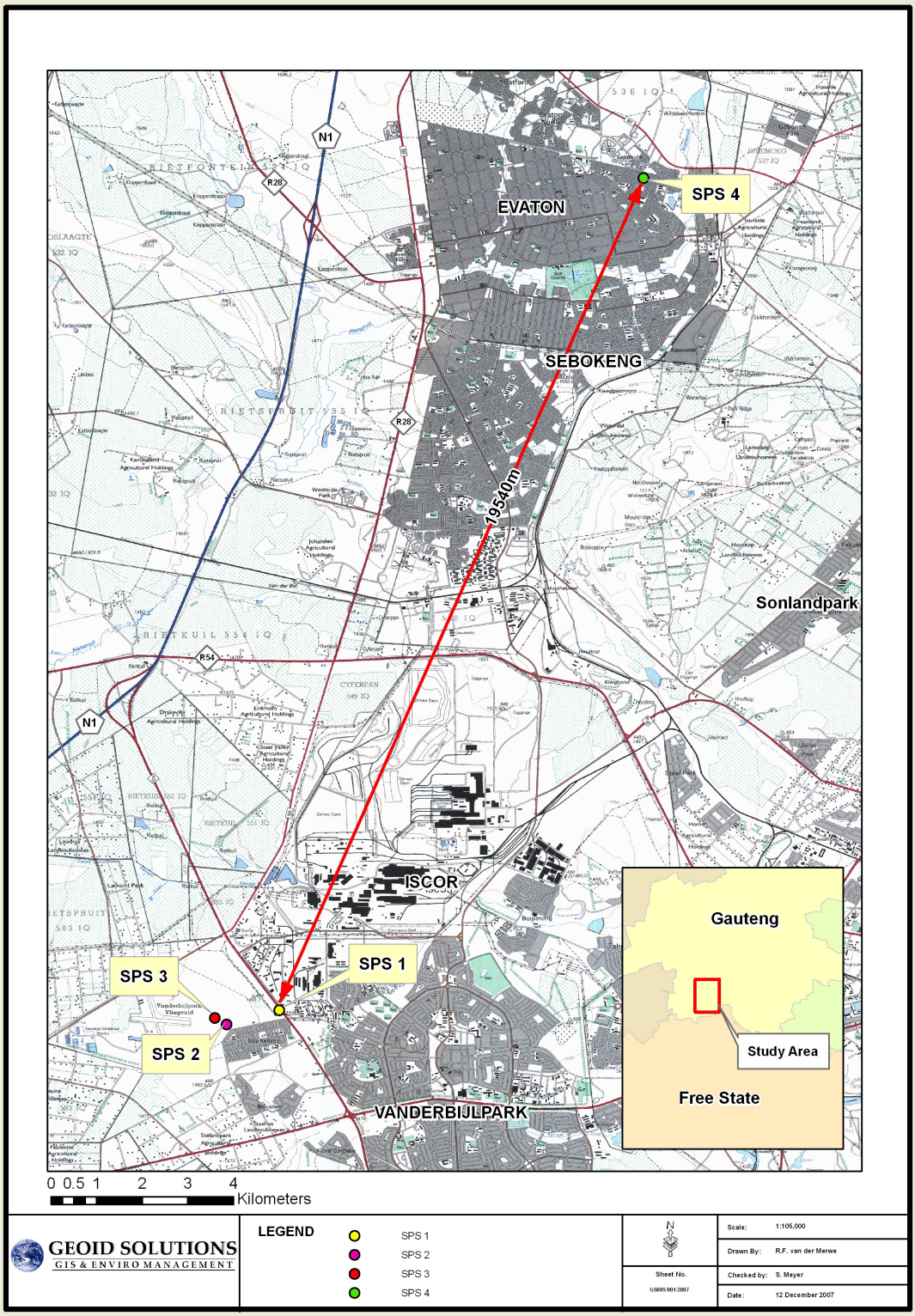

Figure 2.1. Location of the SPS 1, SPS 3, SPS 2 and SPS 4 in Sebokeng

2.2.2 Study subjects

The four schools were surveyed to investigate the possibility of resident owls inhabiting the local area. A 5km radius of each school was scanned for owl pellets, evidence of owl roosting or nesting, and owl activity at dusk and dawn. Through this survey and discussions with local residents and teachers, it was discovered that a resident owl pair was nesting within a fascia board of one of the classrooms at the SPS 2 (Figure 2.2). As a result, no owls were released at SPS 2 since barn owls are territorial. In addition, it was decided not to disturb the breeding pair at SPS 2 because it was paramount for the long term establishment of barn owls within the SPS 1 township of Sebokeng.

The local community was largely unaware of the owls nesting at SPS 2, and this may be the reason that these owls were not killed or chased away. Only the grounds man at SPS 2 and a few of the learners at the school knew about the owls and pointed them out. From discussions with teachers at all four of the schools, and some of the local residents, it was indicated that owls are often killed and sold to the local sangoma.

The fact that the SPS 2 resident owls were not disturbed may also be due to the fact that they were protected within the school grounds. In addition, the owls seemed to remain within a very limited area due to the availability of prey within the school grounds. No other resident owls were found within the $20km^2$ of the study area.

Eight orphaned juvenile barn owls were released by the researcher at SPS 1 and SPS 3. These included two sets of two owls released at each school. Due to the difficulty in sexing young owls, the gender of the owls released was unknown, except for "Dolly" at SPS 1 who produced eggs about 14 months after release.

The barn owls released at the two study sites were obtained from wildlife rehabilitation centres in Gauteng Province, such as "Free Me" in Johannesburg. The age of the owls at the time of release was dependent on the age at which the owls were handed into the rehabilitation centre. However, the optimal age for the release of juvenile owls is between 25 and 30 days (Trapp, 2003). The owls released at Sebokeng schools were generally between 20 and 40 days old. The owls were ringed with unique colours by Jonathan Haw of "Ecosolutions cc" in order to facilitate easy identification later.

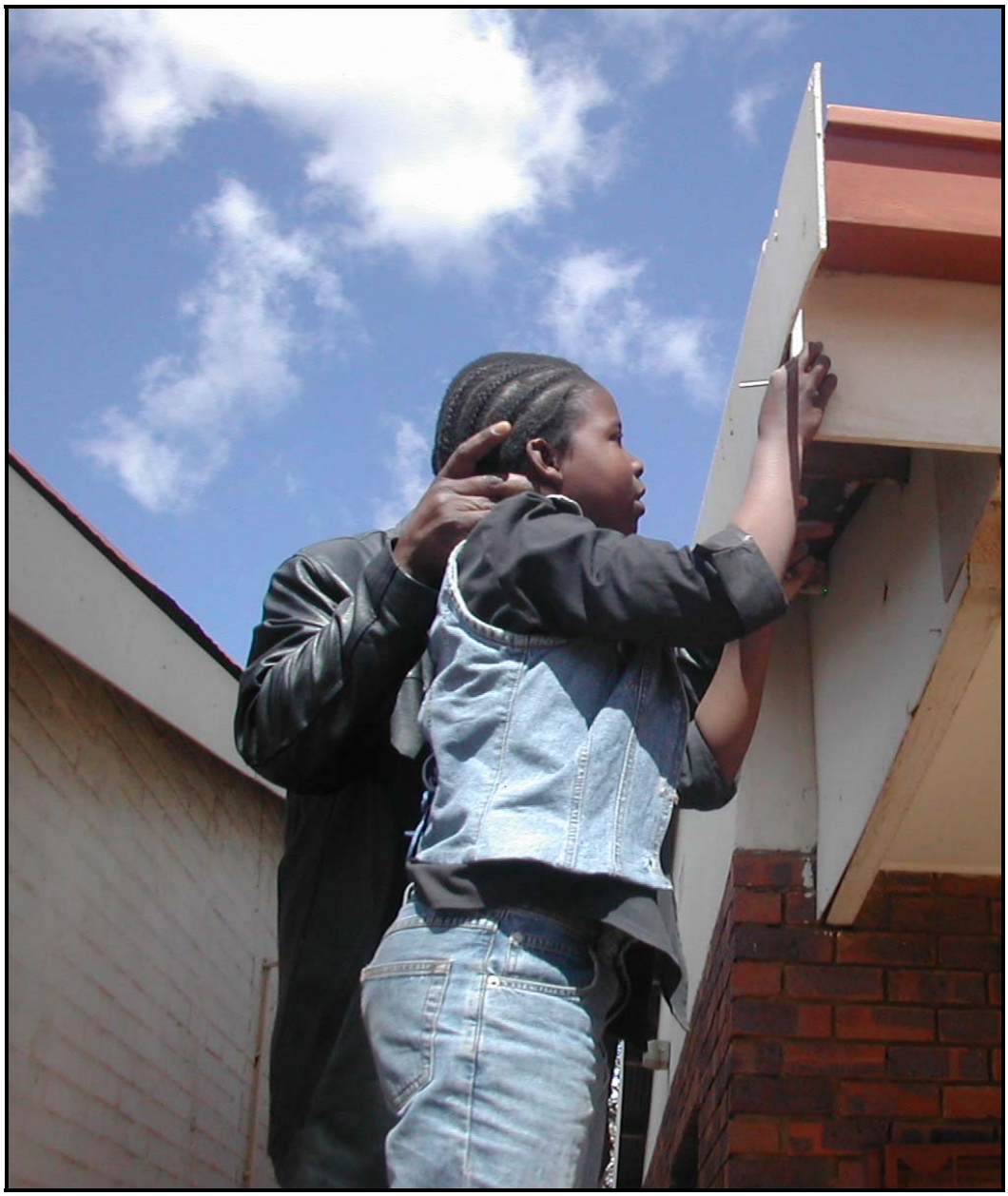

Figure 2.2. Charlotte inspects the resident breeding pair of barn owls at Seeiso

2.2.3 Owl release

At each of the release schools, owl boxes were erected by the researcher, Jonathan Haw and the OWG of the school at appropriate positions on the school grounds, at a height of at least 2.5 metres above the ground. The owl boxes housed the owls before their release, and subsequently served as roosting and/or nesting boxes for the released owls once they had established themselves within their territory.

The owl boxes were made of pine or chipboard and were rectangular in shape. The ideal size for a barn owl box is at least 40 cm tall x 32 cm wide x 60 cm long, with an entrance gap of about 20 cm x 15 cm (J. Haw, pers com, 2004). The owl boxes used for release in Sebokeng were of approximately these dimensions, though the entrance gap was somewhat larger.

While the juvenile owls were kept in the box, the entrance gap was closed with netting to allow air and light in, while safely securing the orphaned owls in the box until they were old enough to fly. In addition, there was a small round feeding hole (about 3 cm in diameter) in the front of the owl box to allow for the insertion of food without the risk of the orphaned owls leaving prematurely (Figure 2.3).

The first pair of owls was set up in the owl boxes on 16 May 2004 at SPS 1 and SPS 3, and the second pair was set up on 7 January 2005, at the same locations. The juvenile owls were kept in the boxes for about 2 weeks, during which time they were fed dead day-old chicks (provided by the Johannesburg Zoo) by the school learners. Three chicks were fed to each owlet daily at dusk.

The learners whistled every time they fed the owls to promote a Pavlovian classical conditioning association with the food. Once the owls had been released by the researcher (i.e. by removing the netting barrier), the learners continued placing the day old chicks on or near the owl box, as the newly released owls would require time to perfect their flying techniques and learn how to hunt effectively before they became fully independent on the supplementary feeding. Often the owls were enticed to the food by the learners' whistles.

The owls returned to the owl box for the food for at least the first week after release. Thereafter, the owls became less dependent on the offered meals, as they became better fliers. Learners gradually reduced the chicks provided to each owl in order to encourage the owls to hunt independently. Gradually, the owls no longer returned to the release boxes for their meals, and the feeding programme was terminated.



Figure 2.3. Owl box being set up at SPS 3

2.2.4 Rat trapping

Snap traps, baited with peanut butter, rolled oats and fruit, and were set by the researcher and the school OWG at SPS 1, SPS 2 and SPS 3 at regular intervals between February 2004 and March 2005. Trapping at SPS 4 (control school with no owls) was set up between May 2004 and March 2005 by the researcher. A total of 15 traps were set for a period of 3 nights at each site, resulting in 45 trap-nights per school per trapping session.

Traps were randomly placed in kitchens, storerooms and along outdoor corridors within the schools, as well as within open veld on the school grounds. Trapping was initiated at SPS 1, SPS 2, and SPS 3 on the 16th February 2004, as these were to be the release schools. The trapping prior to owl release was undertaken to establish baseline conditions that existed on site before external stimuli were introduced to the release schools. On learning that SPS 2 had resident owls on site, this site was converted to a second control site. The other control site (SPS 4), where no owls were introduced, had snap-trapping initiated on the 2 May 2004. The control site did not have trapping carried

out prior to owl introduction as no owls were released at this site and therefore no significant changes were expected in snap-trapping results over time.

Table 2.1 shows the trapping dates for each of the schools. The trapping was only undertaken during school terms as the schools were locked during holiday time and it was not possible to gain access to the areas where the traps were to be set. The learners were assisted by the researcher or participating teachers in setting the traps as we used industrial snap-traps that could be dangerous if not set up properly. The learners checked the traps themselves and were responsible for measuring and weighing the rats, however, the researcher was always present to sex the rats, as this was a more difficult task.

The snap-trapping method for rat capture was initiated after a trial use of live traps was tested in January 2004. Most of the rats were able to chew through the wire mesh to escape the trap and some traps were found more than 50m from the place where they were set. It was decided that the use of snap-traps would be a safer option, as handling live rats can be dangerous, and this would mean that the learners would not be able to do the measuring and weighing themselves. Moreover, rats will have escaped during the handling, thereby making the accurate recording of rat trap results very difficult.

Snap-trapping may have introduced a secondary stimulus into the project and may have skewed the findings of the research, however, as the main aim was to reduce the number of rats in the Sebokeng area and provide a 'hands-on' experience to the learners, the snap-trapping was considered the best option for trapping methodology. The potential impacts of the snap trapping is discussed at length within the discussion in Section 2.4.2.

Trapped rats were weighed to the nearest gram using a kitchen scale and measured (head-body length to the nearest mm). The sex of rats was determined by the anal-genital distances (shorter in females than males) and presence of scrotal testes.

Table 2.1: Snap-trapping sessions at the two control schools (SPS 2 and SPS 4) and the two release schools (SPS 1 and SPS 3) over the duration of the owl release programme.

SPS 1	SPS 2	SPS 3	SPS 4
16 Feb 2004	16 Feb 2004	16 Feb 2004	No trapping
01 March 2004	01 March 2004	01 March 2004	No trapping
22 March 2004	22 March 2004	22 March 2004	No trapping
19 April 2004	19 April 2004	19 April 2004	No trapping
02 May 2004	02 May 2004	02 May 2004	02 May 2004
16 May 2004	16 May 2004	16 May 2004	16 May 2004
07 June 2004	07 June 2004	07 June 2004	07 June 2004
21 June 2004	21 June 2004	21 June 2004	21 June 2004
05 July 2004	05 July 2004	05 July 2004	05 July 2004
21 July 2004	21 July 2004	21 July 2004	21 July 2004
27 August 2004	27 August 2004	27 August 2004	27 August 2004
03 September 2004	03 September 2004	03 September 2004	03 September 2004
17 September 2004	17 September 2004	17 September 2004	17 September 2004
08 October 2004	08 October 2004	08 October 2004	08 October 2004
22 October 2004	22 October 2004	22 October 2004	22 October 2004
05 November 2004	05 November 2004	05 November 2004	05 November 2004
19 November 2004	19 November 2004	19 November 2004	19 November 2004
03 December 2004	03 December 2004	03 December 2004	03 December 2004
07 January 2005	07 January 2005	07 January 2005	07 January 2005
25 January 2005	25 January 2005	25 January 2005	25 January 2005
21 February 2005	21 February 2005	21 February 2005	21 February 2005
07 March 2005	07 March 2005	07 March 2005	07 March 2005

2.2.5 Owl pellet analysis

Owl pellets are the regurgitated masses of the prey hair and bones that the owl does not digest. Owl pellets are usually dropped from a roosting perch by the owl after hunting. I collected pellets on a weekly basis from areas in close proximity to the owl release boxes and known owl roosting sites. Learners assisted in collecting owl pellets over the duration of the project. For the period that the owls were being fed day old chicks, the pellets consisted of chick fluff and these pellets were not analysed.

Once the owls were hunting other prey, the owl pellets were collected and the contents were analysed to determine the prey they consumed. The owl pellets were collected from the released owls as well as from the established owls at SPS 2. A total of 48 pellets were analysed in the laboratory.

For the analysis, the pellet was soaked in 50% alcohol for a few hours, and the contents (only rodent skulls in my study), were carefully extracted and the skull identified by examining the molar tooth pattern. The analysis of the owl pellets was confirmed by Professor Neville Pillay to ensure that the results were accurate.

2.2.6 Data analysis

The total number of rats trapped was expressed as a proportion of trap nights before and after the release of owls and was compared for the SPS 1, SPS 3 using a Fisher's exact test. Comparisons of the proportion of rats among schools when owls were absent or present were made using a χ^2 contingency table. χ^2 tests were also used to determine whether the sex ratio of rodents trapped differed from parity. To compare the lengths and masses of rats trapped, a nested ANOVA was used, in which the schools and sex were independent factors and the presence/absence of owls was the nested factor. Tukey post hoc tests were used to examine specific differences when $\alpha<0.05$.

2.3 Results

2.3.1 Owl Release Programme

The release of the juvenile owls at the two release sites was successful in that the owls were able to hunt successfully on the wing and feed themselves within 14 days of being released from the box; they no longer relied on the dead day old chicks that were supplied after 14 days. In addition, owl pellets indicated that the owls were preying on house rats (see below). This is an important result for the release programme, as it indicates the independence of the juvenile owls in the receiving environment within two weeks of release.

Of the eight owls released within Sebokeng, at least four (50%) of these were observed on site 18 months after the first release. In addition, naturally occurring owls entered the release site and one mated with "Dolly" of Bophelong; the strange owl was recognised because of the absence of an identification ring.

Moreover, only some of the owls utilised the release boxes after they were released and were hunting efficiently. This may be due to the fact that the owls were able to use buildings and trees to roost on and did not rely on the release boxes for shelter and safety. Owls at SPS 3 were seen regularly roosting in a large pine tree on the school grounds. These owls did not return to the owl boxes after release, except to fetch food from the boxes. Owls at SPS 1 were seen at the release box and seemed to utilise the box for sometime after release. Due to the limited timeframe of the project it is uncertain whether the owls continued to utilise the box for any length of time after the release of the second pair of owls at the site.

The fact that the SPS 3 owls were independent of the owl box after release is a good indication that barn owls are able to adapt to semi-urban environments and do not necessarily require nesting boxes to successfully inhabit this type of settlement.

2.3.2 Biological Control of Rats

Table 2.2 indicates any change in the number of rats trapped at each school over the life of the project. Any seasonal changes in rat activity will be indicated within this data set. The data were converted to the proportion per trap night and presented in Figure 2.4. Significantly more rats were trapped at SPS 1 ($p=0.035$) and SPS 3 ($p=0.004$) when there were no owls at these schools (Fisher's exact test).

Table 2.2: Rat numbers trapped at each school over time.

	SPS 1		SPS 3		SPS 2	SPS 4
Date	Before Owls	With Owls	Before Owls	With Owls	Owls on Site	No Owls on Site
16 Feb 04	5		6		2	
1 Mar 04	6		4		1	
22 Mar 04	5		5		1	
19 Apr 04	6		6		2	
2 May 04	4		4		2	6
16 May 04		5		5	1	5
7 June 04		2		2	1	5
21 June 04		5		4	2	4
5 July 04		3		1	1	3
21 July 04		4		3	2	3
27 Aug 04		4		4	1	3
3 Sept 04		2		2	3	2
17 Sept 04		3		3	1	2
8 Oct 04		3		1	1	0
22 Oct 04		2		2	1	2
5 Nov 04		3		2	1	1
19 Nov 04		4		0	1	3
3 Dec 04		3		3	1	1
17 Dec 04		4		2	2	2
7 Jan 05		3		1	1	2
25 Jan 05		1		2	1	2
21 Feb 05		2		2	1	0
7 March 05		1		2	1	2

Two interesting findings emerged from comparisons of schools when owls were present and absent. Firstly, a significantly lower proportion of rats was captured at SPS 2 (with the resident pair of owls) than at SPS 1 and SPS 3 when owls were present ($\chi 22 = 23.96$; $p<0.001$). Secondly, a significantly lower proportion of rats were captured in SPS 4 (no owls present) than at SPS 1 and SPS 3 when no owls were present ($\chi^2_2 = 44.56$; $p<0.001$; Figure 2.4).

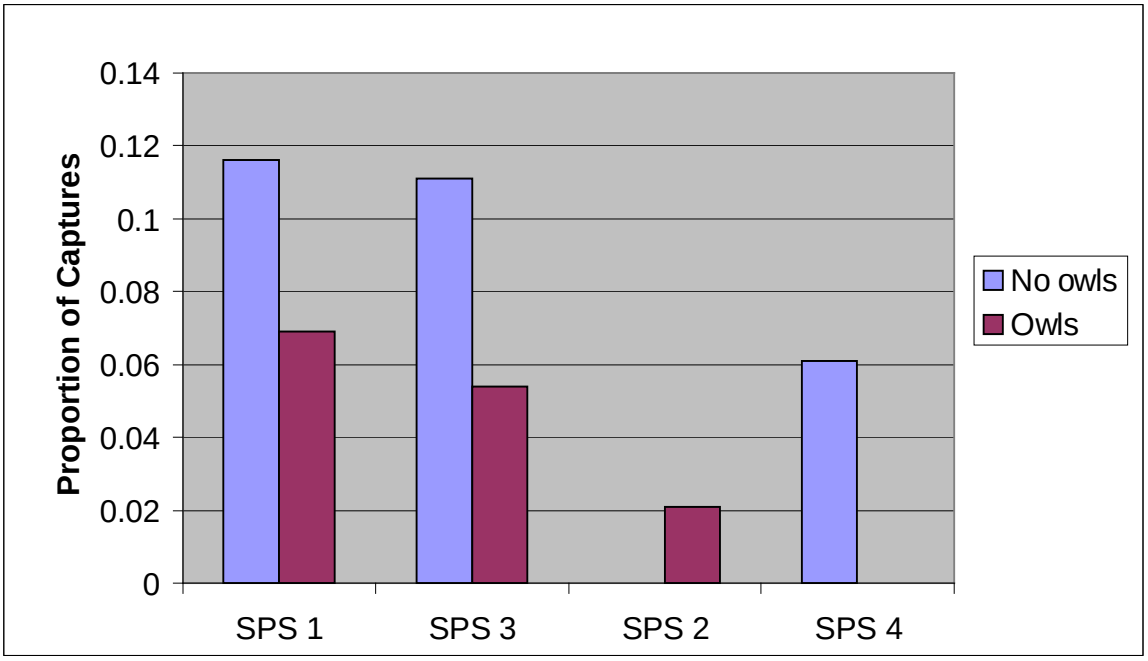

Figure 2. 4. Proportion of rats per trap night for each school when owls were absent and present at the sites

Figure 2.5 provides a comparison of sex ratios of rats (expressed as percentage of males) trapped during the study. In the absence of owls, a similar ratio of males to females were trapped at SPS 1 (χ^2_1 = 2.46; p=0.117), SPS 3 (χ^2_1 = 0.04; p=0.841) and SPS 4 (χ^2_2 = 1.72; p=0.189). However, in the presence of owls, significantly more males than females were trapped at SPS 1 (χ^2_1 = 11.79; p<0.001), SPS 3 (χ^2_1 = 7.05; p=0.008) and SPS 2 (χ^2_1 = 6.55; p=0.01).

Figure 2.6 shows the body length of rats trapped at the four schools when owls were present and/or absent. The school where rats were trapped was a significant predictor of the length of rats (F3,207 = 4.77; p=0.003), with rats trapped at SPS 3 being significantly larger than at SPS 2 (Tukey post hoc tests; Figure 2.6). There was no sex effect (F1,75 = 0.38; p=0.537), but the presence/absence of owls significantly influenced the size of rats (F2,207 = 19.07; p<0.001), with rats being significantly larger in the absence of owls at SPS 1and SPS 3(Tukey post hoc tests; Figure 2.6).

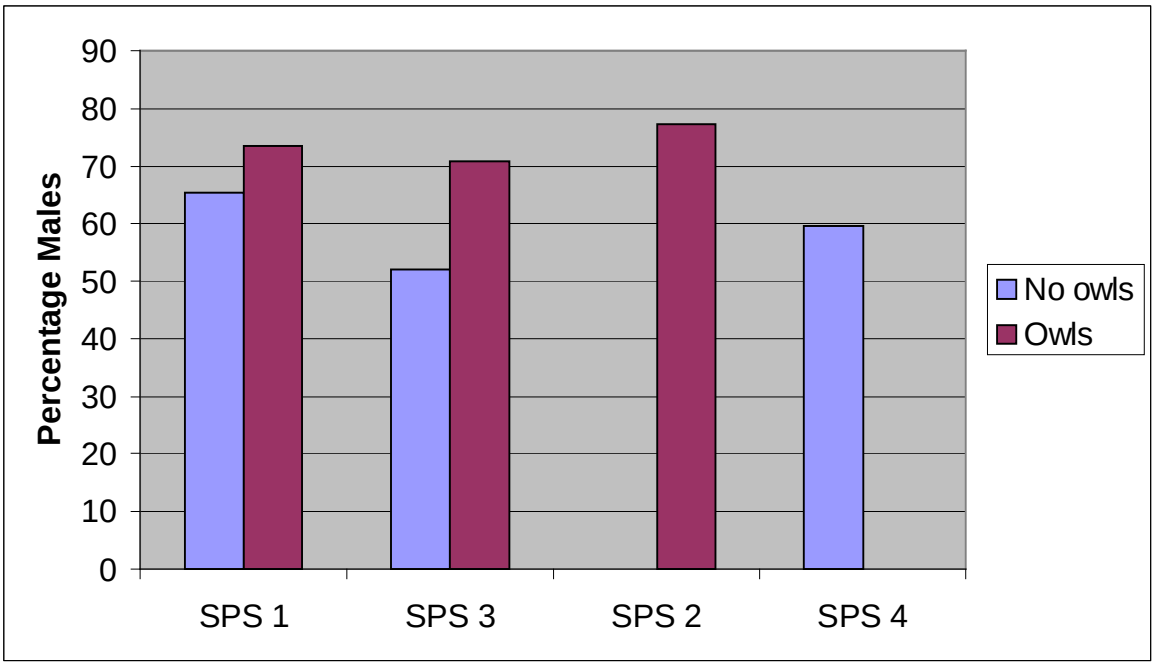

Figure 2.5. Sex ratio, expressed as a percentage of males, of rats trapped at four primary schools where owls were present and/or absent.

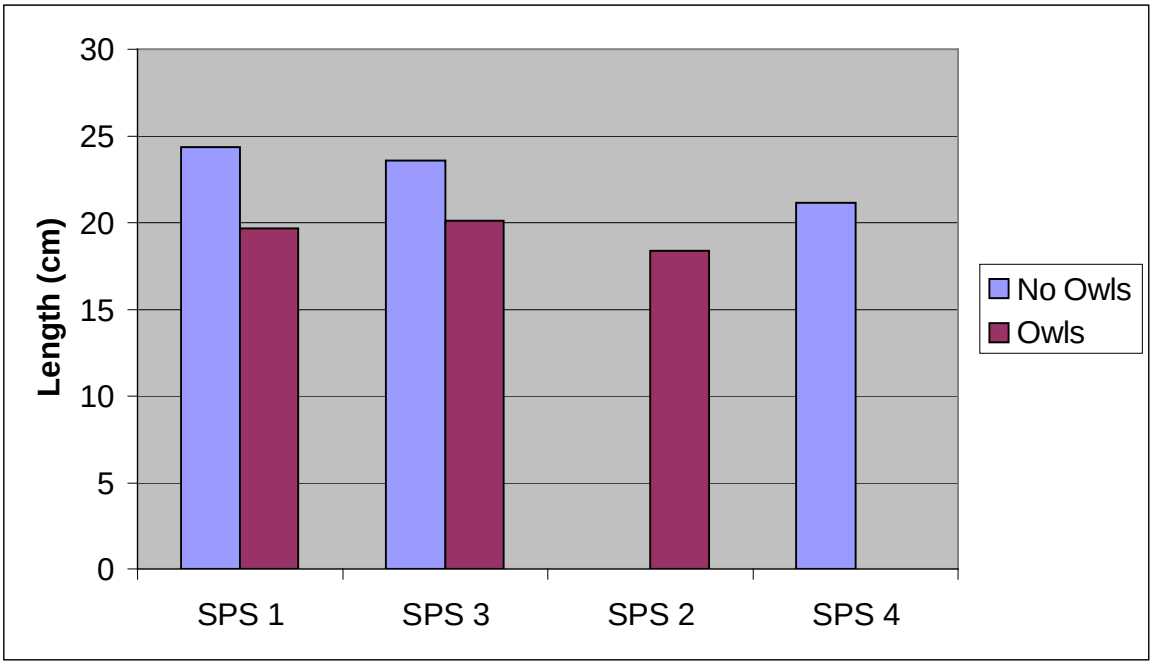

Figure 2.6. Mean (+SE) head-body length of the rats trapped at all four schools when owls were present and/or absent.

Body mass was significantly influenced by the school at which traps were set ($F_{3,207}$ = 3.17; p=0.025). The heaviest rats were trapped at SPS 3 and the lightest were trapped at SPS 2 (Figure 2.7). Neither sex ($F_{1,207}$ = 0.08; p=0.780) nor the absence/presence of owls ($F_{2,207}$ = 2.38; p=0.095) were good predictors of body mass.

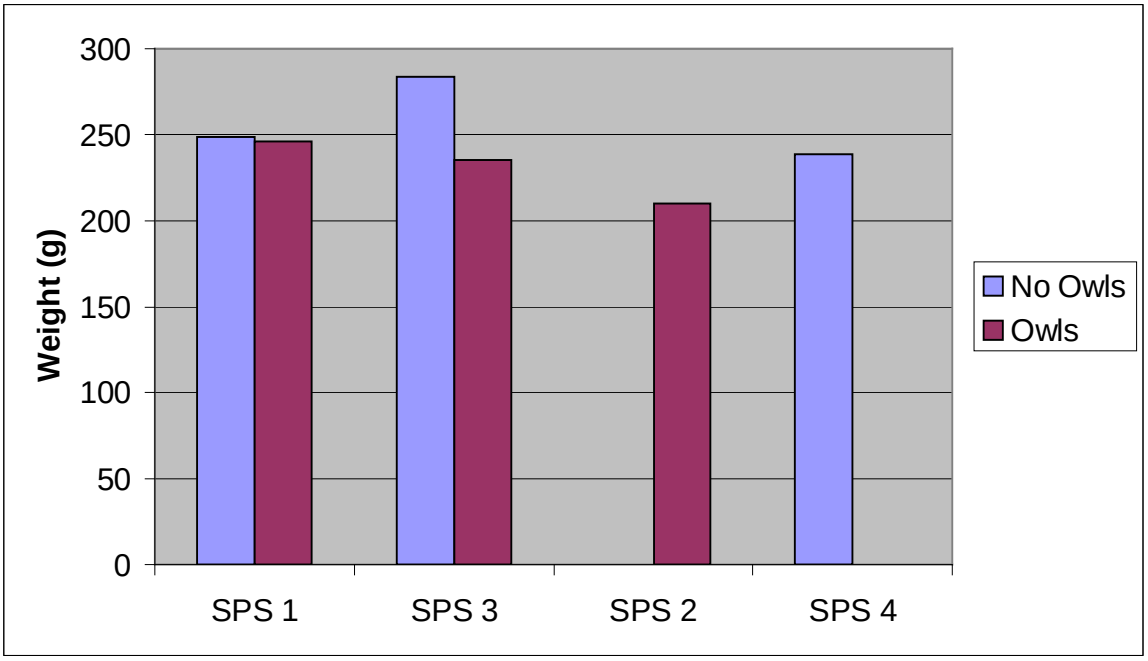

Figure 2.7. Mean (+SE) mass of the rats trapped at the four schools when owls were absent and when owls were present.

2.3.3 Owl pellets

Owl predation on rats was assessed through the analysis of owl pellets collected from the owl roosting sites after their release from the owl boxes. Of the 48 owl pellets analysed, all showed evidence of black house rat skulls, bones and hair. No other prey species was identified in the owl pellets.

2.4 Discussion

2.4.1. Owl Release Programme

The release of barn owls into the Sebokeng semi-urban area was successful, as suggested by the 100% survival of the owls post-release. In addition, the majority of the owls were observed in close proximity to the release sites up to 6 months after release. In addition, one of the owls initiated breeding with a strange male close to SPS 1. This success is most likely due to one or more of four factors, as discussed below.

2.4.1.1.Location of the release sites

The sites were selected to ensure that the owls were provided with sufficient open space for hunting. The three schools utilised as release sites were located within 5km of large areas of open space. These open spaces provided owls with areas for hunting and for establishing nesting and roosting sites over the long term (see Andries *et al.*, 1994).

In addition, the release sites were more than 10km from a highway and large road networks (N1, R57 and R42). This is important as owl mortality on large roads is a major concern when releasing owls into new habitats: owls often scavenge on 'roadkill' and are blinded by oncoming headlights while feeding on the road (Ansara; 2004). The Barn Owl Trust (2006) has found that an estimated 30% of all barn owl deaths can be attributed to road accidents. This is second only to starvation which is estimated to be the most common cause of death at 50% of all mortalities. During the 18 month programme, no released owls were killed on the road.

2.4.1.2. Environmental education and community awareness

The environmental education programme was initiated a month before the owls were introduced. From initial meetings and talks with the teachers, learners and neighbours of the proposed release sites, it was evident that cultural lore, ignorance and fear related of the owls were the major risks to the survival of the owls (Makobela, *pers com*, 2004).

The awareness campaign ensured that most local residents were aware of and participated in the owl release programme. The understanding by residents of the owls' ability to control rats in the area assisted in generating a more sympathetic stance by the community to the project.

Without the environmental education and awareness campaign, there is little doubt that the residents would have killed or chased away the owls. Prior to the initial awareness meeting, the community were not prepared to have the owls introduced into their neighbourhood. Two years after the owl release programme, some residents still reported owl sightings and activities.

2.4.1.3. Extensive available prey base and secure nest sites

The availability of prey at the release sites ensured that the owls did not have to travel far from the release site to hunt and feed. The owls were able to successfully capture and kill rats on site. With small rodents indicated as the preferred prey for barn owls (Carmona & Rivadeneira, 2006; Tores *et al.*, 2007), the availability of rats on site provides the owls with ideal hunting conditions. Moreover, the owls had access to release boxes as nest boxes, which protected them while feeding and provided secure roosting and nesting structures.

2.4.1.4. Resident owls in vicinity of release sites

The existing resident owls at SPS 2, and potentially within adjacent areas, provided potential mating opportunities for the released owls. There was a chance that the released owls would pair up amongst themselves, but the difficulty in sexing juvenile owls meant that there may not have been an adequate number of mates available. In addition, many of the orphaned owls sourced from the rehabilitation centre were from the same clutch of eggs and were related. Therefore, they might not have paired up for breeding and an existing population of barn owls in the area would be necessary to provide breeding mates to the released owls.

One of the released owls ("Dolly") of SPS 1 paired up with a resident owl. The fact that the pair remained within the release area and were observed to have nested and produced young indicates that such a release programme could be viable in semi-urban areas.

During the owl release, the territoriality of owls was considered, and there was the chance that resident owls would be aggressive to the released owls. Barn owls usually have a territory of about $5km^2$ (Carmona & Rivadeneira, 2006). However, in the present study, the resident owls were not observed to be territorial, as occurs in some small mammals (Ostfeld, 1985). This may have been due to the abundance of available prey. Indeed, owls were released 500-800m apart and appeared not to engage in aggressive behaviour.

2.4.2 Biological control of rats

The efficacy of the biological control of rats through the introduction of barn owls was assessed by trapping rats while owls were absent as well as after the release of the owls at SPS 1 and SPS 3, and all the time at SPS 2 and SPS 4. The trapping data indicate that owls potentially have an impact on rat numbers, since significantly fewer rats were trapped when owls were present than absent at SPS 1 and SPS 3. There is a possibility that the rats became "trap shy" over time. However, over the period of the study, more rats were trapped at SPS 4 (no owls on site) than at SPS 2, where there was a pair of resident owls. The number of rats trapped at SPS 4 and SPS 2 did not show a significant decrease over time, which would have been indicative of "trap shy" behaviour. The trapping rates at SPS 1and SPS 3showed a significant decrease in numbers over time and this provides evidence that the introduction of owls had impacted on the numbers of rats trapped.

A significantly lower proportion of rats was captured at SPS 2 than at the other two release schools (SPS 1and SPS 3) when owls were present at all three schools. The SPS 2 breeding pair had been nesting at the school for a number of years, as evidenced by owl pellets and other signs of long term habitation. Teachers at the school indicated that the owls had hatched a batch of owls twice a year for at least the previous three years (Luthuli, pers com, 2004). The long-term presence of owls on site would have impacted on rats at SPS 2.

Prior to owl release, the number of rats trapped at SPS 1 and SPS 3 was more than at SPS 4 (no owls present). SPS 1, SPS 3 and SPS 2 are located in close proximity to at least one informal dumping site. This would have provided ample food sources for rats and which would have supported a large rat population. SPS 4 did not have a dumping site in close proximity to the school.

There were also other demographic influences in respective of the sex ratio and the size of rats trapped. When no owls were present (SPS 1, SPS 3, SPS 4), the ratio of male to female rats trapped was close to parity. However, with the introduction of owls to the sites, significantly more male than female rats were trapped. Reasons for the reduction in female rats snap trapped during owl presence are not apparent, although there may be five explanations for these findings, as discussed below.

1 If owls are selectively preying on female rats, more male rats will be trapped in the snap traps. Several studies on owl predation and sex preference of prey argue that there is a correlation between the sex of the rodent and the selective predation by owls

(Marti & Hogue, 1979; Dickman & Predavec, 1991; Bellocq & Kravetz, 1994; Trejo & Guthmann, 2003). These studies showed that one sex was preferentially preyed upon, depending on the species of rodent.

However, barn owls are opportunistic rather than selective hunters (Tores et al., 2005), taking the easiest or most abundant prey rather than selecting for a specific characteristic of their prey (Yom-Tov & Wool, 1997). Sommer (1999) investigated sex-specific predation on giant rats, *Hypogeomys antimena*, by a small mammal carnivore, *Cryptoprocta ferox*, and a boa, *Acrantophis dumerili*, and found that the preferential predation on one sex was directly correlated with prey behaviour: although both male and female giant rats travelled similar distances to forage, males travelled further from the nest and were victims of predation more often than females. Similar behavioural differences could have influenced the predation of females over males by the barn owls in the present study. However, sex-specific behaviour of was not monitored in this study, so no conclusions can be drawn. It has been established that male lizards travel further from the nest during foraging than females (Stuart-Fox, et al.; 2002). From the aforementioned studies, one would expect more male rats to be preyed upon due to the distances travelled.

2 The reduction in the numbers of females trapped may not be related to the introduction of owls, but rather to females learning to avoid the traps over time (see Griffin & Evans, 2002). However, the trapping data from SPS 2(with the resident owls) showed that more males were always trapped throughout the study. Similarly, at SPS 4(no owls) equal numbers of each sex was trapped throughout the study. Thus, there is no evidence of females learning to avoid traps at both these schools.

3 Trejo & Guthmann (2003) reviewed owl selection of prey by size and sex of rodents, and found that the more active individuals were more vulnerable to owl predation. Individuals that moved into open areas and were more active in these areas were preyed upon more often (Dickman *et al.*, 1991). If so, females may have been more active than males in my study.

4 It is possible that the female rats become less active and leave the nest less frequently in order to avoid predation. Male rats spend more time defending their territories and seeking out mating opportunities (Solomon, 2003), making them more vulnerable to snap trapping as well as owl predation. This argument is supported by the fact that an equal number of male and female rats were trapped at the SPS 4site, where no owls

were introduced, while at SPS 1, SPS 2and SPS 3, more male rats were trapped when owls were present at the sites.

5 It is likely that the increase in male rats in traps is not related to the presence of owls at all, but is merely a coincidence.

It is important that the possible preference of barns owls to prey on female rats be investigated further. A follow up study to assess whether female rats are quicker learners and avoid rat traps, or are being preyed on preferentially by the barn owls. Once this has been established, the potential preference for female rats should be investigated and correlated to gender specific rat foraging patterns and behaviour. If barn owls do preferentially prey on female rats, this would provide an even stronger motivation for barn owls as biological control agents for rats, as preying on female rats is an effective method to reduce the breeding potential of the rat population.

Longer rats were trapped prior to owl release than after owls were present. There are three potential reasons for this finding.

1 As with sex of prey, owls may be selecting for larger rats (Marti & Hogue, 1979 Dickman et al., 1991; Trejo & Guthmann, 2003). However, another study indicated that owls usually select smaller individuals and avoid heavier individuals (Trejo & Grigera, 1998).

2 Longer rats are older animals that become less active when owls are present and therefore less likely to be trapped (Griffin & Evans, 2003).

3 The change in rat size could be an anomalous consequence of larger rats being captured at the start of trapping and the remaining smaller rats are trapped later.

2.4.3 Owl predation on rats

All the owl pellets collected contained remnants of house rats. However, the owl pellet sample was quite small, and although it is reasonable to assume that the barn owls prey mainly on black house rats, one cannot rule out that other prey is being taken. Other studies indicate that barn owls prey on several rodent species and other small mammals (Meek *et al.*, 2003; Trejo & Guthmann, 2003; Carmona & Rivadeneira, 2006). Nonetheless, this is a positive finding in that it indicates that the owls are preying on the target species and that this predation may provide a long term control mechanism for the house rat within the Sebokeng semi-urban area.

However, very few studies have provided documented evidence of owl efficiency in rat predation. Three studies provide some evidence for the efficacy of owls in rodent control. Wood & Fee (2003) studied various methods of rat control in Malaysian agriculture since the 1960s, and provide inconclusive evidence for the efficacy of using barn owls to control rats, *R. tiomanicus, R. argentiventer, R. exulans* and *R, rattus duardii*, in oil palm plantations and other cultivation areas, mainly because of inconsistent reporting on the effect that the owl presence on site had on rat activity. In contrast, in Argentine Patagonia, Trejo and Guthmann (2003) found that 98% of Magellanic horned owl, *Bubo magellanicus*, pellets contained rodent remains. These remains consisted of the sigmodontine rodents *Eligmodontia morgani, Akodonxanthorhinus, A. longipilis, Reithrodon auritus* and *Oligoryzomys longicaudatus*.

Kittlien (1997) found that owl predation on the sigmodontine rodent, *Akodon azarae*, did not demonstrate that naturally occurring owls have any effect upon the abundance of small mammals. However, in this study, an experimental increase in predator abundance showed a significant decrease in the prey population.

2.4.4 Conclusion

The barn owl release programme has been successful in terms of the survival and establishment of the owls in the receiving environment. Meek *et al*. (2003) undertook a 21 year study on the success of owl release in southern England. Fifteen years after the last release, the owl population at the release sites was still increasing. This provides evidence that the successful release of owls can be sustainable over the long term. While the Sebokeng release programme was successful in the short term, a longer term programme is required to assess the sustainable release of owls into a South African semi-urban environment.

In the Sebokeng study, the barn owls released at the three primary schools had a definite impact on the house rat population biology. These results support preliminary evidence from studies by Trejo and Guthmann (2003), Kittlein (1997) and Wood and Fee (2003) about the success of owls as biological control agents for rats. Long term studies such as the one undertaken by Meek *et al.* (2003) should be initiated to include evaluations of: owl release and establishment of the owls at the release site; the success of owls as biocontrol agents of rats; and the long term sustainability of this predator-prey relationship within the South African semi-urban context.

CHAPTER 3. ENVIRONMENTAL EDUCATION

3.1.Introduction

3.1.1. Environmental Education

Environmental education is organised knowledge transfer, focusing on natural environmental processes, functions and habitats (Makoni, 2000). It is the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand the importance of the environment to human survival (Palmer, 1998).

Environmental education aims at teaching communities about the impact of human beings on natural ecosystems and how adaptive human behaviour and resource utilisation can facilitate a sustainable relationship between humans and natural environmental systems (Palmer, 1998). The current trend in environmental education has moved away from an approach of ideology and activism to an approach that allows the target learner to make informed decisions and take action based on firsthand experience, as well as documented data (Malone, 1999).

In Africa, various organisations have been formed to facilitate environmental education, particularly in the SADC region (SADC REEP, 2007). In 1993, the Southern African Development Community Environment and Land Management Sector (ELMS) initiated a programme to support organised environmental education initiatives in southern Africa. The purpose of the Regional Environmental Education Programme is to assist environmental education practitioners in the SADC region to provide knowledge transfer to facilitate sustainable environmental management choices in Southern Africa.

Environmental education policies have also been strengthened to provide a stable structure to the education initiative in SADC countries. In 1992, the United Nations Conference of Environment and Development (Rio Earth Summit) gave high priority in the Agenda 21 to the role of education in enabling sustainable development (Palmer, 1998). The focus of chapter 36 of the document was focused on education in order to nurture the conservation values and respect for natural resources necessary for environmental conservation, social justice and sustainable development (SADC REEP, 2007).

Within the South African context, environmental education is crucial in previously disadvantaged areas, where communities are predominantly illiterate and do not have access to education, and are not exposed to environmental issues due to their general isolation from available information on the internet, television, newspapers and radio talk shows (Malone, 1999). Moreover, it is the lower income community who is utilising natural resources on an intimate basis; i.e. burning of wood, paraffin, coal, as well as the use of surface water bodies for domestic water use (SADC REEP, 2007).

For these reasons, the Sebokeng owl release programme targeted a previously disadvantaged community and utilised Outcomes Based Education (OBE) principles as tools to provide knowledge transfer in the form of environmental education.

3.1.2. OBE as a tool for Environmental Education

Outcomes Based Education (OBE) was introduced by William Spady in the late 1990's (Spady, 1997). OBE works on the principle that outcomes should be produced from the learning experience. According to Gultig (1999), the learner needs clearly defined learning outcomes and associated performance indicators as a foundation for the learning experience.

OBE places more emphasis on the learner actively constructing knowledge rather than the passive transfer of knowledge from the teacher to the learner group, which is the traditional South African teaching method (Palmer, 1998). The teacher is the source of information and the learners are the receptors, with little interactive learning required. The traditional schooling approach relies somewhat on "rote learning" with integral understanding by the learner a secondary objective (Rogoff; 1990). In the traditional system, the teacher is the only source of information and interaction with other learners in the classroom is discouraged (Krashen; 1982).

The OBE method, which has been adopted in South African public schools, is adapted to Vygotsky's concept of the zone of proximal development, which identifies the difference in the levels of intellectual difficulty that learners are able to comprehend (Vygotsky, 1978). Learners each have a zone of knowledge, called 'i'. The extent of this knowledge zone differs from one learner to another. The level of difficulty that a learner can comprehend is called i + 1.

By working in groups, learners' individual zones of knowledge and the levels of difficulty they are able to comprehend overlap. This means that learners can assist each other in gaining knowledge and extending their zones of comprehension (Vygotsky, 1978; Meyer, 2000). Vygotsky (1978) viewed the most effective social interaction as a joint problem solving exercise, with guidance by a person more skilled in that particular topic than the rest of the group.

Rogoff (1990) expressed similar views in her 'Apprenticeship Learning' concept, which encourages learning as a social practice involving more than simply allowing the learners to collaborate in a group. Each 'Apprenticeship Learning Group' must contain at least one learner who is more skilled in the task (Meyer, 2000). This skilled learner will then provide an i + 1 zone to assist other learners in comprehending knowledge beyond their own proximal development zones (Rogoff, 1990). Children thus relate to groups of peers in a way that they are unable to relate and interact with adults because their zones of proximal development overlap and they are able to communicate with each other more easily.

Thus, Vygotsky (1978) and Rogoff (1990) agree on some level that learners provide knowledge transfer and increase their own learning capacity through participation in a problem solving exercise, interacting with more experienced members of the group who help to guide the rest of the learners to a solution.

Krashen (1982) suggested that a 'comprehensible input' needs to be offered at the correct level in order for the learner to be able to digest and use the information. This means that weaker learners are unable to understand the level at which a teacher provides knowledge, but that this information can be translated by another student in the class into a form that is easier for the weaker learner to comprehend.

There are different levels at which information can be absorbed and these levels are important for the education of all learners in the class. Thus, the most proficient learner can translate inputs from the educator into a form more easily comprehensible to an average learner, and, similarly, the average learner can provide this same information at a suitable level to enable the weaker learners to also understand and absorb this knowledge (Meyer, 1998). John-Steiner (1985) reiterates this principle by stating that an understanding of a specific idea or process is more easily comprehended by interaction of a group with a knowledgeable person than by studying the same knowledge while in an isolated manner (without the interaction and input from peers).

Kutrick (1994) stated that, in accordance with social psychological theory, small groups enhance co-operation and allow for individual achievement where each member of the group is equally accountable for some aspect of the group achievements. Furthermore, the multi-literacies pedagogy produced by the New London Group (1996; 2000) encourages that learners should benefit from learning in ways that allow them to participate fully in public community and economic life.

The principles of OBE encourage the introduction of innovative teaching methods and an interactive approach to learning (Makoni, 2000). The present study provides an opportunity for learners to interact with the researcher, to form and work in groups to observe owl behaviour and feeding requirements, and to participate in informing the community of the project. It was anticipated that the students would be an important link between the researchers and the community in the vicinity of the study sites.

3.1.3. Conceptual Change Theory

Posner *et al.* (1982) define conceptual change theory as " . . . the constructive notion that all learning is a process of personal construction and that students, given the opportunity, will construct a scientifically orthodox conception of physical phenomena if they see that the scientific conception is superior to their pre-instruction conception." (Cobern, 1995, pg 2). Novak (2002) assessed that conceptual change is reliant on learners actively integrating new knowledge with existing knowledge. Nersession (1989) has suggested that traditional teaching methods to not successfully facilitate conceptual change in scientific thinking by learners. She recommends that active cognitive knowledge construction is encouraged and that passive knowledge transfer is not effective in changing learner perception in science education.

Within the owl release programme, first hand experience with the owls, the snap-trapping and the collection and analysis of owl pellets, provided the learners with evidence for barn owls as control agents for rats. Moreover, the learning process was not through passive knowledge transfer, but relied on active knowledge construction through experiential learning. This type of learning experience is recommended by Strike and Posner (1982) in their article on conceptual change and science teaching.

From the results of the environmental education, it is evident that many of the learners have changed their perception of the owls through working with the release programme. This change in knowledge and common sense conceptions can be attributed to

experiential learning and knowledge construction by the learners involved in the owl working group.

3.1.4. Other Environmental Education Tools

Methods for Environmental Education are moving away from traditional classroom schooling to more experiential education (Acorn Resources, 2007). The trend in environmental education is to provide the learner with outdoor activities that bring the learner into contact with the environmental element he/she is learning about. Some of these activities include mapping tasks, outdoor camping excursions, orienteering games and outdoor night-time excursions. The Acorn Resources website (www.acornnaturalists.com) provides a list of different activities constructed to assist in environmental education of school learners. Each activity is focused on knowledge transfer of a specific environmental element, e.g. "bird activity", "freshwater ecosystems" and "weather and climate" learning activities.

Where learners are unable to experience outdoor learning, classroom activities have been recommended to provide an experiential knowledge transfer. These activities include group work where, for example, learner groups construct an edible wetland out of food materials (Illinois EPA, 2007).

In Third World or developing countries, the high rate of low-income communities means that resources for environmental education are not available to a large percentage of the national population (Kunzmann & Dericioglu, 1983). In South Africa, experiential environmental education is most easily provided through outdoor activities and interaction with the environment, as was implemented during the owl release programme. Word of mouth knowledge transfer from the learners involved in the release programme to their friends and families is also an efficient means of communicating the learning principles and is not resource-intensive.

3.1.5. How the Sebokeng environmental education objectives were reached

There are five objectives of the Sebokeng environmental education study:

1. Introduce learners to an ecocentric view of owls and their niche in the food chain, while not dismissing their cultural beliefs. This was done by the researcher and the teachers through exposure of the learners to the owls and the provision of information on owls and their role in the food chain by teachers in EMS classes.

2. Encourage learners to investigate scientific thinking and to gain an understanding of the value of conservation efforts. The researcher and teachers achieved this by giving the learners assignments that required scientific thought and by introducing simple environmental principles such as not dumping waste, and not killing animals that are useful to us.
3. Facilitate processes whereby learners understand the importance of owls in the natural ecosystem. This was highlighted through experiential learning during the release programme whereby learners could see evidence that owls were preying on rats (owl pellets) and could begin to understand and appreciate owls as biological control agents.
4. Encourage group work by learners to produce a specific deliverable, e.g. a monitoring programme. This method utilises outcomes based education principles as tools for environmental education. OWG had to work together to monitor owls, feed owls and manage the rat trapping. In this way they gained knowledge through each other.
5. Ensure that learners become involved in a community awareness programme that facilitates the participation of the community in the owl release programme. The learners presented posters at the community meeting and gave talks on their experiences with the owls. In so doing, they became an integral part of the awareness campaign.

The first-hand experience of the learners with the owls provided the mechanism for knowledge transfer and experiential learning by the members of the owl working groups. OBE principles were utilised to encourage learners to interact with the owls and to formulate their own perceptions. Moreover, involving the learners in the community awareness programme encouraged them to investigate the usefulness of owls independently, and express their views to the community at public meetings. In addition, by making groups of learners responsible for the feeding and observation of the owls, the group members learnt to work together and to liaise with each other, the teachers and me, in order to carry out their tasks effectively.

The researcher developed a questionnaire with assistance from Jonathan Haw, and participating teachers from the schools. One of the teachers who helped to compile the questions for the questionnaire had studied psychology at a tertiary level and she provided input in terms of minimising the risk of ‘leading questions’. The questionnaires were completed by learners from SPS 1, SPS 2, SPS 3 and SPS 4 prior to the initiation of the

owl release programme. SPS 1and SPS 3 learners completed an identical questionnaire once the owl release programme had been completed and owls were resident at these schools. The answers given to the questionnaires were used to evaluate the learners in terms of their perceived value of owls in the environment and their knowledge about owls. The effect that the experience of owls on site (SPS 2) and the environmental education (SPS 1and SPS 3) had on learners was also assessed through the questionnaire analysis.

3.1.6. The Revised National Curriculum Statement critical outcomes

The Revised National Curriculum Statement envisages that learners will be able to:

1. Identify and solve problems and make decisions using critical and creative thinking.
2. Work effectively with others as members of a team, group, organisation and community.
3. Organise and manage themselves and their activities responsibly and effectively.
4. Collect, analyse, organise and critically evaluate information.
5. Communicate effectively using visual, symbolic and/or language skills in various modes.
6. Use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
7. Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.
8. Reflect on and explore a variety of strategies to learn more effectively.
9. Participate as responsible citizens in the life of local, national and global communities.
10. Be culturally and aesthetically sensitive across a range of social contexts.
11. Explore education and career opportunities.
12. Develop entrepreneurial opportunities.

(RNCS, page 4)

The owl release programme has had an influence in allowing learners to achieve above outcomes through the process of group work, experiential learning, and critical thinking. Moreover, the learners were involved in community awareness, which will prepare them

for future participation in their school and working careers, and will assist them in communication, which will be required throughout their lives.

3.1.7. Curriculum Structure under RNCS

In 2000, a committee was appointed under the Minister of Education to design and finalise 'Curriculum 2005'. This entailed the development of teacher orientation and training, the development of learning materials, and the provision of teacher support systems. Recommendations by the committee included the following:

1. Streamline design features;
2. Simplify language;
3. Align curriculum and assessment;
4. Improve teacher training;
5. Improve learner support materials; and
6. Improve provincial support.

The environment is categorised under Natural Sciences (NS) and is no longer taught as separate and independent Biology or Science subjects. The Revised NCS addresses principles of social justice, respect for the environment and human rights. The NS includes issues such as poverty, inequality, and HIV/AIDS.

The new curriculum has become more practical and orientated along the achievement of life skills, rather than academic rote learning of theory. This curriculum better prepares the learner for the challenges of starting a career and/or selecting tertiary studies.

The participation in the owl release programme will hopefully assist learners in achieving skills that will stand them in good stead for future life challenges.

3.2.Methods and Materials

3.2.1. Study Site

The study site for the environmental education included SPS 4, SPS 1, SPS 2 and SPS 3 within Sebokeng (See Section 2.2.1). The schools were located within the Bophelong and Evaton areas of the township and were within 20km of each other. Each

school had capacity to accept approximately 1000 learners, with SPS 3 having over 1300 registered learners. The teacher-learner ratio of classes at each school ranged from 1:35 to 1:60.

The learners were predominantly Sotho speaking, but the SPS 3 learners also spoke Xhosa. Learners resided within Sebokeng and came from low-income households, with a large percentage of the learners living in metal shacks. The schools provided lunch to learners, and in many cases, this was the biggest (or only) meal the learners received for the day. Teachers were generally Sotho speaking and resided within Sebokeng and surrounding residential towns (e.g. Vanderbijlpark).

The schools comprised of some brick classrooms and offices (as in the case of SPS 1), but were predominantly prefabricated structures. The number and size of classrooms was limited. At SPS 3, the head master's office was a small prefabricated room.

The schools did not have libraries, computers or any other source of learning material for the teachers to use. Textbooks were not available to the learners in most cases and the education process was hampered by a lack of qualified teachers in the area. However, the teachers who assisted and participated in the owl release programme were extremely dedicated and many were studying part-time to improve their qualifications.

SPS 4 was the control site and no owls were released at this school. However, a learner group was selected and were asked to complete the questionnaire at the start of the project. Thereafter, the learners from this group assisted with snap trapping of rats. however, no Owl Working Group (OWG) was established at this school and the learners were less involved than the OWGs from SPS 1, SPS 2 and SPS 3.

3.2.2. Initial Teacher and Learner Awareness

The headmasters of schools identified for the owl release programme were approached and given background information regarding the proposed project. The biology and science (EMS) teachers were also consulted in order to assess whether the learners would be able to assist with the project under teacher supervision. A presentation was given to the teachers and all school learners to provide the aims and methods of the project. A discussion was facilitated with teachers and learners to assess the feasibility of the project within their schools.

Once the headmaster and teachers had agreed to participate in the project, the teachers at each school selected a learner sample group. These groups consisted of

between 10 and 12 learners from Grades 6 and 7, who were between 12 and 14 years of age. The learners in these groups completed a questionnaire (see below) on their perceptions of owls prior to any experiential work being undertaken.

A knowledge transfer process was undertaken. Where possible, books and photocopied material relating to owls and their predation on rats was made available to the schools. Orphaned owls were brought to the schools and the adaptations of the owls for hunting of rats were discussed, and focused particularly on their silent flight, night vision and superior hearing for location of prey. In addition, learners and teachers highlighted cultural mythology relating to owls and discussed their own beliefs relating to owls as omens.

A sangoma was visited by the researcher and some of the teachers to investigate the use of owl body parts in traditional medicine to set the context for cultural lore relating to owls in semi-urban South Africa (Marcot, 2000). In this way, the cultural beliefs of the local community were investigated, and were not dismissed through the environmental education process.

3.2.3. OBE as a tool for Knowledge Transfer

After the initial introduction to the project and the schools, the learners, teachers and I had a better understanding of the complexity of the study and the tasks that would need to be undertaken by the responsible parties.

The project was set up to provide a group learning experience utilising OBE principles. Learners were able to gain knowledge through first-hand contact with the owls. The learners were also encouraged from the outset to formulate their own opinions and conclusions relating to the usefulness of owls within their community. The teachers and myself supplied supporting information and assistance, but the majority of the learning experience was through group participation and interaction. In this way OBE teaching methods were used to provide the learners with the resources to make independent and educated decisions about the natural environment and owls in particular.

3.2.4. Subjects

The teachers at the release schools and the control schools handpicked the learners used in the experiments. The learner groups at all four schools comprised of both male

and female learners of more or less equal numbers in each group. The learners were able to converse and write in simple English.

At SPS 4 (control school) the learner group was utilised for the initial questionnaire only and was not involved in any additional participation with the release programme. At the original release schools (SPS 1, SPS 2 and SPS 3), these learners formed the "Owl Working Group" (OWG) of their school. The OWG at each of the three schools was established in late March 2004. They were paired off and tasks were delegated to each pair. One learner from each group was responsible for documentation of all observations of the owls within the release boxes. Another learner was responsible for snap trapping rats (see Chapter 2). The OWGs were initially prepared for the owl establishment at the schools and were provided with reading material on owls and their role in the ecosystem. SPS 2 established an OWG before it was known that a resident pair of owls was nesting at the school. However, even though this school became a control school, the OWG was maintained and the learners recorded observations of the owls at their school and became involved in the community awareness programme.

During the time that the owls were in the boxes and for a period of one month after the owl release, the OWGs assisted with the feeding of the orphaned owls at SPS 3 and SPS 1. In addition, the OWGs at SPS 3, SPS 2 and SPS 1 made posters for the awareness campaign and documented the behaviour of the owls for their own learning purposes. The OWGs also assisted with trapping and measuring of rats. The learners were assisted in all tasks listed above for the first week of the project by me and teachers who volunteered to participate in the project.

The learning experience was predominantly through first-hand contact with and observation of the owls at the site. Furthermore, the learners were encouraged to interact within the group and gain knowledge from each other as suggested by OBE learning principles (Spady, 1997). The education was facilitated outdoors and through liaison with the community. Thereby, the learners were able to transfer their knowledge to other Sebokeng residents, in their own language, referencing their own experiences with the owls. In this way, learning was experienced through the OBE principles, rather than the traditional schooling method.

3.2.5. Owl release

The working group learners at the release schools were responsible for feeding the owls and were divided into pairs. Each pair of learners had to feed the owls on a specific day (or days) a week. Dead day-old chickens were obtained from the Johannesburg Zoo and were kept frozen in the fridge at SPS 1. None of the other schools had freezer facilities and had to collect their chicks from SPS 1 each morning and thaw them before the afternoon feeding time. Each owl was fed 3 day-old chicks at approximately 4pm each day. During feeding, the learners would whistle to alert the owls to the availability of food. Over time, the owls associated the whistling with food and this became important once the owls were released from the boxes and required feeding for the first few weeks.

During the period that the owls were within the boxes, the learners recorded observations relating to the owls' behaviour (e.g. vocalisations, or interaction with each other), appetite (e.g. the number of day-old chicks that each owl ate per day) and development (e.g. the change in feather coverage from downy feathers to flight feathers). This facilitated a bonding of the learners to the owls and an experiential understanding of the owl physiology. The learners named their owls and documented personality attributes to the owls.

3.2.6. Rat trapping

Rat trapping took place at all four study schools. Trapping at SPS 1, SPS 2 and SPS 3 was initiated 3 months prior to owl placement at the release schools and continued for the duration of the project (13 months). Trapping at SPS 4 (the control school) was initiated when owls were released at SPS 1 and SPS 3 and continued for the remainder of the project (10 months). Learners at all four schools were provided with snap traps and bait and were assisted in setting the traps. The trap locations were randomly selected along known rat "corridors" to and from sources of food at the school kitchens and store rooms (see Chapter 2 for details).

The OWG recorded the number of rats trapped during each trapping session. I assisted with the sexing of the rats. The learners were provided with measuring tapes and kitchen scales and were responsible for the recording of the lengths and weights of the rats trapped. The initial trapping, weighing and measuring was done as a group with advice from me and from the teachers. Subsequent tasks were completed by the learner groups with some assistance where required. Rat trapping at SPS 4 as undertaken by myself with

assistance by the OWGs from the original release schools (SPS 1, SPS 2, and SPS 3) despite SPS 2 becoming a control school after identifying resident owls at this school.

3.2.7. Community Awareness Campaign

A community awareness campaign was launched. School newsletters were sent out once a month and included information on the owl release programme. In addition, the OWG learners produced posters about their owls and how owls could be useful in controlling rats in Sebokeng. A community meeting was held at SPS 1 and the OWG gave presentations on their experience with the owls in their own languages. This ensured that the local community was made aware of the project and perhaps gained some knowledge relating owls and their role in combating rat infestations.

After the community meeting many of the surrounding residents became involved in the project and would inform the school if they spotted one of the owls. Local residents also reported less rat activity within their homes since the release of owls.

3.2.8. Evaluation of learners

Prior to having any contact with the owls or undergoing any knowledge transfer, the learners selected for the Owl Working Groups were asked to complete a questionnaire (Figure 3.1). At SPS 3 and SPS 1, questionnaires were filled out on 16 February 2004 before the owls were released and again on 25 January 2005 when the owls were established. At SPS 2 and SPS 4, the questionnaires were only completed by the learners at inception of the project, on 16 February 2004.

The questions were aimed at assessing the beliefs of the learners relating to owls and having owls at their schools. The questions were phrased to avoid leading the learner to an answer, where possible. The questionnaire also provided information relating to learner cultural beliefs and the stigma attached to owls. The questionnaires were printed in English, but each question was explained in Sotho and/or Xhosa by the teachers assisting in the project in order to facilitate a better understanding by the learners. The learners completed the questionnaires and I collected these. Identical questionnaires were again completed by the same learners at the end of the project at SPS 3 and SPS 1 to determine whether any of the answers to the questions had changed due to the experience gained through the owl release programme.

The learners at the control schools at SPS 2 and SPS 4 did not complete the questionnaire a second time, since SPS 4 learners did not participate in the environmental education programme, no significant changes to the answers were expected from the control schools. Moreover, I decided to compare SPS 2 learners, where they had first hand experience with resident owls, to SPS 4 learners, where no owls were resident on site. In this was another dimension was added to the study; evaluating the value of direct experience with the owls (SPS 2) against no firsthand experience (SPS 4).

3.2.9. Data analysis

The two sets of questionnaires (before and after owl release) administered to learners at SPS 1 and SPS 3 and the "present" and "absent" questionnaires (completed at SPS 2 and at SPS 4 respectively), were compared statistically. For each question, I analysed the data using a nested generalized regression model (GLZ) with an ordinal multinomial distribution and log link function. In this model, school was the independent factor, the owl absence/presence was the nested factor, and response variables were yes/no answers.

The questionnaire responses provided information relating to the learners' sentiment towards the owls when they were absent and again after the release, when owls were present at the release schools. In addition, answers to specific questions provided insight into the success of the environmental education in terms of the expansion of the learners' knowledge about the owls.

Owl Release Programme Questionnaire

School: ……

Date: …….

Name: …….

1	Have you ever seen an owl in real life?	Y	N
2	Do you like owls?	Y	N
3	Are owls dangerous to people?	Y	N
4	Are you afraid of owls?	Y	N
5	Do you know what owls eat?	Y	N
6	Is your family superstitious of owls?	Y	N
7	Can owls be helpful to people?	Y	N
8	Should people kill owls?	Y	N
9	Are owls important in the food chain?	Y	N
10	Do you want owls at your school?	Y	N

Figure 3.1. The questionnaire completed by learners at participating schools

3.3.Results

There was no school effect on the responses (Table 3.1), indicating that learner perception of owls was consistent, regardless of the school they attended. However, the presence or absence of owls was a significant predictor of learner responses for all 10 questions. Of these, learners who had no prior experience with barn owls (SPS 3 and SPS 1 before owl release and SPS 4), had little regard for owls and little knowledge of owls. Dramatic changes in attitude accompanied the introduction of owls (SPS 3 and SPS 1 after owl release and SPS 2), but may have been the result of several stimuli, including researcher presence, learner self-esteem, and teacher influence. Moreover, the questionnaire answers indicate that learners felt that they had gained knowledge about the owls during the project. This is evident in the change in answers to questions 3, 5 and 9 by learners from SPS 3 and SPS 1.

Table 3.1. The responses about owls of learners from four primary schools in Sebokeng. Questionnaires were provided to the same set of learners before and after owls were released in SPS 1and SPS 3. Statistics = GLZ analyses; for each question, the first row of the statistics indicates learners responses when owls were present and absent, and the second row compares responses by different schools. Number of learners in each school is given in brackets.

Questions		SPS 1(10)				SPS 3(12)				SPS 2(10)		SPS 4(10)		Statistics
		Owls Absent		*Owls Present*		*Owls Absent*		*Owls Present*		*Resident owls*		*No owls*		
		Yes	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	
1	Have you ever seen an owl in real life?	2	8	10	0	1	11*	11	0	9	1	2	8	$\chi^2_1 = 132.78$, p<0.001; $\chi^2_1 = 2.12$, p=0.145
2	Do you like owls?	1	9	10	0	3	9*	11	0	5	5	3	7	$\chi^2_1 = 62.59$, p<0.001; $\chi^2_1 = 0.12$, p=0.729
3	Are owls dangerous to people?	6	4	0	10	8*	4	0	11	3	7	6	4	$\chi^2_1 = 162.48$, p<0.001; $\chi^2_1 = 1.23$, p=0.267
4	Are you afraid of owls?	7	3	0	10	9	3*	0	11	2	8	7	3	$\chi^2_1 = 120.16$, p<0.001; $\chi^2_1 = 2.22$, p=0.136
5	Do you know what owls eat?	5	5	10	0	7*	5	11	0	9	1	3	7	$\chi^2_1 = 163.36$, p<0.001; $\chi^2_1 = 3.01$, p=0.083
6	Is your family superstitious of owls?	8	2	5	5	10*	2	6	5	6	4	5	5	$\chi^2_1 = 92.21$, p<0.001; $\chi^2_1 = 1.34$, p=0.247
7	Can owls be helpful to people?	1	9	10	0	3*	9	11	0	4	6	2	8	$\chi^2_1 = 62.65$, p<0.001; $\chi^2_1 = 2.33$, p=0.1262
8	Should people kill owls?	4	6	0	10	5	7*	0	11	2	8	3	7	$\chi^2_1 = 157.23$, p<0.001; $\chi^2_1 = 0.88$, p=0.348
9	Are owls important in the food chain?	2	8	10	0	4*	8	11	0	6	4	2	8	$\chi^2_1 = 62.22$, p<0.001; $\chi^2_1 = 2.97$, p=0.085
10	Do you want owls at your school?	4	6	10	0	4	8*	11	0	8	2	4	6	$\chi^2_1 = 161.57$, p<0.001; $\chi^2_1 = 2.31$, p=0.129

* One learner left SPS 3 during the study.

An important observation made regarding the difference in the answers between SPS 4 and SPS 2 learners is that the SPS 2 learners, who had been in contact with the owls, were much more positive about the owls than the SPS 4 learners who did not have owls at their school. While only 20% of the SPS 2 learners answered positively to Question 2, 70% of the SPS 4 learners indicated that they were afraid of owls.

3.4.Discussion

Questionnaires were used to assess learner perceptions about barn owls when they were absent and/or present. This provided an indication that the attitudes of the learners to owls had been significantly changed during the owl release programme. Learners at the SPS 4 did not participate in the owl release programme, and only answered the questionnaire once. Similarly, learners at SPS 2 answered the questionnaires once since they had a resident pair of barn owls nesting in the roof of their school building prior to the initiation of the release programme. Comparisons between these schools indicated that the SPS 2 learners are more comfortable and sympathetic to the owls than SPS 4 learners. In addition, the SPS 2 learners appeared to have a greater awareness about owls. SPS 4 learners were more superstitious of the owls and were unaware about the behaviour of owls and their role in the food chain. This may be due to the fact that very few of the learners had ever seen an owl (Question 1), and that they have not had any opportunity to learn about owls. The difference in these answers shows that first-hand experience with the owls can make learners more comfortable with these animals. Moreover, having owls at the school provided SPS 2 learners with experiential knowledge of owls, while SPS 4 learners did not have this knowledge and had not gained this knowledge through other sources.

At SPS 1 and SPS 3, the questionnaires completed before and after the release programme showed that the learners felt they had gained knowledge in terms of owls and their environment. This may be due to an increase in learner self-esteem in working with the owls, or through active knowledge construction by the learner during the release programme. In addition, the comparison of answers before and after the release programme showed that the learners had attained a more ecocentric view of the owls after experience and observation of the owls. This is evident by the fact that 100% of the learners indicated that owls were important in the food chain in their second questionnaire

answers. This dramatic change in perception and knowledge indicates that the environmental education component of this project was successful.

Moreover, the results indicate that environmental education and OBE methodologies are a useful tool in knowledge transfer to previously disadvantaged semi-urban South Africans.

Although the testing of OBE was not an aim of the study, the differences in the responses between SPS 4 and SPS 2 learners supports the OBE theory that experiential learning is important in developing a firsthand understanding of the subject (Makoni, 2000). In addition, the fact that the learners at SPS 2, having actively engaged with the owls, had acquired knowledge of the owls outside of the traditional learning system proves that experiential learning can be an effective tool for traditional knowledge transfer in the classroom (Meyer, 2000).

From the change in answers to Question 6 enquiring about whether their families were superstitious about owls, it is evident that the owl release programme and the knowledge and enthusiasm the learners acquired through the programme actually influenced the opinions of their families. This is an important finding as it provides evidence for group learning and subsequent knowledge transfer to secondary groups (Vygotsky, 1978; Spady, 1997) as a tool for environmental education in previously disadvantaged schools.

SPS 3is located within the poorest area of the four study sites and the learners were the most unruly of the four schools participating in this study (Makobela, pers com., 2004). However, after the initiation of the owl release programme, teachers remarked on the change of behaviour in the learners participating in the Owl Working Group at the school (Hlahlani, pers com. 2005). Mr Hlahlani indicated that the learners in the OWG had become more responsible and enthusiastic in their work and absenteeism had declined for 11 OWG learners.

3.4.1. Conclusion

The results of the questionnaire comparison indicate a significant change in attitude of the learners at the release schools towards the owls. In addition, the responses when owls were present indicate that knowledge transfer has definitely taken place through group work and the first hand experience of the learners to interact with the owls. Discussions with teachers suggest that the learners participating in the programme enjoyed

the OBE learning experience and became enthusiastic about the programme (Luthuli, 2004; Hlahlani, 2005, Makobela, 2005).

This feedback from the owl release programme indicates that the aims of the environmental education component of the study were achieved, as described below.

1. Learners at SPS 1, SPS 3 and SPS 2 indicated an understanding of the usefulness of owls in the food chain and acquired a more ecocentric attitude toward owls and the environment through the owl release programme. This is evident from the change in the answers to the questionnaire after the learners had been exposed to the owls on site;
2. Learners gained an understanding of the value of indigenous species in the environment (Questions 8 and 9);
3. Learners have learned to understand the importance of owls in the natural ecosystem, as evidenced by the positive changes in the answers to Questions 5 and 9.
4. Learners participated enthusiastically in group work and acquired knowledge through group learning experiences. This is evidenced by the change in behaviour of the SPS 3 learners, as well as by the change in answers to the questionnaires after the release programme had been completed;
5. Learners participated in community awareness campaigns and transferred the knowledge they had obtained to family and friends. This can be seen in the change to the answers given to Question 6 of the questionnaire after the learners had been exposed to the owls on site. Moreover, local residents became more active in the project after the community awareness meetings and provided information on the location of the owls. The fact that no owls were killed by local residents is evidence that the residents gained an understanding for the usefulness of the owls in the food chain during the owl release programme.

Therefore, it can be concluded that the environmental education component of the study has proven successful in achieving environmental awareness through group work and experiential learning. This is an important observation of the study and further environmental education through OBE principles should be initiated in South Africa. Opportunities for previously disadvantaged learners to interact with the environment is an important factor in enthusiastic learning of environmental values, which is vital to the conservation of South Africa's remaining natural resources over the long term.

3.4.1.1.Environmental Education Theory

Environmental ideologies develop differently from different social and political contexts and perspectives. In the Western world, enlightenment and science have been very influential, but the Western perception of environmentalism separates environment and development (Palmer, 1998). This is a critical flaw in the environmental theory of Western countries as this view hinders the principles of sustainable development. In South Africa, the environmental theory aims at supporting development, but not to the detriment of natural resources, environmental conservation or human rights (Makoni, 2000).

Environmental education is usually developed to facilitate environmental policies at local, national or international levels. Environmental education paradigms reflect social and environmental ideologies of the target learner and teacher (Palmer, 1998).

The owl release programme relied on the experience of the learners with the owls to inform decisions and perspectives of the learners in this regard. The environmental education focused on description of the subject rather than "prescription", which aims at prescribing perspectives and experiences for the learner (UNED-UK Education Task Group, 1997). The release programme supports the South African environmental theory in that the introduction of the owls was aimed at an integration of nature with the human environment rather than the hindrance of development for environmental conservation purposes.

The changing environmental concerns over time are reflected in the environmental education focus. The current trend in environmental education is relevant to climate change and the conservation of exhaustible resources (Tilbury, 1995). However, the dominant environmental concerns change with community circumstances (Gough & Gough, 2004). While the educated middle- to upper-income communities are able to conceptualise and understand the impact of climate change and habitat loss, the uneducated and lower-income community only has the resources to address environmental concerns impacting directly on their lives (O'Donoghue, 1993; Gough & Gough, 2004). For the residents of Sebokeng, the rat infestation has a direct impact on the quality of life of the community. However, by the introduction of owls to combat the rat activity, the community apparently learnt the value of animals in the food chain and how the disturbance of one part of the cycle can have a detrimental result on human lives.

CHAPTER 4. CONCLUSIONS

4.1. Owl release programme

The success of the owl release programme can be assessed against three specific criteria, as set out below.

1. The survival rate of the released owls was high, as 50% of the owls released were still observed in the vicinity of the release sites up to 18 months after release. Mortality of owls is usually a result of starvation, vehicle accidents, attacks by humans or attacks by other predators (Ansara, 2004). The survival of all 8 owls at the schools may be related to one or more of the following factors: The abundance of prey base, the initial feeding of the owls after release, the community awareness campaign, the location of owl boxes (i.e. roosting sites) away from any tarred roads; and the provision of safe nesting and roosting structures.
2. The assessment of the pellets from released owls showed that only the black house rat, *Rattus rattus*, was consumed. In addition, the rat trapping provided evidence that the owls had impacted upon rat numbers and/or activity at the release sites.
3. While this study was conducted over a relatively short term, the pairing up of one of the released owls with a naturally occurring owl in the study area indicates that the released owls have the potential to become permanently established breeding individuals.

4.1.1 Owls as rat control agents

Traditional methods of rat control rely predominantly on rodenticides, or rat poisons (Bayers, 2007). The poisons used in lower income communities are usually not target specific and are a risk to other animals as well as humans (Komen, 2002). Rat poisons can cause the death of other, non-target rodents and small mammals. Moreover, predators and scavengers that feed on poisoned rats are at risk of being poisoned too (Kogan, 1998).

Another rat control mechanism is the barrier fence, which was implemented in Australia for rabbits and has been used in Asia to control the movement of rats (Aplin *et al*., 2003). However, for effective use of barrier fences, one must have a specific area or infrastructure that is being protected from rat infestation. In addition, some rats (e.g. black rats) may be able to climb the fences and access the site (Moseby & Read, 2006).

Trapping is another commonly used method of rat control. Trapping is usually done by snap trapping, which is not target specific, and runs the risk of killing indigenous rats and mice (Komen, 2002). Moreover, snap trapping must be conducted over a long period to have any impact on the rat population (Alpin *et al.,* 2003).

The above-mentioned methods all require continuous capital input and are not sustainable (CSIRO, 2003). Biological control provides a relatively low cost, sustainable control method. To establish one pair of owls at a site requires an investment of approximately R1 500, including the feeding, nesting box and the owls. Once the owls are established at the site, no further input is required, and the project becomes self-sustaining.

My results contradict the findings of another study of owl (species not reported) predation on a different rodent species, the sigmodontine rodent, *Akodon azarae*. In this study, Kittlein (1997) tested predation of naturally occurring owls on the target rodent species. The results differed to the Sebokeng study in that the owls did not influence prey abundance or demography, which may be related to the presence and the availability of other prey species (Kittlein, 1997). In Sebokeng, the house rat is the preferred prey species for the barn owls and the abundance of rats in Sebokeng apparently provide the owls with an ample prey base.

4.1.2. Measuring the efficacy of the control agent

In order to measure the effectiveness of the biological control agent, there are five criteria that should be assessed (after Murdoch *et al.* (1985).

1. Does the target alien species react to the presence of the control agent?

   From the rat trapping results and analysis of the owl pellets, it is evident that the owls are preying on the rats at the release sites.
2. Are there changes in target species behaviour and numbers?

   In support, the trapping results of the present study showed changes in the demography of rats.
3. Are there long term indicators of alien population number control by the control agent?

   Due to the time constraints of this study, long term trends could not be assessed. However, the fact that the released owls were established in at the release sites over the 18 months of the study and that “Dolly” have paired up with a naturally

occurring owl and had produced her first clutch of eggs gives an indication that the owls will be resident at the release sites over the medium to long term and will therefore could have an impact on the rat population.

4. Is there any evidence that the control agent is impacting on non-target species?

   From the analysis of the owl pellets, the short term assessment indicates that the owls are preying predominantly, if not solely, on the target rat species *R. norvegicus*.

5. Is there any evidence that the control agent has significantly altered the receiving habitat?

   Over the short term of the study, there is no indication that the barn owl presence at the release sites has altered the receiving habitat.

4.2 The Environmental Education Programme

The environmental education and community awareness campaign that were undertaken at the owl release sites were crucial to the successful release of the owls within the Sebokeng community, because of the superstitious and fearful attitude that most Sebokeng residents held towards owls. Without the environmental education at the schools, the teachers and learners would not have agreed to participate in the owl release programme. The results of the Sebokeng environmental education study showed dramatic changes in learner perceptions and knowledge, which were associated with their participation in the release programme.

Experiential learning is, therefore, a valuable tool for environmental education. First-hand experience of environmental aspects can provide a learner with important knowledge, and may facilitate increased environmental awareness, conservation and custodianship by the learner (Palmer, 1989; O'Donaghue, 1993).

I believe that environmental education will make a vital contribution to creating a national environmental awareness among the South African youth. In order to facilitate better environmental practice and understanding of and concern for our natural resources, it is important that learners are exposed to the environment at an early stage of their schooling (Rickinson, 2001).

This is especially true of previously disadvantaged communities who have not been exposed to environmental awareness through media or schooling (Dillon, 2003).

The Sebokeng owl release programme illustrated the importance of making environmental education available to previously disadvantaged communities in South Africa. The cultural lore within black African societies generates a risk to the environment, and particularly to specific plant and animal species (Marcot, 2000). While these cultural beliefs and superstitions are important as inherited traditions, exposure of these communities to the usefulness of aspects in the environment may alter perceptions enough to eliminate the destruction of that aspect of the environment.

In South Africa, it is important to understand the gaps in education between the middle working class and communities living in informal settlements (Gough & Gough, 2004). It is important that these communities are afforded the opportunity to learn about the environment and possibly use the environment to their advantage (O'Donaghue, 1993), as was illustrated by the use of owls to control rat populations in the Sebokeng project

Due to the lack of education of many previously disadvantaged communities and the 11 official languages of South Africa, it is also important to acknowledge the fact that many members of the community will not be able to interpret or understand information provided by an educator or researcher.

4.3 Multidisciplinary approach

The success of my study is based on the unique multidisciplinary approach. The City University London (2007) maintains that multidisciplinary research should embody the following principles: 1) involves researchers from many backgrounds and traditions such as health, social and natural science; 2) involves local people in the research process as actors and active participants, not as passive sources of data; and 3) provides feedback to the communities or institutions participating in the project, which facilitates a positive change in that community or institution.

In order for the owl release programme to have succeeded, it was imperative to ensure that the community became involved in the project. The cultural beliefs of the community generated a risk that the owls would be chased or even killed by local residents. The study integrated knowledge transfer to the learners and greater community, while undertaking the biological control research study. By keeping the community informed about the project, they became more interested in it and observed the results of the snap trapping for themselves.

Janssen and Goldsworthy (1999) suggested that multidisciplinary research is important in addressing many of the newly topical issues in natural resource management. While the practical implementation of this type of research is difficult to achieve, a research project initiated in the early 1990's integrated the input from natural and social scientists in assessing environmental change in semiarid North Central Tanzania (Christiansson *et al.*, 1991). This cooperation between the social and natural scientists facilitated the assessment of land degradation against land tenure, ethnic and social stratification and other social phenomena. In addition, the effects of environmental change were assessed as impacts to social structure. In this way, the multidisciplinary nature of the study provided a more balanced research programme.

The multidisciplinary approach of the owl release programme provided more balanced and integrated results to the study and allowed for the participation of the community in a project, which affected their lives directly. The principles of the multidisciplinary approach were achieved in that: 1) the project was led by school educators, was initiated by the Health Department and was carried out by a natural scientist with input by social scientists through literature reviews and educators through direct participation in the project; 2) the local community was intimately involved in the project and participated in both the environmental education (awareness campaigns) and the biological control components of the project; and 3) the results of the research have been documented for use by future researchers. Moreover, this dissertation will be made available to schools that participated in the project.

4.4 Future Studies

4.4.1 Owls as biological control agents

Future studies should consider longer term monitoring of owls and their prey base over a larger geographical area with several release sites and control sites to provide for more data for a more comprehensive statistical analysis and to negate potential external influences. Such a study could possibly be carried out simultaneously at several South African semi-urban townships over several years. This would account for any location-based influences on the research study, and the longer time frame would allow for a more comprehensive assessment of the impact of the owl presence on rat populations at the release sites.

Owls are known to change their prey based on availability (Kittlein, 1997), so it would be important to monitor whether an increasing owl population size (because of breeding) and a diminishing rat prey base (because of owl predation and better hygiene practices by the human community), if possible, results in changes in owl diet and/or owl distribution.

Moreover, it would be useful to undertake similar rat trapping utilising live traps and marking rats to evaluate whether rats learn to avoid traps and whether female rats avoid traps better than male rats? As discussed on page 31, it would be valuable to ascertain whether female rats are quicker learners and avoid the rat traps over time, or whether barn owls are preying preferentially on female rats. Live traps should be utilised to capture and mark rats, and thereafter assess the number of male versus female rats that are recaptured. This should provide evidence for a difference in experiential learning by male and female rats. Should no difference be found, then follow-on research should establish whether owls are preying preferentially on female rats. Reasons for preferential predation should also be investigated, as much of the existing research has indicated that owls are opportunistic predators (Yom-Tov & Wool, 1997; Torres *et al.,* 2005).

In addition, the use of live traps would eliminate any impact that snap trapping may have on rat numbers and rat behaviour during the research project. The marking and releasing of captured rats could also provide information on the behaviour of longer rats and heavier rats, and this could be correlated with the size of rats preyed upon by the owls. A change in behaviour of older rats (longer rats) could be attributed to the presence of owls. Live traps could assess changes in behaviour and possibly reasons for a change in length and weight of rats captured in traps.

While the release project by Meek *et al.* (2003) in southern England was undertaken over 20 years, no evidence was recorded that the owls released were having a definite impact on the rat populations at the release sites. Similarly, there are no studies undertaken to assess the success of owl release programmes in terms of owl mortality, owl establishment at the release site, and owl pairing and breeding.

4.4.2. Environmental Education in previously disadvantaged South African communities

Due to the high percentage of the South African population that live below the "breadline", and the fact that it is these low-income families who interact with the environment and natural resources on a daily basis through their living conditions and the natural resources they utilise, it is important that environmental education be available to them (Makoni, 200).

The experiential learning about the environment is a valuable tool to environmental education (Palmer, 1998). OBE principles of group learning are also extremely valuable in the South African context where learners may not speak the language of the educator and can then interpret the lesson from group members who may be more proficient (Gough & Gough, 2004). Moreover, group learning is a more interactive knowledge transfer experience that is enjoyable to the learner and also provides social skills to the group members (O'Donoghue, 1993).

In future, the owl release programme could be rolled out nationally to previously disadvantaged semi-urban townships that are geographically widely separated and where rat infestation is a known problem. The experiences (and attitudes) and living standards of the residents in these areas will differ dramatically, which would require that the environmental education programme be tailored to each unique circumstance. Relatively more affluent areas could be compared with poorer areas to determine these differences in order to develop a holistic educational approach. Study materials could be developed and translated into the official languages to facilitate the knowledge transfer.

Another option would be to have workshops training teachers in the principles of environmental education. This "teach-the-teacher" approach would assist in the widest dissemination of the principles resulting from this study. In this way, the environmental education can be coupled to the biological control study and the local residents can participate in the programme and observe the effects first-hand.

5 REFERENCES

Acorn Resources, 2007. www.acornnaturalists.com.

Andries, A. M., Gulinck, H., Herremans, M. 1994. Spatial modelling of the barn owl *Tyto alba* habitat using landscape characteristics derived from SPOT data. Ecography: 17 (3): 278-287.

Ansara, T., 2004. Determining the ecological status and possible anthropogenic impacts on th grass owl (*Tyto capensis*) population in the East Rand Highveld. University of Johannesburg, Unpublished.

Aplin, K. P., Brown, P. B., Jacob, J., Krebs, C. J., Singleton, G. R., 2003. Field methods for rodent studies in Asia and the Indo-Pacific. ACIAR Monograph No. 100, Australian Centre for International Agricultural Research, Canberra.

Babcock, J., Hartman, K., Pedersen, A., Murphy, M., Alving, B., 1993, Rodenticide-induced coagulopathy in a young child. A case of Munchausen Syndrome by proxy. American Journal of Pediatric Hematology/Oncology, 15:126-130.

Bachynski, K. & Harris, M, 2002. *Tyto alba*, (on-line), Animal Diversity Web. http://animaldiversity.ummz.umich.edu.

Barnes, K. N. (ed), 2000. The Eskom Red Data Book of birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Randburg.

Bayer Home Page, 2007. www.bayerhome.co.za.

Beauchamp and Raid, 1997. Internet Article. January 1997. www.napa.ufl.edu.

Bellocq, M. L., & Kravetz, F O., 1994. Feeding strategy and predation of the barn owl (*Tyto alba*) and the burrowing owl (*Speotyto cuniculara*) on rodent species, sex and size, in agrosystems of Central Argentina. Ecologia Austral., 4: 29 – 34.

Bennet, A. F. 1990. Habitat corridors and the conservation of small mammals in fragmented forest environment. Journal of Landscape Ecology. 2:2-3:109-122.

Biodiversity Act, No 10 of 2004. National Environmental Management: Government Gazette Vol. 467, No. 26436, Cape Town, South Africa.

Blaser, M. J., 1996. How safe is our food? Lessons from an outbreak of Salmonellosis. New England Journal of Medicine, 334: 1324 – 1325.

Bolowana, Angela, 9 February 2004. Natal Mercury, page 3.

Brown, J., Collins, A., Duguid, P., 1989. Situated cognition and the culture of learning. Educational Researcher, 18: 32-42.

Callaway, R. M. & Aschehoug, E. T., 2000. Invasive plants versus their new and old neighbors: a mechanism for exotic invasion. Science, 290: 521 – 523.

Carmona, E. R. & Rivadeneira, M. M., 2006. Food habits of the barn owl *Tyto alba* in the National Reserve Pampa del Tamarugal., Atacama Desert, North Chile. Journal of Natural History, 40: 473-483.

Chambers, L., 1997. CSIRO Research Newsletter May 1997. Canberra, Australia.

Cheek, D., 1992. Thinking constructively about science, technology and society education. Albany, New York, State University Press.

Chikwenhere, G. P., & Forno, I. W., 1991. Introduction of *Neohydronomus affinis* for biological control of *Pistia stratiotes* in Zimbabwe. Journal of Aquatic Plant Management JAPMDB, 29: 53-55.

Christiansson, C., Kikula, I. S., Ostberg, W., 1991. Man-land interrelations in semiarid Tanzania: a multidisciplinary research program. Ambio, 20: 357 – 361.

City University London, 2007. www.city.ac.uk.

Cook, R. J., & Baker, K. F., 1983. The Nature and Practice of Biological Control of Plant Pathogens. American Phytopathological Society, St. Paul, USA.

Coles, R. B., & Guppy, A., 1988. Directional hearing in the barn owl (*Tyto alba*). Journal of Comparative Physiology (A), 163: 117 -133.

CSIRO Sustainable Ecosystems, 2003. Newsletter no 16, Canberra, Australia.

De Andrade, V., & Ross, E., 2005. Beliefs and Practices of Black South African Traditional Healers Regarding Hearing Impairment. International Journal of Audiology, 44: 489-499.

De'Ath, A., Garthwaite, D. G., Thomas, M. R., 1997. Pesticide Usage Survey Report 154- Rodenticide Usage on Farms in Great Britain Growing Grassland and Fodder Crops. Ministry of Agriculture, Fisheries and Food & Scottish Executive Rural Affairs Department, York.

De Graaff, G., 1981. The Rodents of Southern Africa. Butterworths Publishers, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, 2006. Regulations in Terms of Chapter 5 of the National Environmental Management Act, 1998, South Africa.

Dickman, C. R., Predavec, M., Lynam, A. J. 1991. Differential Predation of Size and Sex Classes of Mice by the Barn Owl. *Tyto alba*, Oikos. 62: 67-76.

Dillon, J.2003. On Learners and Learning in Environmental Education: Missing Theories, Ignored Communities. Environmental Education Research, 9: 215-226.

Duckett, J. E. 1991. Management of the Barn Owl (*Tyto alba javanica*) as a predator of rats in oil palm (*Elaeis quineensis*) Plantations in Malaysia, IN: Birds of Prey Bulletin No 4.

Faqan, W. F., Lewis, M. A., Neubert, M. G., van den Driessche, P. 2002. Invasion Theory and Biological Control. Ecology Letters,5: 148 -157.

Feare, C. 1979. Ecology of Bird Island, Seychelles. The Smithsonian Institution, Washington D.C., USA.

Feduccia, A. 1999. The Origin and Evolution of Birds. Yale University Press, USA.

Gough, A., Gough, N., 2004. Environmental education research in Souithern Africa: dilemmas of interpretation. Environmental Education Research, 10: 409-424.

Grant, G.S., Petit, T. N., Whittow, G. C., 1981. Rat Predation on Bonin Petrel on Midway Atoll. Journal of Field Ornithology, 52: 336-338.

Gratz, N. G. 1999. Emerging and Resurging Vector-Borne Diseases. Annual Review of Entomology, 44: 51-57.

Griffin, G. F., & Friedel, M. H. 1985. Discontinuous Change in Central Australia: Some Implications of Major Ecological Events for Land Management. Journal of Arid Environments, 9: 63-80.

Griffin, A., S. & Evans, C. S. 2002. Social Learning of Antipredator behaviour in a Marsupial. Animal Behaviour, 66: 485-492.

Gross, A. O. 1912. Observations on the Yellow-Billed Tropicbird (*Phaethon amercanus* Grant) at the Bermuda Islands. Auk, 29: 49-71.

Gubler, D. J., 1998. Resurgent vector-borne diseases as a global health problem. Emerging Infectious Diseases, 4: 442 – 450.

Gultig, J. 1999. Implementing OBE Book 4 – Philosophy. Pretoria, Department of Education.

Hajek, A. E., McManus, M. L., Delalibera, I. 2007. A Review of Introductions of Pathogens and Nematodes for Classical Biological Control of Insects and Mites. Biological Control, 41: 1-13.

Harris, M. P. 1970. The Biology of an Endangered Species, the Dark-Rumped Petrel (*Pterodroma phaeopygia*), in the Galapagos Islands. Condor, 72: 76-84.

Haw, J. 2002-2004. Personal Communication, 'Ecosolutions' - ornithologist consultant, Baviaan's Kloof, Eastern Cape.

Hill, M. P., & Olckers, T. 2001. Biological Control Initiatives against Water Hyacinth in South Africa: Constraining Factors, Success and New Courses of Action, IN: Julien,

M., Hill, M. P., Center, T., & Ding, J. (eds), Proceedings of the Meeting of the Global Working Group for the Biological Control and Integrated Control of Water Hyacinth, Beijing, China, 9-12 October 2000, Australian Centre for International Agricultural Research, Canberra, Australia, pg 33-38.

Hlahlani 2005. Personal communication, Biology and Science Teacher SPS 3, Sebokeng, South Africa.

Hoffman, T 1997. Using Barn Owls for Rodent Control in Vineyards and Orchards, article in Grape Grower Magazine, July 1997.

Hokkanen, M. T., & Lynch, J. (eds) 1995. Biological Control: Benefits and Risks. Cambridge University Press, UK.

Illinois EPA, 2007. ww.epa.state.il.us.

Innes, J. 1990. Ship Rat - The Handbook of New Zealand Mammals. King, C. M. (ed), pg 206-225, Oxford University Press, UK.

Innes, J., Hay, R., Flux, I., Bradfield, P., Speed, H., Jansen, P. 1999. Successful Recovery of North Island Kokako *Callaea cinerea wilsoni* populations, by adaptive management. Biological Conservation, 87: 210-214.

Jackson, B. J, Ashton, A. D. 1992. A review of available anticoagulants and their use in the United States, Vertebrate Pest Conference Proceedings Collection, Proceedings of the Fifteenth Vertebrate Pest Conference, University of Nebraska, Lincoln.

Janssen, W., Goldsworthy, P., 1999. Multidisciplinary research for natural resource management: conceptual and practical implications. Agricultural Systems, 51: 259 – 279.

John-Steiner, V., 1985. Notebooks of the mind: Explorations of Thinking, Albuquerque, University of New Mexico Press.

Kalman, B. 1993. Owls, Crabtree Publications. New York.

Keeling, M. J., Gilligan, C. A., 2000. Metapopulation dynamics of Bubonic Plague. Nature, 407: 903- 906.

Kemp, A. 1987. The Owls of Southern Africa, Struik Publishers, Cape Town.

Kittlein, M. J., 1997. Assessing the Impact of Owl Predation on the Growth Rate of a Rodent Prey Population. Ecological Modelling, 103: 123 – 134.

Kogan, M., 1998. Integrated Pest Management: Historical Perspectives and Contemporary Developments. Annual Review of Entomology, 43: 243-270.

Komen, L. 2002. Newsletter December 2002. Poison Working Group, Namibia.

Konig, Weick & Becking, 1999. Owls: A Guide to the Owls of the World, Yale University Press.

Kovaliski, J. 1998. Monitoirng the Spread of Rabbit Hemorrhagic Disease Virus as a new Biological Agent for Control of Wild European Rabbits in Australia. Journal of Wildlife Diseases, 34: 421-428.

Krashen, S., 1982. Principles and Practice in Second Language Acquisition. Oxford, Pergamon Press.

Kunzmann, K. R., Denicioglu, K. T., 1983. Environmental Education and Training in and for Developing Countries. Arbeitpapier 9. Dortmund University Institute for Spatial Planning.

Kutrick, P. 1994. Use and Effectiveness of Groups in Classrooms: Towards a pedagogy, in Kutrick and Rogers. Groups in Schools, London, Cassells.

Lary, M. J., Lavigne, S. E., Muma, R. D., Jones, S. E., Hoeft H. J. 1997. Breaking down barriers: multidisciplinary education model. Journal of Allied Health. Spring: 26: 2: 63-69.

Lipton, R. A., & Klass, E. M., 1984. Human Ingestion of a "Superwarfarin" Rodenticide Resulting in a Prolonged Anticoagulant Effect. Journal of the American Medical Asociation, 7: 252.

Luthuli, A., 2004. *Personal communication*. Biology and Science Teacher, SPS 2, Sebokeng, South Africa.

Makobela, 2004-2006. *Personal communication*. Head Mistress of SPS 1, Sebokeng.

Makoni, S. (ed), 2000. Improving Teaching and Learning in Higher Education: A Handbook for Southern Africa. Witwatersrand University Press, Johannesburg, South Africa.

Marcot, B. G., P. M. Cocker, and D. H. Johnson, 2000. Owls in lore and culture. Presented at Owls 2000: the biology, conservation and cultural significance of owls. International conference. Canberra, Australia, 19-23 January 2000.

Marti, C. D. & Hogue, J. G, 1979. Selection of Prey by Size in Screech Owls. Auk, 96: 319–327.

Marti, C. D., 1992. Barn Owl, IN: The Birds of North America – Life Histories for the 21st Century, Poole, A. F., Stettenhein, P., Gills, F. B. (eds), The American Ornithologists Union and the Academy of Natural Sciences of Philadelphia, Washington D. C. 5–15.

Martinez, J. A. & Lopez, G., 1999. Breeding Ecology of the Barn Owl (*Tyto alba*) in Valencia (SE Spain). Journal of Ornithology, 140: 93-99.

Meek, W. R., Burnam , P. J., Nowakowski, M., Sparks, T. H., Burman, N. J., 2003. Barn Owl Release in lowland southern England – twenty-one year study. Biological Conservation, 109: 271–282.

Meyer, L., 1998. The introduction of OBE to High Schools in South Africa. Unpublished Honours report. Department of Psychology, Wits University, Johannesburg.

Meyer, L., 2000. An investigation into the kinds of innovative pedagogies involving apprenticeship learning groups and multiliteracies which support learning in culturally diverse classrooms in Johannesburg and the relationship between these pedagogies and the implementation of Curriculum 2005. Unpublished MSc dissertation. Department of Psychology, Wits University, Johannesburg.

Mills, J. N., & Childs, J. E., 1998. Ecological Studies of Rodent Reservoirs: Their Relevance for Human Health. Emerging Infectious Diseases, 4: 529-537.

Moseby, K. E., & Read, J. L. 2006. The efficacy of feral cat, fox and rabbit exclusion fence designs for threatened species protection. Biological Conservation, 127: 429-437.

Murdoch, W. W., Chesson, J., Chesson, P. L., 1985. Biological control in theory and practice. The American Naturalist, 125: 344-366.

O'Donaghue, R., 1993. Clarifying environmental education: A search for clear action in Southern Africa. South African Journal of Environmental Education, 13: 28-38.

Orr, D., & Baker, J. 2007. Biological control: Application of natural enemies. Biological Control Information Centre, NC State University, cipm.ncsu.edu.

Ostfeld, R. S., 1985. Limiting resources and territoriality in microtine rodents. The American Naturalist, 126: 1-15.

Palmer, J. A., 1998. Environmental education in the 21st century: Theory, practice, progress and promise. Routledge Publishers, USA.

Payne, R. S., 1971. Acoustic Location of Prey by Barn Owls (*Tyto alba*). Journal of Experimental Biology, 56: 535-573.

Pech, R. P., & Hood, G. M., 1998. Foxes, Rabbits, Alternative Prey and Rabbit Calicivirus Disease: Consequences of a New Biological Control Agent for and Outbreaking Species in Australia. Journal of Applied Ecology, 35: 434-453.

Pimentel, D., Lach, L., Zuniga, R., Morrison, D. 2000. Environmental and Economic Costs of Non-Indigenous Species in the United States. BioScience, 50: 53-65.

Puckree, T., Mkhize, M., Mgobhozi, Z., Lin, J., 2002. African Traditional Healers: What Health Care Professionals Need to Know. International Journal of Rehabilitation Research, 25: 247-251.

Rejmanek, M, & Richardson, D. M., 1996. What Attributes Make Some Plant Species More Invasive? Ecology, 77: 1655-1661.

Rickinson, M., 2001. Learners and Learning in Environmental Education: A Critical Review of the Evidence. Environmental Education Research, 7: 207-320.

Robertson, H. A., Hay, J. R., Saul, E. K., McCormack, G. V., 1994. Recovery of the Kakerori: An Endangered Forest Bird of the Cook Islands. Conservation Biology, 8: 1078-1086.

Rogoff, B., 1990. Apprenticeship in thinking: Cognitive Development in Social Context, Oxford, Oxford University Press.

South African Development Community, 2007. SADC Food, Agriculture and Natural Resources Programme. www.sadc.int.

Shore, R. F., Birks, J. D. S., Freestone, P., Kitchener, A. C., 1996. Second Generation Rodenticides and Polecats (*Mustela putorius*) in Britian. Environmental Pollution, 91: 279-282.

Solomon, N., 2003. A re-examination of factors influencing philopatry in rodents. Journal of Mammology, 84: 1182-1197.

Sommer, S. 1999. Sex-specific Predation on a Monogamous Rat, *Hypogeomys antimena* (Muridae: Nesomyinae). Animal Behaviour, 59: 1087 – 1096.

South African National Botanical Institute, 2007. www.sanbi.org.

Spady, W., 1997. Outcomes-based Education, its history, philosophy, principles and application (video of a talk presented at the Worcester Teacher's Centre), 4 November 1997, Edumedia, P O Box 13266, Mowbray, 7705.

Stuart-Fox, D. M., Moussalli, A., Marshall, N. J., Owens, I. P F., 2002. Conspicuous Males Suffer Higher Predation Risk: Visual Modelling and Experimental Evidence from Lizards. Animal Behaviour, 66: 541 – 550.

Tbilisi Conference Proceedings, 1977. Intergovernmental Conference on Environmental Education. Tbilisi, USSR, 14-26 October 1977.

The Barn Owl Trust, 2006. Website: www.barnowltrust.org.uk

Tilbury, D., 1995. Environmental education for sustainability: defining the new focus of environmental education in the 1990's. Environmental Education Research, 1: 195-212.

Tores, M., Motro, Y., Motro, U., Yom-Tova, Y., 2005. The Barn Owl – A Selective Opportunist Predator. Israel Journal of Zoology, 51: 349-360.

Trapp, D., 2003. International Barn Owl Restoration Project, Enhancing Tytonidae Owl Species Worldwide, http://ourworld.compuserve.com.

Trejo, A. & Grigera, D., 1998. Food Habits of the Great Horned Owl (*Bubo virginianus*) in Patagonian Steppe in Argentina. Journal of Raptor Research, 32: 306-311.

Trejo, A. & Guthmann, N. 2003. Owl Selection on Size and Sex Classes of Rodents: Activity and Microhabitat Use of Prey. Journal of Mammalogy, 84: 652-658.

Twigg, L. E., Lowe, T. J., Martin, G. R., Wheeler, A. G., Gray, G S., Griffin, S. L., O'Reilly, C. M., Butler, T. L., Robinson, D. J., & Hubach, P. H., 1998. The Ecology of the European Rabbit (*Oryctolagus cuniculus*) in Coastal Southern Western Australia. Wildlife Research, 25: 97-111.

UNED-UK Education Task Group, 1997. Education 21. UNED-UK.

United Nations Environmental Programme, 2000. Global Environmental Outlook, United Nations Environmental Programme Global State of the Environment Report.

United Nations Environmental Programme, McGinley, M. (ed), 2007. Invasive Alien Species and Development Challenges in Africa, The Encyclopedia of Earth, www.eoearth.org.

Von Campenhausen, M. & Wagner, H., 2006. Influence of the Facial Ruff on the Sound-Receiving Characteristics of the Barn Owl's Ears. Journal of Comparative Physiology, 192: 1073-1082.

Vygotsky, L. S., 1978. Mind in Society: Development of Higher Psychological Processes, Cambridge, MA, Harvard University Press.

Weeden, C., Shelton, A. M., Hoffman, M. P., 2006. Biological Control: A Guide to Natural Enemies in North America, Cornell University.

Weinberg, S., 1986. High Intensity Ultrasonic Generator, US Patent 4,566,085, California.

Wheeler, S. H., & King, D. R., 1985. The European Rabbit in Southwestern Australia. III, Survival. Australian Wildlife Research, Australia.

Wicklein, R. C., Schell, J. W., 1995. Case studies of multidisciplinary approaches to integrating mathematics, science and technology education. Journal of technology education, 6:59-76.

Wilson, R. T., Wilson, M. P., Durkin, J. W., 1986. Breeding Biology of the Barn Owl *Tyto alba* in Central Mali. Ibis, 128: 81 – 90.

Wittenberg, R., & Cock, M. J. W., 2001. Global Invasive Species Programme. Invasive Alien Species. How to address on of the greatest threats to biodiversity: A Toolkit of Best Prevention and Management Practices, CAB International., Wallingford, Oxon, UK.

Wood, B. J., & Fee, C. G., 2003. A Critical Review of the Development of Rat Control in Malaysian Agriculture since the 1960s. Crop Protection, 22: 445-461.

Yom-Tov, Y. & Wool, D., 1997. Do The Contents of Barn Owl Pellets Accurately Represent the Proportion of Prey Species in the Field? The Condor, 99: 972 – 976.

Zimmer, C., 2001. Parasite Rex, Free Press, ISBN 0-7432-0011-X.

APPENDIX 1. RAT POISON AND THE POTENTIAL THREAT TO HUMAN LIFE

The following reports are examples of how the availability of rat poisons has generated risk in various forms to human life:

- In Jacksonville Florida, 34 students ingested rat poison that had been sprinkled on salsa. It was suspected that two 7th grade students from the school were responsible (CNN.com. 12 September 2000)
- One hundred and twenty seven people required hospitalisation after three teenagers spread rat poison around Krautheim in Baden Wuerttemburg, Germany. The poison reacted with rain water to produce deadly fumes (Ananova, 5 February 2001).
- At Kaikoura, New Zealand a rat poison spill of 18 tonnes into the sea left traces of the poison in harvested mussels (Cawthorn news, 30 May 2001).
- Palestinian suicide bombers add rat poisons to their bombs as the poisons are anti-coagulants and cause the wounded to bleed uncontrollably (ABC news, 6 August 2001).
- 26 November 2002, rat poison misused at a Chinese rural kindergarten school in Huangzen left 70 pupils and 2 teachers dead (Pravda online, 2002).
- Canberra police issued a warning about recreational drug use after the seizure of Ecstasy capsules containing rat poison (ABC News, 12 September, 2002)
- Part of Arrow Park hospital casualty department in Cheshire, England was forced to close for 12 hours when the body of a millionaire-shipping magnate (Sir Derek Bibby) was found to be emitting toxic fumes. The millionaire had taken aluminium phosphate (a rat poison that gives off fumes when mixed with water). Because of the risk to patients and hospital staff, the hospital's emergency chemical incident procedure was triggered and a large part of the hospital had to be evacuated (The Guardian, 11 October 2002).
- In New York, a 15 month old infant developed permanent brain damage as a result of exposure to highly toxic chemicals in a rodent poison (Cedars-Sinal., 13 March 2003).
- On 23 November 2003, Animal rights activists infected meat with rat poison in Uppsala, 70km north of Stockholm (The Age newspaper, 2003).
- Articles by Lancet in the United Kingdom reported that, during a study of 519 suicides in China (studied by Canadian physician Michael Phillips and his Chinese colleagues), 62% of the victims used rat poison to kill themselves.
- A report detailed several incidents of rat poison murders including:

1. A shop owner poisoning snacks at a rival's store, killing 38 people.
2. A widow spikes the lunch at her husband's funeral, 10 dead.
3. A man seeks revenge against married lover by poisoning her children.

(CBS News, 14 November 2003).