

**Designing Robust Ranger Based Monitoring
Strategies for the Saiga Antelope**
Saiga tatarica tatarica

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Abstract

This investigation sought to develop robust ranger based monitoring strategies for the North-west pre-Caspian population of the saiga antelope, *Saiga tatarica*, in two nature reserves created for its conservation. The saiga is a critically endangered species which suffered a 90% population decline due to poaching for horns to be used in traditional Chinese medicine and for its meat. Monitoring of this species is highly important as despite extensive conservation efforts, poaching is still occurring. The effect of poaching and the conservation work on the status of the species is vital information for effective future conservation planning.

A GIS map was created of each reserve showing the location of vehicle tracks. It was found that there is a significant positive relationship between track density and saiga sightings in the current monitoring system suggesting this may be a significant source of bias. Two experiments into the accuracy of the rangers' count estimates were conducted. A comparison of ranger estimates against photographs taken of saiga herds found the rangers tended to over estimate the number of saiga in a herd, although the data only covered a small range of herd sizes. An experiment using flocks of sheep as a proxy for saiga was conducted. The rangers tended to underestimate the number of sheep in a flock and in some cases there was a significant change in bias as the flock size increased. Finally, distance sampling was evaluated as a potential monitoring technique. However, due to the behaviour of the species it was found not to be suitable due to the model's assumptions not being fulfilled.

The investigation provides recommendations for the future monitoring of saiga, based upon a strip transect sampling system and using stratification of data according to distributions of monitoring effort. This will increase the utility of the data collected by the rangers without having to introduce a complex monitoring system which could affect their ability to fulfil their main role of preventing saiga poaching.

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List of Acronyms

| | |
|--------|---|
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| CMS | Convention on Migratory Species |
| CZBR | Chernye Zemli Biosphere Reserve |
| GIS | Geographic Information System |
| IUCN | International Union for the Conservation of Nature (World Conservation Union) |
| SCA | Saiga Conservation Alliance |
| SE | Standard Error |
| SR | Stepnoi Reserve |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |

Contents

| | Page |
|--|-------------|
| Abstract | 2 |
| Acknowledgements | 3 |
| List of acronyms | 4 |
| 1. Introduction | 9 |
| 2. Background | 12 |
| 2.1 <i>Monitoring strategies</i> | 12 |
| 2.2 <i>Saiga tatarica</i> | 20 |
| 2.3 <i>The study sites</i> | 28 |
| 3. Methods | 32 |
| 3.1 <i>Minimising and quantifying the biases inherent in vehicle transects through evaluating the current monitoring system</i> | 32 |
| 3.2 <i>Assessing reliability of ranger monitoring by analysing the direction and magnitude of errors and biases using an experimental approach</i> | 32 |
| 3.3 <i>Investigating the potential for and utility of alternative sampling methods e.g. distance sampling</i> | 34 |
| 4. Results | 35 |
| 4.1 <i>Minimising and quantifying the biases inherent in vehicle transects through evaluating the current monitoring system</i> | 35 |
| 4.2 <i>Assessing reliability of ranger monitoring by analysing the direction and magnitude of errors and biases using an experimental approach</i> | 40 |
| 4.3 <i>Investigating the potential for and utility of alternative sampling methods e.g. distance sampling</i> | 44 |
| 5. Discussion | 46 |
| 5.1 <i>Minimising and quantifying the biases inherent in vehicle transects through evaluating the current monitoring system</i> | 46 |

| | |
|--|----|
| 5.2 <i>Assessing reliability of ranger monitoring by analysing the direction and magnitude of errors and biases using an experimental approach</i> | 48 |
| 5.3 <i>Investigating the potential for and utility of alternative sampling methods e.g. distance sampling</i> | 50 |
| 5.4 <i>Limitations of the results</i> | 50 |
| 5.5 <i>Recommendations and suggestions for further work</i> | 52 |
| 6. References | 55 |
| 7. Appendix A | 60 |

List of Tables

| | |
|--|----|
| Table 2.1. Pros and cons of plot sampling and distance sampling | 15 |
| Table 2.2. Pros and cons of different sampling methods | 19 |
| Table 4.1. Summary of results from the sheep counting experiments | 42 |
| Table 4.2. Results of paired two sample, two tailed t-tests to compare the effect of the use of tally counters in count accuracy with sheep | 43 |

List of Figures

| | |
|---|----|
| Figure 2.1. Diagram showing the sources of potential error and bias for a vehicle transect survey | 14 |
| Figure 2.2. Histograms showing different detection functions that may be encountered in a distance sampling survey. Reproduced from Milner-Gulland & Rowcliffe, 2007 | 16 |
| Figure 2.3. Current distribution of the five remaining <i>Saiga tatarica</i> populations. Reproduced from Milner-Gulland (2003) | 21 |
| Figure 2.4. Adult female saiga antelope | 22 |
| Figure 2.5. Saiga juvenile hiding in long grass | 22 |

| | |
|---|----|
| Figure 2.6. Saiga horn for sale in a Chinese medicine shop. Photo by Matthias Rossbach from Saiga News, Issue 5. | 23 |
| Figure 2.7. Adult male saiga with characteristic horns. Photo by Richard Reading. Source: USGS. Available from [http://esp.cr.usgs.gov/research/alaska/alaskaC.html] | 24 |
| Figure 2.8. Maps showing the distribution of saiga herd in (a) winter 1957/8 and (b) summer 1958. Reproduced from A. G. Bannikov (1961) Biology of the saiga. Nanka, Moscow. | 26 |
| Figure 2.9. Changes in the core range and limits of dispersion of the Northwest pre-Caspian saiga antelope population. Reproduced from Lushchekina & Struchkov (2001) | 27 |
| Figure 2.10. Area surrounding the two nature reserves showing locations of nearby villages. Satellite image from GoogleEarth | 29 |
| Figure 4.1. GIS map of Chernye Zemli Biosphere Reserve and the Stepnoi Reserve showing the locations of vehicle tracks and key landmarks and saiga sightings locations | 36 |
| Figure 4.2. Regression of density of saiga sightings against track density | 37 |
| Figure 4.3. Regression of saiga herd size against vehicle track density | 37 |
| Figure 4.4. Number of sightings of saiga herds compared to the number of days for which there is monitoring data between September 2003 and February 2007. | 38 |
| Figure 4.5. Mean saiga herd size by month from saiga sightings data collected between September 2003 and February 2007 | 39 |
| Figure 4.6. Mean number of days for which there is monitoring data per month compared to the mean saiga herd size observed between September 2003 and February 2007 | 39 |
| Figure 4.7. Comparison between the numbers of saigas estimated to be in a herd by the anti-poaching rangers and number in photo. | 41 |
| Figure 4.8. Results from the sheep counting experiment with the Stepnoi rangers | 42 |

| | |
|--|----|
| Figure 4.9. Number of saigas in a herd compared to the estimated distance (m) of the herd from the observer | 42 |
| Figure 4.10. The estimated distance between the observer and the saiga herd compared to the percentage difference between the observer estimate of the number of saiga and the number from the photograph | 43 |
| Figure 4.11. Histograms showing the heaping of data collected for estimated distance and angle between observer and saiga herd. | 44 |
| Figure 4.12. Data for estimated perpendicular distance from transect to saiga herd, calculated using distance and angle | 45 |
| Figure 4.13. Regression of percentage difference between ranger estimates of distance compared to the actual distance | 45 |
| Figure A.1. Example of a data sheet used by the anti-poaching rangers in the Chernye Zemli Biosphere Reserve and the Stepnoi Reserve. | 60 |

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1. Introduction

The saiga antelope, *Saiga tatarica*, is a migratory ungulate native to the Russian steppes and the deserts of central Asia. There are five remaining populations which are found in Russia, Kazakhstan, Uzbekistan, Turkmenistan and Mongolia (CMS, 2006). The species is currently designated by the IUCN Red List as being critically endangered (IUCN, 2007). This is due to a dramatic decline in population size since the collapse of the Soviet Union. In this time the global population is estimated to have dropped by 90% (Milner-Gulland *et al.*, 2001). As a result the saiga has been the focus of a large amount of research and conservation action in an attempt to halt the decline of this once numerous species and with the long term goal of its population sizes increasing once more.

The main cause of the saiga's population decline is poaching. Saiga horn is used in traditional Chinese medicine and the meat is sold in local communities for food. This has led to heavily sexually selective poaching of the population. This is because only the male saiga have horns, which are the most valuable part of a carcass. The females are also significantly smaller in size and therefore produce less meat. This makes the males worth substantially more money and this is why the poachers intentionally target them. This caused a reproductive collapse due to the proportion of males in the population falling to such a low level (0.9%) that many females did not reproduce (Milner- Gulland *et al.*, 2003).

As a part of this conservation action there have been two reserves set up in an attempt to protect the North-west pre-Caspian saiga population, one of the five remaining saiga populations. This population, despite its small range, is one of the most numerous. The first reserve to be designated was the Chernye Zemli Biosphere Reserve which was founded in 1990 and was selected as a UNESCO Man and Biosphere Reserve in 1993. The second reserve is the Stepnoi Reserve which was founded in 2000 (Kuhl, 2007). Among the central responsibilities of both reserves are the prevention of poaching of saiga and research into the species. Saiga are found in both reserves throughout the year, particularly in the times just before the rut and calving when the species forms large aggregations in the reserves (CMS, 2006). There has been a large amount of research done and in September 2003, a

monitoring programme was implemented in the reserves. This monitoring programme is based upon opportunistic sightings of saiga by the anti-poaching rangers whilst they drive around the reserves on patrol. A large amount of data has been collected over the last five years as a result of this monitoring system. Unfortunately the utility of the data is currently somewhat limited because there is no way to ensure that the sampling is representative in terms of how the monitoring effort is distributed around the reserves. The monitoring is done from cars travelling along vehicle tracks that are found throughout both reserves. In order to quantify the level of bias (which is vital if an accurate population estimate is to be achieved) in the current system it is important to see how evenly distributed the tracks are throughout the reserves. This is particularly with respect to the topography of the area and the locations of saiga sightings from the current monitoring system. However, there was no map of the reserves showing where the tracks are located. Having a map would make it possible to look at the previously collected data and find out whether the sightings had mostly been restricted to some areas of the reserves (therefore suggesting there might be a bias in sampling effort towards some areas) and to ensure future monitoring effort is proportionately distributed throughout the reserves. Another key issue was that there are no records kept of the areas the rangers visit on their patrols; this also prevents the distribution of monitoring effort being calculated. In addition because the data collection is opportunistic it is therefore unsystematic and liable to be unrepresentative of the whole reserve. There was also no measure of the accuracy of the rangers' estimates of the number of saigas when they counted them, an important factor for group counts because estimates may differ significantly from the actual number. This combination of factors means it is not possible to use the data from the current system to calculate important parameters such as estimated population size or to determine if there have been changes in population dynamics. This is particularly important in saiga conservation due to the dramatic population decline and the selective poaching of males from the population.

A considerable amount of conservation effort has been dedicated to the saiga antelope and so it is important to be able to determine the efficacy of the work that has been done and is ongoing. As there is no robust monitoring system in place, the individual conservation projects' success can be measured, but the impact they have had overall on the saiga

population is not known because there is not an accurate picture of its status. The purpose of this project is to determine the most appropriate monitoring technique to be carried out by the anti-poaching rangers in the two reserves and to provide recommendations for robust ongoing scientific monitoring of saiga population size and dynamics of the North-west pre-Caspian saiga population. This will be done through:

- Minimising and quantifying the biases inherent in vehicle transects through evaluating the current monitoring system.
- Assessing reliability of ranger monitoring by analysing the direction and magnitude of errors and biases using an experimental approach.
- Investigating the potential for and utility of alternative sampling methods e.g. distance sampling.

The thesis begins by introducing the different monitoring strategies that are available and gives examples of where they have been used and the comparisons made between them. A more detailed background about the species is then given, followed by a description of the study sites. The methodology of this investigation is then described followed by the results of the analyses performed. The results are discussed along with their limitations and are contextualised by comparing the results with other studies from the literature. Finally recommendations for improvements to the current monitoring programme are made, along with suggestions for additional work which would help improve the system further.

2. Background

2.1. Monitoring strategies

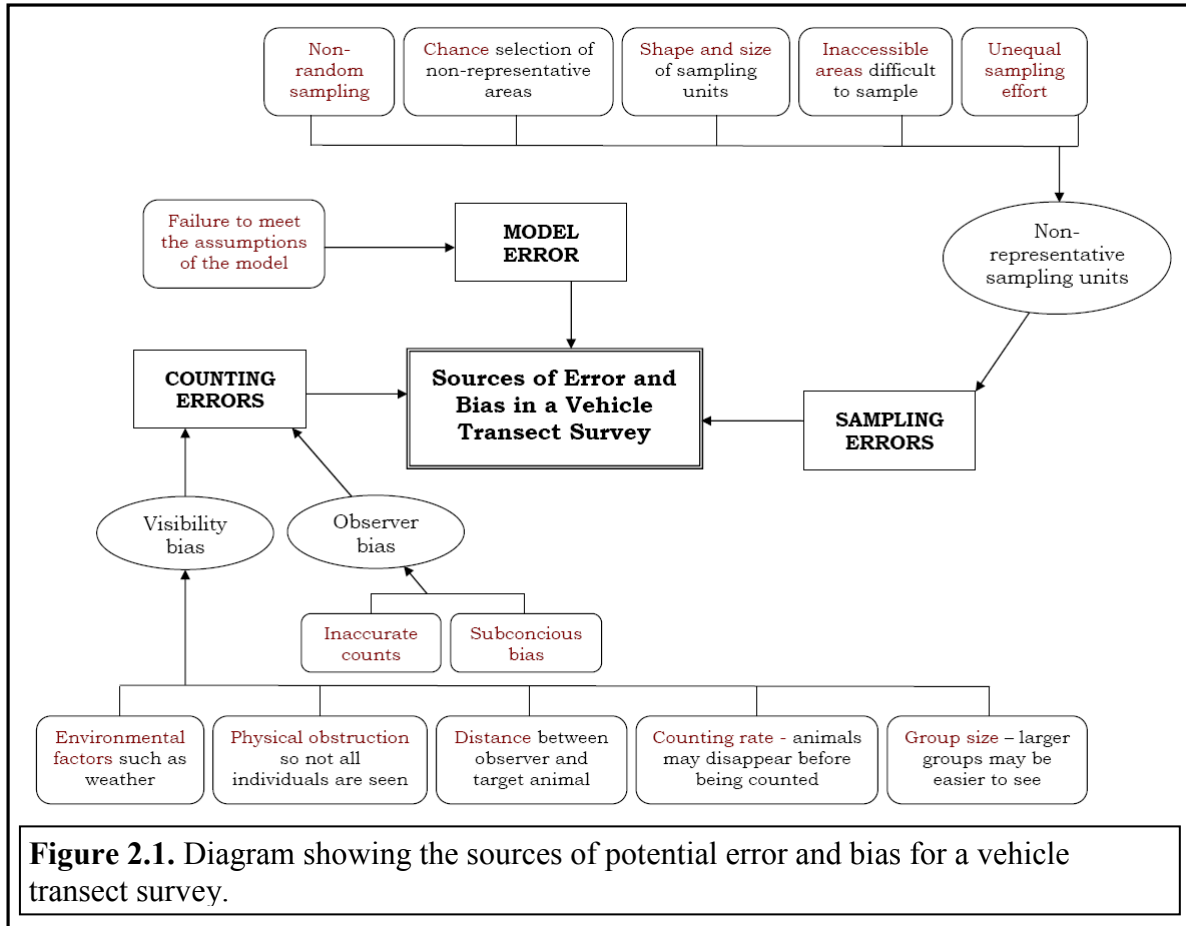
Monitoring a species is the only way to collect information to determine if there are changes in its status over time and is an extremely important aspect of all conservation projects (Plumptre, 2000). Monitoring will usually take the form of assessing the status of the target species; these assessments are gathered over time and used to make inferences about the changes that have occurred (Yoccoz *et al.*, 2001). It is often through long-term monitoring of a species that it is discovered that it is a conservation priority (Yoccoz *et al.*, 2001). There are many ways of monitoring a population of a species, with the strategy employed depending on the species and habitat as well as the type of data that the monitoring strategy is required to produce.

Determining the purpose of the monitoring programme is key to designing an appropriate strategy. There are many reasons why a monitoring programme may be necessary, which can be broadly split into two categories: scientific and management (Yoccoz *et al.*, 2001). Scientific monitoring will tend to concentrate on determining how and why a system works whereas monitoring for management will look at collecting information to ensure that the target species or habitat is managed appropriately. For example, once conservation has begun, monitoring enables practitioners to evaluate whether they are having a positive impact on the survival of the species; it may also allow them to determine which of several strategies is being most effective and enable them to improve and diversify their conservation work. Monitoring is sometimes an area of conservation work that is overlooked, especially during the planning stage of projects (Yoccoz *et al.*, 2001). This may be because it can be expensive and time consuming but nevertheless it is very important (Plumptre, 2000).

The purpose of the monitoring strategy is determined by the information it is required to produce (Yoccoz *et al.*, 2001). Different species will have different causes for concern and so it is important to investigate and determine these before a strategy is finalised. For

example, in a situation where there are low recruitment levels in a population, monitoring the total population size would probably be less effective than monitoring the population's age structure. Data that can be collected about a population includes total population estimates, recruitment rates, mortality rates, sex ratio and age structure. There are also other important considerations when designing the monitoring strategy which include theoretical factors such as the bias, accuracy and precision of different techniques. There are more practical concerns as well, such as the amount of time and resources necessary for the monitoring strategy to be successful and whether there are the finances to support it in the long-term. For a monitoring system to detect change, it needs to collect data over time. If there are not the resources to sustain a system in the long-term, then its utility is called into question. Focardi *et al.* (2005) were investigating the suitability of distance sampling for monitoring roe deer (*Capreolus capreolus italicus*) which, due to budgetary constraints, they could not perform during a period when the population crashed.

It is important to take account of factors such as accuracy, bias and precision, as they impact directly on the validity of the results produced by a monitoring system. If the causes of change on a population are to be understood, precise and unbiased estimates of population dynamics are very important (Ogutu *et al.*, 2005). Accuracy refers to how close an estimate is to the actual figure; for example if a herd of animals is counted and recorded as containing 65 animals when there are actually 67, then this is an accurate estimate. If however there are actually 90, then it would be a very inaccurate estimate (Milner-Gulland & Rowcliffe, 2007). If there is consistent inaccuracy in a system and it is not corrected for, then it will lead to bias in the data collected. This in turn will affect the results of the survey and could lead to erroneous conclusions being reached about the status of the population, potentially resulting in poor or inappropriate management decisions being made. The level of precision in a monitoring system is important as it will affect the system's ability to detect changes in the population. Precision is determined by the amount of variability in the data; where the variability is high (and therefore the precision is low) then the system will have a low power to detect change. The level at which a system needs to be able to detect change will vary, although the higher the power of detection, the better. If however, a monitoring system requires a 40% change in population size for it to detect a significant change then its utility



will be limited for monitoring a population for conservation purposes as by the time a significant change is detected the population may have crashed. It is argued that using biased estimates, where the bias can be corrected for and it increases the power to detect change in the population, may be worthwhile (Plumptre, 2000). Sources of error and bias are shown in figure 2.1.

There are many different types of monitoring models that have been developed for estimating population size, for example: plotless sampling, plot sampling, distance sampling and mark-recapture (Milner-Gulland & Rowcliffe, 2007). Plotless sampling is designed for the study of immobile species, such as plants, as it relies on finding the nearest neighbour of randomly selected individuals in the population. Mark-recapture involves, as the name suggests, catching individuals in a population and marking them, releasing them and then recapturing individuals to see how many marked individuals are caught again; this information is then used to calculate a population estimate. Plot sampling uses a designated

Table 2.1. Pros and cons of plot sampling and distance sampling

| | Pros | Cons |
|-----------------|---|---|
| Plot | <ul style="list-style-type: none">- Simple to implement- Simple to analyse- No model error | <ul style="list-style-type: none">- Assumes all animals seen, which may be untrue |
| Distance | <ul style="list-style-type: none">- Uses detection probabilities, model assumes not all individuals are seen and adjusts for this | <ul style="list-style-type: none">- Several major assumptions- More complex to analyse- Need large data set to achieve high levels of precision |

area, such as a quadrant or strip transect, and samples all the individuals in that area. It is a simple model as all individuals within the area are assumed to have been detected and as such has no model error (Milner-Gulland & Rowcliffe, 2007). Distance sampling assumes that as the distance increases, the probability of seeing all individuals of a population along the transect decreases. The distance of animals observed whilst traversing a transect is therefore recorded and used to calculate a population estimate by compensating for the change in detection probability. Where an animal is highly mobile, such as the saiga antelope, plotless sampling is not appropriate and mark-recapture becomes more difficult as catching them safely is harder. This means the most appropriate strategies are plot sampling, in the form of a strip transect, and distance sampling. These two strategies are described below and a summary of the pros and cons of each is given in table 2.1.

Plot sampling assumes that all individuals of the target population within a certain distance of a transect are seen and recorded, as a result it is only suitable for highly visible species (Eberhardt, 1978). A population estimate is then calculated by working out the density of animals seen during the sampling using the following equation:

$$D = n / (k a) \quad \text{Equation 2.1}$$

Where D is the estimated population density, n is number of individuals seen, k is the number of plots and a is the area of each plot. The overall estimate is calculated by

$$N = D A \quad \text{Equation 2.2}$$

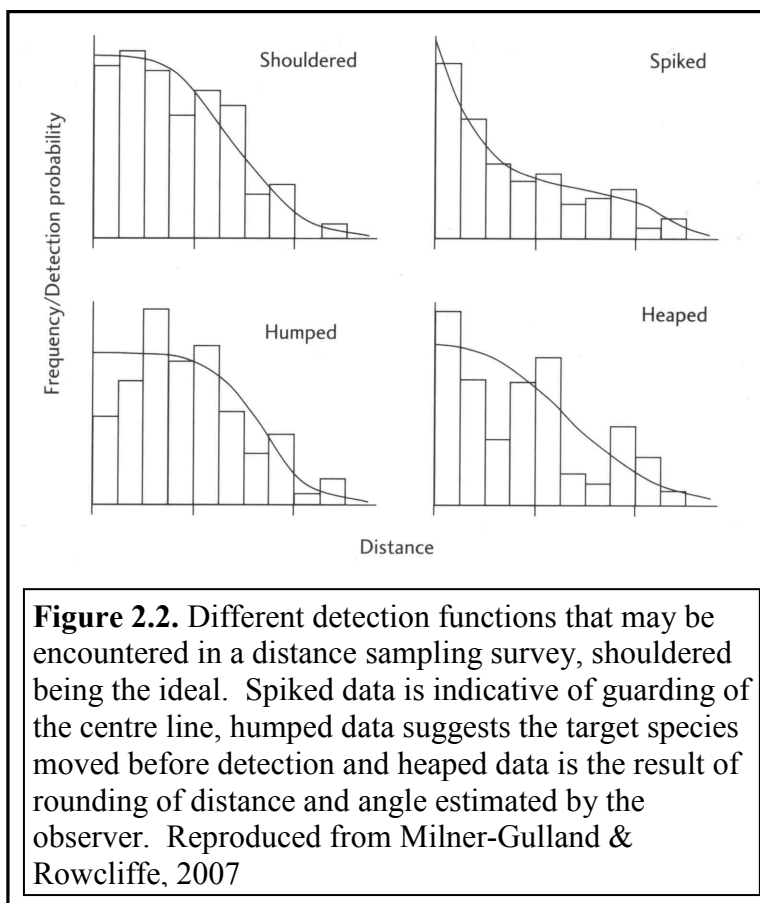
Where N is the population estimate and A is the total study area. The main advantage of plot sampling is its simplicity. It has no model error attached to it, therefore minimising

statistical uncertainty (Milner-Gulland & Rowcliffe, 2007). However this is also its disadvantage as no correction for detectability is incorporated into it (Burnham *et al.*, 1985).

Distance sampling is a more complex monitoring technique than strip transect sampling. It is not assumed that all the animals within a certain distance of a transect are sampled, the detection probability of an individual by an observer is modelled according to its distance from the transect. The population estimate is calculated by

$$D = N / (L w p) \quad \text{Equation 2.3}$$

Where D is estimated population density, N is number of objects seen, L is total length of transects, w is maximum detection distance and p is the proportion of animals seen (Milner-Gulland & Rowcliffe, 2007).



As distance sampling is a more complex model it makes several assumptions. The first assumption is that all the individuals that are on the line of the transect (i.e. where the perpendicular distance of the animal from the transect is zero) are detected. This is a very important factor, if this is not the case then the population estimate will be biased low (Buckland *et al.*, 1993). It is however, also important that the observers do not guard the centre line by putting more effort into

detecting animals on the transect than elsewhere. When this occurs and the perpendicular distance data is plotted as a histogram it appears to be spiked (figure 2.2.) there will be a

large number of observations on the centreline which will quickly fall away. This will make the population model imprecise and highly sensitive to fluctuation in frequencies (Buckland *et al.*, 1993).

The second assumption is that when animals are detected they have not been disturbed by the presence of the observer and are still in their initial locations (Buckland *et al.*, 1993). This is also an important assumption as if it is not fulfilled it will have an impact on the data collected and the final population estimate will therefore be biased. If the animals have a tendency to move away from the observer this will cause the data to be humped. When the data is plotted onto a histogram it will appear that the highest probability of seeing an animal is not at the centre line but several metres further away (Figure 2.2.). This would lead to an underestimate of the true population size; however if this is an issue it should be detectable from the data. It is rarer for an animal to have a tendency to move towards the observer but it has an equally serious impact on the final result. In fact, this situation is more difficult to detect from the data collected as it does not produce a characteristic shape when plotted as a histogram and so may be more likely to be unnoticed. In this situation then the estimate will be higher than it should be, which is problematic as it may lead managers to believe the species is more numerous than it is and therefore that there is less need to invest in its conservation. It is not necessarily an innate problem if the animal does move during the survey, as long as its original location can be noted and that position recorded. It is much more of a problem if the animal takes evasive movements before being detected (Buckland *et al.*, 1993).

The third major assumption is that all measurements are exact (Buckland *et al.*, 1993). This can be difficult to ensure, especially when observer estimates are being relied upon. Measurement accuracy can be affected by both poor observer estimation and by heaping, which is where measurements are rounded up or down to the nearest whole number. The effect of these can be reduced through strategic grouping of data, either during collection (where for example the distance would be given as 100-150m) or during the analysis stage. However it is important for data to be as accurate and precise as possible as this will give a better estimation of population density.

Distance sampling has been used successfully to monitor roe deer (*C. c. italicus*) in Italy (Focardi *et al.*, 2005). Different techniques were used in order to allow comparisons. The monitoring programme that was already in place involved a general count of ungulates in the study area each year. For the distance sampling, transects along roads were used and only animals seen before flushing were used. A mark-recapture survey was also performed as a confirmatory study. The results showed that distance sampling was a viable monitoring strategy as there was no difference between the results from distance sampling and mark-recapture. However, a disadvantage of the strategy was that as the species became rarer, around the time of a population crash, the estimates from the distance sampling became more imprecise.

An example where the effectiveness of strip and line transects has been compared is Olsen *et al.* (2005). Long distance vehicle transects were used to estimate the Mongolian Eastern Steppe population of Mongolian gazelle (*Procapra gutturosa*). The population estimates resulting from each technique were similar but the strip transect had a much larger standard error and so the confidence intervals for the estimate were much larger. Ogutu *et al.* (2005) also compared the two techniques for monitoring mammals in the African savannah. It was found that the population estimates produced by strip transects were lower than with distance sampling, but more precise. This low bias was due to decreasing visibility with distance which is not corrected for in strip transect sampling. As a result it was concluded that distance sampling was the most appropriate technique.

For all monitoring strategies the location of sampling sites is extremely important (Norton-Griffiths, 1978). They must be located in a randomised fashion so that there is no risk of the investigator introducing bias by positioning them in areas that “feel right” or that will give “better” results. Such cases may result in non-representative sampling and the resulting estimates would be heavily biased, or even completely wrong. If a species tends to be found in clusters or shows preference for some areas or habitats, then stratification can be used to ensure that a representative sample is taken (Norton-Griffiths, 1978). Within the different levels of stratification the sampled areas should still be chosen randomly. One example of a way of doing so would be to divide the total area to be sampled into a grid and

then use a random number generator to determine which sections to sample. The size and shape of the monitoring units will be partially determined by the method of sampling, for example point sampling, where an observer stays in one place and samples the surrounding population, will cover a much smaller area than an aerial survey. Table 2.2. gives a summary of the different methods available and the advantages and disadvantages of each.

An important consideration when choosing a method, as well as considering possible biases and the level of precision that could be expected, is its efficiency and feasibility. Gaidet-Drapier *et al.* (2006) investigated the efficiency of the different techniques available for monitoring large African mammals. They concluded that, although expensive, aerial census techniques were relatively efficient especially for sampling very large mammals such as elephants (*Loxodonta africana*). They found that the most efficient (in terms of cost and detection) were bicycle counts as they were inexpensive and required low levels of man power. The simpler methods were found overall to be most efficient although they would

| | Pros | Cons |
|----------------|---|---|
| Point | <ul style="list-style-type: none"> - Inexpensive - Very little disturbance to target species | <ul style="list-style-type: none"> - Covers very small area - Inefficient due to travelling time between points |
| Foot | <ul style="list-style-type: none"> - Inexpensive - Little disturbance to species - Low man power requirements, only one person needed to conduct survey - High detection rate | <ul style="list-style-type: none"> - Covers small areas - Initially time consuming as have to mark out tracks |
| Bicycle | <ul style="list-style-type: none"> - Inexpensive - Little disturbance to species - Efficient - Low man power requirements, only one person needed to conduct survey | <ul style="list-style-type: none"> - Requires good tracks - Covers small area |
| Car | <ul style="list-style-type: none"> - Can cover large area - Maintains constant speed | <ul style="list-style-type: none"> - Expensive - May disturb animals - Several people needed - Issues with reduced visibility due to factors such as dust |
| Aerial | <ul style="list-style-type: none"> - Cover very large areas - Less labour intensive - Quite efficient | <ul style="list-style-type: none"> - Very expensive - May disturb animals - Specialist - Need to have many people involved |

Table 2.2. Pros and cons of different sampling methods

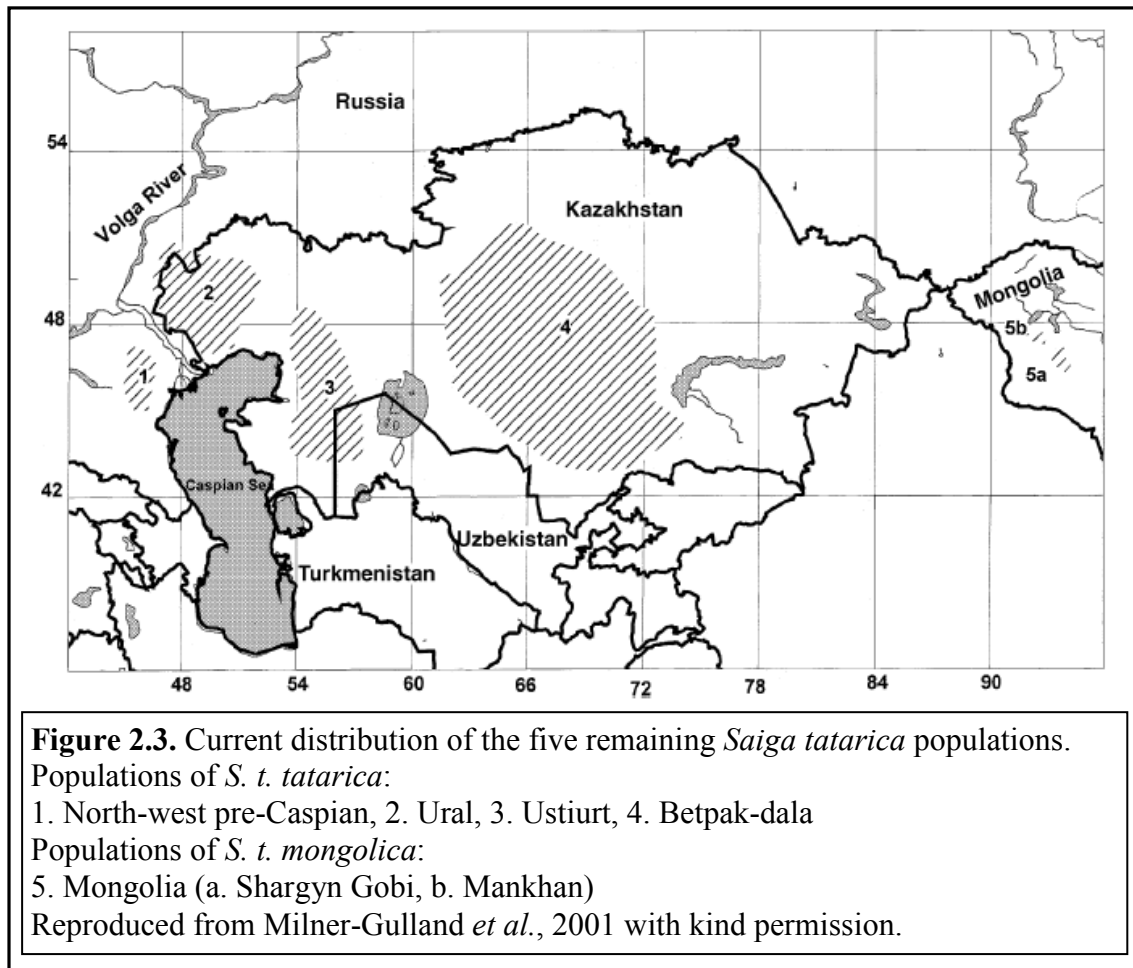
only be suitable for use in relatively small management areas. Vehicle transects were not found to be very efficient; however, in large areas where aerial surveys are not possible they may be quite effective.

This monitoring programme will be a single species programme conducted at two nature reserves by rangers whose primary role is prevention of poaching. In other situations where rangers have been used to monitor an animal population it has proved successful at providing data for management decisions. It is however very important to keep the system simple and be realistic about the results it can obtain when monitoring is not the rangers' primary responsibility. It is also important that the system is designed to be sustainable (Gray & Kalpers, 2005). Using rangers limits the data collected as it relies on opportunism and therefore the results of such studies are unlikely to reach the rigorous standards of a scientific monitoring system. But where the aim is management of a population and influences on it, a highly rigorous system may be unnecessary and may not respond quickly enough to emerging problems (Gray & Kalpers, 2005). Where monitoring is for management it is not important for a species to experience a significant population decline before the trend is acted upon. Ranger based monitoring of gorilla (*Gorilla beringei beringei*) in the Virunga-Bwindi region of East Central Africa has produced some very important data for the management of the species. It allowed surveillance of illegal activities, guided tourism activities, gathered data on gorilla ecology and promoted regional links between protected areas (Gray & Kalpers, 2005). This is an example where ranger based monitoring has been very useful and shows that it can obtain data efficiently and should be able to do so rigorously enough to allow appropriate decisions to be made and inferences drawn as to the status of the population.

2.2. *Saiga tatarica*

The saiga antelope *Saiga tatarica* is a migratory ungulate which is found across the Russian steppes and the deserts of central Asia (Kuhl, 2007). It has two subspecies, *S. tatarica tatarica*, which is the more widespread of the two subspecies and *S. tatarica mongolica*, which, as its name suggests, is found only in Mongolia (Milner-Gulland *et al.*, 1995).

Historically the saiga had a very large range which stretched across Europe and Asia; remains have been found in Pleistocene deposits in western Europe and Britain (Lushchekina & Struchkov, 2001). The range of the saiga has dramatically decreased since then and there are now just five remaining populations as shown in figure 2.3. (Milner-Gulland *et al.*, 2001; CMS, 2006). These populations have significant distances between them and so are unlikely ever to reconnect. The five populations cover part of the territories of Russia, Kazakhstan, Uzbekistan, Turkmenistan and Mongolia. The North-west pre-Caspian population is in the Russia Federation near the Caspian Sea. The Ural, Ustiurt and Betpak-dala populations are in Kazakhstan and Uzbekistan with the annual migrations sometimes taking them as far south as Turkmenistan. The Mongolian population, which is comprised solely of the *S. t. mongolica* subspecies is divided into two subpopulations, the Mankhan and the Shargyn Gobi (CMS, 2006; Lushchekina & Struchkov, 2001). This project is focussed on the North-west pre-Caspian population of *S. t. tatarica*.



S. tatarica has an interesting and unique life history. Saiga have a harem breeding system, and so from mid November will start to form harem herds before the rut in December. The rut is highly temporally synchronised and so lasts only a few days (Bekenov *et al.*, 1998). The harems would normally be of between 2 and 15 females although much larger groups are not uncommon (Bekenov *et al.*, 1998). Males will defend their harem of females from other males, and each female is mated with several times. In common with other polygynous ungulates the males play no part in raising the young (Myserud *et al.*, 2002).

The females (figure 2.4.) give birth in highly temporally and spatially aggregated calving groups, usually at the beginning of May. The aggregations may comprise thousands of animals but only last for approximately a week (Kuhl, 2007). Females will often produce twins which gives the saiga a very high reproductive potential and has allowed them to recover from high levels of offtake and near extinction in the past (Bekenov *et al.*, 1998). Females are fecund from 7

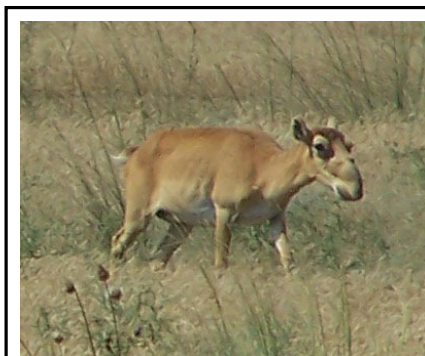


Figure 2.4. Adult female saiga antelope

months and so are able to, and usually do, reproduce in their first year, although it is rare for them to produce twins. Males take longer to mature, becoming sexually mature at approximately 19 months (Bekenov *et al.*, 1998).

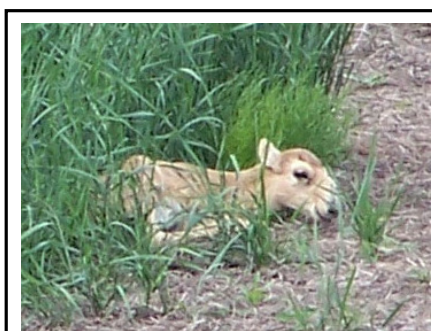


Figure 2.5. Saiga juvenile hiding in long grass

Saiga calves do not immediately start to follow their mother after they are born (figure 2.5.). This is a more typical behaviour in ungulate species that give birth in aggregations, such as wildebeest (*Connochaetes* spp.). Instead, they remain near where they were born for several days and exhibit 'hider' behaviour (Bekenov *et al.*, 1998). During this time the female saiga only return briefly to feed their calves each morning and evening; other than this the calves are left

entirely on their own. This strategy is thought to have developed to increase the chance of

the calves' survival through a predator swamping effect (Kuhl, 2007; Caro, 2005). There are many species that will prey on saiga calves, such as wolves (*Canus lupus*) and steppe eagles (*Aquila nipalensis*), however each predator is only able to consume a certain number of calves each day. By having a large number of calves produced at the same time a greater proportion will survive as the number that the predators can take overall will be limited (Caro, 2005).

The saiga is currently listed as critically endangered on the IUCN Red List (IUCN, 2007). It was upgraded in 2002 before which it was listed as near threatened. The species was upgraded due to a dramatic decline in numbers, the average total population for *S. t. tatarica* was 823,300 between 1980 and 1990, by 2000 it had dropped by 81% (Milner-Gulland *et al.*, 2001). The annual decline in the years 1998-1999 was 35% but the next year, 1999-2000, had risen to 56% (Milner-Gulland *et al.*, 2001). This decline was caused by a massive increase in poaching. The saiga was also hunted to near extinction during the first part of the twentieth century, but the species was able to recover due to the strict political regime during the Soviet period when a complete ban on hunting saiga was instigated (Milner-Gulland *et al.*, 2001; Lushchekina & Struchkov, 2001). In addition, the border with China was closed, therefore preventing the supply of horns into the Chinese traditional medicine trade (Milner-Gulland *et al.*, 2001). The complete ban on hunting lasted until the 1950s which allowed the species to recover its numbers. After this time commercial hunting began but was strictly controlled and the population was closely monitored, with aerial censuses being carried out annually (Milner-Gulland *et al.*, 2001). Once the Soviet Union collapsed the border with China reopened and the rural economy crashed. This meant people living in rural areas were unable to make a living as they once did, often as farmers, and caused people to turn to poaching saiga. Saiga provided a good source of income. Saiga horn is used in traditional Chinese medicine



Figure 2.6. Saiga horn for sale in a Chinese medicine shop. Photo by Matthias Rossbach from Saiga News, Issue 5.

(figure 2.6.) as a fever suppressant (Chan *et al.*, 1995), it is a sought after ingredient and so is worth a lot of money, fetching \$600 per kilogram in the early 1990s (Mallon & Kingswood, 2001). The saiga meat also provides a source of food and could also be sold locally providing a second source of income. Despite saiga hunting being banned since 1991 in Kalmykia (Chan *et al.*, 1995) poaching still occurs and globally seizures of illegally sourced saiga horn are not uncommon. For example, there was a seizure in January 2007 of animal derivatives at the Russian-Chinese border which included 531 saiga horns; in Taiwan in April 2007 customs officials seized 680 saiga horns (TRAFFIC, 2007).



Figure 2.7. Adult male saiga with characteristic horns.
Photo by Richard Reading.
Courtesy of USGS
(<http://esp.cr.usgs.gov/research/alaska/alaskaC.html>)

Female saiga do not have horns and are also significantly smaller than the males, meaning they are worth substantially less money. As a result, poachers specifically target adult male saiga (figure 2.7.). This sexually selective hunting has led to the sex ratio of the saiga populations becoming extremely skewed. It is possible, in a polygynous animal such as the saiga, to have a skewed sex ratio without it causing problems to the population dynamics. This is because males mate with multiple females so it is still possible to have very high levels of fertilisation with very low numbers of males (Mysterud *et al.*, 2002). In fact, recruitment rates may increase due to the proportion of the population that are adult females increasing (Milner *et al.*, 2007). For saiga, the natural proportion of males in an unharvested population is between 20% and 25% (Milner-Gulland *et al.*, 2003). However, the sexually selective poaching of saiga has been so extreme that the recorded proportion of males in the North-west pre-Caspian population has been as low as 0.9% which led to a collapse in the population's reproductive system (Milner-Gulland *et al.*, 2003). This is the equivalent of 1 male per 106 females, and caused very unusual behaviour during the rut, when older females were observed congregating around males and preventing

juvenile females from gaining access to them; this meant that the most first year females did not reproduce (Milner-Gulland *et al.*, 2003; Caro, 2005).

The saiga is a gregarious species and usually forms herds of thirty to forty animals. Herd size varies depending on the time of year and on environmental factors such as food availability and the weather (Bekenov *et al.*, 1998; Sokolov, 1974). The largest groups are seen in April when the herds can be numbered in the thousands as the saiga congregate in the calving areas (Bekenov *et al.*, 1998). Throughout the summer months, during and after calving, smaller groups are common as the females tend to disperse more widely and the herds begin to migrate to summer grounds (Bekenov *et al.*, 1998). The migration back to the wintering grounds starts as the weather becomes colder and wetter and is completed by November when large herds form again before the rut (Bekenov *et al.*, 1998). Herds are generally very fluid in their composition and will change and reform so there is normally little structure other than one lead animal (usually a female). This leader will watch for danger and is usually the first to run away (Bekenov *et al.*, 1998). During the rut however, there is more of a structure to the herds as the male in charge of the harem asserts its dominance (Sokolov, 1974).

Saiga migration, in common with many species of mammal that migrate long distances, has been disrupted in recent years (Teer *et al.*, 1996; Berger, 2004). Figure 2.8. shows the distribution of saiga in winter 1957/58 and summer 1958. Now not all individuals in the population migrate every year but generally, in Kalmykia, the winter distribution occurs in the south of the country, around the area of the two reserves (Sokolov, 1974). The migration to the wintering grounds finishes around October although may be later (Sokolov, 1974). In spring the population migrates north, the extent depending on the amount and location of summer precipitation (Sokolov, 1974). In more recent years traditional migration routes have been disturbed through the erection of fences and phone and power lines. A major obstacle are the irrigation canals that criss-cross the steppe. Saiga can swim well but they nevertheless represent a significant barrier as the banks can be steep and muddy; for example, in 1990 14000 saiga drowned trying to cross a steep sided canal (Teer *et al.*, 1996). A result of these disturbances is a change in the range of the saiga population as shown in

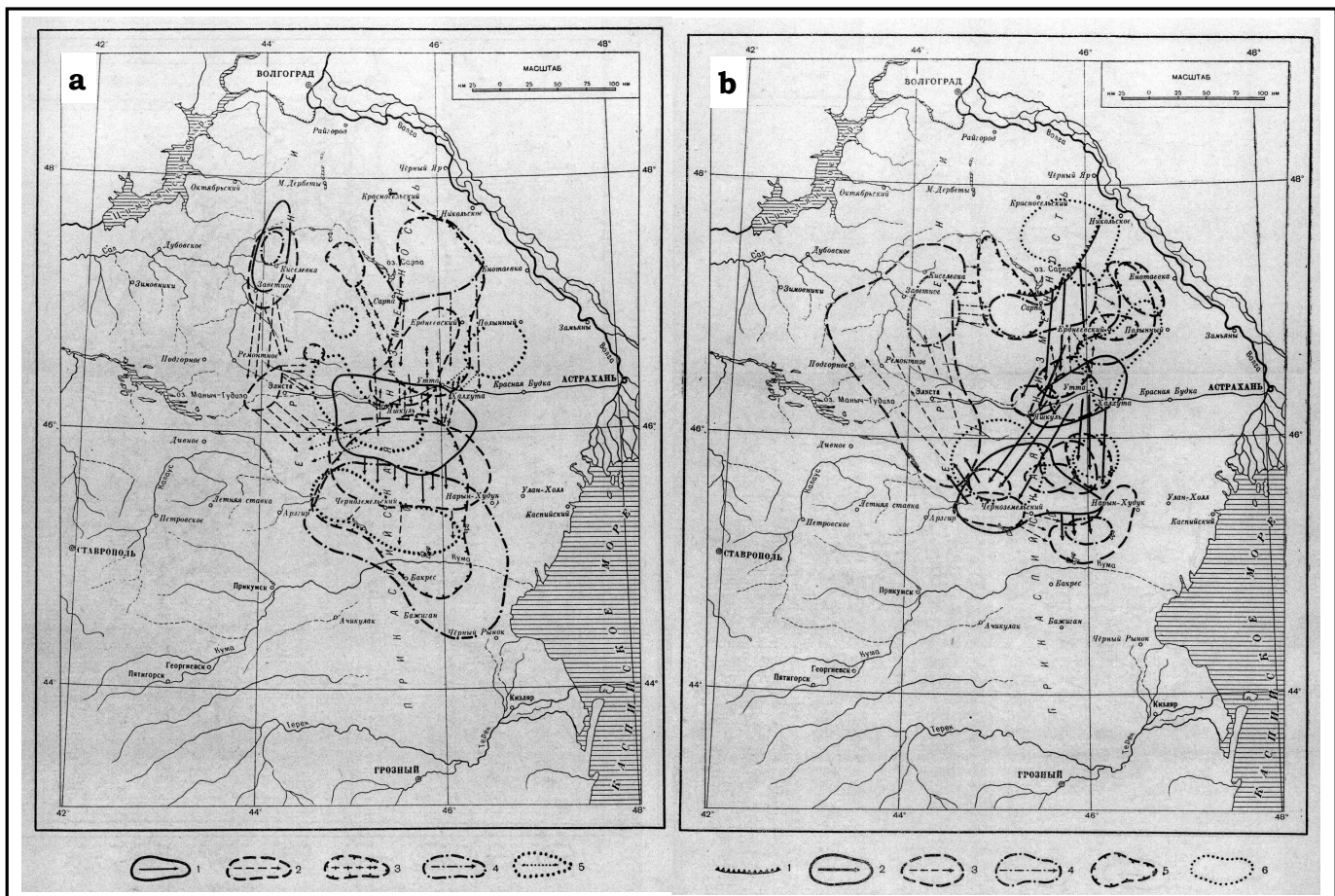


Figure 2.8. Maps showing the distribution of saiga herd in (a) winter 1957/8 and (b) summer 1958.

a. Legend

- 1 – Second half of November 1957
- 2 – December 1957
- 3 – January 1958
- 4 – February 1958
- 5 – March 1958

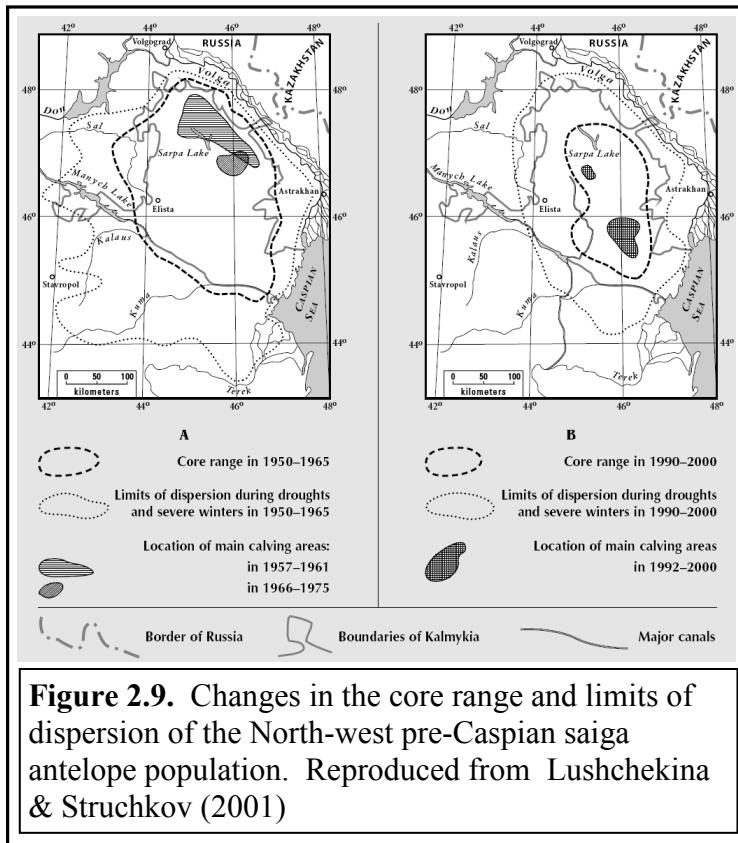
b. Legend

- 1 – Mass calving southern boundary
- 2 – Second half of May 1958
- 3 – June 1958
- 4 – July 1958
- 5 – August 1958
- 6 – September 1958

Reproduced from A. G. Bannikov (1961) *Biology of the saiga*. Nanka, Moscow.

figure 2.9. The range is much smaller and the saiga core range is now much further to the south of Kalmykia. In this area are two reserves created for the protection of the steppe habitat of the saiga.

Currently the status of the saiga antelope is still precarious, although there has been some improvement in recent years in some of the populations. The Convention on Migratory Species (CMS, 2006) lists two of the populations as declining (Ustiurt and Mongolian). The Ural population is thought to be stable. The Betpak-Dala population is listed as increasing in



size, the North-west pre-Caspian population is thought to be stable but may also be increasing. This is a result of a large amount of research and conservation effort that has been expended over recent years in an attempt to halt and reverse the decline in saiga antelope numbers. This has been done through the creation of nature reserves, scientific research, public education and anti-poaching efforts, making the saiga arguably the antelope species receiving the most conservation support (Gray,

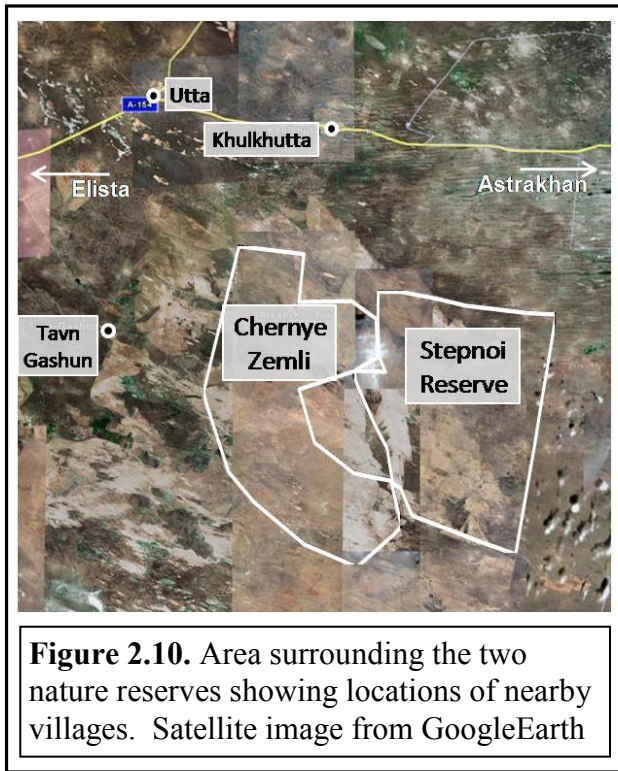
2008). In Kazakhstan, home to three of the five populations of *S. tatarica*, the government has invested heavily in anti-poaching patrols and carries out regular aerial surveys (Arylov *et al.*, 2004; Norton-Griffiths & McConville, 2007), as well as establishing new nature reserves and passing new legislation to protect the species. In Kalmykia, efforts have been made to increase conservation and a decree on emergency measures for saiga conservation has been passed by the President (Arylov *et al.*, 2004).

There has also been international support. Since being listed as a CITES appendix II species in 1994 (Chan *et al.*, 1995), trade in saiga horns has been monitored by the TRAFFIC network. In 2002 *S. tatarica* was added to appendix II of the Convention on Migratory Species and in 2006 a Memorandum of Understanding was signed by all range states except Russia (CMS, 2006). However, Russia has intimated it will sign soon (Gray, 2008). There has also been funding from abroad for research and conservation projects by organisations such as the Darwin Initiative and the British Council BRIDGE Programme (which has provided the funding for this project). In order to try and ensure effective conservation of

the species the Saiga Conservation Alliance was set up as a collaboration of stakeholders from all the range states in 2006 (SCA, 2008). It is important that these conservation activities are continued and the effectiveness of the projects monitored. The most direct way of doing this is by monitoring the saiga populations to see if they are declining, stable or increasing. To do this there must be robust long-term monitoring programmes in place for each of the populations which will detect changes in the sizes of the populations and their demographics.

2.3. The study sites

This study centres on the North-west pre-Caspian saiga population which is found in the south west of the Russian Federation (46°N, 46°E) (Kuhl, 2007). Its range is relatively small but nevertheless it is one of the larger populations, consisting of between approximately 23% and 29% of the global saiga population (CMS, 2006). The saiga range covers two administrative areas of the Russian Federation, the Republic of Kalmykia and the Astrakhan province (CMS, 2006). The main habitat is steppe, a vast area of undulating grassland, in which dominant species include grasses such as *Stipa* and *Festuca* spp. and some small shrubs such as *Artemisia* and *Salsola* spp. (Kuhl, 2007). Until recently much of the Russian steppe suffered from desertification. This was as a result of over-grazing of livestock as during the 1960s and 1970s farmers began to settle in one place and to develop stationary farms. During this time the number of grazing animals increased fourfold leading to severe degradation of the grassland habitat (Abaturov, 2007) with 30,000 to 50,000 hectares a year turning to desert in Kalmykia during the 1980s (Lushchekina & Struchkov, 2001). This in turn led to a decline in the number of animals grazed on the steppe and caused many farms to be abandoned as they were no longer financially viable (Abaturov, 2007). This decline, combined with the creation of nature reserves, has contributed to the restoration of the steppe and a reduction in the area covered by sand.



The core range of the North-west pre-Caspian population is covered by two nature reserves; the Chernye Zemli Biosphere Reserve and the Stepnoi Reserve (see figure 2.10.). Both of the reserves were set up to facilitate research and conservation of the saiga population. Both of the reserves have saiga in them throughout the year, particularly during the winter and spring months as the saiga rut in December and then the birthing aggregations in May are often on reserve territory (CMS, 2006). During the hot, dry summers the saiga will tend to migrate

north of the reserves to find water and green vegetation (Kh. B. Mandjiev, pers. comm.)

The Chernye Zemli Biosphere Reserve is in the territory of the Republic of Kalmykia, which is an autonomous republic in the Russian federation. It was established in 1990 and since 1993 has been a part of the UNESCO Man and the Biosphere network (Kuhl, 2007; UNESCO, 2008). The reserve has two parts, one in the west of Kalmykia protecting the Manych Gudilo Lake, which is also a RAMSAR wetland, and the other, main area, is in the south east of the republic in the pre-Caspian lowlands (UNESCO, 2008). The reserve has a core area of 121,901 hectares and a buffer zone of 90,000 hectares (Centre for Russian Nature Conservation, 2008; Kuhl, 2007). It is a “zapovednik”, the highest designation a reserve can be given in the Russian Federation (Kuhl, 2007). As such no one without authorisation is allowed to go onto their land and there is no farming allowed in the core area of the reserve.

Neighbouring the Chernye Zemli Biosphere Reserve is the Stepnoi Reserve. The two form an almost continuous area with only a small area of private land between them (figure 2.10.).

The Stepnoi Reserve was founded in 2000, also with the intent of saiga conservation. It is run and funded by the Astrakhan province; however this is a source of low level conflict between the reserves due to an ongoing border dispute. The Stepnoi Reserve has an area of 87,000 hectares and is classed as a zakaznik, or managed resource area, which has a lower level of protection (Kuhl, 2007). This means that the rangers have no power to prevent people from entering the reserve and there are farms within the area of the reserve, although the amount of livestock they are allowed to keep is limited and there is now a core zone with stricter regulations.

The reserves both employ anti-poaching rangers whose job it is to protect the saiga whilst they are in the reserves. Such patrols are quite successful although there are still reports of poaching and of saiga meat being sold to order in villages near the reserves (A. A. Lushchekina, pers. comm.). Since September 2003 the rangers have also collected data opportunistically on saiga numbers. They do this by recording key information about any saiga herds they see as they drive around the reserve looking for poachers. A large amount of data has now been compiled (1510 entries between September 2003 and February 2007). However, as monitoring is not the rangers' primary role in the reserves, the utility of the data collected is currently somewhat limited. This is due to several reasons; there is no record kept of area surveyed, only locations of saiga sightings and there is no estimate of the accuracy of the rangers' count data. Also the monitoring is done from cars driving along vehicle tracks, this is to ensure that there is minimal damage to the steppe habitat. This presents an immediate source of potential bias as it is probable that the tracks are not evenly distributed throughout the reserves and therefore the saiga's range and so would not be representative (Norton-Griffiths, 1978). This is an important factor because if the tracks tend to be more common, or more commonly used, in areas where there are few saiga (either by chance or because the saiga tend to move away from well used tracks) then this would lead to a biased population estimate; in this case it would make it appear that there were fewer saiga than there actually are. This could lead to erroneous conclusions about the saiga's status being made. There is no map of either reserve which shows where the vehicle tracks are located. If one was available this could be used to stratify the reserves according to track density and ensure the sampling is proportionate. There is also no randomisation of

the area sampled, currently the rangers go to areas they want to go to or where they think the saiga will be. The extent to which this can be changed may be limited as the rangers will need to continue to visit areas which they believe to be important to prevent poaching. Continuing to work with the rangers is very important as due to the nature of their jobs they are integral to saiga conservation and are keen to be involved. They have also now built up several years of experience in monitoring and observing saiga. This project aims to improve the current system and create a robust monitoring strategy ensuring the data collected by the rangers has greater utility. This must be achieved whilst not affecting the rangers' ability to perform their central role of preventing the poaching of saiga.

3. Methods

3.1. Minimising and quantifying biases in vehicle transects through evaluating the current monitoring system

Maps of both the Chernye Zemli Biosphere Reserve and the Stepnoi Reserve were created using the ArcGIS programme ArcMap 9.2. On to these were plotted locations of vehicle tracks and the key local landmarks which the anti-poaching rangers use as reference points. The location data of saiga sightings that were collected between September 2003 and February 2007 were also plotted onto the map. A 5km by 5km grid was then drawn over the reserves to enable a spatial analysis to be completed. Within each grid square the total track length was measured and track density per km² was calculated. This was compared to the number of saiga sightings that were located within the grid square and the number of saiga in each herd to determine whether they were related. This was done by regressing the number of sightings and herd size against track density so see if there was a significant relationship. The saiga sightings data collected between September 2003 and February 2007 was then used to examine the relationship between the number of sightings recorded each month and the number of days there were records for (to see if the number of days was an important factor in the amount of data collected). For a copy of the data sheet currently used by the anti-poaching rangers see appendix A.

3.2. Assessing reliability of ranger monitoring

The accuracy of the rangers' estimates was evaluated by photographing herds of saiga as they were counting the saiga and recording the sighting as they normally would. The photographs were taken using a Kodak Z740 camera using the "burst" function which allowed a rapid sequence of photographs to be taken. This was to prevent saiga being photographed twice and therefore double counted from the photographs. Each herd was photographed several times to minimise any bias caused by some individuals not being visible. The photographs were then printed out and assembled and the number of saiga counted, where the quality of the photograph was low or there was uncertainty regarding the

accuracy of the count the data was not included in the analysis. The number of saiga counted in the photographs was then compared with the rangers' estimate of how many saiga there were in the herd by plotting the number of saiga in the photo against the estimated number. The percentage difference was then calculated for each sighting as well as the mean and standard error. The percentage difference was regressed then against the number in the photograph to determine if the percentage difference between the two changed significantly as the group sizes increased.

There was also an experiment conducted using sheep as a proxy for saiga. In this experiment three farms were visited for each reserve and the rangers counted three different flocks of sheep. For each flock they gave an estimate for the number of black sheep and then the total number of sheep in the flock. This was done to evaluate the rangers' accuracy in estimating saiga herd structure by using counting of black sheep as a proxy for counting the number of male saiga in a herd. This was done first by estimating the numbers using binoculars and counting, as the rangers normally would when counting saiga. This was then repeated using tally counters to see if this would alter the estimate, this means the results were not independent and so to see if there was a significant change in accuracy when using a tally counter, a paired t-test was used. For each situation the rangers were asked to give an exact estimate of the number of sheep as well as a minimum and maximum number. The estimates were then compared to the actual number of sheep which was obtained from the shepherd who owned and looked after the flock. The estimated number of sheep was then regressed against the actual number to explore the relationship, using the exact estimates and median of the maximum and minimum estimates.

Estimated saiga herd size was compared to the estimated distance of the herd from the observer, as was the percentage difference between the rangers' estimates of saiga herd size and the number seen in the photographs of the herds. This was to determine whether the herd size was affected by the tracks and whether the accuracy of the rangers' estimates changed as the distance between them and the saiga increased.

3.3. Investigating the potential for and utility of alternative sampling techniques

Each time a saiga herd was seen the rangers recorded the sighting as they would under the current monitoring system but also including an estimate of the distance of the herd from the observer and the angle from the transect. The GPS location of the observer when the herd was seen was also recorded along with data regarding herd size and composition. Where possible saiga herds were counted before they were disturbed by the presence of the vehicle. The distance and angle data was then plotted as a histogram to show the spread of the data and to determine whether there was evidence of heaping. The perpendicular distance of the herds from the track was then calculated and plotted as a histogram so its suitability to be used for distance sampling could be evaluated.

An experiment to look at the accuracy of the rangers' distance estimates was also carried out. The rangers were asked to estimate the distance to a conspicuous object, such as a tree. Their estimates were compared to the actual distance which was measured using a GPS device (Garmin eTrex H). The percentage difference between the estimated and actual distances was calculated as well as the mean and standard error. The estimated distances were then regressed against the actual distance to explore whether the estimates significantly changed in accuracy as distance increased.

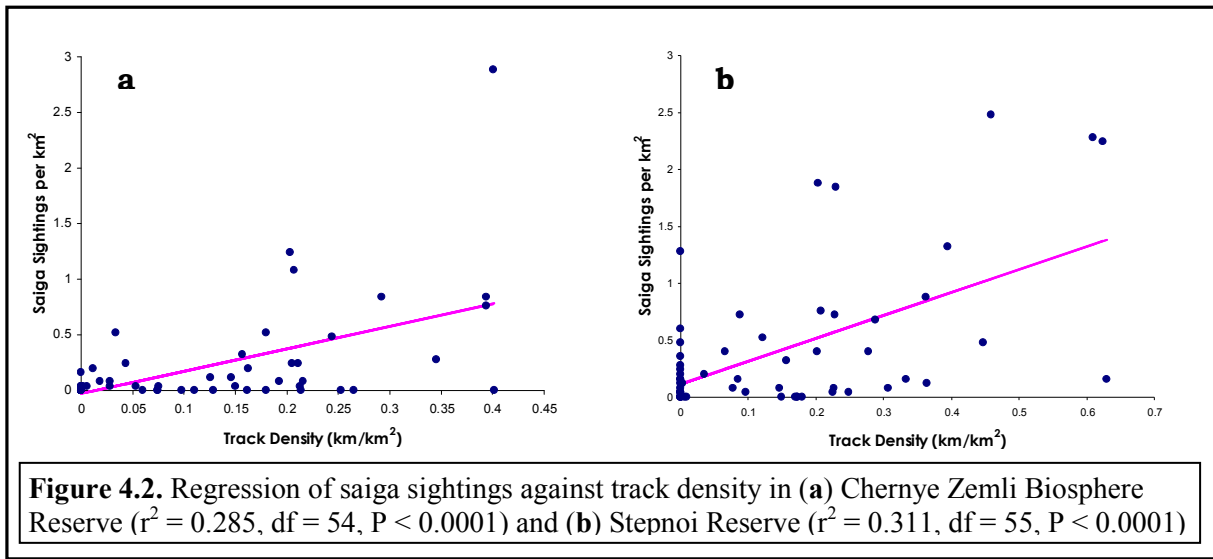
4. Results:

4.1. Minimising and quantifying the biases inherent in vehicle transects through evaluating the current monitoring system

Using ArcGIS ArcMap 9.2 a map was drawn of the Chernye Zemli Biosphere Reserve and the Stepnoi Reserve (figure 4.1.). The map has the locations of all known vehicle tracks and key landmarks identified by the anti-poaching rangers. These included Atsan Khuduk, which is the Chernye Zemli rangers' base camp, and Volga, which is where the Stepnoi rangers would like to build a similar base camp. The boundary of the Stepnoi Reserve was plotted and an approximate boundary for Chernye Zemli was drawn, this was estimated from the locations of landmarks. On to this map was then plotted all the locations of saiga sightings recorded by the anti-poaching rangers between September 2003 and February 2007; this was all the long term data that was available.

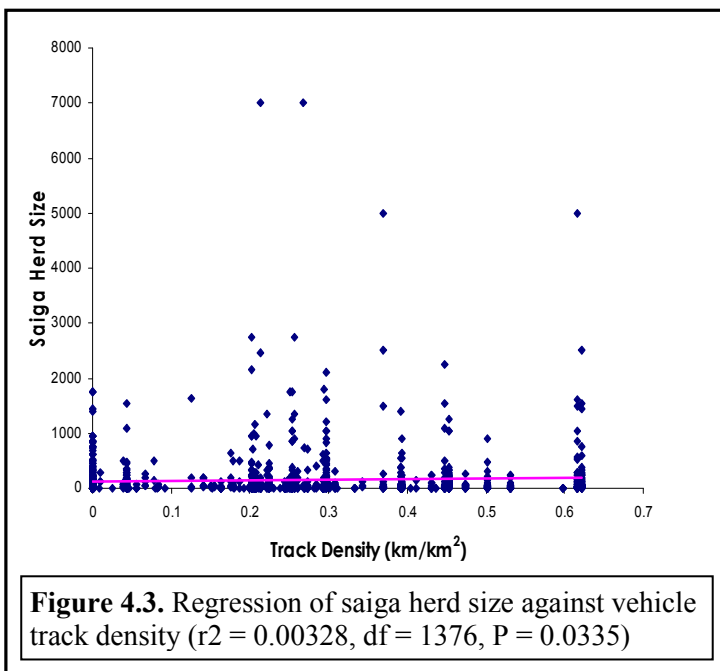
As can be seen from the map, the data appears to be biased towards areas where there are many tracks. To determine whether this was a significant relationship a grid of 5km by 5km squares was drawn over the map. Then, within each square of the grid inside the reserve boundaries, the total length of tracks was compared to the number of sightings. In the Chernye Zemli Biosphere Reserve the mean track density was found to be 0.12 km/km² and the mean density of saiga sightings was 0.22 per km². For the Stepnoi Reserve the mean track density was found to be 0.15 km/km² and the mean density of saiga sightings was 0.42 per km². There was a significant positive correlation in both reserves, as track density increased so did the number of saiga sightings (see figure 4.2.).

There are a number of sightings that are located outside of both reserves. Although the rangers do go outside the reserves at times, there are many more located outside the reserves than would be expected. This may be due to the GPS location data either being incorrectly recorded or a different grid system being used accidentally, therefore making the sightings appear to be outside of the reserve, when they may not have been. To see whether as track density increased there was an affect on group size these two variables were plotted on a



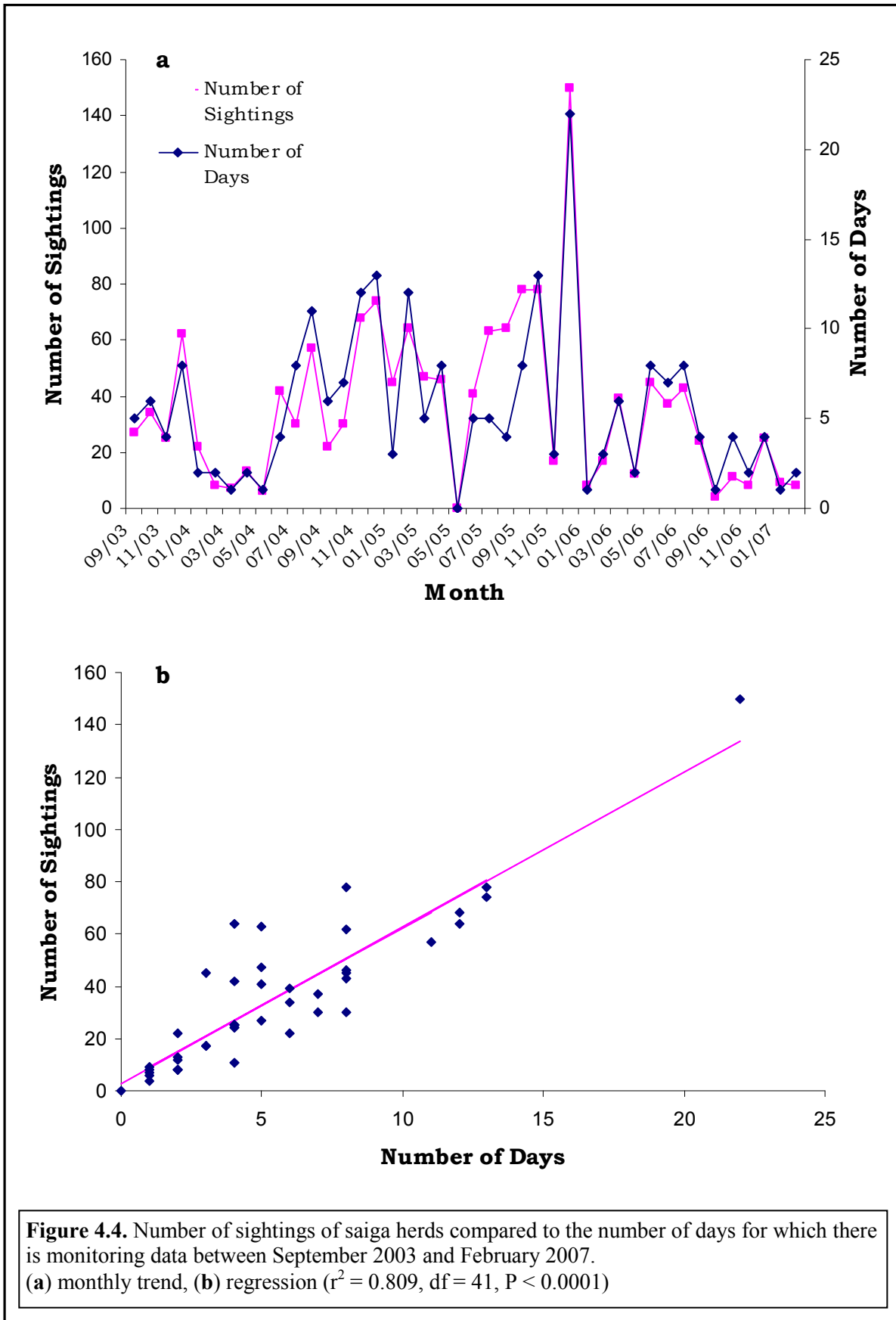
scatterplot. There was found to be a slight but significant positive correlation. As track density increased so did group size (figure 4.3.).

The number of sightings each month was then plotted against the number of days that there were records of monitoring activity. It was found that the two were very highly correlated (figure 4.4). As the number of days spent sampling increased, so did the number of sightings. It was also found that the mean number of sightings during the period September



2003 to February 2007 was 6.48 per day that saiga sightings were recorded ($SE = 0.019$). However, when all days between the start and end of the period were taken into account, the mean dropped to 1.19 sightings per day ($SE = 0.0035$).

The long term data was also used to plot mean group size for each month of the year. This was done for each year separately to see if



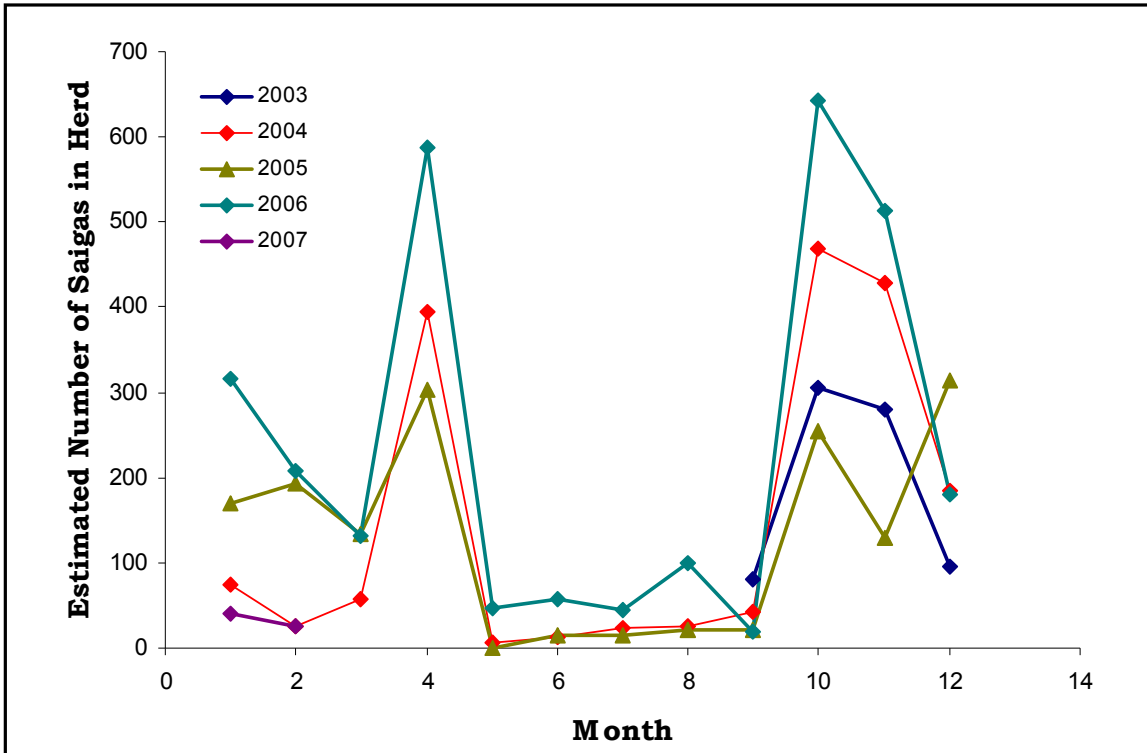


Figure 4.5. Mean saiga herd size by month from saiga sightings data collected between September 2003 and February 2007

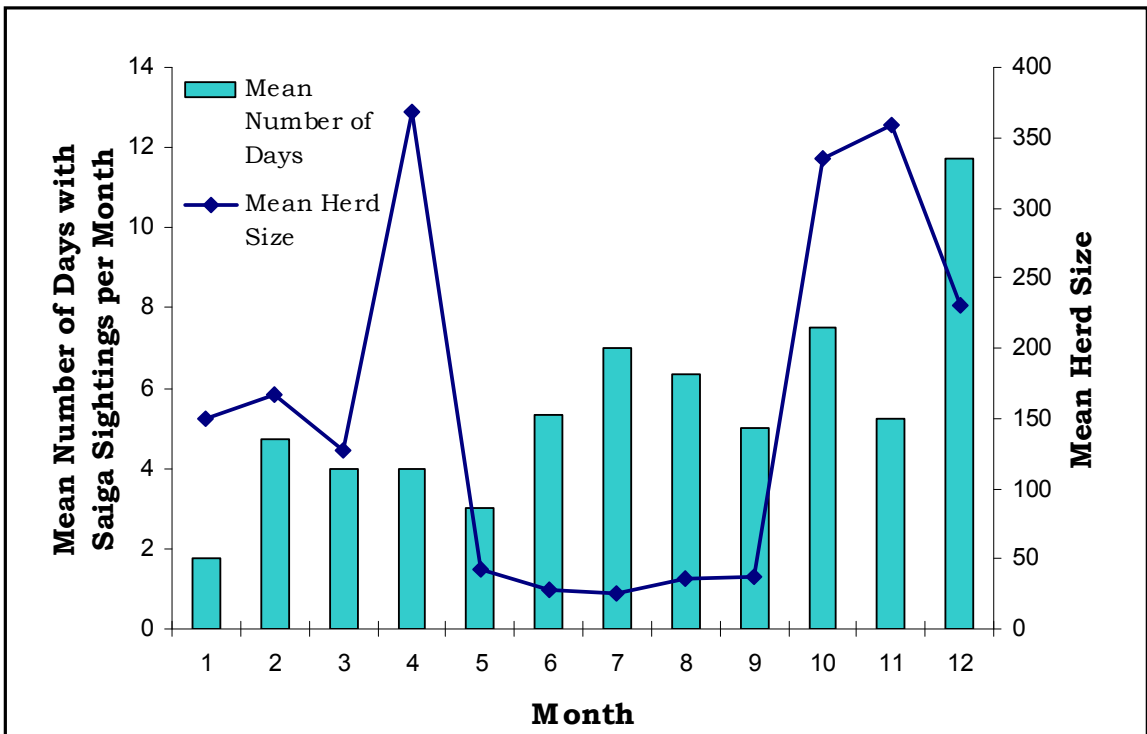


Figure 4.6. Mean number of days for which there is monitoring data per month compared to the mean saiga herd size observed between September 2003 and February 2007

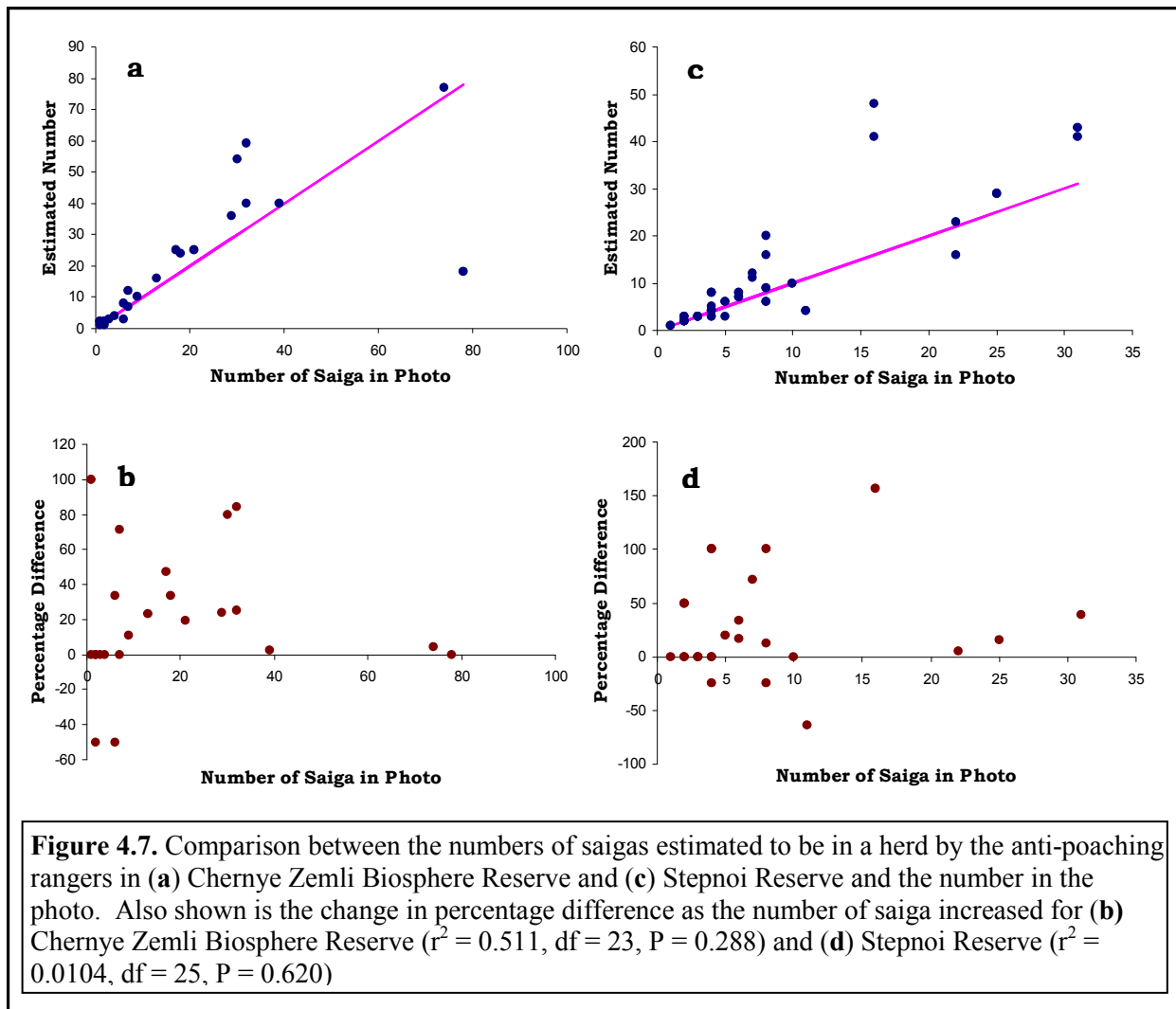
there was evidence of a trend in mean group size across the years. Figure 4.5. shows that although there is a slight upwards trend it is not consistent. Each year has similar mean group sizes during the different months of the year. As would be expected, group sizes are largest during April (just before the calving) and during October and November (just before the rut). Group size is lowest during the summer months of May to September and during the winter in January and February (during calving and migration).

The number of days that there were sightings was then regressed against the mean monthly herd size. This was to see if the rangers appeared to sample more when herd sizes were largest (figure 4.6.). The relationship was found not to be significant, the rangers sampling was not affected by group size.

4.2. Assessing reliability of ranger monitoring by analysing the direction and magnitude of errors and biases using an experimental approach

To determine the accuracy of the rangers' estimates of saiga numbers their estimates of the size of saiga herds were compared to the number of saiga seen in a photo of that herd. In both reserves it was found that the rangers tended to overestimate saiga numbers. The rangers in the Chernye Zemli Biosphere Reserve showed a mean percentage difference of 20.07% (SE = 9.184). In the Stepnoi Reserve the rangers had a mean percentage difference of 25.22% (SE = 9.364). Neither group of rangers showed a significant change in bias as group size increased. The Stepnoi rangers overestimated slightly more but both groups had similar standard errors (figure 4.7.).

A summary of the results of the sheep counting experiment can be found in Table 4.1. It shows a large difference between the results from the Chernye Zemli Rangers and the Stepnoi rangers. The Chernye Zemli rangers tended to underestimate the number of sheep in each situation whereas the Stepnoi rangers tended to overestimate. As group size increased the Chernye Zemli rangers did not record a significant change in accuracy for any treatment. However, the Stepnoi rangers did show a significant change on all treatments other than the exact count with no tally counter. The Stepnoi rangers, as the number of animals increased,



moved from over-estimating the number of individuals to underestimating the number of individuals (figure 4.8.). This is why their mean percentage difference is so low and why the standard error is so high. This suggests that the accuracy of the Chernye Zemli Biosphere Reserve rangers remains about the same whether they are counting only the males in a herd (represented by counting only the black sheep in the flock) or whether they are counting the whole herd. The Stepnoi rangers, it may be inferred, may overestimate the proportion of the herd that are the males as they tended to overestimate the number of black sheep within the flock.

The data about saiga herds, that was collected whilst on patrol with the rangers, was then used to determine whether the number of saiga estimated to be in a herd was affected by the

Table 4.1. Summary of results from the sheep counting experiments

| Reserve | Type of estimate | Tally counter? | Mean percentage difference | Standard error | Regression | | | |
|---------|------------------|----------------|----------------------------|----------------|-------------------------|----|-------|-----|
| | | | | | r ² | df | P | Sig |
| CZBR | Exact | Yes | -9.32 | 2.53 | 1.69 x 10 ⁻⁶ | 17 | 0.996 | |
| CZBR | Exact | No | -12.90 | 3.72 | 1.16 x 10 ⁻³ | 17 | 0.893 | |
| CZBR | Min Max | Yes | -13.89 | 3.30 | 6.81 x 10 ⁻⁵ | 17 | 0.974 | |
| CZBR | Min Max | No | -13.96 | 3.20 | 1.69 x 10 ⁻³ | 17 | 0.871 | |
| SR | Exact | Yes | 14.26 | 11.15 | 0.113 | 29 | 0.070 | |
| SR | Exact | No | 8.54 | 10.30 | 0.142 | 29 | 0.040 | * |
| SR | Min Max | Yes | 9.51 | 10.70 | 0.131 | 29 | 0.050 | * |
| SR | Min Max | No | 6.61 | 10.34 | 0.154 | 29 | 0.032 | * |

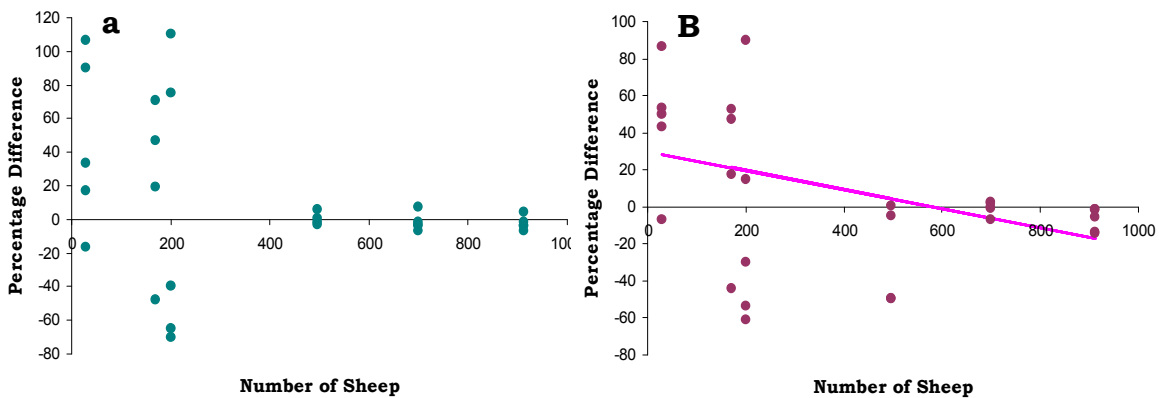


Figure 4.8. Results from the sheep counting experiment with the Stepnoi rangers. (a) exact estimate of the number of sheep without using a tally counter (b) exact estimate of the number of sheep using a tally counter

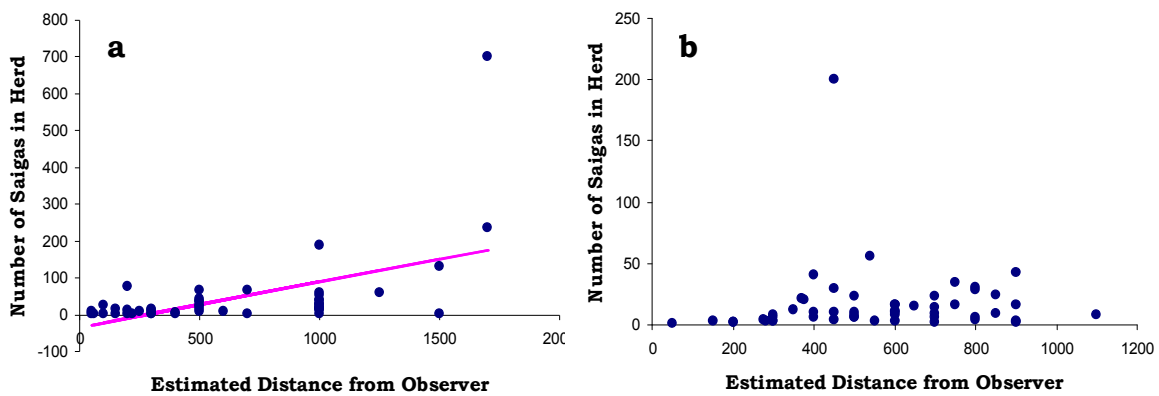


Figure 4.9. Number of saigas in a herd compared to the estimated distance (m) of the herd from the observer from observations by rangers from (a) Chernye Zemli Biosphere Reserve with regression line ($r^2 = 0.276$, $df = 48$, $P = 0.0001$) and (b) Stepnoi Reserve ($r^2 = 0.00231$, $df = 51$, $P = 0.735$)

Table 4.2. Results of paired two sample, two tailed t-tests to compare the effect of the use of tally counters in count accuracy with sheep

| Reserve | Type of estimate | t-test | |
|---------|------------------|--------|-----|
| | | P | Sig |
| CZBR | Exact | 0.0817 | |
| CZBR | Min Max | 0.770 | |
| SR | Exact | 0.180 | |
| SR | Min Max | 0.421 | |

estimated distance of that herd from the track (Figure 4.9.). A significant correlation was found in the Chernye Zemli data. As the estimated distance increased, the estimated group size increased also, which may suggest some avoidance of tracks by large groups. In the Stepnoi Reserve data no correlation was found. This data was then also used to examine the relationship between

estimated distance to a herd and the percentage difference between the estimated number of individuals and the actual number (Figure 4.10.). There proved to be a nonsignificant correlation of -0.243. The distance between the observer and the herd appeared to be of low consequence to the accuracy of the estimate of the number of saiga in the herd.

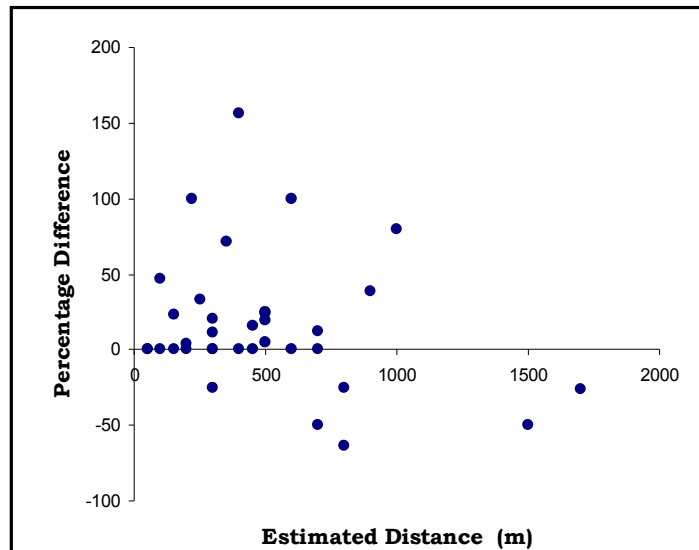
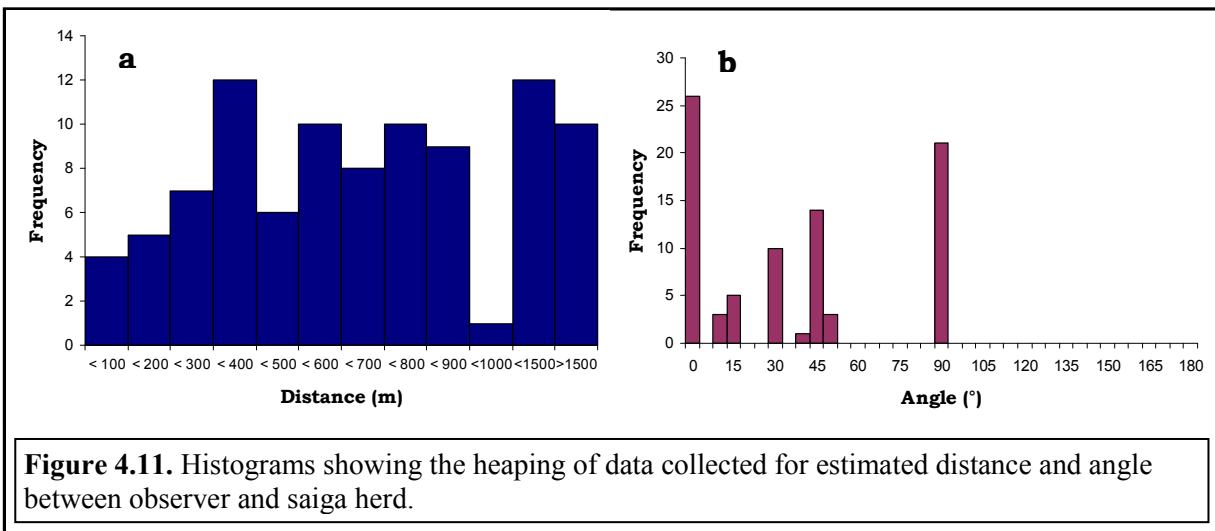


Figure 4.10. The estimated distance between the observer and the saiga herd compared to the percentage difference between, the observer estimate of the number of saiga and the number from the photograph

4.3. Investigating the potential for and utility of alternative sampling methods e.g. distance sampling

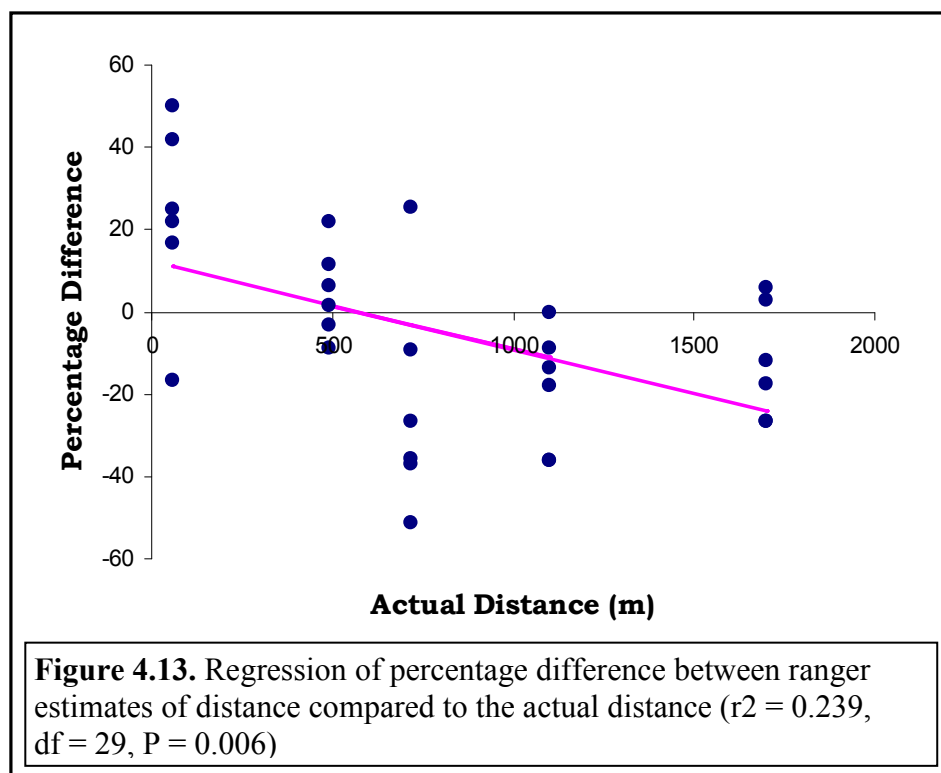
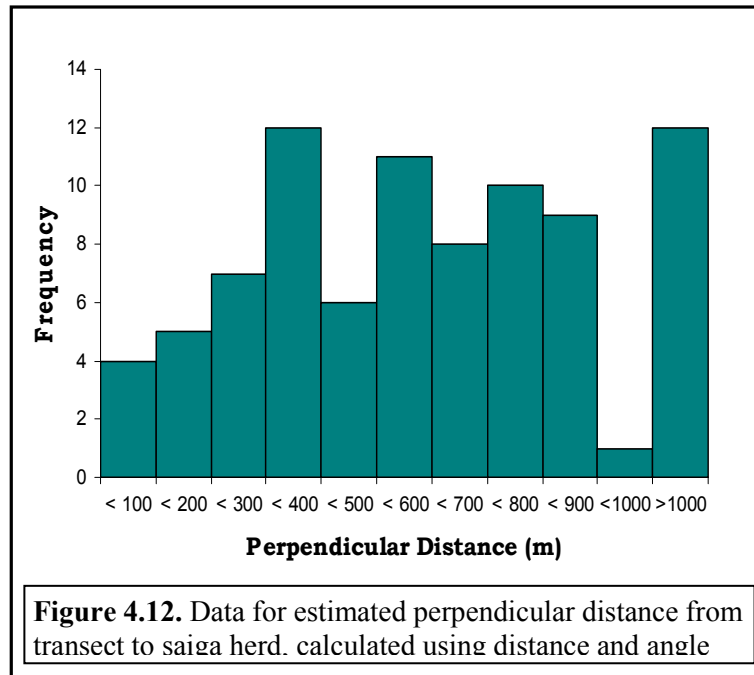
To investigate the potential for using distance sampling techniques, distance and angle data were collected for saiga sightings whilst on patrol with the rangers. There was evidence of heaping in this data (figure 4.11.). The data had to be collected using only observer estimates, this was due to the speed at which the saiga run; it was not possible to use a rangefinder or other equipment to estimate distance or angle to the location at which the saiga were first seen as it took too long. The saiga would have moved away before it was possible to get a reading. As the steppe is generally very featureless it was also not possible to rely on using cues at points where the saiga were seen to record the data either.



The perpendicular distance between the transect and the saiga groups was calculated using this data. The shape of the histogram of perpendicular distance (figure 4.12.) is indicative that there is a tendency for the saiga to move away from the observer prior to detection.

To explore the accuracy of the rangers' estimate of distance an experiment was conducted where they were asked to estimate the distance between themselves and various landmarks at a variety of distances. The actual distance was measured using a GPS device (Garmin ETrex H). The estimated distances were then regressed against the actual distance (Figure 4.13.).

It was found that there was a significant change in the rangers' accuracy. At small distances the rangers tended to overestimate the distance and at longer distances they would underestimate.



5. Discussion:

5.1. Minimising and quantifying the biases inherent in vehicle transects through evaluating the current monitoring system

The results showed that there are several significant sources of potential bias in the current monitoring system. One of the most important sources of bias that was identified was the unequal distribution of the vehicle tracks in the reserves. Both Chernye Zemli Biosphere Reserve and Stepnoi Reserve have a greater density of tracks towards the north of their territories. This is probably a result of the rangers' belief that the majority of the saiga poachers are from the villages of Khulkhutta and Utta (Kh. B. Mandjiev, pers. comm.), both of which are to the north of the reserves (figure 2.10.) combined with the rangers' base camps being situated in these areas (which is where they live whilst on duty). This bias in the distribution of the tracks will have to be compensated for if the utility of the data collected is to be improved.

The finding that there was a significant relationship between track density and the number of saiga sightings recorded between September 2003 and February 2007 is also an important consideration, as is the fact that there is a positive correlation between track density and group size. It seems unlikely that the saiga are attracted towards the tracks because they are disturbed whenever a vehicle passes, so this suggests that the areas the rangers sample most often are the areas of high track density towards the north of the reserves. However, it is not possible to be definite as to whether this is the cause of this observation due to there being no record of the areas that the rangers have monitored, only where they have seen saiga. Therefore there is no measure of monitoring effort for any of the tracks. For a monitoring strategy to be successful the area must be sampled representatively otherwise it will lead to an inaccurate picture of the system being formed (Norton-Griffiths, 1978), which may be detrimental for the conservation of the species in the future. There are tracks in the reserves which have few or no records of saiga sightings along them. This seems unlikely to be representative of the true distribution of the saiga because these tracks are to the south of the reserves where there is less disturbance. However, because there is no record of monitoring

effort or distribution there is no way to be certain of this. Also, if the rangers were recording where they had been, it would give an indication of whether the locations of saiga sightings that were outside the reserves (figure 4.1.) were accurately recorded. As there is an unavoidable source of bias due to the unequal distribution of the tracks, stratification of the sampling area would be the most appropriate way of limiting the effect of bias on the population estimate (Norton-Griffiths, 1978). The bias cannot be eliminated entirely due to the need to use vehicle transects which introduces an inescapable bias (Norton-Griffiths, 1978). Bårdsen and Fox (2006) found a significantly higher encounter rate for chiru, or Tibetan, antelope (*Pantholops hodgsoni*) on cross country transects than on track transects. However, this did not result in a difference in estimated density.

The strong relationship found here between the number of days that the rangers monitor and the number of sightings of saiga there are, is to be expected due to the rangers only recording when they had seen saiga. As the mean number of sightings for each day there are records is 6.48, this suggests that when the rangers are looking for the saiga they tend to see a large number. This drops to 1.19 sightings a day when all of the days for which there was no data were also included. It shows the level of uncertainty that develops when only presence is recorded; to get a true picture of the situation absences need to be recorded also. It is interesting to note that the apparent monitoring effort (i.e. the number of days samples were collected on average each month) does not vary in conjunction with the mean saiga group size. Bias can be introduced into a monitoring system through the observers changing when or where they monitor in order to increase the amount of data produced, this may be accidental or subconscious, but it will still have a large impact on the resulting data (Sutherland, 2000). It would seem this is not occurring in this situation as if it was the case it would be expected that monitoring would be greatest during times of larger herd sizes because they are easier to see.

The data on herd size collected between September 2003 and February 2007 showed a slight, but inconsistent increase in group size. This is not unexpected but is an encouraging observation regarding the status of the saiga population. The North-west pre-Caspian population is thought to be stable or possibly increasing (CMS, 2006) which tallies with

these findings. The data is also consistent with the literature on saiga group sizes through the year (Bekenov *et al.*, 1998; Sokolov, 1974), with the largest groups forming just before the rut in December and just before calving in early May.

5.2. Assessing reliability of ranger monitoring by analysing the direction and magnitude of errors and biases using an experimental approach

The finding that the anti-poaching rangers tended to overestimate the number of saiga in a herd may be due to them subconsciously inflating their estimates (Sutherland, 2000) combined with only having a short amount of time to actually count the animals due to the speed at which the saiga run away once disturbed. Although the accuracy estimates of saiga herd size did not change significantly as herd size increased in either reserve, this was calculated using a comparatively small range of herd sizes. When correcting for counting bias in future this is important to note as it is likely that over larger group sizes bias will increase. Such an effect was found by Daniels (2006) for red deer (*Cervus elaphus*). A similar technique was used of comparing observer estimates to photographic data. For small herd sizes (3 to 49 individuals) the mean percentage difference was 0.5 between the observer counts and the photographic counts. This increased to a 16% difference for large groups (105 to 197 individuals). This implies that larger groups are more difficult to count accurately and so this must be taken into account in the confidence with which these estimates are treated.

The accuracy investigation using the sheep showed very different results. This is probably a result of the circumstances of the two investigations being inevitably different despite everything possible being done to keep the situations as similar as possible. The major difference was that the flocks of sheep moved at a much slower pace than the herds of saiga did, which meant that the rangers had a longer amount of time to count how many individuals there were in the flock. The Stepnoi rangers showed a significant change in the accuracy of the estimates as the flock size increased. This did not occur with the Chernye Zemli rangers; however the sample size in this reserve was smaller than in Stepnoi, which may have contributed to this finding (number of rangers in Stepnoi = 5, in Chernye Zemli =

3). The Stepnoi rangers tended to over estimate at lower numbers, when they were counting the black sheep in the flock, and underestimate at higher numbers, when they were counting total flock size. This may have an implication for their estimates of the number of male saiga within a herd. If at lower quantities they overestimate numbers of the target component of the herd, combined with the tendency to overestimate saiga numbers, this may lead to inflated estimates of the number of males in the population. The extent to which this would affect the proportion of males estimated to be in the population cannot be determined from this data, as if the over estimation is to a similar amount it may cancel out the effect. This is an important factor, particularly in this species and population, due to the importance of having an accurate estimation of the proportion of males in this population.

The use of tally counters did not significantly alter the rangers' accuracy. For the rangers in the Chernye Zemli reserve, it slightly worsened their estimates whereas in the Stepnoi Reserve it slightly improved them. Tally counters can be used in an attempt to improve observer estimates and so this finding is worth taking into account, but not all the observers' estimates will actually be improved by their use. However, this may be worthwhile exploring further in any subsequent investigation, as in this experiment, due to time and logistical constraints, the with and without tally counter treatments were not fully independent.

The distance between an observer and a target animal is thought to be an important factor in counting bias, as animals get further away they may become more difficult to see, causing some individuals to be missed from the count (Buckland *et al.*, 1993). This is an important source of bias. This study however found no significant correlation between the estimated distance to the herd of saiga from the observer and the accuracy of the rangers estimate of that herd. This is an important finding because the saiga tend to be seen from a large distance (herds were often estimated to be 1000m away and on several occasions as far as 1750m) and so knowing this does not affect the accuracy of the rangers' estimates, at least for small herd sizes, shows this should not have a great effect on the results. This is especially important because there was a positive correlation found between estimated

distance and herd size, possibly suggesting that larger herds tend to avoid the tracks and so accurate estimation of their numbers is particularly important.

5.3. Investigating the potential for and utility of alternative sampling methods e.g. distance sampling

The results for the investigation into the feasibility of distance sampling suggest that in this situation it would not be an appropriate technique. Humping of the perpendicular distance results for the distance sampling suggests that the saiga were moving evasively before they were detected. The range experiment suggested that there was a lot of error and variability in the rangers' estimates which changed significantly as the distance increased from overestimation at small distances and underestimation of larger distances. Therefore two of the main assumptions of the distance sampling model are not fulfilled, meaning that the bias and error that would be the result of using this technique outweigh the benefits of it. It is better to use a simpler technique such as plot sampling, where all the assumptions are fulfilled, than try to use a more complicated model where the assumptions are violated. In this case plot sampling in the form of strip transects seems the most appropriate technique. This is because it requires little change from what the rangers currently do. Also, because there was no correlation found between the accuracy of estimates of saiga herd size and the distance to the herd, combined with the type of habitat (flat grassland with low vegetation), and the skittish behaviour of the species (flushing even when a vehicle is still several hundred meters away), means that the detection rate can be hypothesised to remain fairly constant to a distance of several hundred metres.

5.4 Limitations of the results

There were several limitations which affected the extent of the results of this project. The first were time constraints which limited the amount of time that could be spent in the field collecting data. This was due to various logistical difficulties, such as finding a translator. This shortage of time was further compounded by a number of large steppe fires that broke out during the time spent at Chernye Zemli Biosphere Reserve. The steppe fires were

believed to have been started by poachers in order to drive the saiga out of the reserves and beyond the protection of the rangers (Kh. B. Mandjiev, pers. comm.). This meant that several days of field work were lost because all of the rangers were working to put the fires out. Then, once the fires had been extinguished the majority of the rangers were no longer available to take part in the investigation as they could not be spared from their anti-poaching responsibilities. All these factors limited the quantity and breadth of data that could be collected.

Another factor was that due to the time of year that the study was conducted (June - July) the extent to which the accuracy of the ranger's count estimates could be determined was limited. This was because the average saiga herd size is at its lowest during the summer months and so the group sizes seen were generally quite small. This meant that although accuracy could be estimated for smaller groups it has not been possible to estimate the accuracy of estimates for larger groups. There were some sightings of larger groups but these were rare and there were not enough for them to be included in the analysis. The trend with these few larger herds suggested that the degree of overestimation of numbers in large herds was higher and may in fact be significantly higher than in smaller herds. This is particularly important because as the larger groups have more animals in them an inaccurate count will have a bigger effect on the end estimate of abundance because they contain a larger proportion of the total population. The time of year also had an effect on the number of saiga there were in the territory of the reserves. The grass in the reserves becomes very dry during the summer months, making it less palatable for the saiga. The saiga therefore migrate towards the channel which runs along the western boundary of the Chernye Zemli Biosphere Reserve and towards the north in search of green vegetation. This meant that there were few saiga in the Stepnoi Reserve and that long distances had to be travelled to find any. This limited the number of rangers who were available to take part in the saiga counting accuracy experiment and also meant that the number of data points was reduced.

Despite the limitations in the data, there are many useful conclusions and inferences that can be reached from it. The significant positive correlation between track density and number of sightings shows that it is very important that the monitoring effort is evenly distributed

around the reserves. In particular this will involve ensuring that the areas towards the south of the reserves are visited regularly, as at the moment these areas are under represented in the data. It is possible this is due to there being fewer saiga in these areas, but this needs to be confirmed through records being kept of areas visited and sampled. It is also important that when the rangers are monitoring is recorded. This is because currently there is no way of knowing whether the reason why there are so many days in the long term data when there were no sightings is due to the rangers not going out on some of the days, saiga not being seen on these days or if records were not made of any sightings.

Recommendations and suggestions for further work

As a result of these considerations it is recommended that plot sampling in the form of strip transects is used for the monitoring of the saiga populations in the Chernye Zemli Biosphere Reserve and the Stepnoi Reserve. It will be important to ensure all tracks are driven along and sampled, ideally at least once a week but, at the absolute minimum, once a month. The rangers will have to start to record every day they have monitored, where they have been each time and the route they took. It is extremely important they no longer continue only recording when and where they have seen saiga. These data can then be used to stratify the reserves according to track density and monitoring effort, therefore allowing the data collected to be used proportionately. The territory will then be covered in a representative manner without having to introduce a complicated sampling regime which could affect the rangers' ability either to monitor or prevent poaching effectively. The data collected by the rangers can be adjusted to reduce count bias at small herd sizes and therefore improve population estimates using the mean percentage difference data collected. These adaptations will improve the utility of the data but in order for the monitoring programme to produce meaningful results, it is important that the monitoring strategy remains consistent in the long term.

Due to the importance of monitoring the saiga population a key policy recommendation is to make it part of the official work of the Stepnoi rangers. Currently the Stepnoi rangers only monitor the population on an unofficial basis. Changing this may help enable increasing

collaboration between the two reserves, at least as far as monitoring the saiga population is concerned, and could even encourage greater data sharing.

There are various pieces of further work that could be done to improve the monitoring strategy and build upon the work described here. One aspect would be to complete another investigation into the accuracy of rangers' estimates of saiga herd size at a different time of year. This would be especially valuable if it was completed at times of year when herd sizes are largest such as just before the rut in October and November. Another useful investigation would be into the accuracy of rangers' estimates of the number of males in a herd. The sheep counting experiment showed the Stepnoi rangers' overcounting when asked to count a subsection of the flock. From a distance determining which saiga are male is more difficult than picking out black sheep from a flock and so whether this effect is seen when counting saiga would be very interesting to investigate, particularly in light of the reproductive collapse (Milner-Gulland et al, 2003) caused by a dearth of males in the population. Another interesting investigation would be to look at the extent of avoidance of vehicle tracks by the saiga population. This may have an important impact on the amount of data collected and the level of bias in the data when done from vehicle tracks (Bårdsen & Fox, 2006).

Once the adapted monitoring strategy has been implemented various analyses of the data will be possible to further the understanding of the North-west pre-Caspian saiga population. When the rangers start collecting data regarding their movements around the reserve it will be possible to see when and where saiga were and were not seen. This presence and absence information will allow analyses of saiga movements to be performed. It may also aid the rangers in their anti-poaching duties. By having a record of when different areas of the reserve are visited it would enable them to ensure the whole reserve is appropriately monitored.

In conclusion, this project has made recommendations for the improvement of the North-west pre-Caspian saiga population monitoring strategies that are carried out by the anti-poaching rangers employed by the Chernye Zemli Biosphere Reserve and the Stepnoi

Reserve. This is to increase and improve the utility of the data collected so that relevant inferences can be made about the status of the population within the reserves. This has been done by quantifying the level of bias in the different aspects of the monitoring system, therefore allowing appropriate alterations to be identified. If the recommendations from this project are implemented the data collected in future by the anti-poaching rangers should be more representative, as it will be possible to stratify it according to monitoring effort. It is also now possible to correct for counting error for small herd sizes, further reducing the bias.

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Лушгушев СВ
 Лушгушев АВ
 1-03-072 Ткачев Н.Н.



| Маршрут № | № по GPS | Дата | Время | | Координаты | Погода | Температура | | Кол-во сайгачков | | | Половозрастной состав сайгачков | | | | Другие наблюдения, кол-во | | | | | | | | | |
|-----------|----------|----------|-------|-------|----------------------------|--------|-------------|------|------------------|-----|------|---------------------------------|-------|----------|-------|---------------------------|--------------|------|-----|-----|-----|-----|-----|-----|-----|
| | | | Нач | Окон | | | Мин | Макс | Точн | Мин | Макс | 2004 г/р | Самцы | 2004 г/р | Самки | Старш с 2004 | Старш с 2004 | Овец | Кор | Лош | Люд | Маш | МТЦ | Х/л | вол |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 1-03-072 | 9:30 | 9:40 | N 45°53'47" E 46°35'02" | B | +1 | 53 | 108 | | | 12 | | 96 | | | | | | | | | | | |
| | | 072 | 10:00 | 10:15 | N 45°59'22" E 46°31'42" | | | | 274 | | | 3 | | 257 | | | | | | | | | | | |
| | | | 11:30 | 11:45 | N 45°59'15" E 46°33'03" | | | | 68 | | | 4 | | 53 | | | | | | | | | | | |
| | | | 12:18 | 12:57 | N 45°58'40" E 46°30'62" | | | | 117 | | | 2 | | 104 | | | | | | | | | | | |
| | | 2-03-072 | 6:45 | 6:57 | N 46°00'05" E 46°30'43" | B | 0 | +2 | 214 | | | 214 | | 200 | | | | | | | | | | | |
| | | | 7:28 | 7:37 | N 45°57'11" E 46°29'07" | | | | 169 | | | 4 | | 156 | | | | | | | | | | | |
| | | | 9:40 | 9:50 | N 45°58'21" E 46°43'23" | | | | 227 | | | 6 | | 209 | | | | | | | | | | | |
| | | | 11:20 | 11:38 | N 45°45'21" E 46°32'28" | | | | 400 | 430 | | 12 | | | | | | | | | | | | | |

Figure A.1. Example of a data sheet used by the anti-poaching rangers in the Chernye Zemli Biosphere Reserve and the Stepnoi Reserve. Headings read: Date, Time (Beginning, End), Location (N,E), Weather, Temperature (Min, Max), Number of Saigas (Exact, Min, Max), Age / Sex Structure (Male [Juvenile, Adult], Female [Juvenile, Adult]), Notes, Number of Other Observations (Sheep, Cow, Horse, People, Vehicle, Wolf,