CHANGES IN AN ISOLATED HEDGEHOG POPULATION

SUMMARY

Changes In An Isolated Hedgehog Population

The current Hedgehog population was introduced to Alderney by the island residents in the 1960s. Three pairs were kept as pets but escaped and successfully established a population. In 1993 a study estimated that there were between 299 and 995 Hedgehogs.

In September 2008 another survey was performed. Four weeks were spent surveying Alderney's Hedgehog population. Fifteen transects were chosen and walked in different combinations every night during the four weeks. Every Hedgehog spotted was weighed, measured and marked with spray paint so it could be easily identified if caught again. The colour of the Hedgehog was also recorded (either brown, blonde or an intermediate colour).

A vegetation survey was also done which involved assigning different areas of the island into one of the seven vegetation categories. The areas that each of these vegetation types covered were calculated and used to estimate the number of Hedgehogs on Alderney. The final estimate was 1315 Hedgehogs, with densities varying from 0.88/ha to 9.47/ha, 75% were found to be blonde and intermediate.

The blonde and intermediate coloured Hedgehogs are this colour because they have a condition known as Leucism. Leucism is a condition that prevents colour pigments from being deposited into the fur and spines. In mainland Europe they are extremely rare but on Alderney they have become fairly common. The main reasons for

Hedgehogs' success on Alderney is thought to be because there are no major predators on, such as Badgers and Foxes. The blonde animals are extremely obvious and therefore on the mainland would be easy prey for predators.

The Hedgehogs were weighed on capture and the population appears to be healthy with the majority of animals weighing between 400 and 800g, therefore most are already at a suitable weight for hibernation which begins in November. (Hedgehogs need to weigh at least 450g to survive hibernation (Morris 1995)).

A questionnaire was also handed out to the island residents, the aim was to gather information on Hedgehogs that are visitors to gardens. The majority of Hedgehogs that visit gardens are blonde. 29% of those that replied to the questionnaire said they fed the visiting Hedgehogs. Hedgehogs seem to be thriving on Alderney.

ABSTRACT

Changes In An Isolated Hedgehog Population

Hedgehogs were introduced to Alderney, one of the Channel Islands where the have become successfully established. The Hedgehog population of Alderney has a high number of leucistic animals, which are extremely rare in other places. The first study done on Alderney's Hedgehog population was in 1993 by Alison Tutt. Tutt made a population estimate and estimated the percentage of the population that was leucistic. It has been fifteen years since Tutt's study and no other Hedgehog surveys have been undertaken.

This study aims to make a population estimate and estimate the percentage leucistic animals in the population and compare the results with those from 1993. Fifteen transects were surveyed during September 2008. 54 Hedgehogs were captured and marked. Hedgehog densities varied form 9.47/ha (Transect O) to 0.88/ha (Transect J). A rough vegetation survey was undertaken and allowed an approximate population estimate to be made. It was estimated that there were roughly 1315 animals on Alderney. 75% of the population was found to be leucistic. Habitat type has a significant affect on Hedgehog density and no abiotic factors were found to have a significant affect on the number of Hedgehogs sighted. The results indicate that the population has increased in size and in the percentage of leucistic animals over the past fifteen years. A questionnaire was distributed to every house on the island to gather information on the Hedgehogs that visit the residents' gardens. The responses support the high prevalence of Leucism in the population. The major reasons thought to be responsible for the increase in size and Leucism are the absence of mammalian predators, the abundance of food and nesting sites and genetic drift.

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1. LITERATURE REVIEW

1.1 Hedgehog Distribution

There are two species of European Hedgehog, the Western European Hedgehog, *Erinaceus europaeus,* which can be found across Western Europe, the UK, Ireland, Southern Scandinavia and across into Estonia and Northern Russia; and the Eastern European Hedgehog, *Ericnaceus concolor,* found across eastern Europe, Israel and Turkey then eastwards into Russia and Asia. (Seddon *et al* 2001). *E. europaeus* is abundant in farmland, forests, urban and suburban habitats (Morris 1995) it is a solitary animal that occupies non exclusive home ranges (Morris *et al* 1992; & Doncaster 1992). Population estimates of *E. europaeus* were carried out in the UK in 2005, it was estimated that in England there were about 1,100,000; in Scotland 310,000; and Wales 145,000. In the 1950s the UK Hedgehog population was estimated to be 36,500,000 which is significantly larger than the 2005 estimate (Battersby 2005).

1.2 Possible Causes For The Decline In Hedgehog Abundance

One of the reasons suggested as responsible for the dramatic decline in Hedgehog numbers is the change in agricultural practice that has taken place since the 1950s. These changes have resulted in increased crop yields but have also had negative effects on Hedgehogs and other non agricultural farmland species. These changes include a large amount of grazing land being converted to arable land, increased field sizes by the removal of hedgerows which provide favourable nesting sites for many species, and an increase in the use of pesticide which has lead to a decrease in the abundance of invertebrate species. Invertebrates are a valuable food source for Hedgehogs and many farmland birds (Battersby 2005; Benton *et al* 2002; & Huijser *et* *al* 2000). The declines in farmland bird populations have been studied, and their abundance has been found to be positively correlated with invertebrate numbers. Benton 2002 investigated the abundance of birds and invertebrates in agricultural areas and looked at changes in their abundance over time. Benton found that Sky Lark and Grey Partridge numbers had declined over time, this decline was associated with a decrease in invertebrate abundance. The Grey Partridge decline has been specifically correlated with the decline in the in Sawflies.

Another reason thought to have contributed to Hedgehog decline in the UK is the increase in vehicular traffic since the 1950s, road fatalities are thought to have resulted in the extinction of local Hedgehog populations (Huijser *et al* 2000; & Kristiansson 1990). Kristiansson (1990) identified traffic as the major cause of mortality in Hedgehogs during the summer months in Southern Sweden but also argues that the threat of traffic is sometimes over exaggerated. Between 113,000 and 340,000 Hedgehogs have been estimated as traffic victims in the Netherlands each year (Huijser *et al* 2000). Huijser (2000) studied the effect of traffic on Hedgehog density in populations that are in close proximity to roads, and compared the results with densities of populations not so close roads. Huijers was unable to prove that traffic had a significant affect on Hedgehog density but concluded that Hedgehog density is reduced by about 35% when in close proximity to roads. The Mammal Society has estimated that in the UK approximately 100,000 Hedgehogs are victims of traffic each year (Mammal Society National survey of road deaths).

1.3 Main Factors That Regulate Hedgehog Abundance

Hedgehog distribution has been found to be correlated with food availability. Hedgehogs are insectivores, their diet has been studied and found to consist mainly of ground living invertebrates such as Beetles, Slugs, Earwigs, EarthWorms and Caterpillars, these constitute 55% of their total food intake (Yalden 1976). The rest of their diet is opportunistic, they have been known to eat chicks and eggs of ground nesting birds and small rodents (Jackson 2006; Jones *et al* 2005; Kristiansson 1990; & Parkes 1975).

Predation plays a major role in Hedgehog distribution and abundance, the presence of Badgers (*Meles meles*) can especially affect Hedgehog distribution. Doncaster (2001) investigated the response and dispersal of Hedgehogs that were introduced to novel environments. The results indicated that Hedgehogs favoured some habitats over others and that the presence of Badgers most likely played a role in Hedgehog dispersal after their introduction. The Eurasian Badger is considered as the most important predator of the Hedgehog .Badgers are not just predators but are also potential competitors of the Hedgehog (Young *et al* 2006). Badgers are therefore described as Intraguild predators of the Hedgehog (a guild is a group of species that use the same potentially limiting resources (Polis *et al* 1987)). Doncaster (1992) investigated the role of Intraguild predation in regulating Hedgehog density, it was noticed that Hedgehogs avoided areas with a high density of Badgers. Hedgehogs in Badger free areas dispersed across the area.

Predation and competition in most studies are assessed separately, but a few have investigated them together for example Segio (2003) studied the Eagle Owl (*Bubo*

bubo) which predates on Black Kites but also competes with the Kites for spatial refugia. As a result of both predation and competition by the Eagle Owl, Black Kites are absent from many areas which provide potentially suitable Kite habitat. Another example is provided by Sunde (1999), it was found that the Eurasian Lynx (*Lynx lynx*) was a major predator of the Fox (*Vulpes vulpes*) as well as a competitor, they compete for prey such as the Roe Deer (*Capredus capredus*) and the Mountain Hares (*Lepus timidus*). Intraguild predation can result in the decrease in the abundance of the prey species where the predator and prey live together and even its local extinction (Fedriani *et al* 2000).

1.4 Reasons For The Successful Introduction Of Hedgehogs

Hedgehogs like many other mammals such as the Black Rat (*Rattus rattus*), Rabbits (*Oryctolagus cuniculus*) and the domestic Cat (*Felis catus*) and Dog (*Canis familiaris*) have been introduced by humans to many parts of the world which are outside their normal range. In these new environments these species have successfully adapted and established populations and in most of these places have become pests. They have caused major economic and ecological problems as a result of predation and over grazing of endemic fauna and flora. The consequence of predation and overgrazing is the extinction the endemic species (Elswerth *et al* 2002). Rabbits (*Oryctolagus cuniculus*) for example have been responsible for the local extinction of 26 species of plant on the Hawaiian Island of Laysan as a result of over grazing (Courchamp *et al* 1999); The Black Rat (*Rattus rattus*) has had a significant impact on the fecundity and recruitment of birds such as the Artic Pipit on South Georgia and the Laysan Albatross in Hawaii by predating on the chicks and eggs of these birds (Dobson 1988).

Hedgehogs were introduced to South Uist in the Outer Hebrides in 1974 where they have successfully established a population that has spread to the neighbouring islands of Benbecula and North Uist. Hedgehogs predate on the eggs and chicks of the ground nesting birds and their success has meant that these birds are now seriously threatened. The birds have no anti-predator behaviour to avoid the threat posed by the Hedgehogs because they have not evolved in the presence of this threat. A recent population estimate has suggested that across all three islands there are approximately 4000 Hedgehogs, creating a major problem for conservation (Jackson 2006; & Jackson 2007).

Jackson (2007) explored the factors that affect Hedgehog abundance in the Outer Hebrides, Jackson concludes that the absence of Badgers and Red Foxes, the light road traffic, and the environmental conditions particularly temperature are important in determining Hedgehog density. The temperatures on South Uist have increased by 0.06 ° C per year over the past 20 years, Hedgehogs are thriving in this warmer climate. Jackson (2006) explores the breeding biology of the introduced Hedgehogs, the breeding season was found to last from April to early September. Because of the early start to the breeding season some females were able to have up to two litters a year. Jackson estimated that there were approximately 4000 young produced per year in the Outer Hebrides, the average number of off spring per adult female was estimate at about 4.04 per year. Females were also found to be highly promiscuous, so reducing male density would have little affect on female productivity posing a major problem for effective control programs.

Hedgehogs are not only considered as a pest in the Outer Hebrides but are also thought of as a problem for conservation in New Zealand, where they were introduced from Europe in the nineteenth century. They have been recorded predating on the eggs and chicks of endangered braided riverbed birds such as Black Stilts and Black Fronted Terns, and a study of their diet indicated that they also consumed a huge number of Coleopterans, raising worries about threats to rare endemic beetle populations such as the Chafer (*Prodontia matagouriae*), and *Metaglymma aberrans* a Carabid (Jones *et al* 2005). Hedgehogs' successful dispersal across New Zealand since their introduction is thought to be due to the different climatic conditions which have lead to changes in the Hedgehogs breeding biology. Parkes (1975) found that the hibernation period was reduced from five months (the period spent in hibernation by European populations) to three months, this is thought to be a consequence of the milder winters experience in New Zealand. The reduced hibernation period has resulted in an extended breeding season. Similar to the Outer Hebrides, Badgers and Foxes are also absent from New Zealand which must also contribute to the high Hedgehog densities.

The absence of parasites can also affect the abundance of species that have been introduced to new environments. Experimental evidence has indicated that introduced populations can have fewer parasites than their source populations. For example the European Starling (*Surnus vulgaris*) was introduced to New York City in 1890-1891, the number of parasites present on the ancestral population of those introduced was compared with the numbers on the ancestors of the source population in Europe. The European Starlings had 41 species of parasite where as the American Starlings had just 9 parasite species (Torchin *et al* 2003). There are no studies on parasites and Hedgehog abundance, but the Flea (*Archaeopsyllus erinacei*) has been reported as absent from the Hedgehog populations in New Zealand (Parkes 1975) and Alderney (Tutt 1993), Hedgehogs in the UK can have up to 500 Fleas per animal (Morris 1995).

1.5 History Of Hedgehogs On Alderney

Erinaceus europaeus is not native to Alderney, one of the Channel Islands located 15km off the North coast of France. The date of their first introduction is unknown but it is thought to have been sometime after 1810. Accounts from the islands residents have indicated the presence of the normal brown coloured individuals during 1910-1920, but these disappeared during the Second World War. A questionnaire distributed in 1989 to all residents on the island has given an indication of how and when the current Hedgehog population was introduced. In the 1960s three pairs of Hedgehogs were said to have been imported as pets by some of the islands residents, one pair was from the Harrods pet shop and the others may have come from Guernsey, all pairs managed to escape. The Hedgehogs were all the normal brown colouring, but 67% of the respondents of the 1989 questionnaire said they had seen blonde Hedgehogs. Another questionnaire was circulated and 45.5% of those that had completed it reported the presence of blonde Hedgehogs (Morris *et al* 1996). In 1993 Alison Tutt carried out a population estimate of the islands Hedgehogs using mark recapture and line transect methods, the results suggested there were between 229 and 995 Hedgehogs, 25.4% of which were estimated to be leucistic (Tutt 1993). Tutt also estimated the abundance of the EarthWorm (*Lumbricus terrestris*) on some of the study sites. Worms are an important component of Hedgehogs diet as mentioned above and it was found that Hedgehogs were slightly more abundant in areas with higher Worm densities.

1.6 Leucism

Alderney's blonde Hedgehogs are not albino but leucistic. Leucism is often confused with albinism, both are inherited colour mutations that result in the lack of colour because of the absence of melanin. Mammal and bird colouration is due to two main melanin pigments, eumelanin and phaeomelanin. Eumelanin is responsible for the black, grey and dark brown colours and phaeomelanin for the red to yellow colouring. Melanin is produced by a series of chemical reactions (Acevedo *et al* 2008; Goncalves *et al* 2008; & Van Grouw 2006). Albinism is the total lack of the melanin pigments in all cells. This absence is the result of a mutation that means tyrosine is not oxidised in the first step of the chemical reaction involved in the production of melanin. The amount of oxidation determines the colour, black is the result of a strong oxidation reaction and brown a weak oxidation reaction. An albino individual thus has no colour in the eyes, skin, tissues, feathers or fur. The eyes and skin appear pink because the blood can be seen through the colourless tissues (Van Grouw 2006).

Leucism is the partial lack of the melanin pigments eumelanin and phaeomelanin in the feathers and fur of the animal. In leucistic animals tyrosine is oxidised and melanin is produced normally but a mutation exists in the process involved in depositing pigments into the feathers or fur. Leucism results in white fur or feathers, but normal coloured skin and eyes, this allows leucistic animals to be distinguished form albinos (Van Grouw 2006). Both Leucism and albinism are autosomal recessive inherited disorders (Bechtel *et al* 1985; Forrest *et al* 2000; & Van Grouw 2006), therefore they are not sex linked or associated with age (Morris 1996).

Leucism has been recorded in a number of species other than Hedgehogs including Antartic Fur Seals (*Arctocephalus gazell*e) (Acevedo *et al* 2006 & Hofmeyr *et al* 2005), Eared Grebes (*Podiceps nigricolli*) (Jehl Jr 1985), the Black Rat Snake (*Elaphe obsolete*) (Bechtel *et al* 1985), King Penguins (*Aptenodytes patagonicus*), Royal Penguins (*Eudyptes schlegeli*) (Forrest *et al* 2000), the Rufous-Bellied Thrush (*Turdus rufilentris*) (Goncalves *et al* 2008) and the Southern Lapwing (*Vanellus chilensis*) (Cestari *et al* 2007). The appearance of Leucism in a population is thought to be associated with genetically inbred populations (Goncalves *et al* 2008), which is almost certainly the case with both the Antartic Fur Seal and the Southern Elephant Seal. Both species have rapidly increased in numbers after their populations were severely depleted and facing extinction from uncontrolled fur hunting in the nineteenth and early twentieth century (Bester *et al* 2008 & Hofmeyr *et al* 2005) with the end of hunting the remaining small populations began to increase rapidly in size, only a small proportion of the genetic variability in the pre-hunted population will have been present in the remaining individuals (Nei *et al* 1975; & Schwaegerle *et al* 1979), if just one individual possessed the leucistic allele and mating occurred between parents and offspring the occurrence of Leucism would have appeared in the population (Freeman *et al* 2007).

This process is also thought to be the likely explanation for the appearance of leucistic Hedgehogs on Alderney (Tutt 1993). At least one of the introduced animals must have been a carrier of the rare recessive leucistic allele, and because of the small number of introduced individuals (just three pairs) there would have been a considerable amount of inbreeding, (Freeman *et al* 2007; & Tutt 1993) leucitic individuals would start to emerge within a few generations. 1 in 1000 Antartic Fur Seal pups (Hofmeyr *et al*

2005) and 1 in 146,000 Royal Penguins (Forrest *et al* 2000) are leucistic. Leucism in Hedgehogs on mainland Britain is extremely rare, but in Alderney 25.4% of the population in1993 was lecusitic, the explanation for this may be that leucisitic individuals are subject to increased predation on the mainland.

1.7 Predation and conspicuous colouration

The colour of an animal affects its risk of predation which can influence the evolution of different colour morphs in a species (Forsman *et al* 1998; Forsman 1999; & Johannesson *et al* 2002). Conspicuous colour morphs have a higher risk of being predated on than cryptic ones. This is an idea that has been investigated. *Cepaea nemoralis* and *Cepaea hortensis* have several different colour morphs, variation exists in the shell ground colour and whether there is banding or not on the shell. The frequency of the different morphs varies from place to place with the most cryptically coloured morphs at the highest frequencies. The reason proposed for this is that the song Thrush (*Turdus ericetrum*) eats a higher number of conspicuously coloured individuals because they are easier to spot (Carter 1986).

Johannesson (2002) found that populations of Marine Snails (*Littorina* species) experienced a reduction in the number of different colour morphs when they were among sea weed compared those that inhabited the rocks, the explanation for this was that some colour morphs are more conspicuous in the seaweed and are more likely to be predated on by the wading birds.

Another investigation concentrated on Gupies (*Poecilia reticulate*), which have a very complex colour pattern, with a high degree of polymorphism. The frequency of the different colour morphs was found to vary with the selection pressures of the predators, the most conspicuous individuals had a higher chance of being eaten and were thus present at lower frequencies in the population (Endler 1980).

1.8 Estimating Biological Populations Using Line Transects

In 1993 Tutt used two basic methods to estimate the size of Alderney's Hedgehog population, Mark recapture and Line transects. Line transects have been widely used to estimate the size of various biological populations, including large mammals in African forests (Plumptre 2000); Green-rumped Parrots (*Forpus passerinus*) in Venezuela (Casagrande *et al* 1997); Red Deer (*Cervus elaphus*) in Scotland (Trenkel *et al* 1997); Kangaroos and Wallabies (Southwell 1994); Ptarmigan (*Lagopus* species) (Pelletier *et al* 1997); and Primate densities in West African Rainforests (Whitesides *et al* 1988). Line transect sampling is a simple method and can be used when quick population estimates are required. The line transect method is explained in Buckland 2001. There are five basic assumptions:

i) Objects are randomly distributed over the study area.

ii) The objects in the study area are seen with a probability of 1.

iii) Any movement by the objects is slow relative to the speed of the observer, and is independent of the observer.

iv) Sightings are independent events.

v) No animals are counted more than once (Buckland *et al* 2001; Buckland 1985; & Whitesides *et al* 1988).

Mark recapture has also been extensively used in population studies including population estimates of Hedgehogs in Southern Sweden (Kristiansson 1990), Tigers

(*Panthera tigris*) in India (Karanth 1995) and Rainbow Trout (*Oncorhynchus mykiss*) in America, where it is extremely important for fisheries management that an accurate population estimate is made on a regular basis (Rosenberg *et al* 2005). Tutt used several methods to analyse the mark-recapture data including the Lincoln index, Baileys triple catch, Jolly-Seber and the Haynes method.

For this study it was decided that just one method would be used, The Line transect method was chosen. The Line transect method is more effective at estimating the size of a dispersed population (Thomas *et al* 2002), Hedgehogs are solitary animals and therefore highly dispersed throughout their range (Morris *et al* 1992; & Doncaster 1992). It also does not require a sufficiently high number of recaptures to be made to make a reliable population estimate unlike the mark recapture method (Rosenberg *et al* 2005; & Tutt 1993). All the mark-recapture methods have been developed for large numbers of captures, and Tutt therefore explains that they may be less accurate than the Line transect method at estimating Alderney's Hedgehog population because of the low number of captures made.

2. AIM

The main Aim of this study is to obtain an approximate population estimate for the Hedgehogs on Alderney and to determine what percentage of the population is leucistic. The results can then be compared with the results from the 1993 study by Tutt to determine any changes in Alderney's Hedgehog population over the last 15 years.

It is predicted that the Hedgehog population will have increased in size, and that the leucistic individuals will make up a higher percentage of the population now than they did in 1993. These predictions are based on observations made before the study took place.

3. METHOD

3.1 Estimating The Population Size

3.1.1. The Study Areas

Fifteen transects were identified and labelled A-P, thirteen transects (A-N) were the same as those walked by Alison Tutt in 1993. The survey sites chosen by Tutt were selected because they provided a transect of a reasonable length, there was good sighting distance either side of the transect and the grass was relatively short which allowed Hedgehogs to be easily spotted. It was decided that two additional transects (O and P) should be surveyed, this would mean a greater amount of the island would be surveyed, more data would be collected and would thus give a more accurate population estimate than was obtained by Tutt in 1993.The locations of both transects were chosen because they fitted Tutts selection criteria, they had relatively short grass and were a reasonable length with good sighting distance either side. Table 1 provides information on the habitat type of each the transects surveyed.

Table 1: The 15 transects surveyed and their habitat type.

Transect	Habitat type
A	Rough, grazed grassland
B	Golf course short/mowed grassland
C	Golf course short/mowed grassland
D	Cricket pitch short/mowed grassland
E	Airport
F	Airport
G/H	Airport
I	Airport
J	Road verge short/mowed grass
K	Maritime/mowed grassland
L	Golf course short/mowed grassland
M	Rough, grazed grassland
N	Rough, grazed grassland
O	Garden, rough grassland
P	Rough, grazed grassland

Photos of six of the transects can be seen in Figure1.

Figure 1: Photos of six out of the 15 survey sites. (A) Transect J, the road transect, short grassland. (B) Transect C one of the Golf course transects, short grassland. (C) Transect K Maritime grassland. (D) Transect A rough grassland grazed by cattle. (E) Transect N Rough grassland and Bracken. (F) Transect O, rough grassland.

The exact location of the transects was put on to Google Earth and can be see in Figure 2.

Figure 2: The Location of the 15 transect from Google Earth Imaging

3.1.2. Method For Collecting Hedgehog Data

Each night from the 1st September to the 26th September a different combination of transects were walked. All transects were walked six times, three times in each direction. The transects were all walked during the day before they were studied at night. The coordinates of both ends of each of the transects were recorded using a palm top GPS and noticeable landmarks were recorded, this was to ensure that the starting and finishing points were found in the dark when visibility was reduced. The date, time, and weather conditions were all recorded onto the survey form before each transect was walked.

Two surveyors walked the transect with torches each night, the torches were pointed at middle distance from the surveyors and moved slowly in a sweeping motion over the study area. If a Hedgehog was spotted one person would walk towards the Hedgehog shinning the torch on it to stop it from moving away. The other person would carry along the transect until they were directly opposite the Hedgehog, from this position the perpendicular distance of the Hedgehog from the transect could be recorded. The Hedgehog was then weighed (using a cotton bag and a spring balance), measured (whilst tightly curled in a ball the circumference was measured with a tape measure), and checked for Fleas, from this information the health of the population can be determined.

The Hedgehog was then marked using car spray paint (blue for leucistic individuals and white for brown. See Figure 3), each Hedgehog was given a different marking and assigned an ID number so it could be easily identified if recaptured (The ID catalogue can be seen in Appendix A). The coordinates of where the animal was found was also recorded.

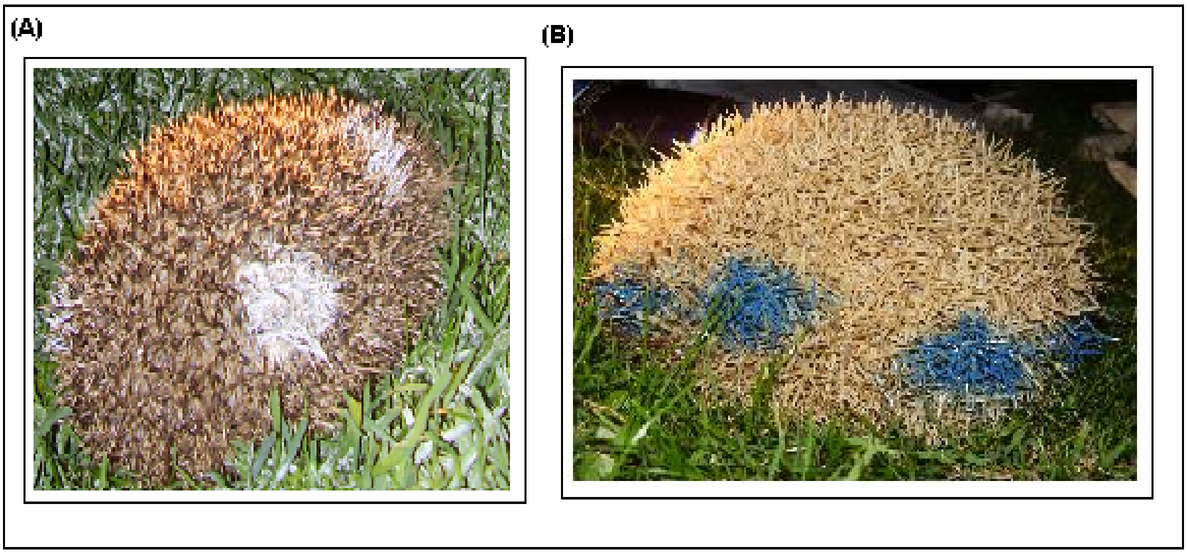

Figure 3: An example of two Hedgehogs marked with car paint. (A) A brown Hedgehog with white paint. (B) A leucistic Hedgehog with blue paint.

Transect J (the road transect), was the longest transect and therefore was not walked like the others. One surveyor cycled whilst the other drove a car very slowly, the headlights of the car were used to illuminate the transect, when a Hedgehog was spotted the person cycling could easily jump off and catch the Hedgehog before it ran away.

3.1.3. The Vegetation Survey

Three days were spent driving round the island splitting the vegetation type of each area into one of seven categories; mowed grassland, rough grassland, maritime grassland, bracken dominated scrub, other scrub areas, trees, and residential areas (the same categories used in the 1993 study by Tutt). The type of vegetation was recorded on to an Ordinance Survey (OS) map (see Figure 4). Areas that were not accessible by car were surveyed on foot. From the OS map the number of hectares of each vegetation type were calculated and used in the population estimate. The information that was recorded on the OS map was then transferred on to Google Earth Imaging (Figure 9) which represents the data clearly.

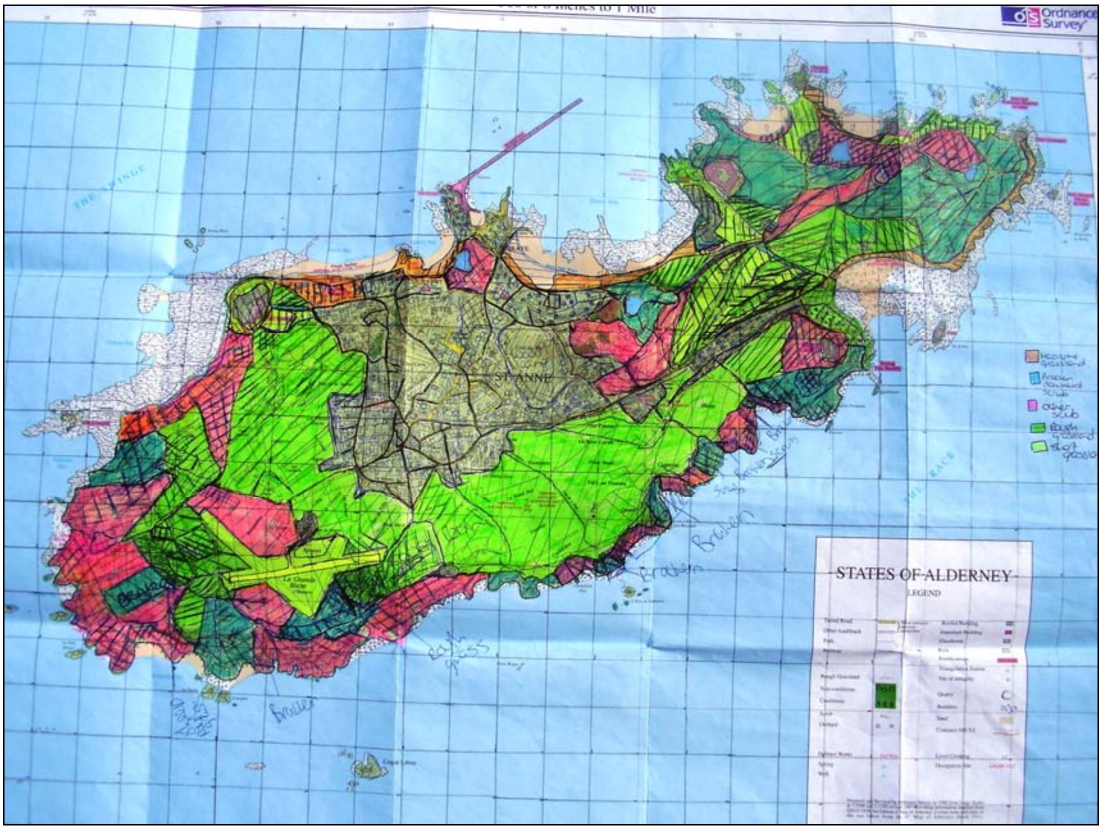

Figure 4: Photo of the Ordinance Survey map used to mark out the different vegetation types across the island.

3.1.4. Calculating The Population Estimate

The line transect method of sampling was used to calculate the population estimate. The method used was similar to the one used by Hoodless (1993) to estimate the density of the Fat Dormouse (*Glis glis*), Buckland (2001) and Anderson (1979) were also used in the method design. Figure 5 is diagrammatic representation of a transect and explains how the data collected can be used to calculate a population estimate.

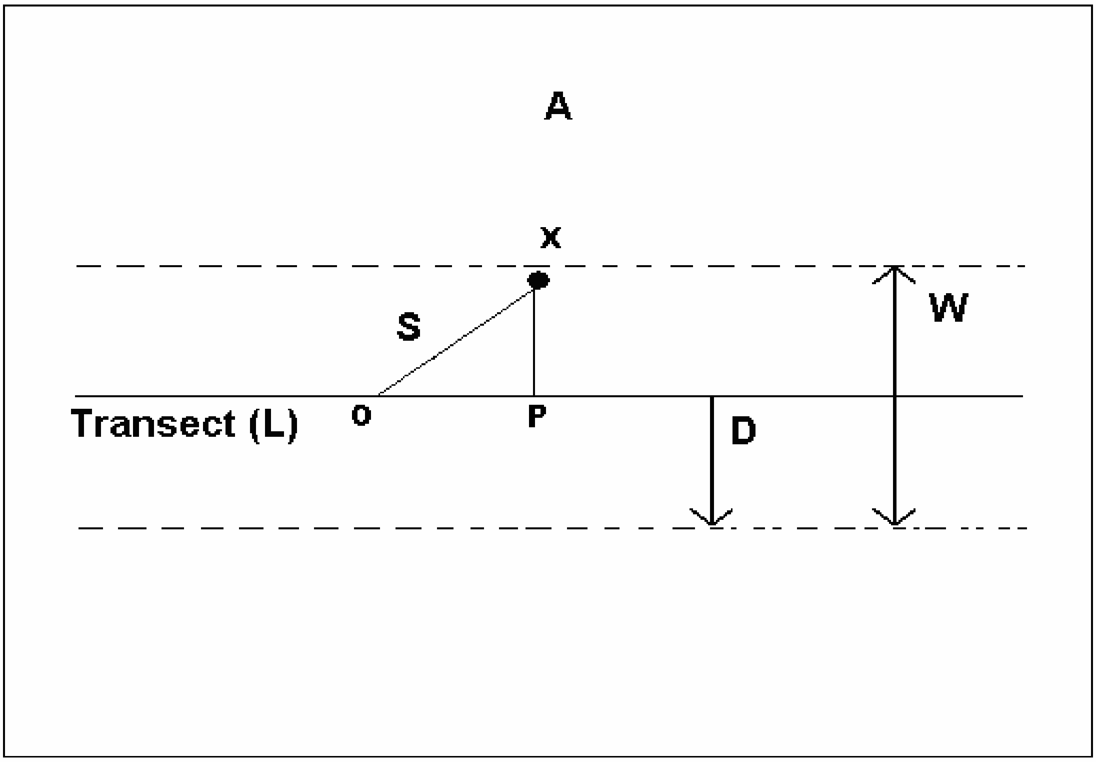

Figure 5: A diagrammatic representation of a transect modified from Anderson *et al* 1979. A = area studied, D = Effective sampling width, L = Length of transect, O = position of the observer when the animal is sighted, P = point on the transect which is perpendicular to the animal, S = sighting distance, W = Sampling width, X = position of the animal when it is sighted.

The first step is to calculate the sampling width of each transect which can be done in two ways, the first was done by plotting the cumulative percentage of animals seen as a function of the perpendicular distance. Two regression lines were fitted to the points and the corresponding distance from the transect of where the two regression lines meet was taken as the effective sampling width. The second estimate of the effect sampling width was calculated using a frequency histogram of the perpendicular distances from the transect that each animal was spotted. The first interval at which the number of animals seen dropped to less than half of the previous interval was taken as the 'Fall off distance'. The effective sampling width is calculated using the fall off distance from equation 1:

Equation 1: Effective sampling width = Nt / Nf x FD

Nt = Total number of animals seen, Nf = the number of animals seen at distances less than the fall off distance and FD = the fall off distance.

The mean of the two effective sampling widths was calculated then multiplied by 2 to get the sampling width. The total area surveyed was obtained using the sampling widths just calculated and multiplying these by the length of the transect. The lengths of each of the transects were given in metres by Google Earth. The coordinates of both points of each of the transects were put into the Google Earth programme and the transect lines drawn between them. The exact length of each one could then be obtained. Because the length was in metres, it had to be converted to hectares, thus the density of each transect was calculated as the mean number of Hedgehogs per hectare. The density per transect was calculated using equation 2:

Equation 2: Density = density per hectare x area

The population estimate was calculated using the results of the vegetation survey. The mean number of Hedgehogs per hectare for the transects that represented a particular vegetation type were multiplied by the total number of hectares of that vegetation type (Hoodless et al 1993).

3.2. Statistics

The Minitab statistics programme was used to perform a one way ANNOVA on the effect of habitat type on Hedgehog density. Mann-Whitney U tests were used to test whether the climatic conditions affected the number of Hedgehogs captured and if there was any bias towards the leucistic animals which were more conspicuous than the brown.

3.3. The Questionnaire

A total of 800 questionnaires were distributed to every house on the island. Three days (Saturday13th, Sunday 14th and Monday 15th September) were spent cycling around the island posting a questionnaire through the post box of every house. A map was used to ensure every house received just one questionnaire. Once every house on a particular road had received a questionnaire it was coloured in on the map. A box was place in the wildlife trust office to collect the completed forms. The aim of the questionnaire was to provide some information on the Hedgehogs that visited peoples' gardens since gardens were not included in the survey sites. For an example of the questionnaire see Appendix B.

4. RESULTS

4.1. Population Estimate

The Line transect method was used to make a population estimate of Alderney's Hedgehogs. To do this the effective sampling width was first calculated by plotting the cumulative percentage graphs and frequency histograms for each transect (see Appendix A). The sampling widths obtained from those graphs can be seen in Table 2.

Table 2: The effective sampling widths and sampling widths obtained from the cumulative percentage graphs and frequency histograms for each transect and the average sampling width used to calculate the area surveyed

Transect	Cumulative %(m)	Frequency Histogram(m)	Average(m)
A	8.8	10	18.80
B	29	40	69.00
C	27	20	47.00
D	25	10	35.00
E	7.8	10	17.80
G/H	56	10	66.00
I	12.8	10	22.80
J	29	10	39.00
K	23	30	53.00
L	43	20	63.00
N	14.4	20	34.40
O	23.6	10	33.60

The Hedgehog density per hectare for each transect was calculated and the results can be seen in Table 3. No Hedgehogs were found on transects F, M and P, therefore the density could not be calculated. Transect O (a rough grassland transect) had the highest density with 9.47/ha and transect J (road transect) has the lowest density with 0.88/ha

Table 3: The number of Hedgehogs per hectare for each transect.

Transect	Density/ha
A	4.02
B	3.24
C	3.43
D	8.57
E	3.96
F	0.00
G/H	1.45
I	6.71
J	0.88
K	3.79
L	7.07
M	0.00
N	2.49
O	9.47
P	0.00

The information in Table 3 and the Table 1 (which provides information on the habitat type of each of the transect) can be used to calculate the densities per hectare for Four of the habitat types that are represented by the transect. The results can be seen in Table 4. Short/mowed grassland had the highest Hedgehog density with 4.64/ha where as the Airport (Residential and Runway) had the lowest density with just 3.03/ha. A one-way ANNOVA was performed and found that habitat type had a significant affect on Hedgehog density ($F_{2,12}$ = 7.48, P = 0.008).

Table 4: The number of Hedgehogs per hectare in the four habitat types represented by the transects.

Habitat type	Number of Hedgehogs'/ha
Maritime Grassland	3.79
Rough Grassland	3.20
Short grassland	4.64
Residential/Runway	3.03

The total population was calculated using the total area of the island that the four habitat types cover and the calculated Hedgehog densities. It was estimated that Alderney's Hedgehog population is approximately 1315.

4.2. Climatic affects

The weather conditions and the presence of moonlight varied from night to night during the study, the average number of Hedgehogs sighted on nights when it was dry, wet, cloudy, clear, when moonlight was present and when it was absent are presented in Figure 6. Man-Whitney U tests were performed to test whether the different climatic conditions affected the number of Hedgehogs sighted. There was no significant difference between the average number Hedgehogs caught on cloudy nights with the number caught on clear nights ($P = 0.8179$), on wet nights with dry nights ($P = 0.7750$) and on nights when there was moonlight present with those when it was absent ($P = 0.1489$).

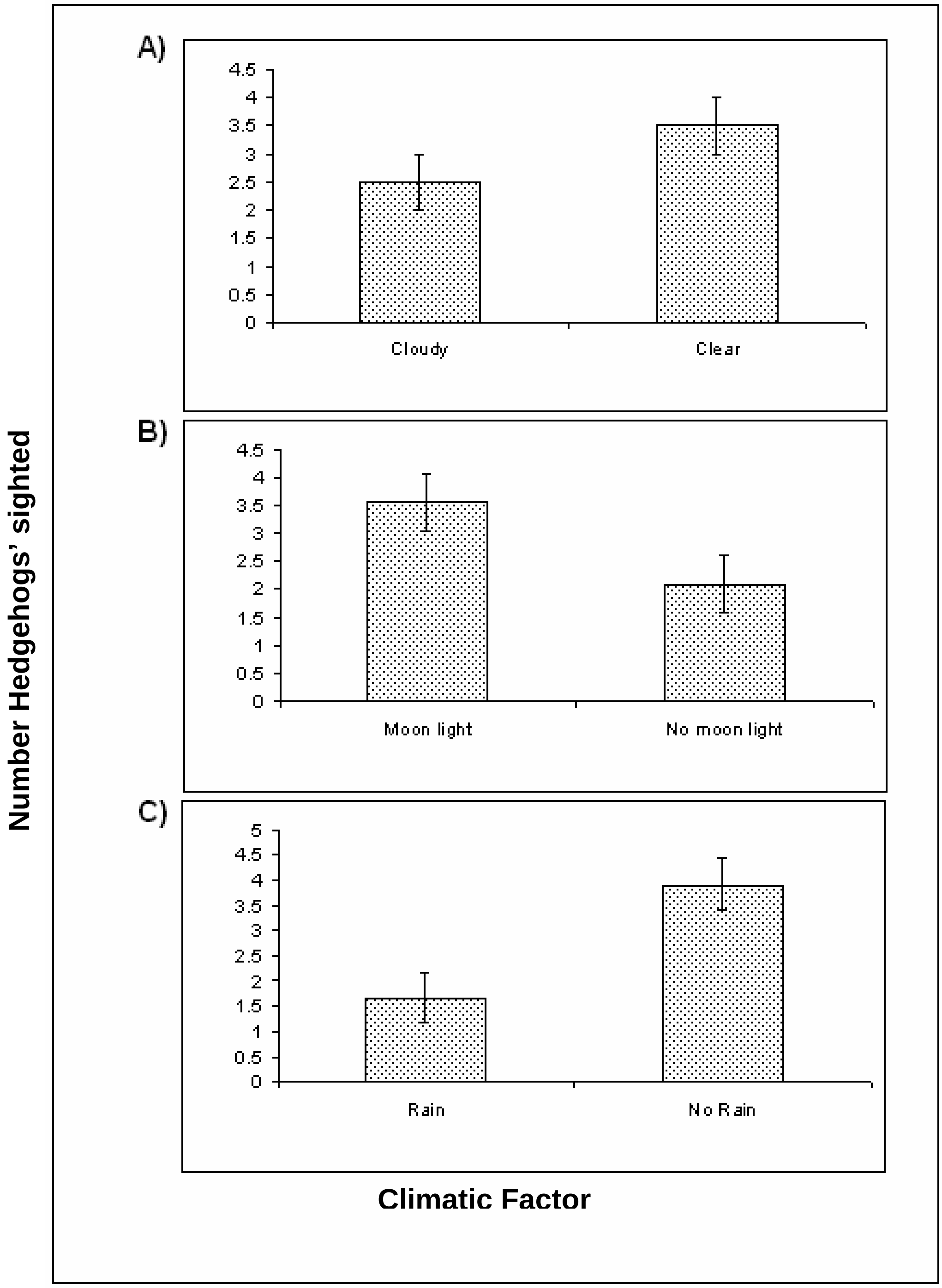

Figure 6: The average number of Hedgehogs sighted during the study when the climatic conditions differed. (A) On nights with and without cloud cover. (B) On Nights with moonlight and those without moonlight. (C) Nights with the presence of rain and those without.

The average temperature of each day the survey was carried out and the number of Hedgehogs sighted on those days is plotted in Figure 7. A Correlation was performed to test the effect of temperature on the number of Hedgehogs sighted, and it was found that there was no correlation between temperature the number of Hedgehogs sighted ($r = 0.010$, $P = 0.963$).

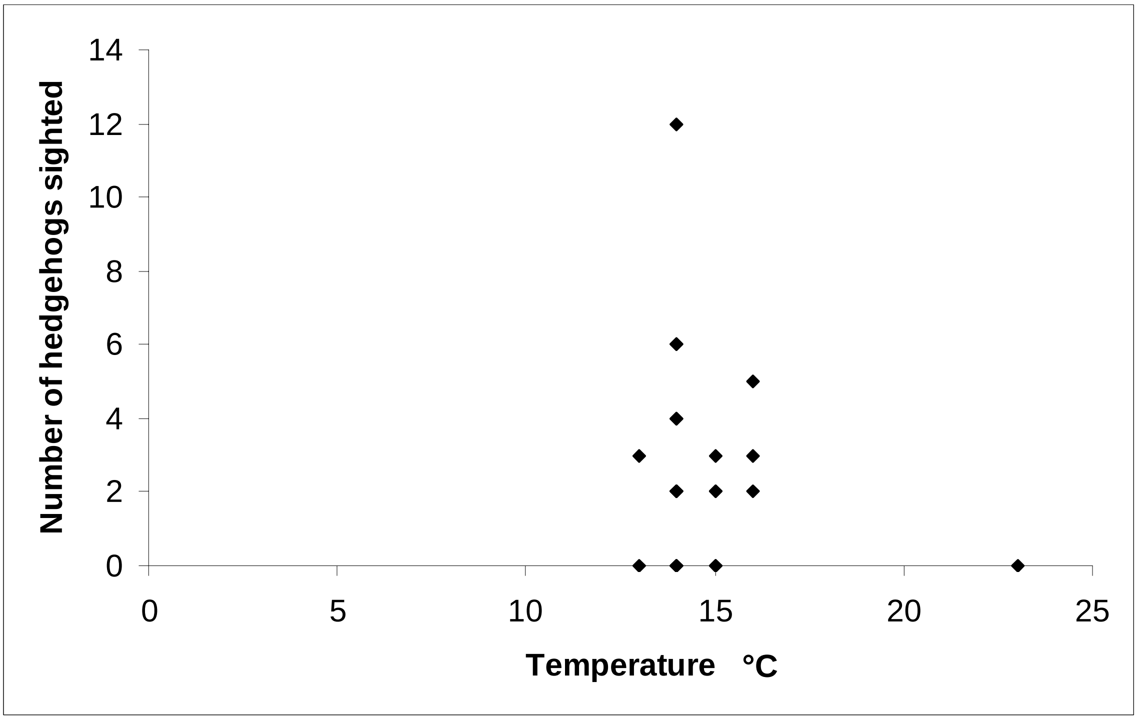

Figure 7: The average temperature (°C) on the days the transects were surveyed and the number of Hedgehogs sighted.

There are no abiotic factors that were investigated that affected the number of Hedgehogs caught on different days of the survey.

4.3. Leucism

More leucistic animals were caught than brown during the study and the total numbers of each colour caught can be seen in Table 5. Leucistic animals were more conspicuous than the brown, to ensure that there was no bias towards the leucistic animals a Mann-Whitney U test was performed. The results confirm that there was no bias towards the leucisitic animals (P = 0.1145).

Table 5: The total number of brown and leucistic Hedgehogs sighted during the study.

Colour	Number sighted
Brown	14
Leucistic	40

It was estimated that leucistic animals composed 75% of the population on Alderney.

4.4. Population Information

Every Hedgehog caught was weighed the results are presented in Figure 8.

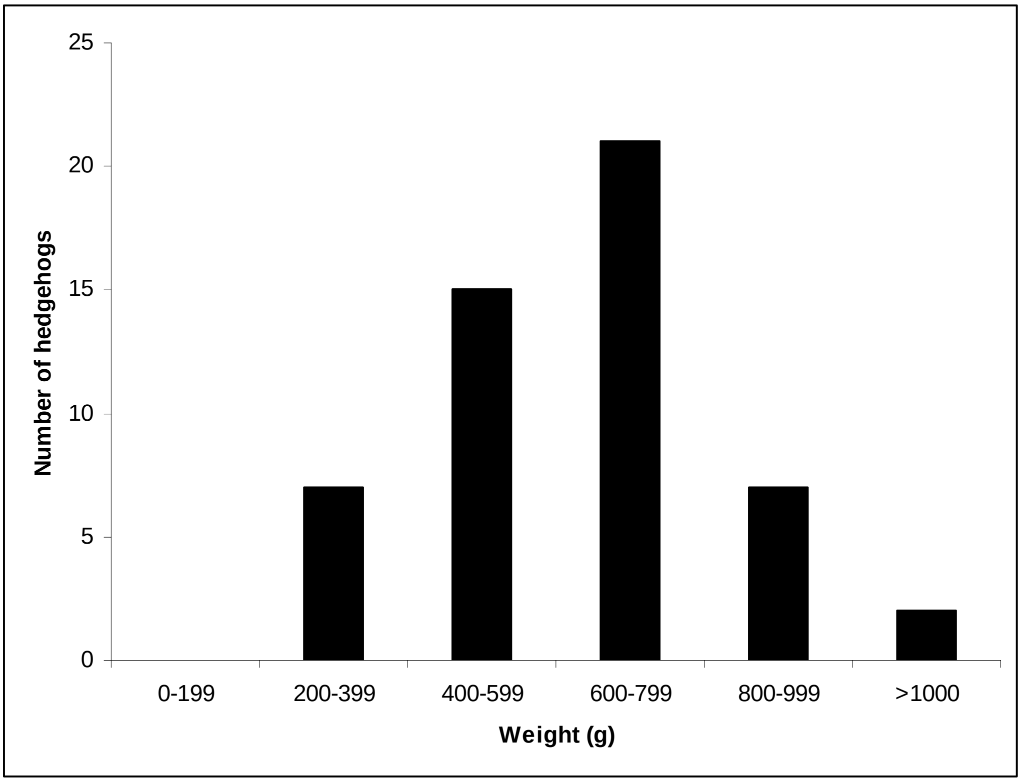

Figure 8: The weights of the Hedgehogs captured.

Most of the Hedgehogs caught were in the middle weight categories (400-599 and 600-799). As well as weighing the Hedgehogs they were also checked for Fleas, no Fleas were found on any of the captured Hedgehogs.

3.5 Vegetation survey

The results from the OS map are displayed using Google Earth Imaging and this can be seen in Figure 9.

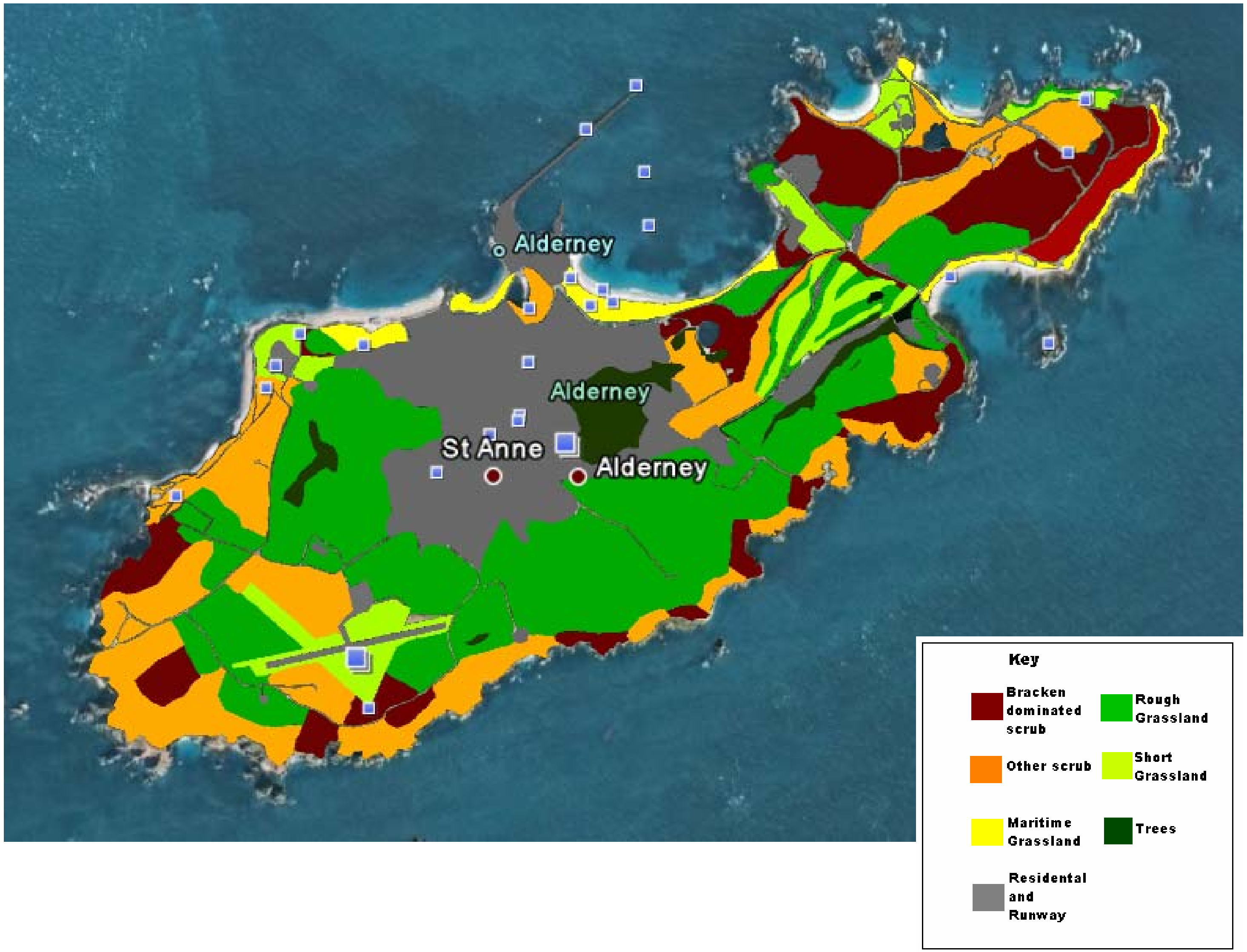

Figure 9: The results of the vegetation survey presented in Google Earth Imaging.

The percentage coverage of the seven habitat categories was calculated using the OS map and the results are presented in Figure 10. Rough grassland covers the majority of the island covering 41.68%, Woodland had the least percentage coverage making up 3.13% of the island.

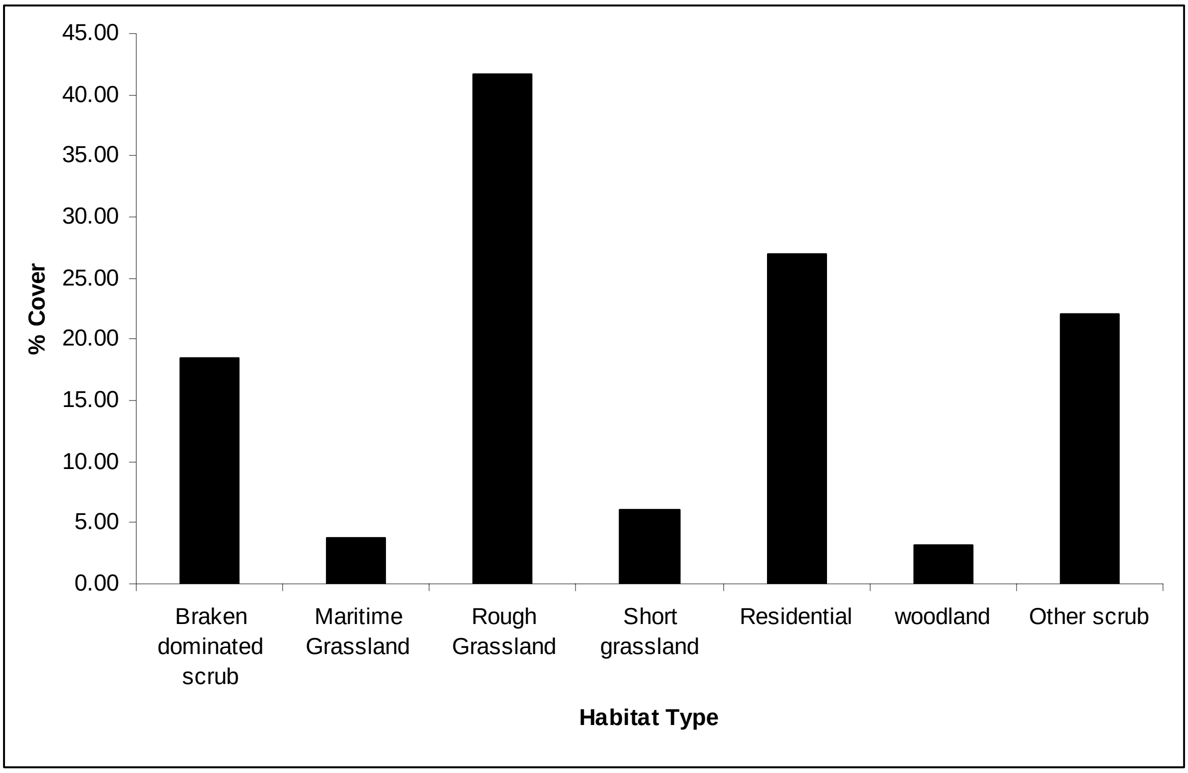

Figure 10: The percentage cover of the seven vegetation types.

4.6. Questionnaire

There was 131 replies to the questionnaire, 56.49% of those that replied indicated that they have Hedgehogs visiting their gardens, 48.65% of those said Hedgehogs visited on a regular basis i.e. more than once a week. Figure 11 presents the percentage of responses that have said they have leucistic or brown Hedgehogs visiting. 73.64% answered that they have leucistic Hedgehogs visiting their gardens and 9.3% said they have brown Hedgehogs visiting their gardens.

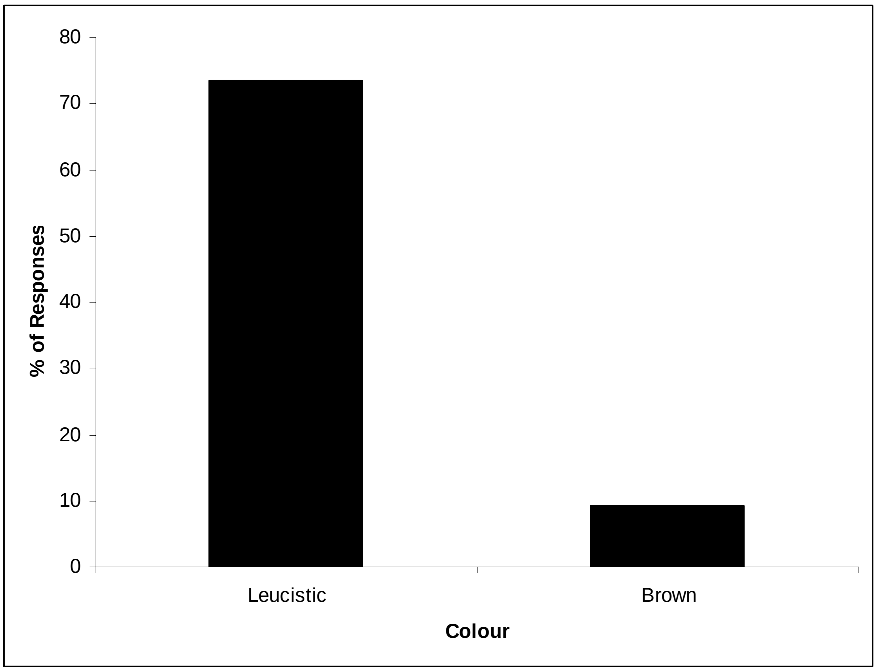

Figure 11: The percentage of those that replied to the questionnaire that have leucistic and brown Hedgehogs visiting their gardens

28.9% of those that said they had Hedgehogs visiting their gardens said that they fed those that visited

5. DISCUSSION

5.1. Hedgehog Density And Abundance

The number of Hedgehogs calculated per hectare varied from 0.88/ha on transect J to 9.47/ha on transect O. Hedgehogs appear to be at a higher density than those in other studies; Jackson(2007) found there to be between 0.11 and 0.37 Hedgehogs/ha on South Uist in the Outer Hebrides; Kristiansson (1990) estimated that there were between 0.30/ha and 0.78/ha in Southern Sweden; Campbell (1973) estimated that in some Lowland pasture areas in New Zealand there were between 4/ha and 8/ha; and Parkes (1975) estimated the density of Hedgehogs in Manawatu New Zealand as 1.1/ha during the winter and 2.5/ha during the summer. Hedgehog abundance and distribution is known to be affected by the distribution of food, the abundance of predators and parasites, the availability of nest sites, human activity and climatic conditions.

5.1.1. Climatic Conditions

To ensure that the weather conditions experienced whilst undertaking the study had not influenced the number of animals caught each night Mann-Whitney U tests were performed. The results of which indicate that the presence of rain, the temperature, and the presence of cloud and moonlight had no affect. Therefore no abiotic factors that were investigated affected the number of Hedgehogs caught each night of the study. Climatic conditions are a factor that can influence Hedgehog abundance and may explain the high Hedgehog density on Alderney. The climate on Alderney is milder than that of the UK and as a result more individuals are likely to survive the winter months. Kristiansson (1990) found that long, cold winters reduced the chance of Hedgehogs surviving the winter months. On Alderney the summers can be warmer than the mainland. Kristiansson also found that long mild summers made it possible for females to have more than one litter; Jackson (2006) found in the Outer Hebrides that females could have up to 2 litters a year, the first at the end of May/June and the second at the end of July to early September; Parkes (1975) found that in New Zealand the milder climate had resulted in a reduced hibernation period and therefore consequently an extended breeding season. The summer climate in Alderney may be favourable for females to have 2 litters, which could have contributed to the increase in Hedgehog abundance since 1993. The weather conditions also have an affect the abundance of food.

5.1.2. Food Abundance

The climate has an effect on the abundance and distribution of food. Hedgehogs are insectivores, their diet consists mainly of ground dwelling invertebrates including Worms and Beetles. Both Jackson (2006) and Parkes (1975) found that the milder conditions resulted in a higher abundance of invertebrates; Brockie (1975) found that in lowland areas where Hedgehogs were abundant, invertebrates were also numerous especially from spring to autumn. Alderney may have higher invertebrate densities than the mainland and can therefore support higher Hedgehog densities.

A Worm count was attempted, in 1993 the results indicated that the Hedgehog distribution was vaguely correlated with that of Worm densities. Unfortunately the Worm count attempted in the present study was unsuccessful. It is noticed from weather data from 1993 that the weather conditions of September 1993 were wetter than those of 2008. Estimating Worm densities is difficult because many have deep permanent burrows (Edwards 2004). The amount of moisture in the soil has an affect on the vertical distribution of Worms in the soil profile, the drier the soils the deeper they are situated, this is because they have cutaneous respiration (Edwards 2004; & Jimeriz *et al* 2000). The more rain experienced in 1993 would have meant that the Worms were situated higher in the soil profile.

From the questionnaire results 29% of those that replied said they fed the Hedgehogs that visited their gardens, it was also noticed whilst undertaking the study that there were large numbers of Slugs around. An estimation of Slug densities was not carried out but the large numbers observed and the questionnaire results indicate the high availability of food.

5.1.3. Predation And Parasites

In the UK Hedgehog abundance and distribution have been found to be negatively correlated with that of Badgers. Badgers are not only predators of Hedgehogs but also act as potential competitors for invertebrates. In a study by Young (2006) on the 'Abundance of Hedgehogs in relation to the density and distribution of Badgers', it was found that Hedgehog densities ranged from 0/ha to 0.79/ha which is a much lower estimate than that made by this study on Alderney. Young found that Hedgehogs actively avoided areas populated by Badgers. Doncaster (1992) also found that Hedgehogs avoided areas occupied by Badgers, Hedgehogs were found to be absent from Whytham Woods, Oxfordshire because of the high Badger population. Jackson (2004) mentions that the absence of Badgers played a key role in the establishment and success of the Hedgehogs introduced to the Outer Hebrides. Brockie (1975) found in New Zealand (where Badgers were also absent and hedgehog densities were higher than those found by Young and Doncaster) there was limited predation of Hedgehogs, on rare occasions Dogs and Magpies had been observed attacking Hedgehogs. Hedgehogs in New Zealand also experienced only limited competition for food from Rats and Mice. On Alderney there are no Badgers and very limited competition if any. Brockie described Hedgehogs as filling an “Ecological vacuum” in New Zealand, this term may also be used to describe Hedgehogs on Alderney.

When introduced to new environments the absence and reduction of parasites can contribute to the successful establishment of the species (Torchin et al 2003). Hedgehogs on mainland Europe have been found to carry up to 500 Fleas (*Archaeopsyllus erinacei*) (Morris1995). Alderneys Hedgehogs are free of Fleas so too are the Hedgehog populations of the Outer Hebrides (Jackson 2006 & 2007). It is not know whether the absence of Fleas is important in determining Hedgehog densities.

5.1.5. Habitat Availability

An ANNOVA was performed on type of habitat and the number of Hedgehogs caught. The type of habitat was found to have a significant affect on the number of Hedgehogs caught. More Hedgehogs were found on the short grass transects, the golf course (Transect B, C, and L) and the cricket pitch (transect D) than any of the other transects the reason for this may be that it is easier to forage in the short grass and the short grass areas may have higher invertebrate densities. Brockie (1975) found that pasture land (which is generally short grass) had a high invertebrate abundance and thus high Hedgehog densities. Transect D has the most residential setting of all the transect, Hedgehogs have been said to be abundant in urban and residential areas (Doncaster 1992; & Morris 1995). In a study by Driezen (2007) it was found that Hedgehogs avoided arable land in favour of urban habitats. The reason for this is that they provide excellent winter nest sites such as sheds and outhouses (Brockie 1975; & Morris 1995). The increase in residential areas in Alderney may have contributed to the increase in Hedgehog density by providing more potential winter nest sites. Another reason residential areas are thought to be popular with Hedgehogs is that they are generally avoided by Badgers (Doncaster 1994). On Alderney this is not the case since Badgers are absent.

The vegetation survey results give an indication of the amount of suitable Hedgehog habitat on Alderney. On Alderney short grassland only makes up about 6% of the island and Residential areas make up about 27% of the island which is a slight increase from the percentage cover of residential areas in 1993. Rough grassland covers the majority of the island and it was estimated that the Hedgehog density in these areas is approximately 3.20/ha. Kristiansson (1990) indicated Hedgehog density is most likely to be influenced by food availability and winter nest sites than density dependent factors, this lead Tutt (1993) to conclude that on Alderney Hedgehog density is affected by the availability of food and water rather than the area of the island.

5.1.6. Affects Of Traffic On Hedgehog Density

Hedgehogs are regular victims of traffic, Huijser (2000) estimated that between 113,000 to 340,000 Hedgehogs were killed a year in the Netherlands by traffic. The Mammal Society did a survey on mammal road deaths in 2005 and found that approximately 100,000 Hedgehogs were killed a year on UK roads (Mammal society National survey of Road deaths online at http://www.abdn.ac.uk/~nhi775/road_deaths.htm. Accessed 13/02/1009).

The disturbance caused by roads (pollution and management of the road verge) can affect Hedgehogs that are several kilometers from the road itself (Formann 1998). Huijser (2000) and Orlowski (2004) found Hedgehog abundance was reduced by 35% near roads in the Netherlands and Poland. Roads also provide a barrier to Hedgehog dispersal (Formann 1998; &Rondinini et al 2002) the construction of new roads has split up Hedgehog populations into smaller more isolated populations (meta-populations). These populations experience greater fluctuations in size and are more prone to extinction (Formann 1998).

On Alderney the roads are not wide and the traffic is light and is therefore are easily crossed by Hedgehogs. One Hedgehog was observed crossing the road during the study period and only 2 Hedgehogs were spotted as traffic victims.

5.2. Population Information

5.2.1. Leucism

Leucistic animals are more conspicuous than the normal brown coloured animals and more leucistic animals were observed during the study than brown. Therefore a Mann Whitney U test was performed, the results of which indicate that there was no bias towards the leucistic animals. Leucism has been calculated to make up 75% of the population. The high prevalence of Leucism is supported by the questionnaires results.

It can be seen from Figure 11 that Leucism in the population has increased from 25% in 1993 to 75% in 2008.

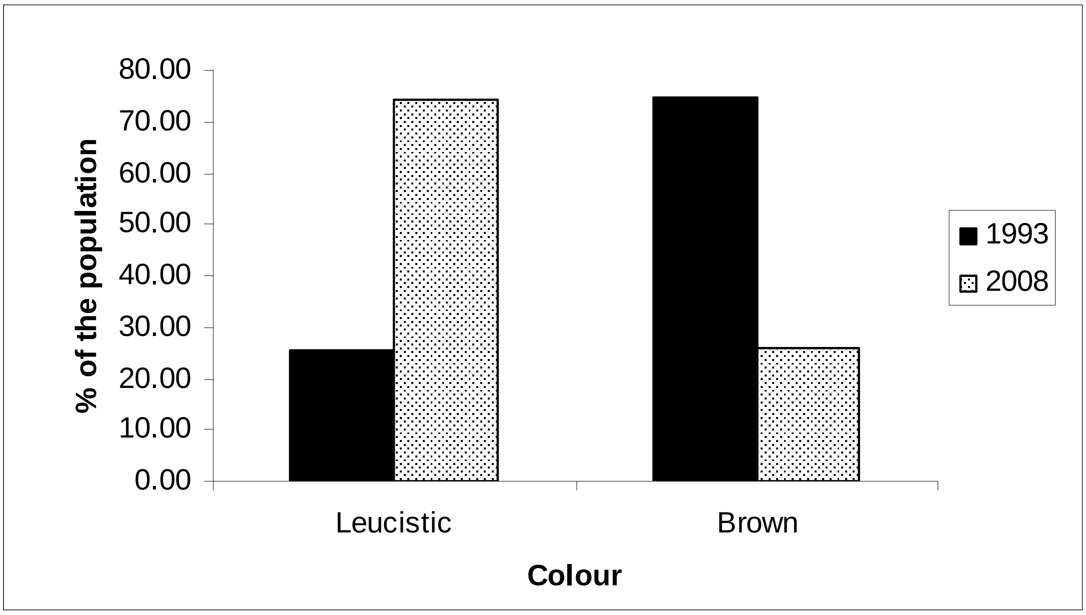

Figure 11: The percentage of leucistic individuals in the population in 1993 and 2008

Leucism is extremely rare in Hedgehogs on mainland Europe, in the UK only a couple cases have been reported in the past few years. The reason for the infrequent occurrence of Leucism is most probably because leucistic animals are more conspicuous and therefore more likely to be predated on by Badgers, and consequently have a selective disadvantage. It has already been stated that Badgers and Foxes are absent on Alderney, their absence means leucistic Hedgehogs suffer no selective disadvantage.

Goncalves (2008) has discussed why leucistic Rufous-Bellied Thrush (*Turdus rufiventris*) are not more abundant, and concludes that they are more conspicuous to predators and therefore more likely to be predated on. Goncalves also noticed that leucistic birds appeared to be more prevalent in urban areas the reason for this is thought to be because they are less affected by predators in the urban environments. Acevedo (2008) also argued that leucistic individuals are more conspicuous after four leucistic Fur Seal Pups were not re-sighted and concluded they must have fallen victim to predators.

The increase in Leucism within the population may be the result of genetic drift. Genetic drift is strongest in small populations that experience no migration. Alderney's founding Hedgehog population was small and because Alderney is an island the population is isolated from other Hedgehog populations on Guernsey, Jersey and mainland Britain. The founding population as has already been pointed out must have had a least one animal carrying the rare recessive allele. Through inbreeding Leucism became prevalent and because there is limited or no selection on the island neither the brown nor the leucistic Hedgehogs would have been selected for or against. Genetic drift works when selection is absent. As the population increased in size from the founding population, through genetic drift and by chance the leucistic alleles became fixed in the population (Freeman *et al* 2007; & Whitlock et al 2000). Genetic drift leads to a decrease in the heterozygotes which may explain why Leucism has risen from 25% since 1993 to 75% in 2008 and why brown Hedgehogs are becoming less common.

5.2.2. Other Population Features

The Hedgehog population appears to be healthy, most Hedgehogs caught were in the middle weight categories (400-800g), Morris (1995) has said that they need to be at least 450g to survive winter hibernation, this is because they lose 40-50% of their body weight during this period (Kistiansson 1990). Just over 80% of the population were already at a sufficient weight to survive hibernation. Weight can also indicate the age of Hedgehogs, from the information gathered on weight it can be see that there are few young around, animals that weigh between 450g-680g are approximately a year old (Tutt 1993). About 20% the population weighs below 500g and are probably this years young. A few animals were in the lower weight categories and were probably the result of late litters.

Determining the sex of the animals caught during the study was difficult, when caught the animals curled up into tight balls and it was difficult to get them to uncurl without distressing them. It was thus decided that it would be best not to sex the Hedgehogs since this information was not essential for the study. In 1993 the sex ratio was 1:1 this ratio has been found in other Hedgehog populations such as those in the Outer Hebrides (Jackson 2007) and in Southern Sweden (Kristiansson 1990).

5.3. Further Work

The only studies on Alderney's Hedgehogs are the present study and the 1993 study by Alison Tutt therefore no work has been done on what controls the Hedgehog population on Alderney. The abundance of food and available nest sites have been discussed as possible factors that control population density a study could be done to quantify food abundance and nest availability and correlate it with Hedgehog density.

On Alderney Hedgehogs are not considered pests like they are in the Outer Hebrides and New Zealand this may be because their impact on the island's ecosystem has not be studied, further work might include an investigation in the Hedgehogs ecological impact on the island.

Alderney has a milder climate than the UK, this might bring about changes in their breeding biology as it has done in the Hedgehog populations in the Outer Hebrides and New Zealand. A study may look at whether there have been any changes to their biology since being introduced to Alderney.

It is not known whether the Hedgehog population has reached the carrying capacity of the island another population study could be performed in fifteen years time to assess any population changes.

The effect the absence of Fleas has had on the Hedgehog densities is unknown and no studies could be found that had investigated this, further work could look at this.

5.4. Conclusion

Hedgehogs have thrived on Alderney. Tutt expressed concern that a decline in Alderney's Hedgehog population in the future may lead to their extinction, since they have already become extinct once on the island. The results of this study indicate that Alderney's Hedgehogs are not at risk of extinction at the moment, their population has increased since 1993. They also appear to be healthy and the majority of those captured are already at a sufficient weight to survive hibernation, and none of the animals have Fleas. There appear to be no major causes of Hedgehog mortality on Alderney; the road traffic is light; the climate is milder than that of mainland Britain; and there are no major predators. Although no investigation was done on the food abundance it is thought that there is no food shortage.

The Hedgehogs are popular among the islands residents. The questionnaire results indicate that a large number of residents feed the Hedgehogs that visit their gardens, this most probably contributes towards the Hedgehogs putting on enough weight to survive hibernation. There are also likely to be to be lots of suitable winter nest sites in the residential areas. Leucistic animals now make up 75% of the total population, the fixation of this rare recessive allele in the population is a result of the founder effect, genetic drift and chance.

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APPENDIX A

Table1: The length of each transect in metres and the coordinates of both ends of each transect

		Point 1		Point 2	
Transect	**transect length(m)**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
A	794.7	49.7142	-2.1876	49.7189°	- 2.1792°
B	358.12	49.7187°	- 2.1834°	49.7205°	- 2.1792°
C	620.32	49.7183°	- 2.1850°	49.7216°	- 2.1781°
D	266.66	49.7176°	- 2.2036°	49.7174°	- 2.2031°
E	850.6	49.7062°	- 2.2209°	49.7076°	- 2.2089°
F	850.6	49.7058°	- 2.2207°	49.7072°	- 2.2088°
G		49.7063°	2.2176°	49.7043°	- 2.2145°
H	628.25	49.7042°	- 2.2144°	49.7066°	- 2.2124°
I	392.34	49.7091°	- 2.2211°	49.7066°	- 2.2172°
J	2905.42	49.7242°	- 2.1801°	49.7202°	- 2.1779°
K	596.62	49.7206°	- 2.1982°	49.7212°	- 2.1897°
L	494.26	49.7169°	- 2.1873°	49.7207°	- 2.1838°
M	351.56	49.7133°	- 2.2176°	49.7144°	- 2.2129°
N	467.8	49.7234°	- 2.1809°	49.7272°	- 2.1774°
O	125.77	49.7191°	- 2.1761°	49.7194°	- 2.1765°
P	220.35	49.7133°	- 2.2198°	49.7113°	- 2.2192°

Table2: The Number of Hedgehogs caught on each transect during the survey.

Transect	Number hedgehogs found
A	3
B	4
C	5
D	4
E	3
F	0
G/H	3
I	3
J	5
K	6
L	11
M	0
N	2
O	2
P	0

Table3: The weather conditions recorded whilst walking the transects.

Date	Weather observed each night of the survey
01/09/2008	Overcast, windy, slight rain
02/09/2008	Clear, dry, strong wind
03/09/2008	Windy, clear, dry, no moonlight
04/09/2008	Cloudy, dry, slight wind, light rain began
05/09/2008	Weather extremely bad, survey aborted
07/09/2008	Clear with scattered cloud, dry, still, low moonlight
08/09/2008	Overcast, dry, slight breeze
09/09/2008	Clear, dry, half moon, slight breeze
10/09/2008	Cloudy, dry, slight breeze
11/09/2008	Clear, dry, slight breeze, 3/4 moonlight
12/09/2008	Clear, scattered cloud, Dry, moonlight
14/09/2008	Cloudy, Full moon, Dry, slight breeze
16/09/2008	Cloudy, dry, slight breeze, moonlight
17/09/2008	Scattered cloud, dry, slight breeze, moonlight
18/09/2008	Cloudy, slight breeze, Dry
19/09/2008	Clear, dry, cold, moonlight, very still
22/09/2008	Cloudy, windy, dry
23/09/2008	Cloudy, windy, dry
24/09/2008	Cloudy, dry, slight breeze, light rain started
25/09/2008	Clear, dry, slight breeze, no moonlight, rain started
26/06/2008	Strong Breeze, dry, clear

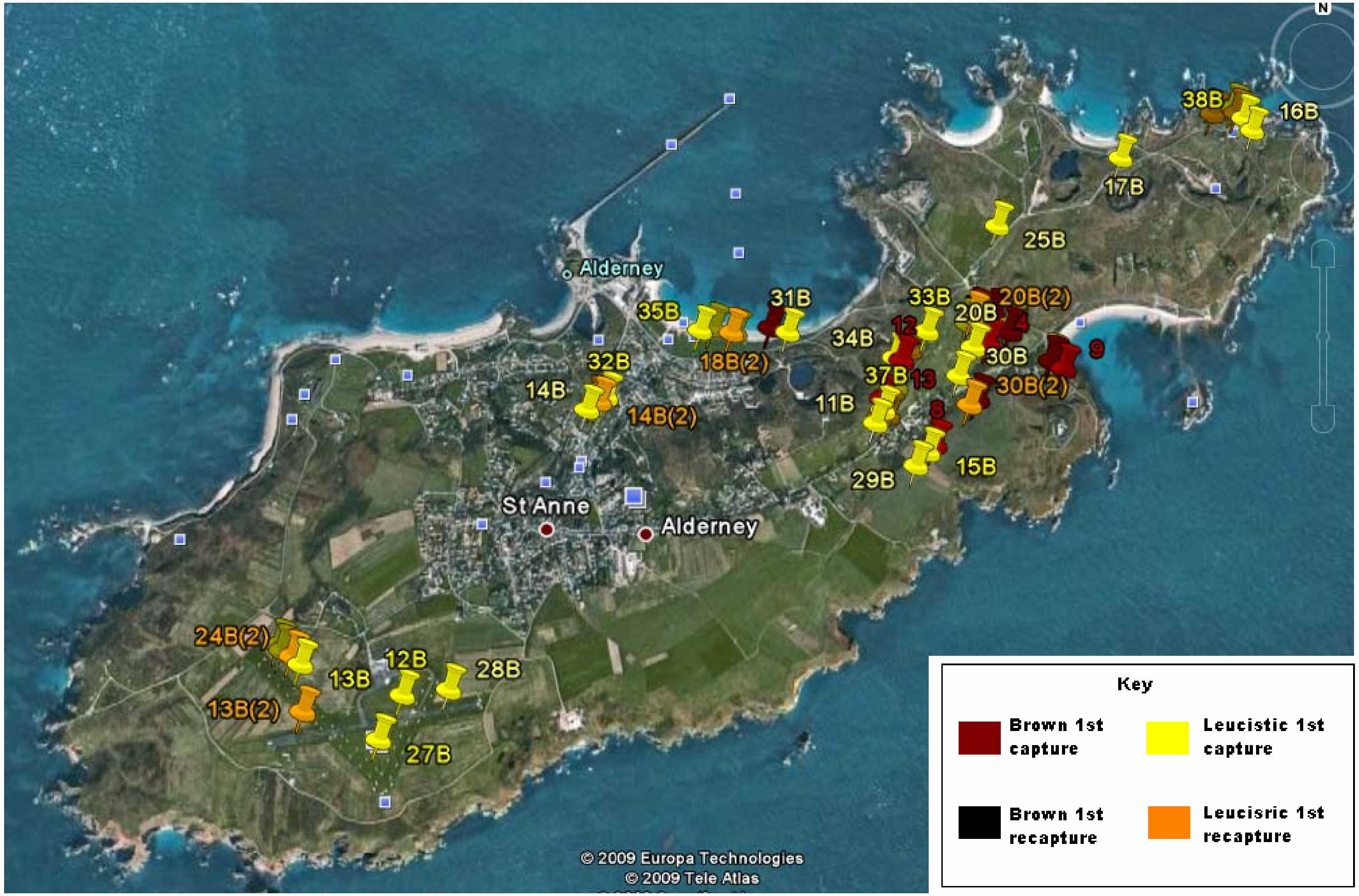
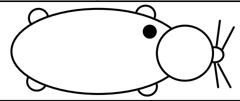
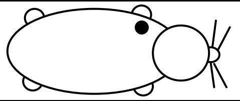
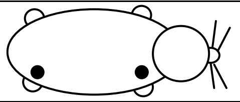
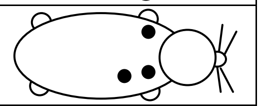
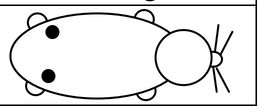
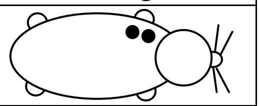
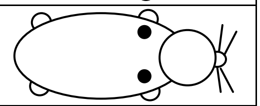
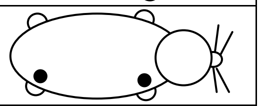
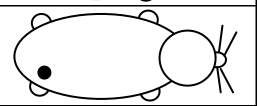
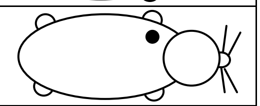
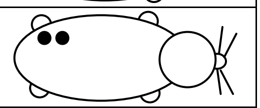
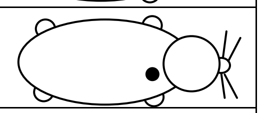
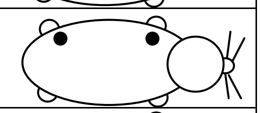
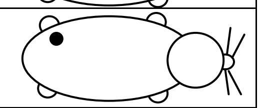
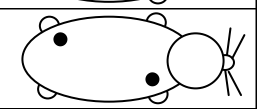
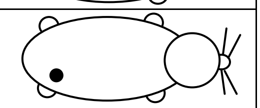
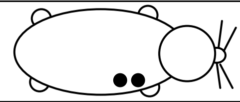
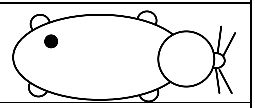
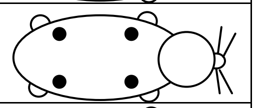
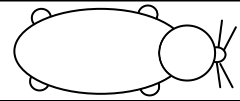
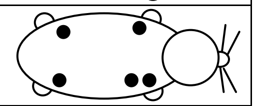
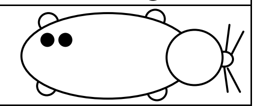
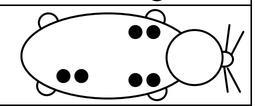
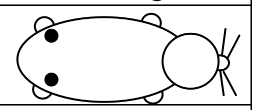
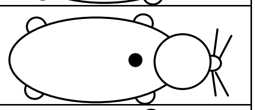
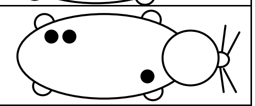
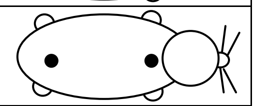
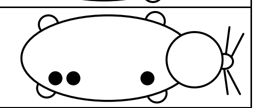
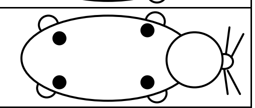
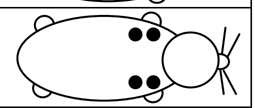
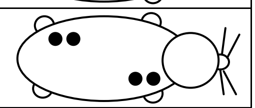
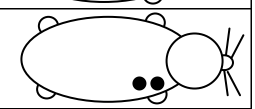
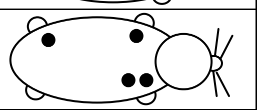
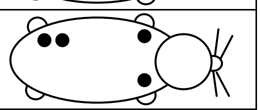
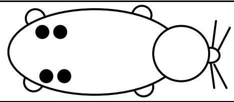
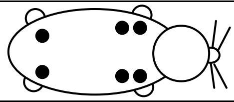
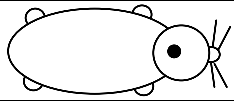
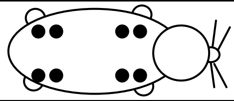
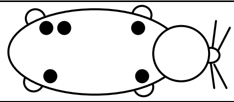
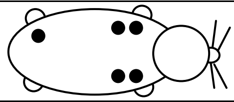
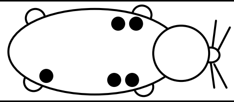
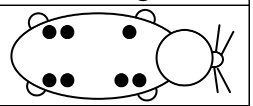
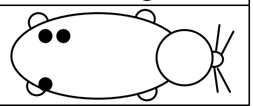
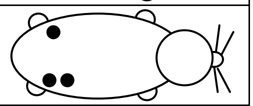
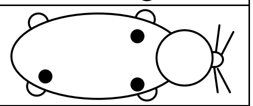
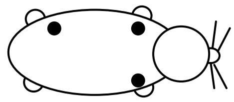
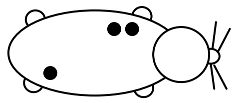
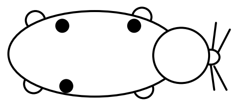
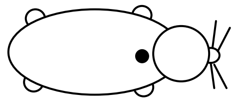
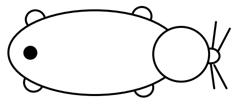
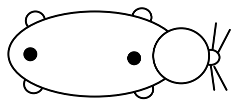


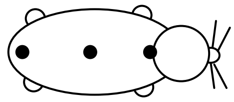
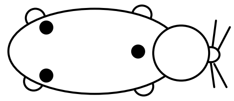
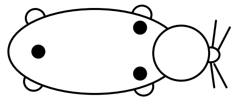
Figure1: The locations where each Hedgehog was captured. Provided by Google Earth.

Table4: The ID number, the transect the animal was found on, the weight (g), circumference (mm), colour (1=Blonde, 2=Intermediate, & 3=Brown), and marking of all the Hedgehogs' captured during the study.

Id	Transect(s)	Weight/g	Circ./mm	Colour	Marking
1	C	685		3	
1B	C	540		2	
2	B,C	680		3	
2B	C,L	590-600		1	
3	K	610	440	3	
3B	C,B	425		1	
4	B	750	450	3	
4B	C,L	540-560		1	
5	O	810	491	3	
5B	C	500		2	
6	O	850	473	3	
6B	C	620		2	
7	A	700	437	3	
7B	L	680		1	
8	A	630	450	3	
8B	C	625		1	

9	O	900	482	3	
9B	C	530		1	
10	C	560	442	3	
10B	L	680	509	1	
11	C	900	492	3	
11B	L	220	356	1	
12	L	500	386	3	
12B	E	290	349	2	
13	L	660	465	3	
13B	I	660	448	2	
14	A	340	355	3	
14B	D	750	460	1	
15B	A	350	348	2	
16B	J	940	467	1	
17B	J	800	442	1	
18B	K	540	458	1	
19B	B	240	344	2	
20B	B	670	454	1	

21B	C	590	439	1	
22B	L	510	419	1	
23B	O	260	345	1	
24B	I	1040	486	1	
25B	N	590	393	1	
26B	I	940	481	1	
27B	G	450	399	1	
28B	E	1010	506	1	
29B	A	760	448	1	
30B	Longis Road	740	481	1	
31B	K	750	467	1	
32B	D	390	379	2	
33B	L	890	468	2	
34B	L	700	451	1	
35B	K	610	449	1	
36B	K	600	442	1	
37B	L	340	385	1	

38B	J	690	416	1	
39B	J	500	427	1	
40B	H	560	431		

The sampling widths were calculated from the cumulative percentage graphs and frequency histograms below.

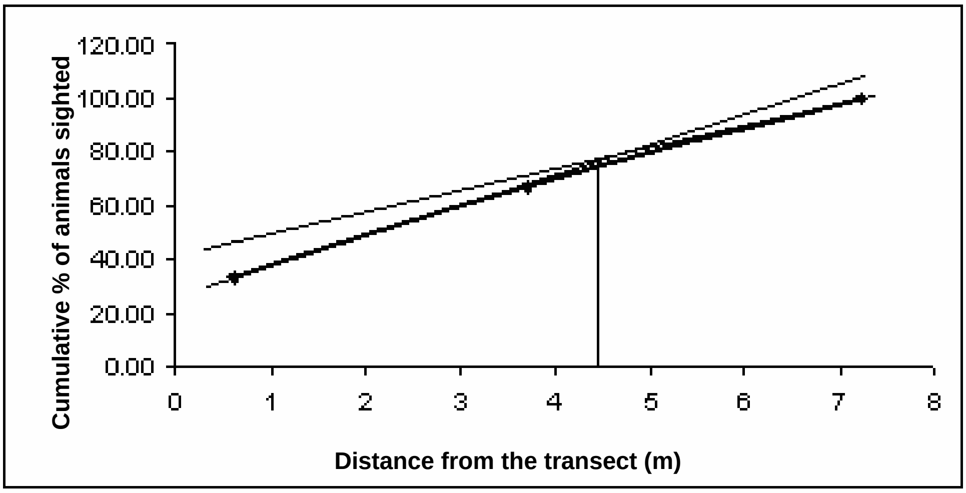


Figure2: Transect A Cumulative Percentage Graph

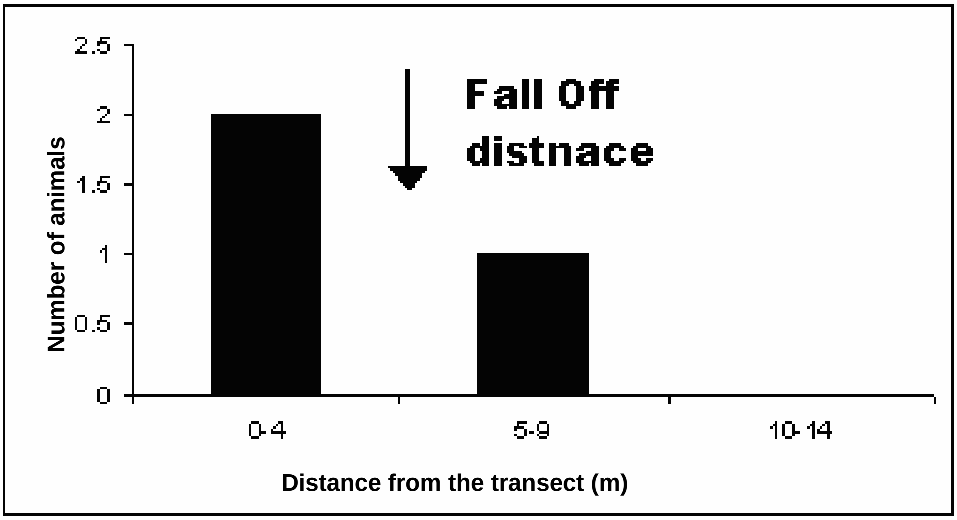


Figure3: Transect A Frequency Histogram

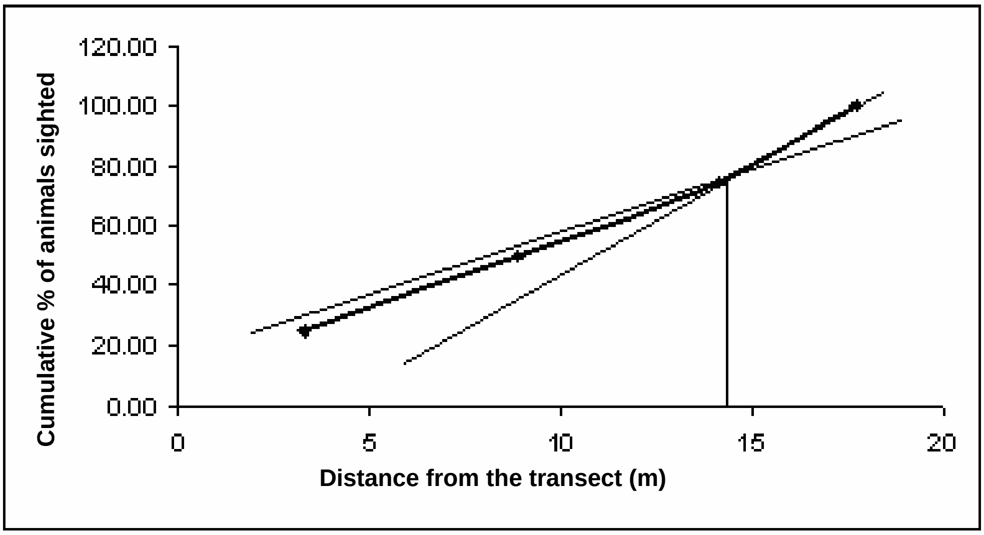


Figure4: Transect B Cumulative Percentage Graph

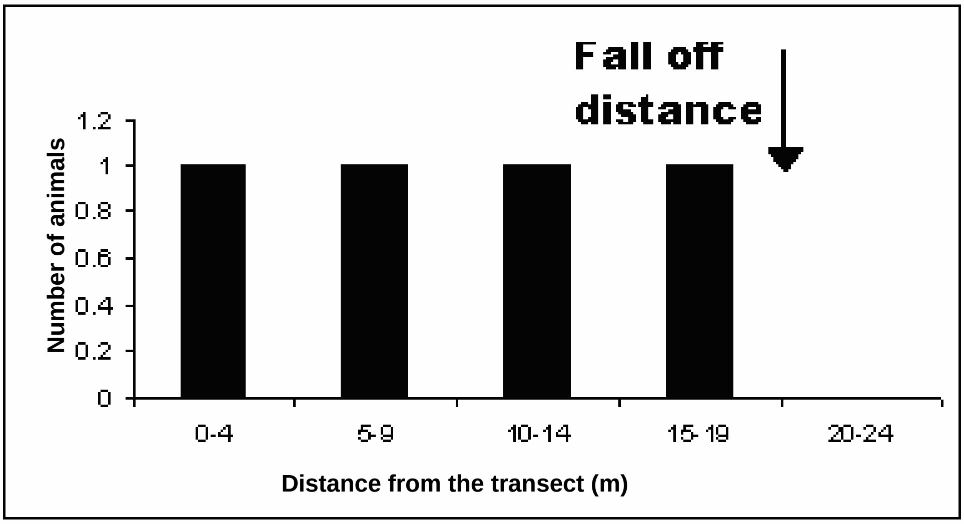


Figure5: Transect B Frequency Histogram

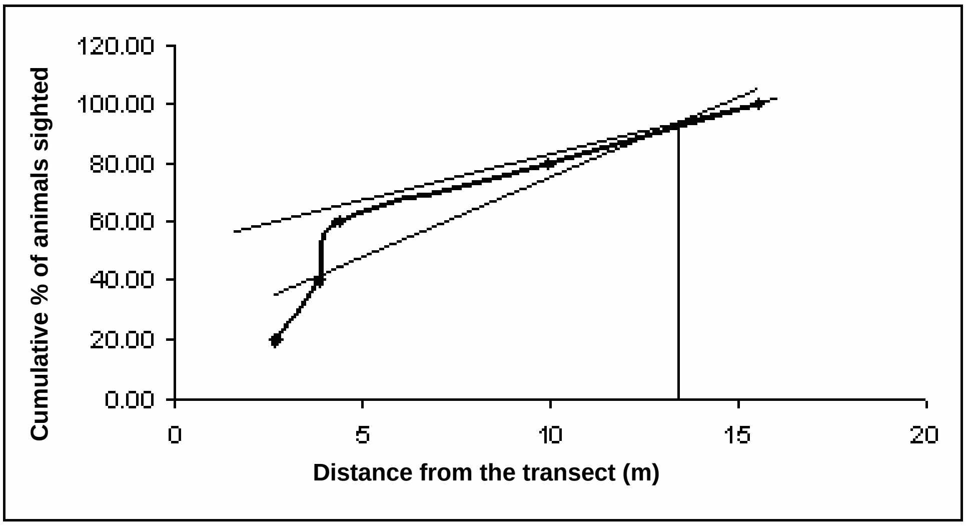


Figure6: Transect C Cumulative Percentage Graph

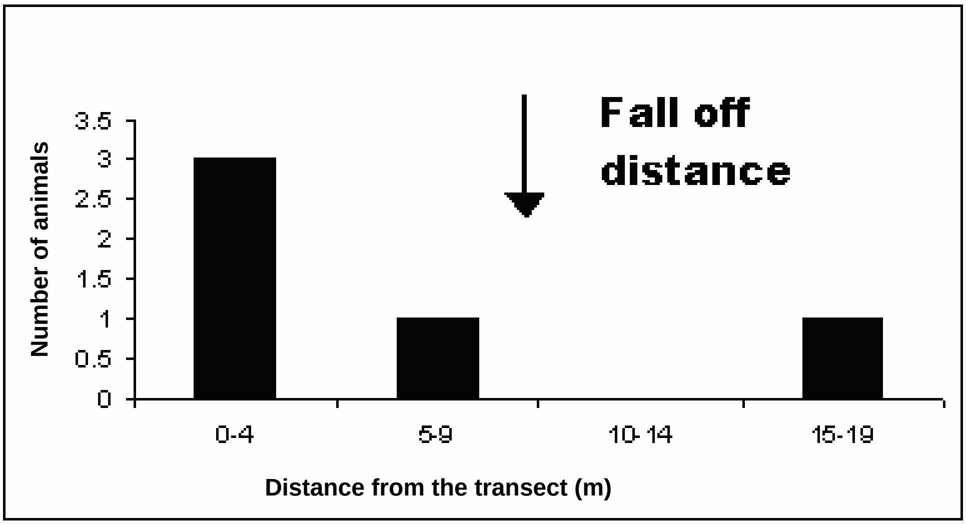


Figure7: Transect C Frequency Histogram

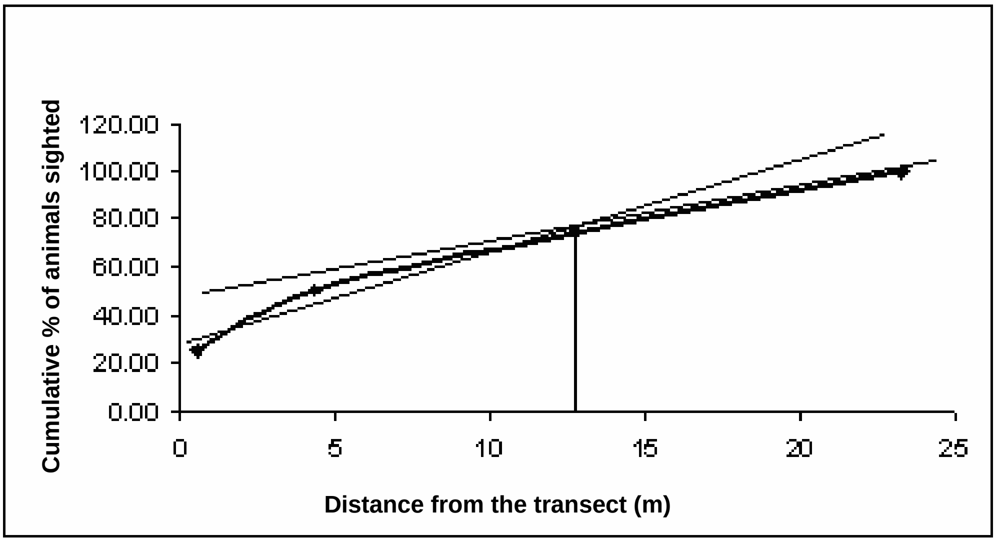


Figure8: Transect D Cumulative Percentage Graph

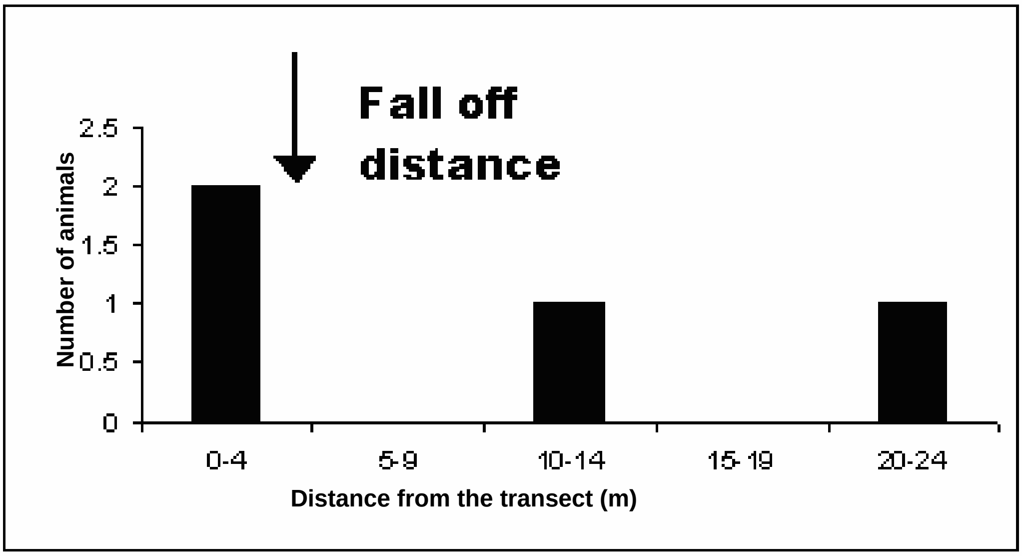


Figure9: Transect D frequency histogram

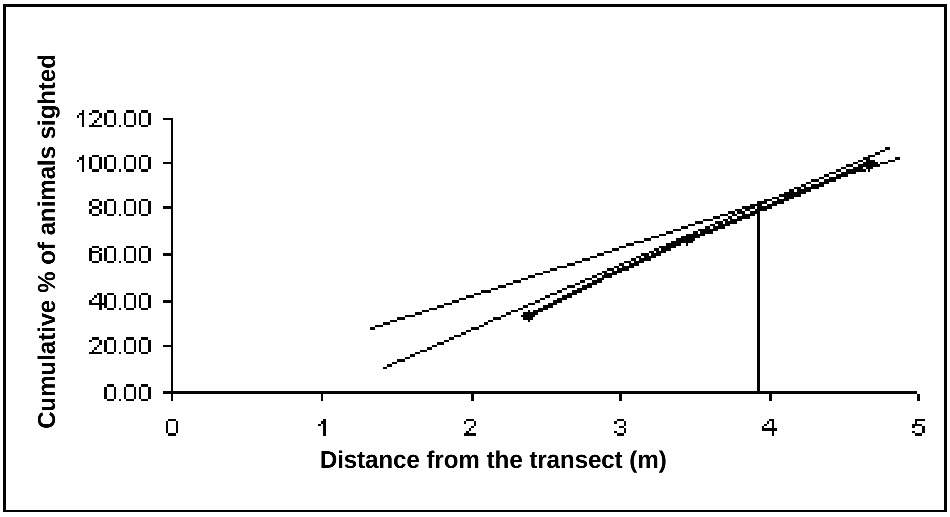


Figure10: Transect E Cumulative Percentage Graph

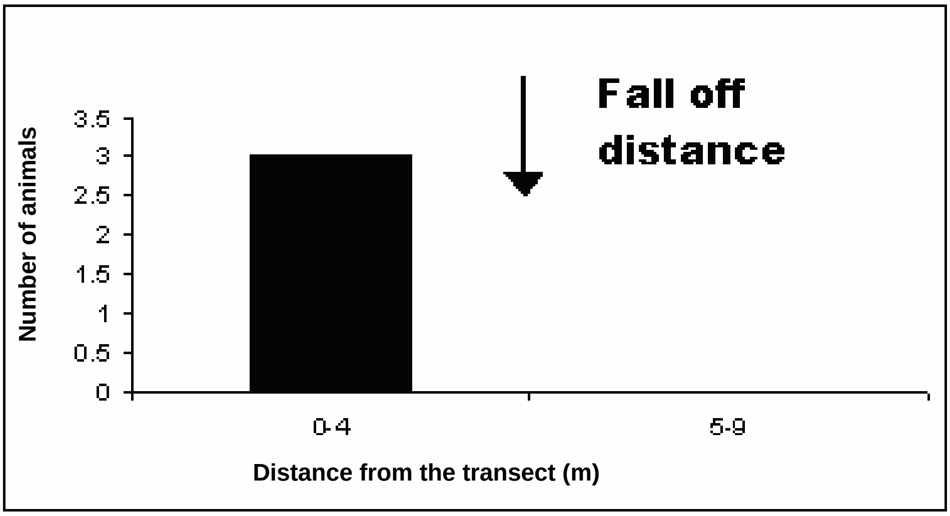


Figure11: Transect E Frequency Histogram

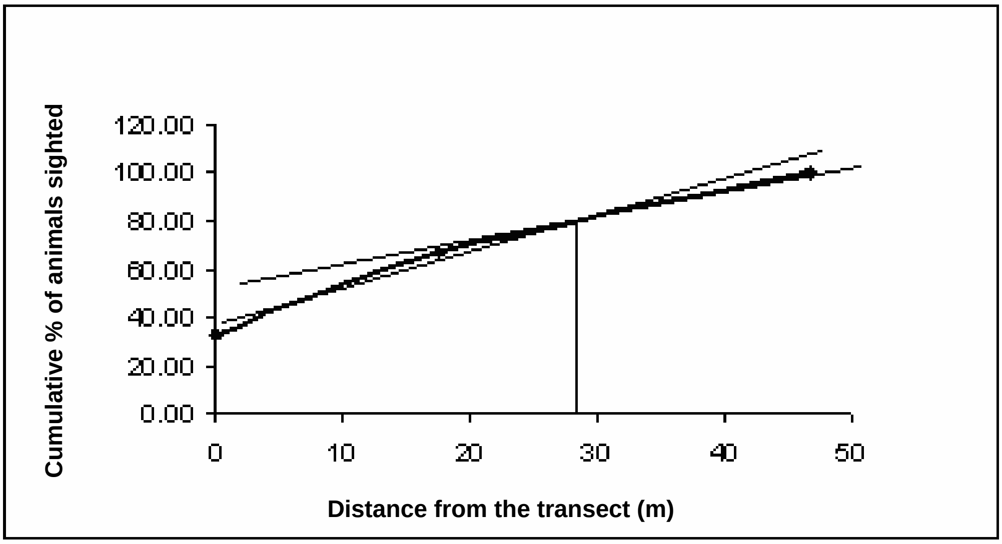


Figure12: Transect G/H Cumulative Percentage Graph

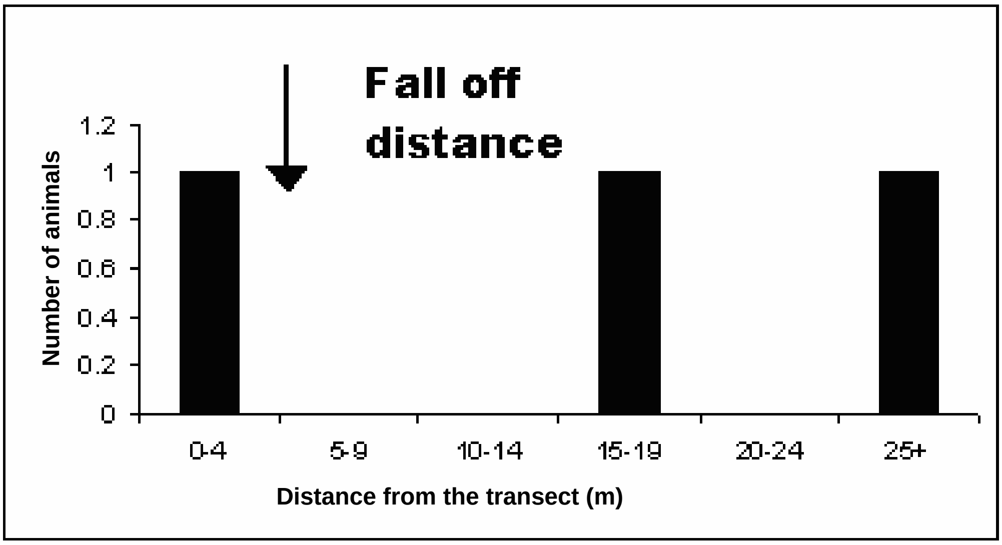


Figure13: Transect G/H Frequency Histogram

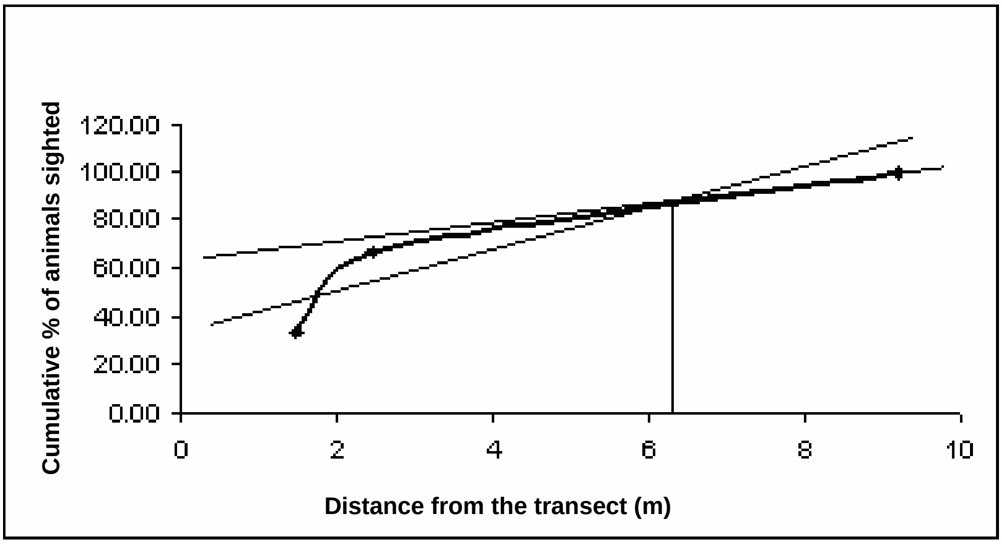


Figure14: Transect I Cumulative Percentage Graph

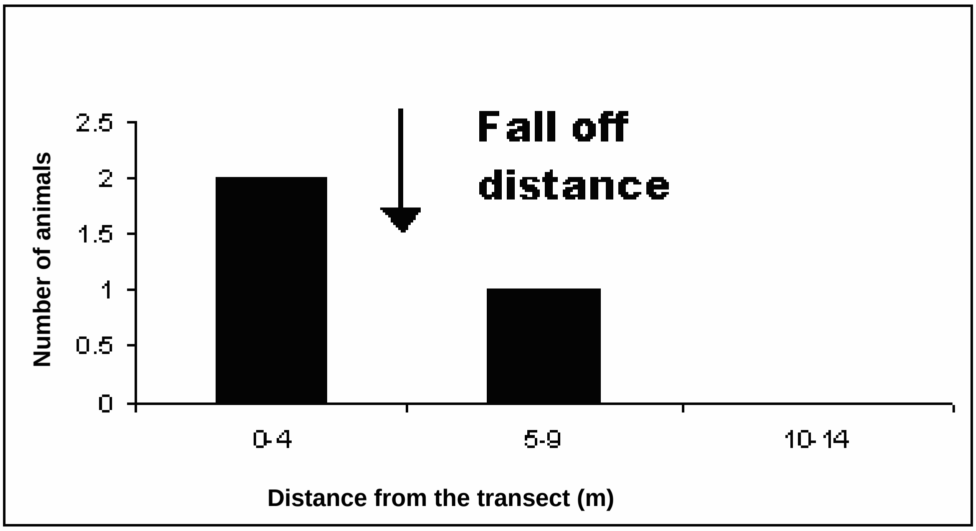


Figure15: Transect I Frequency Histogram

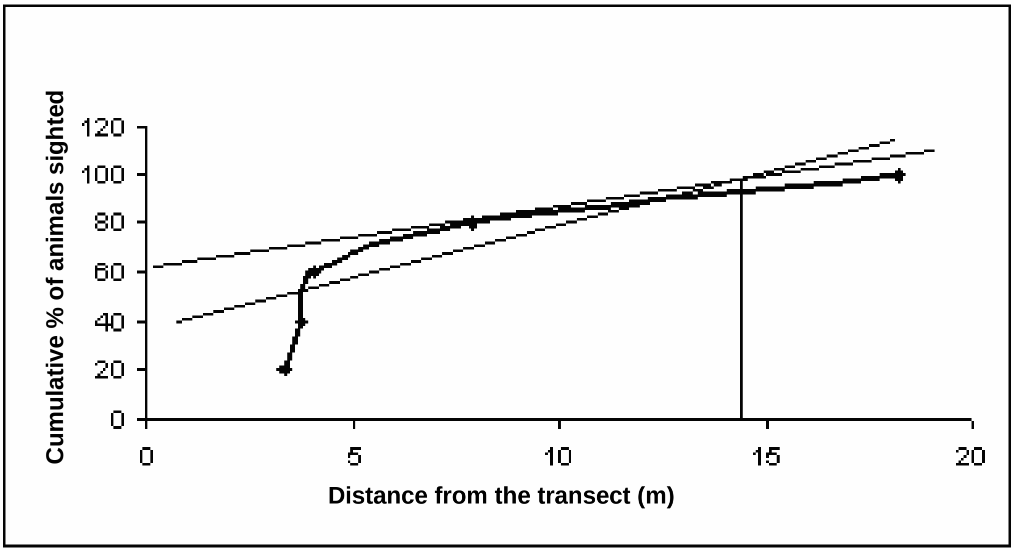


Figure16: Transect J Cumulative Percentage Graph

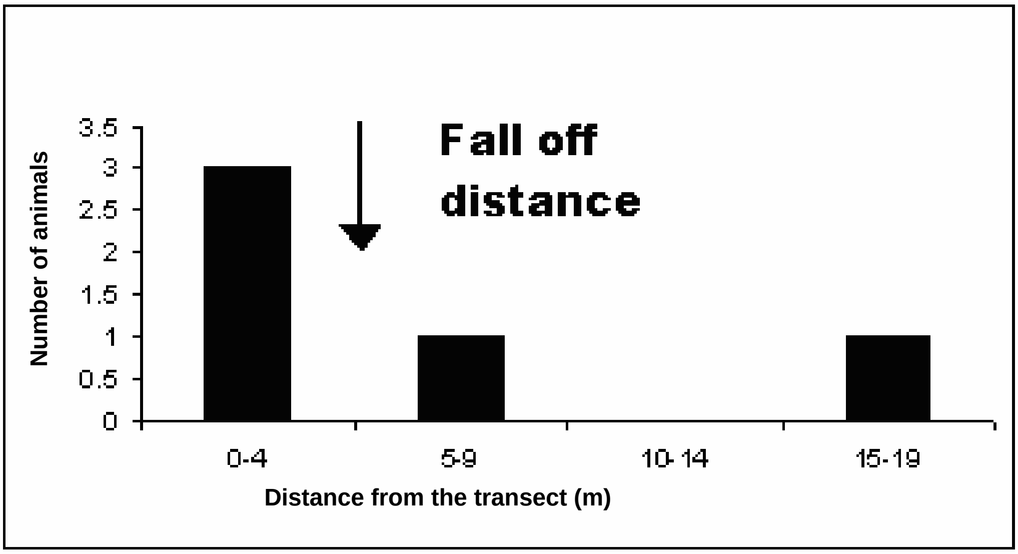


Figure17: Transect J Frequency Histogram

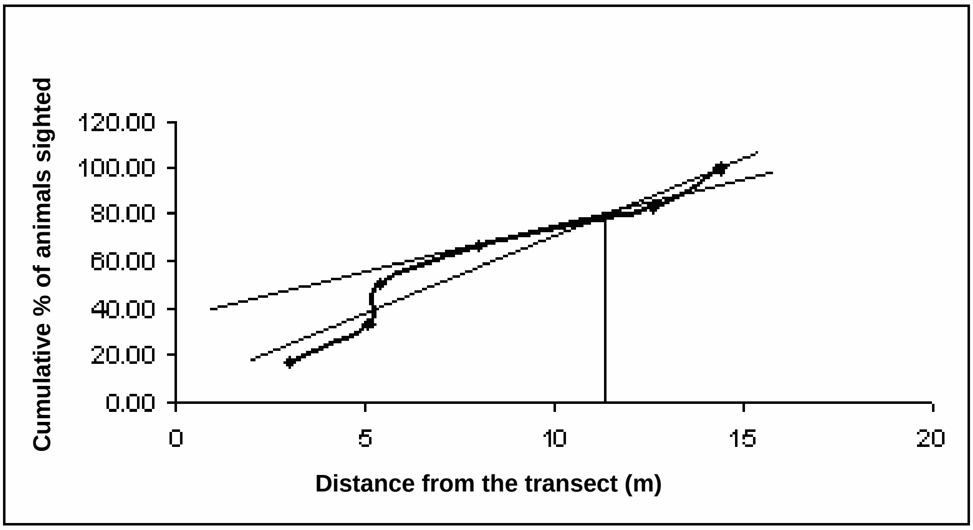


Figure18: Transect K Cumulative Percentage Graph

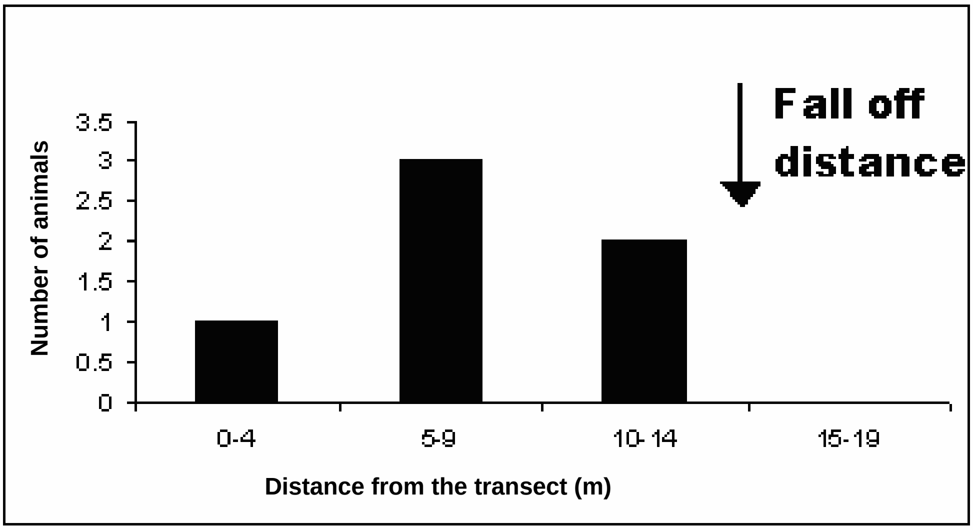


Figure19: Transect K Frequency Histogram

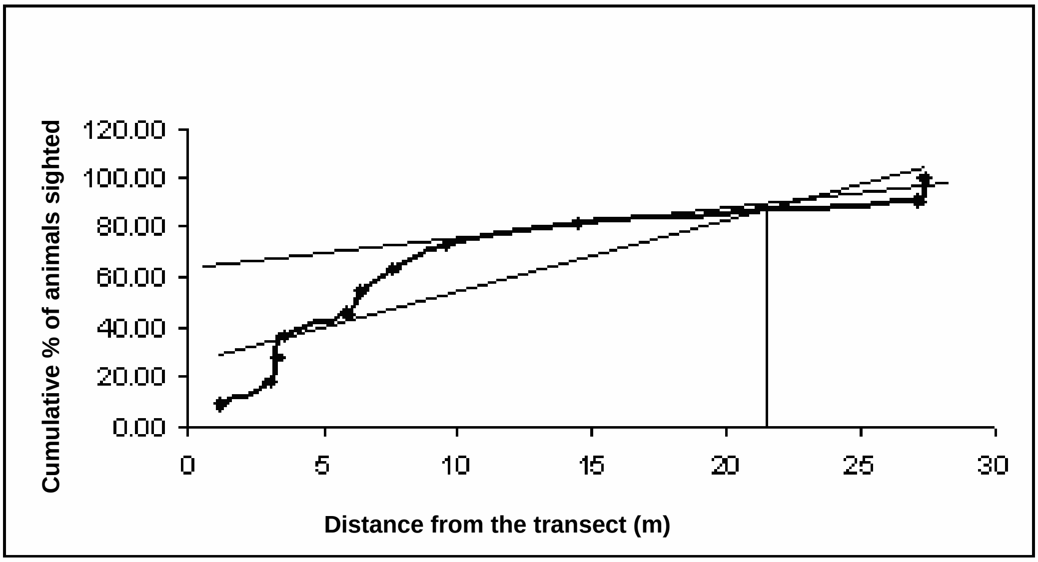


Figure20: Transect L Cumulative Percentage Graph

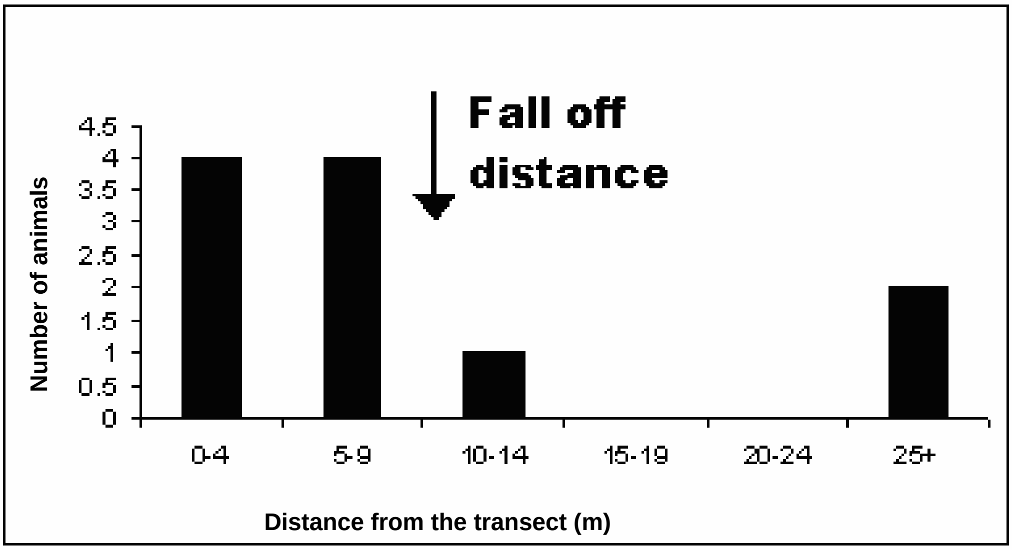


Figure21: Transect L Frequency Histogram

Figure22: Transect N Cumulative Percentage Graph

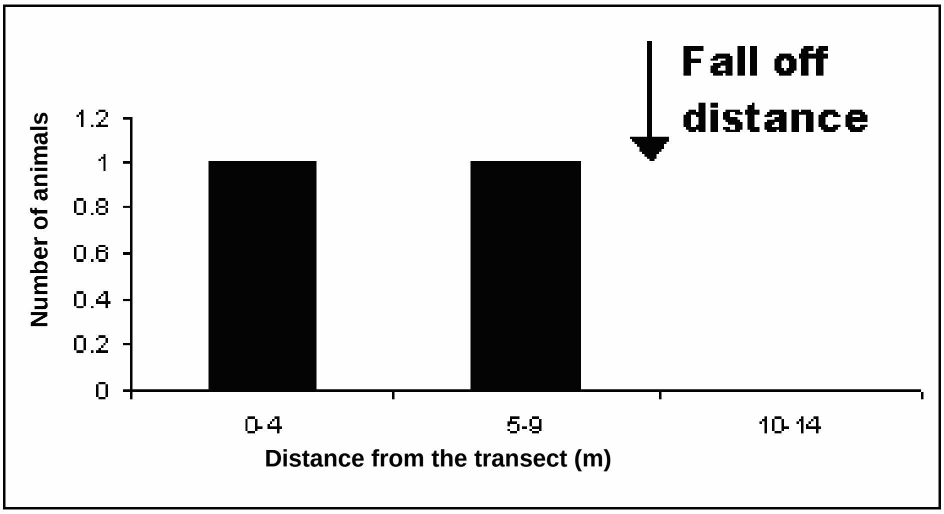


Figure23: Transect N Frequency Histogram

Figure24: Transect O Cumulative Percentage Graph

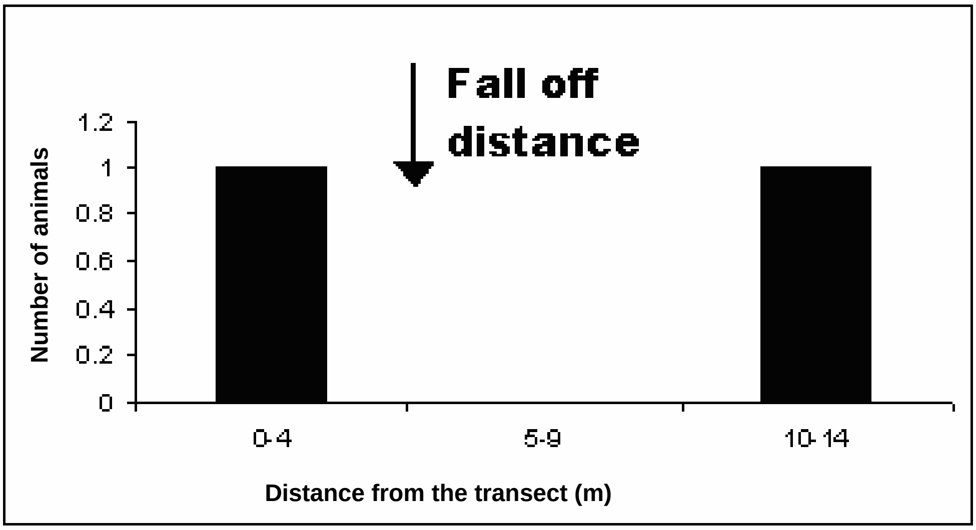


Figure25: Transect O Frequency Histogram

Table5: The effective sampling widths from the cumulative percentage graphs and the frequency histograms and the sampling widths for each transect.

Transect	Cummulative%(M)		Frequency Histogram(M)		Average(M)	
	Effective width	Sampling Width	Effective width	Sampling Width	Effective width	Sampling Width
A	4.4	8.8	5	10	9.40	18.80
B	14.5	29	20	40	34.50	69.00
C	13.5	27	10	20	23.50	47.00
D	12.5	25	5	10	17.50	35.00
E	3.9	7.8	5	10	8.90	17.80
G/H	28	56	5	10	33.00	66.00
I	6.4	12.8	5	10	11.40	22.80
J	14.5	29	5	10	19.50	39.00
K	11.5	23	15	30	26.50	53.00
L	21.5	43	10	20	31.50	63.00
N	7.2	14.4	10	20	17.20	34.40
O	11.8	23.6	5	10	16.80	33.60

The results of the Questionnaire are presented in the Tables 6, 7 and 8.

Table6: Number of replies to the question ‘How often do Hedgehogs’ visit your garden?’

How often do Hedgehogs’ visit your garden?	Number of replies
Every night	21
few times a week	15
few times a month	6
few times a year	32

Table7: Number of replies to the question ‘Which coloured Hedgehogs’ visity your garden?’

Which colour visits your garden?	Number of replies
Blonde	64
Intermediate	12
Brown	31

Table8: Number replies to the question ‘Do you feed the Hedgehogs’ that visit your garden?’

Do you feed Hedgehogs’ that visit your garden?	Number of replies
Yes	22
No	52

APPENDIX B

Table1: An example of the survey from that was completed every time a transect was walked.

TRANSECT LINE:			**DATE:**				
WEATHER:							
START TIME:			**END TIME:**			**START POINT:**	
ID NO.	WEIGHT	LENGTH	COLOUR	RECAP	FLEAS	P. DIST.	COORDS

Hedgehog Survey

My name is Becky Brown and I am a final year biology student at the University of Southampton. I need to conduct a third year project, which is very important for my studies and final mark. I am investigating the size of the Hedgehog population here on Alderney and how this population has changed since 1993 when a previous study was conducted. I will also be looking at how the proportion of blonde Hedgehogs' has changed over this time. I would really appreciate it if you could help me with my project by taking a few minutes to answer the following questions. Please return completed forms to the wildlife trust offices before the 29th of September 2008.

Delete as appropriate:

1.Do you have Hedgehogs' visiting your garden? Y / N

2. How often do they visit? Every night / A few times a week / A few times a month / A few times a year

3. How many Hedgehogs' do you usually see at one time?
…………………………

4. What colour are the Hedgehogs' that visit your garden? Blonde / Brown / Intermediate*

5. Approximately how many of each colour do you see per night?

6. Do you feed your Hedgehogs'? Y / N

7. If yes to question 6 what do you feed them?
………………………………………………

Please provide any additional information below:

*

Intermediate colour – In-between the brown and the blonde colourations.

Figure 1: The questionnaire that was distributed to every house on the island.

University of Southampton

School of Biological Sciences

Risk Assessment Form

Procedure	Walking line transects in the dark					
Assessor	Rebecca Brown	**Location**	Alderney		**Date**	1/09/08
Supervisor	Guy Poppy	**Review dates**	01/09/08	30/09/08		

List Hazards		***Control Measures***	***Level of Risk***
Name	***Hazard***	***e.g. GLP, Fume Hood***	***(Low/Medium/High)***
Dark related	Tripping/falling	Carry torches, watch where your going and take care when walking	Low
	Not being seen by vehicles whilst walking on the road	Wear reflective clothing and avoid walking on roads where possible	Medium
	Falling off bike whilst cycling in dark to transects	Use bike lights, wear helmets and reflective clothing	Medium
Weather related	Dangerous weather conditions	Check weather in advance and wear suitable clothing, do not survey in severe weather	Medium
Hedgehog related	Bites/scratches	Wear protective gloves when handling	Low
Airport related	Emergency planes landing	Keep vigilant whilst walking the transects	Medium

Medium/High Risks ***(other than GLP)***		***Persons identified as at risk***	***Additional Controls***
Name	Hazard		
Dark related	Walking on the roads	The surveyors	
	Cycling in the dark	The surveyors	
Weather related	Dangerous weather conditions	The surveyors	
Airport related	Emergency plane landing	The surveyors	