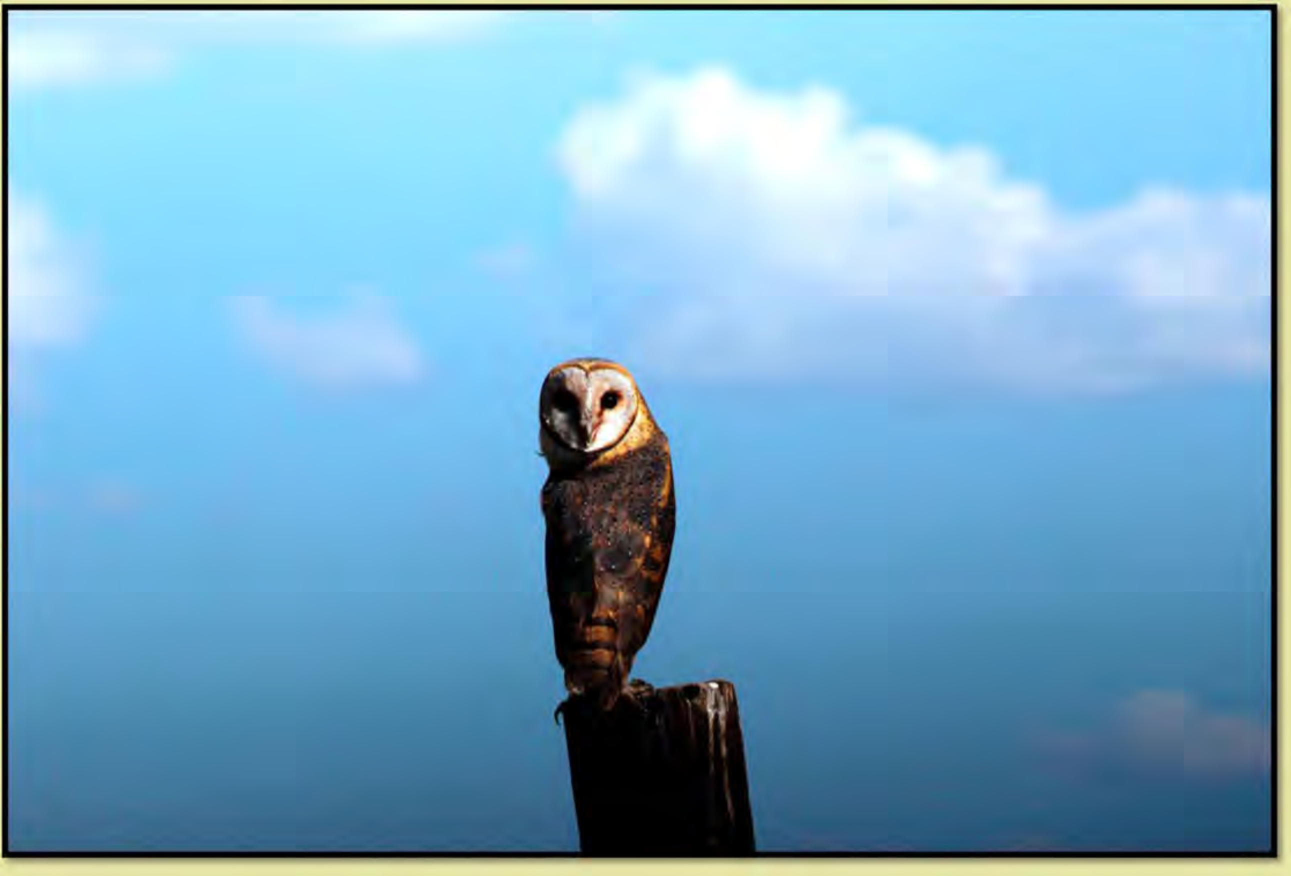

Using occupancy models and nest monitoring to quantify barn owl (*Tyto alba*) presence and diet in an agricultural matrix

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Introduction

- Predation plays an important role in prey population regulation, population cycles and structuring prey communities.
- Predation impact depends largely on predator densities, distribution and the feeding ecology of the predators.
- This study aims to increase our understanding of a common avian predator (Barn owl; *Tyto alba*) predation on a potential rodent pest (gerbil, *Gerbilliscus sp.*), as well as occupancy rates in an agricultural matrix.
- We assessed the efficacy of barn owls as a biological control agent using the following methods: 1) monitoring reproductive success, 2) using occupancy modeling to determine barn owl detectability and occupancy rate and 3) investigating feeding preferences.

Study area

- Situated in the Ottosdal (26.000; -26.800) and Wolmaransstad (25.9807; -27.1957) districts, North West Province, South Africa (Fig. 1); covering an area of 1070km².
- Summer rainfall area with mean annual precipitation (MAP) 520-533 mm and mean annual temperature (MAT) 16.8˚C - 17˚C.
- Vegetation consisting mainly of Klerksdorp Thornveld Savannah and Western Highveld Sandy Grassland vegetation units, landscape comprising of plains, or slightly irregular undulating plains.
- Predominant land use is almost exclusively maize crops.

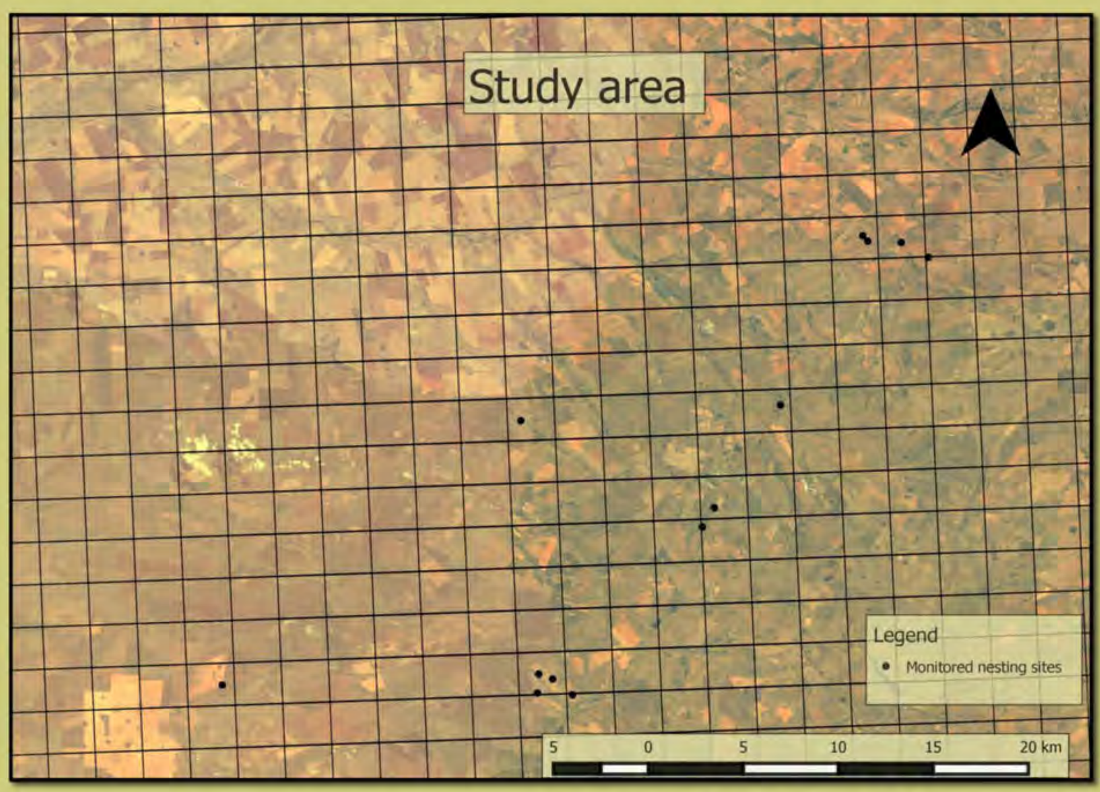

Figure 1: Occupancy grids overlaid over study site in the Ottosdal and Wolmaranstad districts, Northwest Province South Africa.

Figure 2: Barn owl chick

Figure 3: Monitored nest box

Methods and Results: Barn owl reproductive success

- Thirteen barn owl nests were monitored by personal visits as well as motion activated cameras attached to the nests (Fig. 2 & 3).
- Nests were located either in crops itself or near human settlement in barns.
- The owls had a high breeding success rate, where the majority of chicks reached adulthood (Table 1& Fig. 4).

Table 1: Occupancy of nesting sites and development cycles of monitored barn owls

Parameter	Values
No. of nesting sites monitored	13
Average monthly nest occupancy	10.7 ± 0.5
Average monthly occupancy by paired owls	10.2 ± 0.4
Average monthly occupancy by single females	0.4 ± 0.5
Total no. of clutches	18
Total no. of eggs	51
Average monthly no. of clutches	1.6 ± 1.1
Average monthly no. of eggs overall	5.9 ± 5.6
Average no. of eggs/clutch	3.8 ± 2
Total no. of chicks	52
Average monthly no. of nests with chicks	3.3 ± 1.9
Average monthly no. of hatclings overall	5.8 ± 6.1
Average no. of hatchlings per nest	3.5 ± 1.6
Total number of fledgelings	47
Average monthly no. of fledgelings	5.2 ± 4.5
Average no. of fedgelings per nest	4.7 ± 3.6

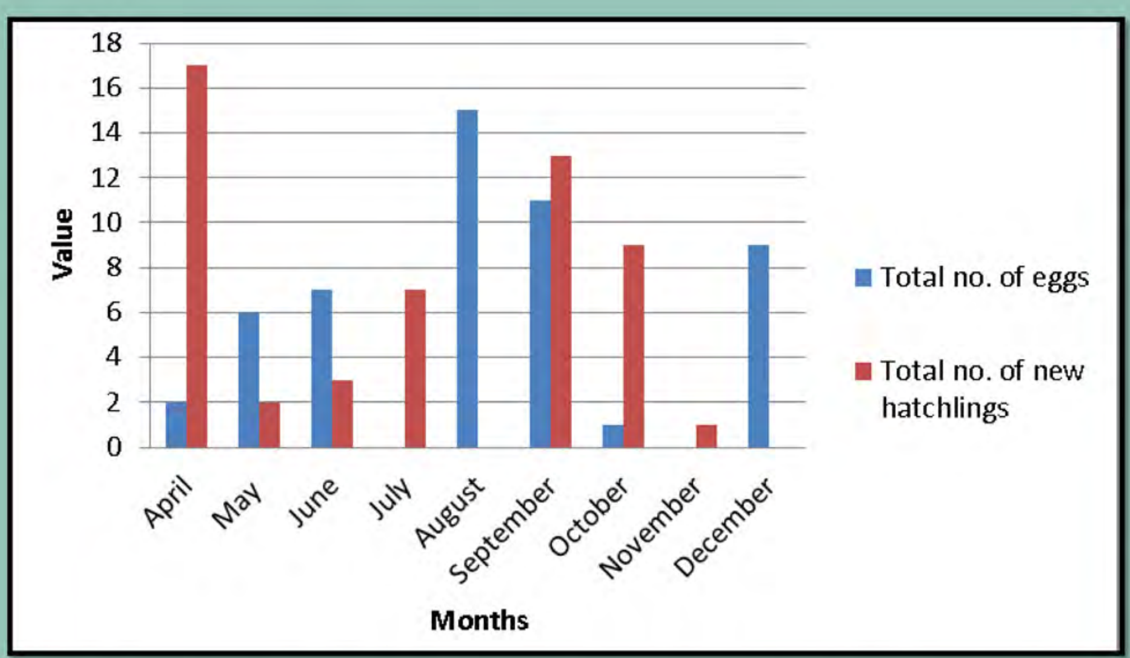

Figure 4: Breeding results, in terms of total no. of eggs and hatchlings per month, for the period of April 2014 until December 2014

Methods and Results: Feeding preferences

- Nine hundred and forty nine regurgitated barn owl pellets were collected around nesting sites (April - December 2014) (Fig. 5)
- A total of 811 "unknown" skulls and/or jaws were identified by comparing four factors to reference specimens using Factor Discriminant Analysis (FDA's) (Figure 8): 1) Jaw length (Fig. 6), 2) molar row length, 3) tooth socket formation and 4) if the incisor teeth are grooved or not
- Of the 4 variables used, the tooth socket formation/type were the most indicative in discriminating species (82% of F1), followed by the type of incisor (92% of F2).
- Results indicated that *Mastomys sp.* (50.18%) were the most commonly selected prey species, with *Gerbilliscus leucogaster* (45.62%), the second most preyed upon species. The latter species are currently known as the major rodent pest within the study area.
- Other rodent species found within the pellets include *G. brantsii* (1.97%), *Otomys* sp. (0.98%), *Rhabdomys pumilio* (0.61%), *Cryptomys hottentotus* (0.49%) and *Rattus rattus* (0.13%).

Methods and Results: Occupancy modeling

- For occupancy modeling we overlaid the study area with 44 grids (Fig. 1) (2.5km x 2.5km grids ~average home range size of owls; Bond, Burnside, Metcalfe, Scott & Blamire, 2004).
- Night transects were carried out during the wet (November-December) and dry (June-July) season, applying constant effort.
- Transects were driven at 40km/h, covering as many grids possible (minimum of 20/night) to detect barn owls.
- Variation in detection probability and occupancy were determined by fitting a multi-season occupancy model using the 'unmarked' package in program R (Fiske & Chandler, 2011; R Development Core Team 2010).
- Biologically and methodologically relevant parameters used in the model include:1) seasonal influences, 2) number of sampling occasions per season, 3) both the difference in season and the number of sampling occasions and 4) the percentage crop within each grid (Table 2).
- A total of 92 owl sightings were made (23 dry season & 69 wet season) (Fig. 7).
- Season had the greatest effect on detection probability (p =0.31) (Table 2).
- The most parsimonious models suggested constant site occupancy (Table 2).

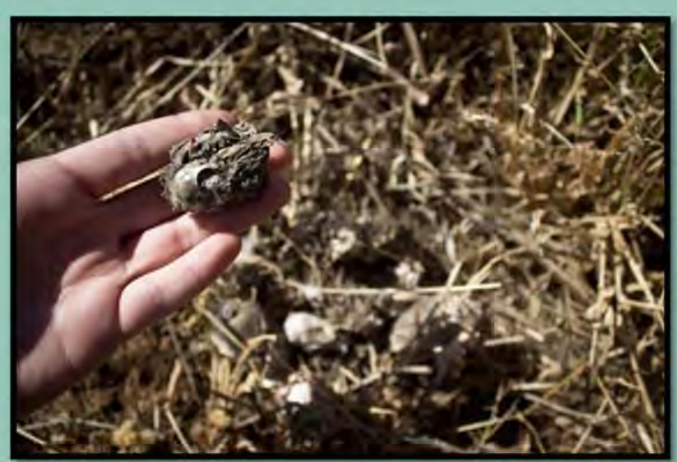

Figure 5: Regurgitated owl pellet

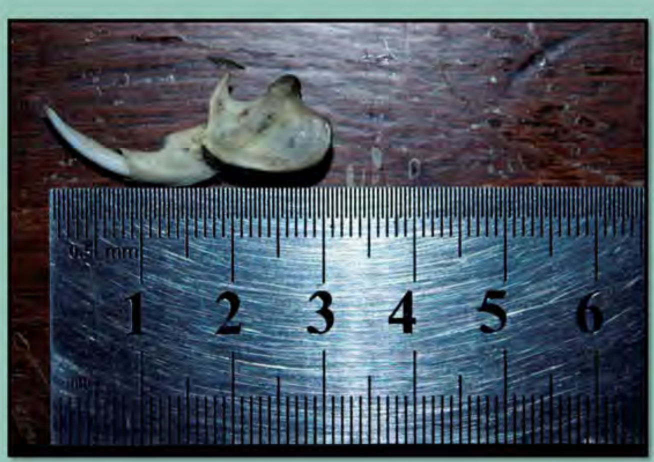

Figure 6: Jaw measurements

Figure 7: Sighted barn owl during night drive

Table 2: Detection probabilities and site occupancy rates for owls in the agricultural matrix of the North West province. Table includes AIC values, AIC model weights (w_i), detection probabilities (p), and site occupancy (ψ) with associated standard error (SE(ψ)).

Model	AIC	w_i	p	ψ	SE (ψ)
ψ(.)p(season)	5 342.95	0.7	0.31	0.62	0.1
ψ(.)p(.)	4 347.10	0.1	0	0.61	0.1
ψ(.)p(season.sampling occasions)	13 351.64	0.01	0	0.58	0.09
ψ(.)p(sampling occasions)	8 352.17	0.007	0	0.57	0.08
ψ(% crop)p(.)	5 363.13	0.00006	0.21	0	0

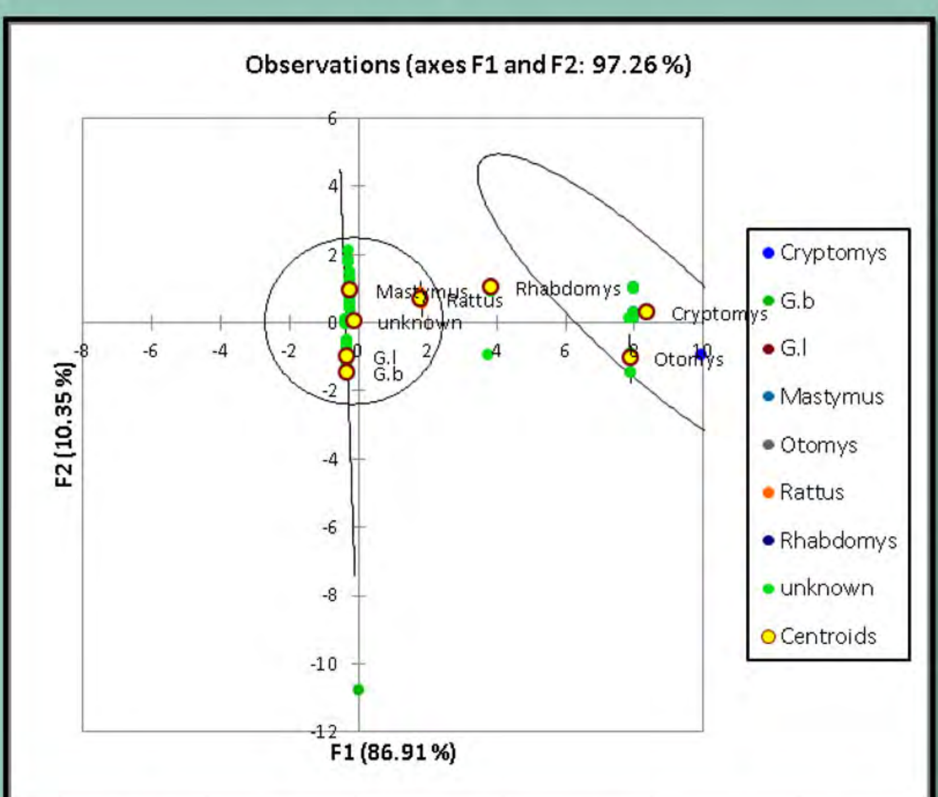

Figure 8: Species discrimination based on skulls found in regurgitated owl pellets.

Discussion

- Owls were successful breeders in the agricultural matrix.
- There were seasonal variation in owl detection probability, with higher rates in wet season. This suggest that owls are either more active and/or more abundant in wet season.
- Site occupancy were constant, suggesting that current land matrix has no limiting factors affecting owl occupancy.
- Nonetheless, breeding success had a cyclic pattern, suggestion that owl reproduction (and hence abundance) are affected by prey populations.
- Furthermore, owls preyed mainly on one or two selected genera, suggesting specialist predation.
- Our results suggest that the agricultural matrix can harbour viable owl populations, that owls predate on rodent pests and can therefore play an important role in bio-control of rodent pests.

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