The importance of anthropogenic effects in habitat use and territory size of Northern Anteater-chats (*Myrmecocihla aeithiops*) near Amurum Forest Reserve, Jos-plateau, Nigeria

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Occurrence of animals in an area and the size of territories they occupy is a function of resource availability and the environmental conditions in that area. Territory location in birds is often determined by availability of nesting habitat and we investigate whether this is the case for the little studied Northern Anteater-chat *Myrmecochila aeithiops*. Territory size and location were mapped over two months in 2012 at 25 different sites where the birds occurred in central Nigeria and compared to 25 random sites where they did not, 500m away. Vegetation variables, invertebrate abundance indicators, anthropogenic variables (availability of nest-sites) and bird community components were measured and compared with adjoining areas (500m away) from which the birds were absent in order to determine important factors determining territory location and size. Territories were 1.23 ha (± 0.14 SE) in size and were widely separated and so non-contiguous. Increasing numbers of abandoned wells, ant nests and termite mounds increased the probability of territory occupation. Territory size increased with the number of Anteater-chats but decreased with increasing number of ant nests and overall bird diversity that were probably proxies for habitat quality. Overall, choice of preferred areas for the Northern Anteater-chat was centred on nesting sites and then habitat quality and group size probably determined territory size.

According to the habitat selection theory, individuals select the highest quality habitats that are available in a heterogeneous landscape to maximize their fitness returns (Morris 2008). Thus, the territory size in a selected habitat for birds is often a product of resource availability and abundance (Calsbeek & Sinervo 2002). The cost of defending a territory may be quite high but benefits usually outweigh the cost: an optimal territory size is one in which net benefits are greatest (Both & Visser 2003). Defended territories are usually characterised by the availability of food, nest sites and roosting sites (Newton 1992). In this study we investigate the factors determining territory size and location of the Northern Anteater-chat (*Myrmecocichla aeithiops*) in Nigeria, as a case study of a tropical bird, where the factors determining territories are relatively little studied compared to temperate species, and because the species is poorly known in West Africa (Mundy & Cook 1972, Mundy & Cook 1974). The West African population of the Northern Anteater-chat is widely spread but only locally common with large areas unoccupied (Del Hoyo *et al*. 2005), the occupied areas can be aggressively defended against conspecifics (pers.obs), therefore we refer to occupied areas, or home ranges, as “territories” throughout this paper.

Northern Anteater-chats are described as being dependent on unlined wells or other earth holes for nesting (Keith *et al*. 1992). They are also described as being highly territorial (Keith *et al*. 1992) with several related individuals defending their territories in groups of 2 to 20 individuals (Mundy & Cook 1972). This suggests that nesting resources may be of great value and potentially in short supply and thus the most important factor in determining the distribution of territories. Furthermore Northern Anteater-chats may forage frequently in the presence of other species in the same foraging guild (Keith *et al*. 1992) suggesting that food resources are less important in territoriality. We therefore tested the hypothesis that the location and size of Northern Anteater-chat territories is primarily determined by the availability of nesting sites.

Methods

Northern Ant-eater Chats are found mainly in the Sahel and Sudan savannah regions of West Africa. Their range, however, also extends southwards to the Jos-plateau in central Nigeria (Keith *et al*. 1992). The study was carried around the Amurum Forest Reserve and surrounding villages (9°83′-9°91′N and 8°93′-9°7′ E), on the Jos Plateau, in the central part of Nigeria. The surrounding villages include;

Laminga, Kerker, Itsisa, Zarazon, Gwafan, Rizek, Kwanga, Kampala and Furaka, Sabon kaura and Kudedu (Fig. 1). Average rainfall is about 1400mm per year and daytime temperatures range from 20-35°C (Molokwu *et al*. 2008, Ezealor 2002)

The area surrounding Amurum Forest Reserve is typical of the Jos-Plateau landscape, comprising scattered granitic outcrops ranging from 1200m-1450m above sea level. The vegetation is scattered bush and grass, grazed by cattle with sparse riparian forests, extensive cultivation and abandoned tin mining sites (Elgood *et al*. 1994, Vickery & Jones 2002). Dry abandoned wells which were formerly used for irrigation are not uncommon because farmers often practice shifting cultivation. In some cases, abandoned wells can be observed close to long-deserted mud houses.

Field data were collected between 10 May and 14 July 2012. Sites where the Northern Anteater-chats were known to exist from a reconnaissance survey carried out prior to the experiment were visited; new sites were also found during the study period. 21 Northern Anteater-chats from 10 territories were trapped with mist nets. Playback calls facilitated trapping of Northern Anteater-chats in their territories because the birds showed a high degree of aggression to territory intrusion by conspecifics. Each trapped bird was ringed with a uniquely numbered metal ring and a three-ring combination of plastic colour rings. Although a lot of effort was put into finding new territories within the study area, it cannot be categorically stated that all the territories in the study area were found and sampled. Nevertheless the species is highly detectable and occurs in open habitats, suggesting that few if any territories were missed.

Territory size sampling was carried out in the morning between 06h30 and 08h30 and in the evening between 16h00 and18h00. Individual birds were observed through binoculars for 20 minutes at a distance not less than 150m to avoid observer interference on bird behaviour. Each point where the bird perched, fed or performed any other activity was noted and marked with a Global Positioning satellite System (GPS; Garmin eTrex® version 3.10) after the 20 minutes of focal observation. This was carried out for each colour-ringed bird in every recognised territory. Using QGIS® version 1.7.4 software, 95% Minimum Convex Polygons (MCP) were generated using the “home range analysis” tool (plugin). The areas of the MCPs were calculated in ARC GIS® version 10.0. An average of about 10 separate points where the birds perched and performed other activities were recorded in not less than two observations at every territory.

Habitat variables which characterised the environment were categorized as invertebrate abundance indicators, vegetation variables, anthropogenic variables (presence of buildings, roads and wells) and bird community components – see Table 1). They were measured in a 20m x 20m quadrat randomly placed in each Northern Anteater-chat territory and at randomly selected points where Northern Anteater-chats were absent 500m away from each territory. In selecting the random points, random numbers > 0 < 1 were generated in R® version 2.1.4, the generated numbers were multiplied by 360° to give an angle which was traced from the North on a compass (Skalski 1987). Where Northern Anteater-chats were observed within 200m radius of random points, such points were immediately reclassified as“presence” sites, and further random points were added to the study. We estimated abundance of crawling and flying insects by using pitfall traps and sweep nets respectively. At each 20m x 20m quadrat, five pitfall traps were randomly placed at a distance not less than 5m apart. Eighty sweeps using a sweep net 30cm in diameter were carried out at each quadrat. Insect species caught by both methods in every quadrat were sorted according to insect orders and then counted. A five-minute point count was carried out at every territory and random point to determine bird diversity and abundance in the territories and random points. All birds seen and heard were recorded and all records were combined to give a total abundance of all species. Point counts were conducted in very open, sparsely vegetated habitat where detectability was not considered an issue over the relatively small scale of the Northern Anteater-chat territories. The Shannon-Weiner index was used to calculate bird diversity.

All data were analysed using R® version 2.14.0 statistical software package. Significance of all tests were accepted at $\alpha<0.05$. Models were checked for violation of assumptions using Quantile-Quantile (Q-Q) plots. A t-test was used to determine differences in habitat qualities between territories of Northern Anteater-chats and the random points to allow simple illustration of differences between selected and non-selected habitats. Then a multivariate Generalised Linear Model (GLM) with a binomial error structure was used to determine which of these habitat variables best predicted habitat selection in Northern Anteater-chats. Presence/absence of the Northern Anteater-chat was set as the dependent variable while the vegetation variables, invertebrate abundance, anthropogenic factors and bird community components were the explanatory variables. A further General Linear Model was used to determine the variables predicting territory size. The areas of the Minimum Convex Polygons for the territories was set as the dependent variable while the vegetation variables, invertebrate abundance, anthropogenic factors and bird community components were set as the explanatory variables. For both model types, the best for each was chosen using the following procedure. Initial models contained all habitat variables as explanatory factors and included all two-way interactions. A final best model was then identified using a step-wise backward elimination method, based on the lowest AIC and highest AIC weight.

Results

The mean MCP area of Northern Anteater-chat territories as obtained from the study was 1.23 ha ± 0.14 (N=25, range 0.18 – 2.7 ha). The territories did not overlap and were widely spaced from one another (Figure 1).

A total of 25 territories and 25 random points were surveyed. A comparison of the habitat variables using a t-test showed that most of the measured habitat variables at the territories of Northern Anteater-chats were not significantly different from those of the random sites. Percentage bare rock cover, number of termite mounds, number of ant nests, and number of abandoned wells in the territories were significantly different from those of the random sites (Table 1).

The number of abandoned wells turned out to be the most significant predictor of territory location for Northern Anteater-chats (Table 2) with the probability of occurrence rising if one or more wells were present in a territory (Figure 2). As the mean number of ant nests and termite mounds increased so too did the probability of occurrence, although the relationship with the number of termite mounds was only marginally significant (Table 2).

The number of Northern Anteater-chats was the most significant determinant of territory size in Northern Anteater-chats (Table 3), with territory size increasing with the number of birds (Figure 3). Territory size was significantly smaller for territories with higher bird diversity and there was also a marginally significant decrease in territory size with increasing number of ant nests (Table 3).

Discussion

Variation in territory size and density is common both within and between bird species (Marshal & Cooper 2004, Adams 2001). Territory sizes of Northern Anteater-chats in this study ranged from 0.19 ha to 2.77ha. This is similar to the range of territory sizes studied in other tropical passerines, with often large variations in range size (e.g. Chaskda 2011, Pickman 1987). Variability of territory size in Northern Anteater-chat can be partly attributed to group size, with larger groups – almost certainly adults with young or retained young from previous breeding attempts – having larger territories. Most territories of Northern Anteater-chats are usually at very low densities (Keith *et al*. 1992; Mundy & Cook, 1974), and the fact that territories of Northern Anteater-chats are widely spaced and non-adjoining as presented in this study shows that territories can probably be expanded so as to maximize resources for the accommodation of non-breeding juveniles.

This study showed that habitat selection of Northern Anteater-chats is likely to depend on availability of nesting sites which are in most cases dry abandoned wells. Furthermore, in four different territories where abandoned wells were not recorded, these were centred on the banks of gullies where nesting tunnels were observed, indicating the importance of habitat that will allow nesting. The choice of territory location for most tropical birds generally largely depends on the availability of nesting sites rather than local variation in food availability (Stutchbury & Morton 2001). Even though resources are abundant, high competition for resources which allow successful reproduction such as safe nesting sites have probably led to a selection for a K life history strategy in Northern Anteater-chats. Nest predation in tropical birds is often very high (c.77%) (Remeš *et al*. 2012) and as a result, selection of habitats that have safer nesting sites is often made by tropical birds in order to maximize their fitness (Remeš *et al*. 2012). Northern Anteater-chats may have such a strong preference for wells rather than digging their own tunnels in gullies because wells may have a much lower predation risk compared to gullies: in our experience nest sites in gullies appeared much more conspicuous and vulnerable to predation but this remains to be tested.

This study showed that ant nests and termite mounds, which probably indicate abundance of ants and termites, respectively, are also important factors in habitat choice of Northern Anteater-chat. Abundance of food is frequently of secondary importance in habitat choice of tropical birds (Stuchbury and Morton 2001) because tropical birds are generally faced with low starvation risk (Brandt 2006). Nevertheless food abundance still affects territory size in many species (Marshall & Cooper 2004). The negative relationship between diversity of other birds and territory size of Northern Anteater-chat as shown in this study possibly points to the fact that high quality habitats attract a lot of heterospecifics. It is easier to measure diversity of other bird species at Northern Anteater-chat territories than the resource levels for Northern Anteater-chats. Although numbers of ant nests, termite mounds and insects in territories of Northern Anteater-chats have been sampled, there may still remain other un-sampled variables which allow for smaller territory size. Such variables may be indicated by high bird diversity. Therefore, if bird diversity is a proxy for habitat quality, Northern Anteater-chats have larger territories in areas with lower resource availability.

Territorial behaviour is important in spacing out birds within a habitat (Newton 1992); as a consequence, local populations of birds are regulated at fairly stable densities especially when territory sizes are not extremely variable (Adams 2001). However, the distribution of territories in this study, suggests that Northern Anteater-chats defend large non-contiguous territories centered on key resources (wells), and these key resources may be in short supply, being widely separated. Therefore territoriality and breeding success may hinge on long term ownership of the nesting sites, rather than defence of an area or boundary per se. Given the short period of research and the relatively large area of study and the rocky undulating terrain of the Jos Plateau, we believe that not all territories will have been sampled. But apart from a few villages where more than two Northern Anteater-chat territories were recorded, we observed that the territories were all widely separated. Northern Anteater-chats also occupied gullies and these may perhaps represent lower quality habitats: gullies appeared to be reasonably available but only occasionally used perhaps suggesting that they may serve as poorer quality or even sink habitats when high quality source habitats are unavailable. However, without breeding data, lacking from the present study, it is impossible to determine whether this is occurring, or whether the anteater chats are at carrying capacity. Further studies on the survival and dispersal of young Northern Anteater-chats may explain the role of territoriality (or home-range behaviour) in population regulation of Northern Anteater-chats.

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Table 1: Comparison of habitat variables measured within random sites and Northern Anteater-chat territories in and around Amurum Forest Reserve. All distances are in meters. Statistically significant differences in these values as univariate pairs are in bold: the best model from the full multivariate analysis is in Table 2.

Parameter	**Mean Number at Random points**	**Mean Number at Territories**	sd	**t**	**df**	**p**
Number of trees	0.8	0.6	1.3	0.6	33.5	0.52
Number of shrubs	20.5	12.2	16.9	1.7	36.1	0.08
Percentage bare ground cover	31.4	34.0	21.5	-0.4	45.3	0.65
Percentage bare rock cover	15.8	0.8	20.5	2.7	24.6	0.01
Mean grass height	18.4	0.9	19.8	1.6	25.9	0.11
Number of termite mounds	0.8	1.8	1.6	-2.2	37.2	0.03
Mean number of ant nests	0.4	0.7	0.5	-2.4	40.9	0.02
Insect abundance	243.9	268.6	227.0	-0.3	46.2	0.70
Distance from nearest building	205.3	178.5	220.0	0.4	45.1	0.67
Distance from nearest farm	76.0	110.6	185.0	-0.6	38.2	0.51
Distance from nearest road	334.3	157.1	251.2	2.8	46.3	0.01
Number of abandoned wells	0.04	1.3	1.3	-3.9	24.8	<0.01
Bird diversity	1.9	1.9	0.8	0.2	47.0	0.77
Bird abundance	19.0	25.3	16.2	-1.4	34.9	0.17

Table 2: Important predictors of territory location of the Northern Anteater-chat. The best model: Presence or absence = number of termite mounds + mean number of ant nests + number of abandoned wells, family=binomial, N = 50, degrees of freedom for all terms 1,46. The best model had an AIC-value of 36.0 and AIC weight of 1.0 compared to the second best model with an AIC-value of 42.2 and AIC weight of 0.1.

Variable	**Estimate**	**Standard Error**	**F-value**	**p**
(Intercept)	-3.9	1.2		<0.01
Number of termite mounds	0.6	0.3	8.7	0.06
Mean number of ant nests	3.0	1.1	15.8	0.01
Number of abandoned wells	3.7	1.2	44.7	<0.01

Table 3: The relationship between territory size of Northern Anteater-chats with ant nests, bird diversity and number of Northern Anteater-chats occupying the territory. The best model: Territory size = mean number of ant nests + bird diversity + number of Northern Anteater-chats, Number of territories = 25. $F_{3,21}$=9.2. Overall adjusted model R^2 = 0.51. Degrees of freedom for all terms 1,21. The best model had an AIC-value of 504.6 and AIC weight of 0.79 as against the second best model with an AIC-value of 505.1 and AIC weight of 0.11.

Parameter	**Estimate**	**SE**	**T**	**p**
Intercept	13003	4846	2.7	0.01
Mean number of ant nests	-3934	2171	-1.8	0.08
Bird diversity	-3477	1496	-2.3	0.03
Number of Northern Anteater-chats	3740	1190	3.1	<0.01

Figure Legends

Figure 1: Map of the study area showing territories of Northern Anteater-chats in the villages surrounding Amurum Forest Reserve.

Figure 2: The probability of occurrence of Northern Anteater-chats with the number of abandoned wells present. Points are 0 and 1 because they show presence/absence data. The solid line is fitted through the average of the presence and absences, for each value of number of wells (with dashed lines showing one standard error for the fitted average line – see parameter estimates from the model in Table 2). The raw data of the frequency of presence and absences is shown using a sunflower plot: the number of petals indicate the number of points that were scored as either presence (top, Y = 1 axis) or absence (bottom, Y = 0 axis).

Figure 3: The size of Northern Anteater-chat territories with number of conspecifics in the territory. The solid line is the predicted relationship (back transformed) from the top model in Table 3 (with dashed lines showing the predicted relationship plus or minus one standard error).

Fig. 1

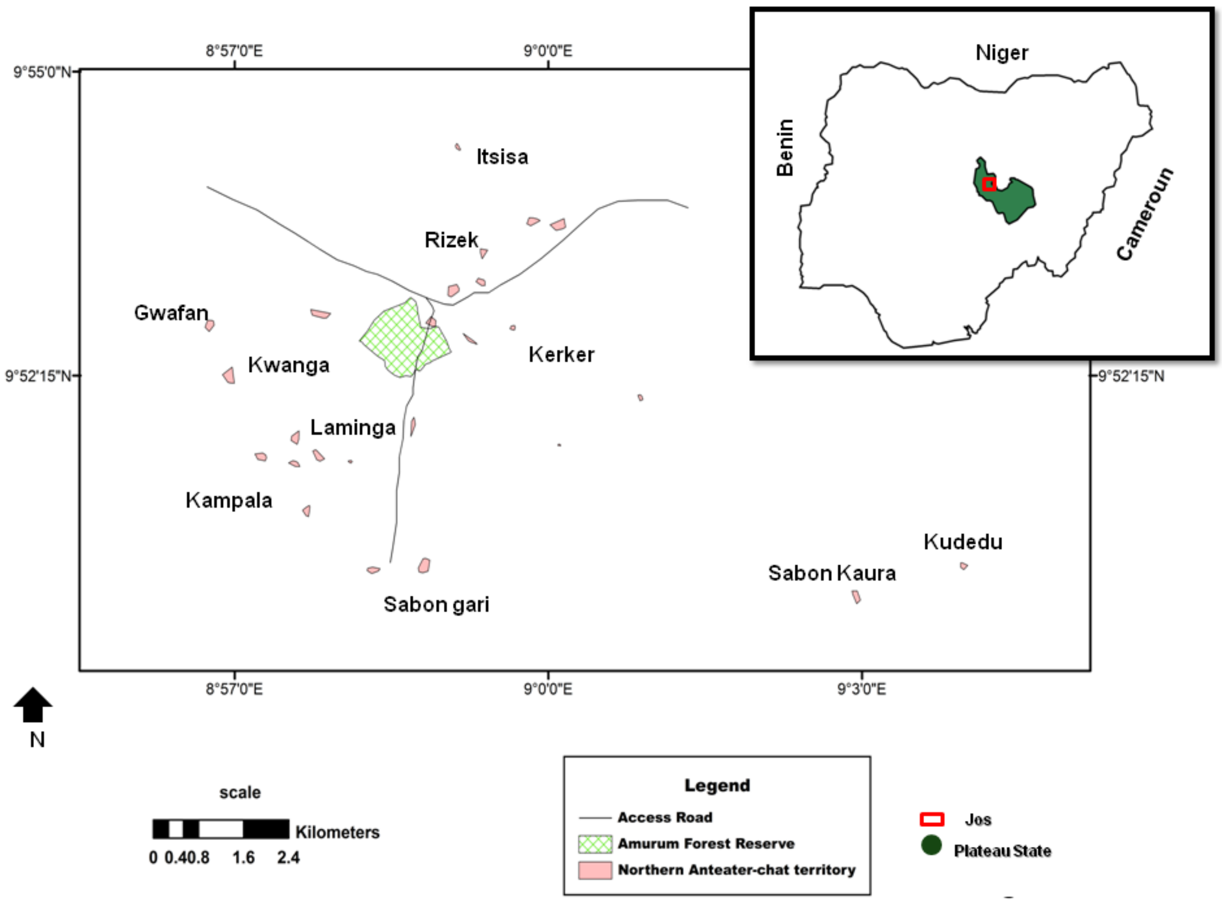

8°57'0"E
9°0'0"E
9°55'0"N
Niger
Benin
Cameroun
Itsisa
Rizek
Gwafan
Kwanga
Kerker
9°52'15"N
Laminga
Kampala
Kudedu
Sabon Kaura
Sabon gari
9°3'0"E
N
scale
Kilometers
0 0.40.8 1.6 2.4
Legend
Access Road
Amurum Forest Reserve
Northern Anteater-chat territory
Jos
Plateau State

Fig. 2:

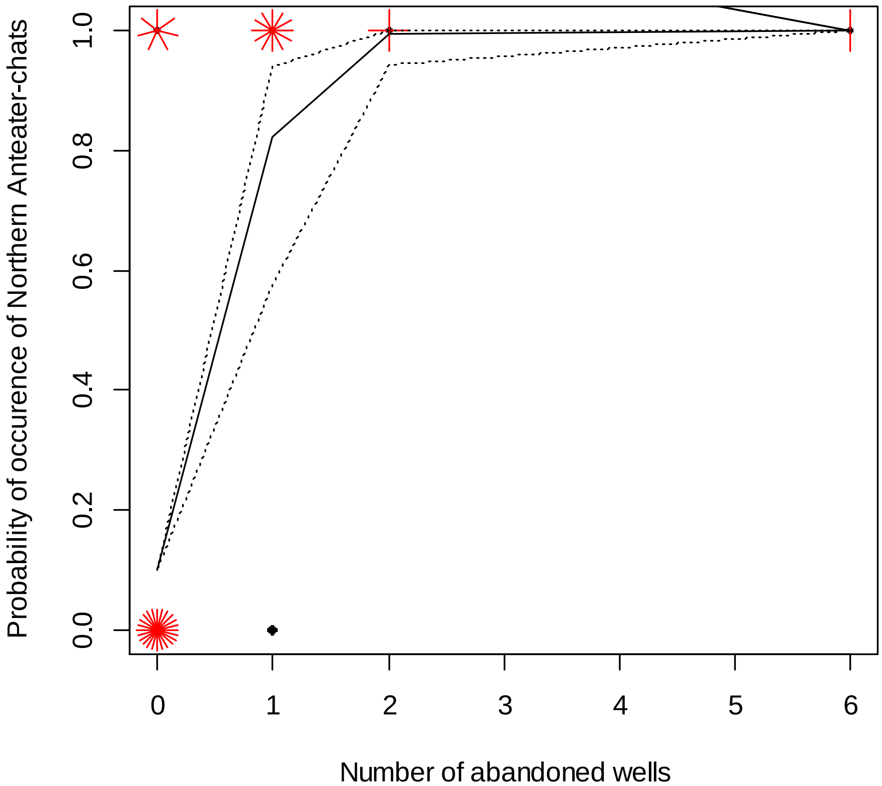
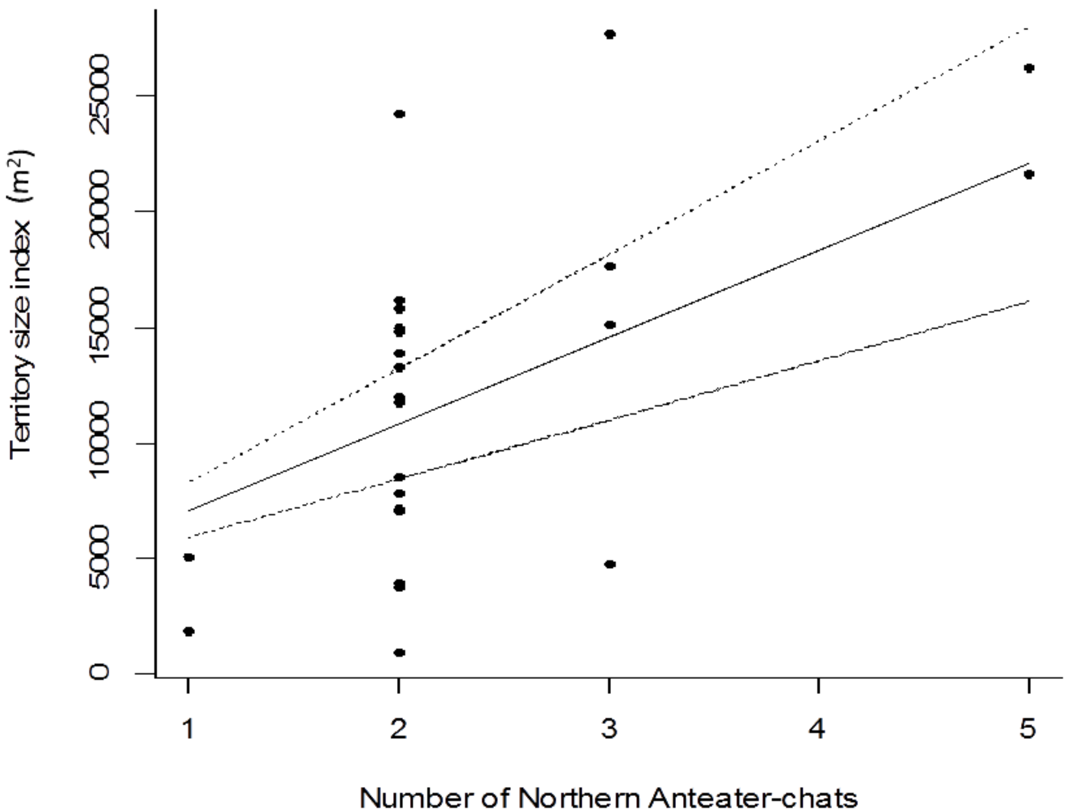

Probability of occurence of Northern Anteater-chats
0.0
0.2
0.4
0.6
0.8
1.0
0
1
2
3
4
5
6
Number of abandoned wells

Fig. 3



Territory size index (m2)
0
5000
10000
15000
20000
25000
1
2
3
4
5
Number of Northern Anteater-chats