Nature Conservation and Plant Ecology Group

Thesis report

Habitat use of breeding and chick rearing redshanks (*Tringa totanus*) in the Westerlanderkoog, Noord-Holland

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Photo on front page of a male redshank by Jelger Herder,
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Abstract

The Netherlands is an important country for meadow birds because of its large area of wet grasslands, since the 1960's they undergo a marked decline. The run back of breeding success is seen as the main cause for the decline of Dutch meadow birds. This study examines spatial territory use of the redshank during the breeding season.

Redshanks spent most of their time within the near surroundings of their nest. About 50% of the observations of redshanks in the breeding phase were found within 40 m of the reference point and more than 80% of the observations within 70 m in this period. Over 50% of the observations in the chick phase were within 40 m and about 90% within 70 m. Birds tend to stay about 20-40 m from the nest in stead of closer to the nest. Most redshanks stayed in the near vicinity of their nesting area with their chicks. This area is thus not only preferred to breed but also to stay with the chicks.

Observations on the tidal mudflats indicate that redshanks may fly at least 1.5 km to forage on high quality food sources. They tend to do this more often in the breeding period then in the chick phase.

Home-range sizes were on average 0.56 ha large with the Minimum Convex Polygon method and 0.22 ha with the Concave Polygon method. Shape of home-ranges tented to be more oval than round. Overlapping of neighbouring home-ranges of redshanks occurred. On average 4.66 % of the home-ranges was overlapping between adjacent redshanks.

1. Introduction

1.1 Background

Many bird species, particularly waterfowl and waders, are associated with lowland wet grasslands in Europe. The Netherlands is an important country for waders because of its large area of wet grasslands. Most of these wet grasslands have been under agricultural management for centuries. For some wader species, they became their most important breeding place: over 80 % of the EU's black-tailed godwits nest in Dutch agricultural grasslands. For other meadow birds these percentages are somewhat lower: oystercatchers (50%), lapwings (27%) and redshanks (24%) (Groot and Van der Jeugd, 1994). Most of the breeding species have declined in numbers and ranges in the last 40 years as a consequence of increasing intensity of the agricultural management of these grasslands and especially in response to increases in fertilizer inputs and drainage regimes (Holloway, 1996; Beintema et al., 1997).

From 1975 onwards the Dutch government has applied various agri-environment schemes to stop the declines of meadow birds. The most widespread form of agri-environment scheme in The Netherlands, the management agreement, has existed since 1981 (Beintema et al., 1997). Although the measures themselves changed somewhat through time, most agreements focussed on the maintenance of wader bird populations and obliged farmers to postpone agricultural activities such as mowing to a set date in June or July, this to provide safe hatching of meadow bird's nests and increase chick survival (Beintema and Müskens, 1987; Schekkerman, 1997).

Site fidelity is common among waders (Thompson and Hale, 1989; Groen, 1993) and this fact has been used with the implementation of protection measurements. If birds have been unsuccessful with producing chicks, they commonly move their territory the next year. So if successful pairs breed close to last years nest site and unsuccessful breeders move further, you would assume that fields with management agreements, with high breeding success, would support higher densities then fields without management agreements. However, Kleijn et al. (2001) did not find higher breeding numbers of waders on fields with management agreements and concluded that management agreements are not effective in protecting (meadow) birds.

There is a need for a matrix of mowed and unmowed fields on landscape scale: swards

of different heights at landscape scale in the months May and June. The adjustment to landscape level, flexible application of this so called “mozaïekbeheer”, and development of a quality norm are interesting new elements in meadow bird conservation. From 2010 onward this mozaïekbeheer will be the norm. Meanwhile it has to become clear what requirements are needed to let this protection measurements become effective. Because previous studies in The Netherlands on meadow birds especially focussed on the nest and chick phase, little is known of the factors which define the choice to settle and breed at a location. This study is part of a larger study about the spatial scale at which agri-environment schemes are effective in protecting or restoring farmland biodiversity. During spring of 2004 two populations of meadow bird species, lapwing and redshank, were studied to determine territory size and use of these meadow birds and find the right spatial scale to implement the schemes. This study will examine spatial territory use of the redshank during the breeding season and aims to answer the following questions:

- *How do redshanks use their territory throughout the breeding season?*
- *Do redshanks make use of nearby high quality food sources?*
- *What are the characteristics of territories of redshanks?*

1.2 Redshank

1.2.1 Distribution of redshanks

The redshank (*Tringa totanus*) has an extensive Palaearctic distribution, breeding from Iceland to Eastern China, mainly in the temperate and boreal zones. In the western part of its range, it also breeds in the sub arctic and Mediterranean zones (Trolliet in Hagemeijer & Blair 1997). Its distribution centres are further south than those of similar species such as greenshank (*Tringa nebularia*), and spotted redshank (*Tringa erythropus*) but there are zones of sympatry. In Europe three subspecies occur: *Tringa totanus totanus* in Ireland to European Russia, *Tringa totanus robusta* in Iceland and Faeroes, and *Tringa totanus ussuriensis* from western to eastern Siberia (Beintema et al.1995).

Long-term trends in The Netherlands vary according to habitat. Grasslands and heath populations have declined strongly since the 1950s. Numbers breeding on salt marshes have increased. Overall, since the 1960s the population has declined by more then 50%, down to

24.000-36.000 breeding pairs by 1989-1991. The decline is attributed to drainage work and agricultural intensification, which has reduced the species habitat (Osieck and Hustings, 1994).

After the breeding season part of the Dutch population stays in the tidal zones of the Wadden Sea or Delta area in Zeeland, while others depart early to more southerly areas. A large part of Dutch redshanks winters along the coast of South-western Europe and Western Africa (Nijland, 2002).

1.2.2 Habitat

In the Netherlands redshanks have a clear preference for salty grasslands, even in the inland. Circumstances in salty grasslands apparently are very attractive for redshanks. Influencing factors could be the structure of the vegetation, penetration resistance of the soil and available food in the wet drains. For example around the Klaarkampermeer in Friesland Red Fescue (*Festuca rubra*) and Salt Marsh Rush (*Juncus gerardii*) provide a low soft, very fine structured grass cover, in which redshank prefer to make their nest (Beintema and Timmerman, 1976). On Schiermonnikoog (Van Dijk, 1979) redshanks tend to nest in tussocks of Sea Wormwood (*Seriphidium maritimum*) and in somewhat rough tussocks of grass in short vegetation. Few nests were found in extensive tall vegetation. On the German Baltic Sea coast, most redshanks breed in short grassed moist meadows with ditches (Stiefel and Scheufler, 1984). The sides of the ditches are often preferred to breed, because they are slightly higher then the surrounding area. Therefore they are dryer and the vegetation is denser. This provides redshanks better cover. Also the nest will stay dry longer with lasting rain.

Vegetation height and density are of more importance then plant/grass species (Larsson, 1976; Reitsma, 1989). Redshanks accept a wide variety of grazing pressure. A mowing experiment on an airfield in England showed that if the grass was longer than 10 cm the number of redshanks slightly increased (Brough and Bridgeman, 1980). However, although redshanks are well adapted to walking in tall grass, they prefer to breed in short grass meadows with various higher areas of taller grass. They avoid extended areas with tall grass.

1.2.3 Reproduction behaviour

Redshanks have explicitly high site fidelity, both male and female birds. Grosskopf (in Stiefel and Scheufler, 1984) found over two to seven years, almost without exception, territories were within 50 m of the territory of previous years. Besides being faithfull to their site, redshanks are also highly loyal to their partners.

The start of the laying of eggs is strongly affected by availability of food and temperature progress. However there is a great variety between birds. Microclimate and vegetation type are also important factors. Higher elevated spots dry up earlier and therefore have a taller sward with the start of breeding of redshanks.

In the beginning of the breeding season redshanks make so called play nests or fake nests. Eventually the eggs are laid in one of these nests. During the breeding period material from the surrounding vegetation is put in and around the nest. While on the nest, the bird uses its bill to pull accessible nesting material out of the soil or surrounding loose lying material into the nest to improve the nest. The materials consist of dry grasses and small leaves. Surrounding grasses are pulled over the nest in a hood-shape. The nests are hard to distinguish from the surrounding vegetation and therefore hard to find.

Grosskopf (1958) found that completing a clutch takes almost five days. Normally a clutch consists of four eggs, but sometimes the female stops with two or three eggs. It can occur that the eggs are laid in different nests, because the female is unknown with the real nest or because of disturbance.

Breeding starts after the fourth egg is laid or in the preceding night. Total breeding period is on average 24 days with variation between 22 and 36 days. Usually the eggs hatch at the same time. Depending on the weather, time of hatching and intensity of disturbances the chicks stay in the warm nest for 4 to 30 hours. They can live on their yoke stock for another 1.5 to 2.5 days. After that the parental birds tempt the chicks to go to better forage areas. Hale (1980) observed a pair of redshanks travelling 2 km with their one day old chicks. Normally one parental bird stays with the chicks while the other bird is on the outlook from a higher point. The chicks find their own food and decide the route to go, guarded by their parents. After three weeks the chicks are left alone for a few hours a day and soon the family bond is over. With 27 to 33 days the chicks are able to fly.

2. Methods

2.1 Area description

The study site was situated in the north of the province of Noord-Holland on the former island of Wieringen (figure 1). Wieringen is surrounded by the Wadden Sea (North), IJssel Lake (East), Amstel Lake (South-West) and the reclaimed land of the Wieringermeer (South). The formal island consists of mounts (remnants of glacial till) created by retreating ice sheets from the second last ice-age (Ten Cate, 1980). Between these mounts low-lying polders are present, the so-called *Kogen*. These polders consist of grasslands on clayey soils with the parcels separated by ditches. From the start three polders or kogen were selected for fieldwork: the Westerlanderkoog, the Oeversekoog and the Normerpolder. These three polders were selected because in these polders redshanks were present. Close to Quarantaine, colour-ringed redshanks were seen foraging at the Wadden Sea on a high water refuge. This place was used to do observations of foraging at a large distance.

Figure 1: Map of Wieringen and surroundings with the Westerlanderkoog (1), the Oeversekoog (2), the Normerpolder (3) and Quarantaine (4)

The first polder, the Westerlanderkoog, is on the southwest point of Wieringen. The Westerlanderkoog, south of Westerland, is a nature reserve for meadow birds and wintering geese. It has a specific management for this purpose and a controllable groundwater level. All parcels are surrounded by ditches and most of them have small drains. The whole polder consists of grasslands. In early spring a mixture of manure and straw was applied on most fields. A large number of meadow birds are breeding in the polder. Until the 20th of May, about 1500 brent geese (*Branta bernicla)* kept the grass short in most parts of the polder before leaving for their breeding grounds. Before that date only few areas with higher vegetation were present, that could be used by redshanks as suitable nesting places. After the brent geese left, grass started to grow fast and within a few weeks most vegetation was too high for good observations. However until then this polder was a good place to do observations. Because of the presence of a dike (surrounding a large part of the polder) and a road, the biggest part of the polder could be observed. Besides that, a large number of redshanks were present and most of the couples succeeded in hatching their eggs.

On the east side of Wieringen, south of Den Oever, the Oeversekoog is situated. It is a small polder, with most parcels having agri-environment schemes for meadow birds. A large part of the polder consists of grassland with only a few parcels for maize or potato. There were no geese here to keep the grass short, but on some parcels dairy cattle or sheep were present. Also some parcels were mowed which started in the beginning of May. There is a road crossing the polder and a small dike is present on the south-side protecting the polder from the (former) sea. These structures created good conditions to do observations. In contrast with the Westerlanderkoog only few redshanks were present here and little birds succeeded in hatching their eggs.

The Normerpolder on the northwest side of Wieringen is the polder that is closest to the Wadden Sea, with only a dike separating the two. Like the Oeversekoog, most parcels have agri-environment schemes for meadow birds and mowing practices started here a little later then in the Oeversekoog. A large number of redshanks were present and most birds succeeded in hatching their eggs. But a large part of the polder was difficult to observe.

The Wadden Sea, north of Wieringen, is well-known for its international importance for migratory and wintering birds. In this tidal system a lot of food is available for birds including redshanks. Close to a place called Quarantaine, on the northwest point of Wieringen, there is a high water refuge which does not flood during high tide, so birds can

keep foraging here in the shallow water and on the mudflats. At this place birds could be observed if they were foraging at the Wadden Sea (for observations of foraging at a large distance).

2.2 Field work

Fieldwork was carried out between beginning of April and half June. It was performed with the use of telescopes (20-60x magnification). The strategy was to note sightings of colour-ringed redshanks on detailed maps by writing down the code of their rings. During the breeding season a number of new birds were ringed. Because the danger of birds abandoning their nests, they were caught after halfway their breeding period. This means that there are no observations of these birds in the first half of their breeding period.

The sightings were carried out from hides, cars, roads or dikes. From these points the biggest part of the polders could be observed and birds could be followed, except if they happened to be on their nest, in tall vegetation, ditches or outside the polder. In the beginning of the fieldwork the polders could easily be overlooked due to short vegetation. However, few observations were made, because redshanks were very elusive. They tended to sleep or forage in or close to ditches. This made it difficult to read the code of their ring. They showed this shy behaviour all along the breeding period. After the eggs hatched, the behaviour of redshanks completely changed. Now they aggressively tried to protect their chicks and were aware of attackers, usually on the outlook from poles or fences. This behaviour made the fieldwork a lot easier and most observations were done during this period.

Another problem of the fieldwork was to find the nests. Redshank nests are well-hidden in the grass thus very hard to find. Trying to find all the clutches would mean a lot of disturbance, possibly resulting in abandonment of clutches. Therefore not all nests were found and exact location of the nests stayed unknown.

As the fieldwork proceeded, the decision was made to focus on the Westerlanderkoog. This was done because of the large numbers of redshanks present here and the good observation possibilities of the polder. The data of the Oeversekoog have been left out of the analyses, because there were very few redshanks present and they had little success in hatching their eggs. The data of the Normerpolder have been left out of the analyses because the vicinity of the Wadden Sea had a disturbing effect on the birds and the whole polder could

not be overlooked.

2.3 Data analyses

Before data analyses could be performed on the sightings, sightings were split into two categories: during breeding period and after breeding period (chick phase). The distance to the nest (if available) was calculated for all sightings. Also the distance to a central point of individuals was calculated. Central point means an average point of all the observation points of an individual redshank, thus a central point of the observations. This was done because exact nest location was only available for a part of the colour-ringed population. This way, observations of the other part of the dataset were useful too. After this calculation, distance classes were introduced. Distance classes of 5m, 10m and 20m were tried, but eventually the choice was made to use the 10m class distribution. The 10m class was the best estimate for the sightings, because the observations had to be plotted on a map and the scale of the maps did not allow doing this more accurately.

To get the best impression of reality, another application was implemented. A distribution for an "average" bird was created. The total number of observations per distance class was divided by the number of redshanks with one adjustment. Birds with a lot of sightings were given more weight to the average then birds with few sightings, this with the idea that more sightings reflect a better distribution of reality. This way an average line of where to expect an individual bird was created.

With the use of the sightings of individual birds, home-range sizes were calculated. A home-range is the area in the breeding site where the bird was observed. They are called home-ranges and not territories because it was not seen that the birds actively protected this area.

Two different methods have been used: the Minimum Convex Polygon (MCP) and the Concave Polygon (CP). The MCP-method is one of the first and simplest methods to calculate the size of a home-range (Mohr, 1947 in Harris, 1990). According to Harris (1990) it is the most frequently used method. This method connects the outer observations to create a convex polygon. The CP-method is different from the MCP-method because it tries to create the smallest possible polygon. This is done by connecting all sightings to create a concave polygon.

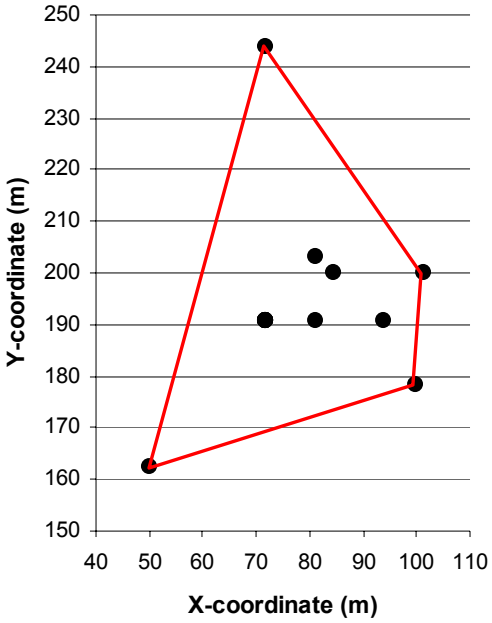

Figure 2: Home-range determination of bird C55 with the Minimum Convex Polygon method

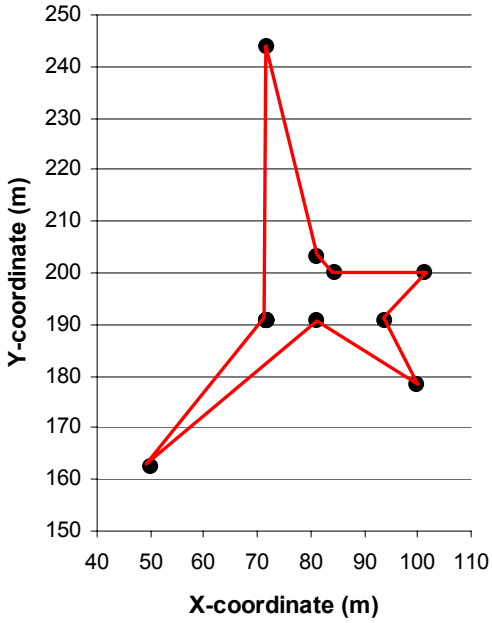

Figure 3: Home-range determination of bird C55 with the Concave Polygon method

The shape of the home-ranges was also checked. This was done to check whether home-ranges were round-shaped or not with the use of the following formula:

$$Shape\ Index = Circumference/2\sqrt{\pi} * \sqrt{Area}$$

If the outcome of the formula is one, the home-range is perfectly round. The higher the value is (the value can't be lower then one), the more irregular the shape. This was only done for the home-ranges with the MCP-method because home-ranges with the CP-method were very irregular and obviously not round.

To see if home-ranges of individual birds were overlapping, we determined the area of overlap for both methods. Besides the area of overlap, also the percentage of home-range what is overlapping was determined. It was calculated especially for neighbouring redshanks, except for paired redshanks, which were expected to have a large area of their home-range overlapping.

2.4 Statistics

Statistical analyses were performed on all data analyses. To determine statistical differences the programme SPSS 11.5 for Windows was used (SPSS-Inc). For the data analyses on the

distance classes of sightings first the standard error was determined. Additionally a post hoc test (Tukey's Honestly Significant Difference) was performed to evaluate differences among means of distance classes for the "average bird". With the use of a post hoc test, the interaction between these means was visualized easily. Classes that differed significantly from each other were put in different (sub) sets and distance classes which were related were put in the same (sub) sets.

Differences between the two methods for determining home-ranges were tested with the Mann-Whitney-U-test. It is a non-parametric test to compare differences between two series. For the shape of home-ranges a one-sample t-test was carried out to test the hypothesis if the shape was round, with the value 1. A one-sample t-test was also used to test the hypothesis whether overlap occurred; it occurred if the values were significantly different from zero (no overlap).

3. Results

3.1 Observations

A total of 22 individual redshanks, nesting in the Westerlanderkoog, were used for the following analyses. Some of these colour-ringed birds were paired. No distinguish has been made between male and female because most of the time it was hard to see the difference due to variation in plumage. Nest location was known of 14 redshanks. During the breeding period nine redshanks were caught on the nest, but only two of them were seen in the breeding period. Observations of 14 birds were used for analysis during the breeding phase and observations of 20 birds in the chick phase. Ten redshanks were observed on mudflats near Quarantaine.

3.1.1 Observations during breeding period

During the breeding period 72 observations were made of colour-ringed redshanks in their breeding area. This number is made up by seven redshanks with known nest location and seven birds with unknown nest location. Only two birds caught on the nest were seen in the breeding period. Because they were caught when eggs almost hatched, little time was left in the breeding period and this way few observations of these birds were done in this period.

For the observations the distance to the nest was calculated. Unfortunately only 31 observations were made of birds with a known nest location. The method used to include the 41 observations with unknown nest location was by introducing a central point of the observations of an individual redshank as a reference point in stead of nest. The distance between these two reference points is 29.7 ± 10.7m (n=7) and is significant different from zero (p=0.000, T-Test, test value = 0). However, to get a picture of the other observations and not leave this data unused, the central point method has been used for all 72 observations. Also for the 31 observations with known nest location the distance to the nest was calculated.

Distribution of both methods[1] is shown in figure 2. The distribution with the nest as a reference point method seems irregular, i.e. no smooth curve, because of the low number of observations. 48.4 % of the observations are within 40 m of the nest and 80.7 % is within 70 m. Distance class 20-30 m contains most observations.

Observations with a central point as a reference point are more evenly distributed. 50 % of the observations are within 40 m and 86.1% within 70 m. The distribution shows a peak

[1] Appendix A

of observations in distance classes of 20-30 and 30-40 m from the central point. Both methods show little observations close to the reference points and the number of observations is going down in classes further away. Class >100 m should be taken apart from the other classes because this class includes all observations more then 100 m away from the reference point, so this is not a 10 m interval.

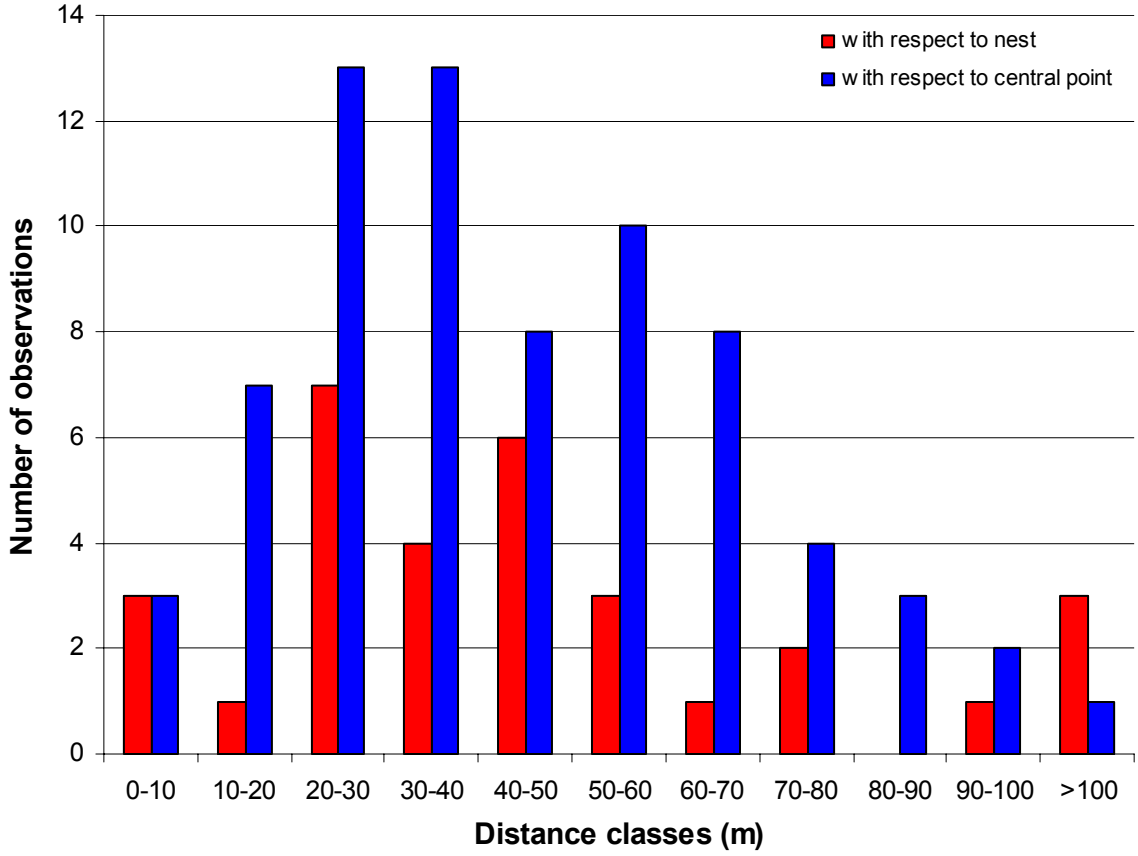

Figure 4: Distribution of observations over breeding classes of 10 m during the breeding period with respect to nest (N=31) and central point (N=72)

To see if distance classes are related to each other, a weighted line has been used. The use of a weighted line resembles the real situation better, because individual redshanks with more observations are given more weight to the total. This way an average line is created. In figure 3 weighed lines both with respect to nest location and central point, are shown.

The lines show that it is more likely that a redshank spends time in the middle distance classes then in distance classes near the nest or central point or distance classes further away.

However the line for observations with respect to nest location is not smooth at all. This could be explained by too little observations. More observations might give a more gradual line.

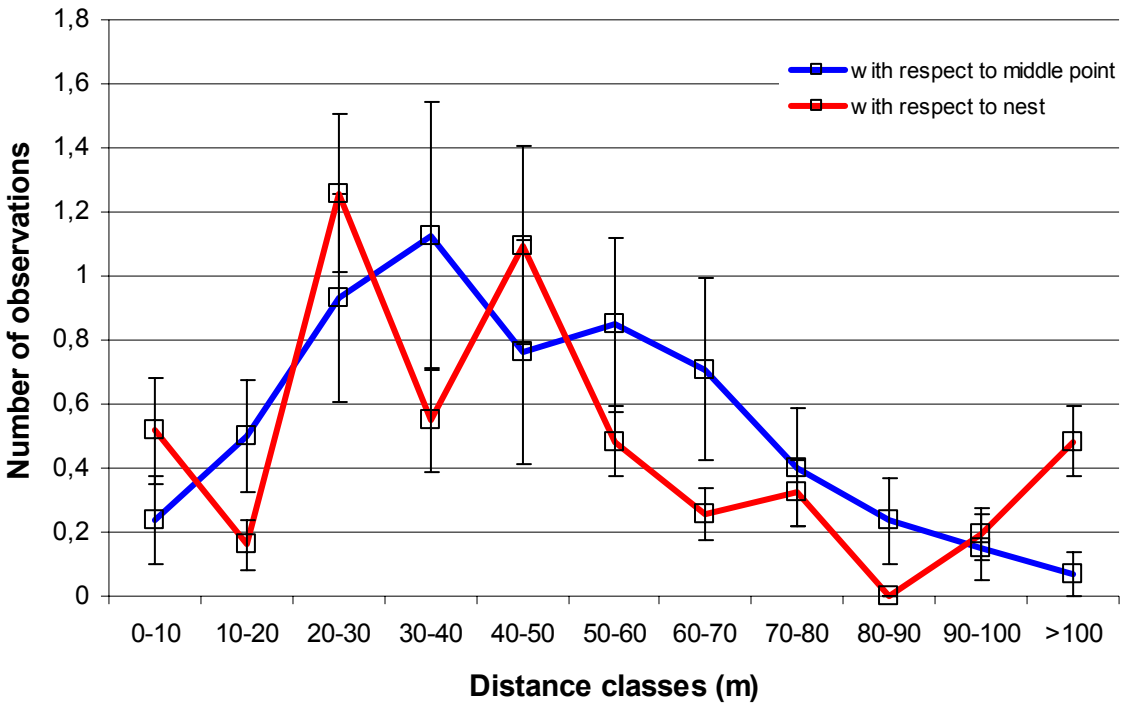

Figure 5: Distribution of average (weighed) observations (± standard error) during the breeding period with respect to nest location and central point

To find a relationship between distance classes, Tukey's-HSD (Honestly Significant Difference) test has been used. It calculates whether there are significant differences between classes. However no significant differences were found. Part of that is perhaps explained by the low number of observations.

3.1.2 Observations in chick phase

In total 272 observations of colour-ringed redshanks in their breeding area were done in the chick phase. Like with the observations of the breeding period, the difference between the central point and nest location methods was calculated. The two points are on average 30.14 ± 17.48m (n=12) apart and this difference is significant from zero (p=0.000, T-Test, test value = 0). Compared with the results during the breeding season there is little difference (i.e. 29.66 ±

10.65m), even though there are far more observations done in this period. This suggests that redshanks do not use their territory randomly and the nest is not in the centre of their territory.

A total of 195 observations[2] were done on 14 individual redshanks with known nest location. 56.4% of the observations were within 40 m from the nest and 89.2% within 70 m (figure 4). Of the 272 observations[3] with respect to the central point, 77.2% were within 40m of the central point and 91.5% within 70 m. 20 redshanks contributed to this number of observations.

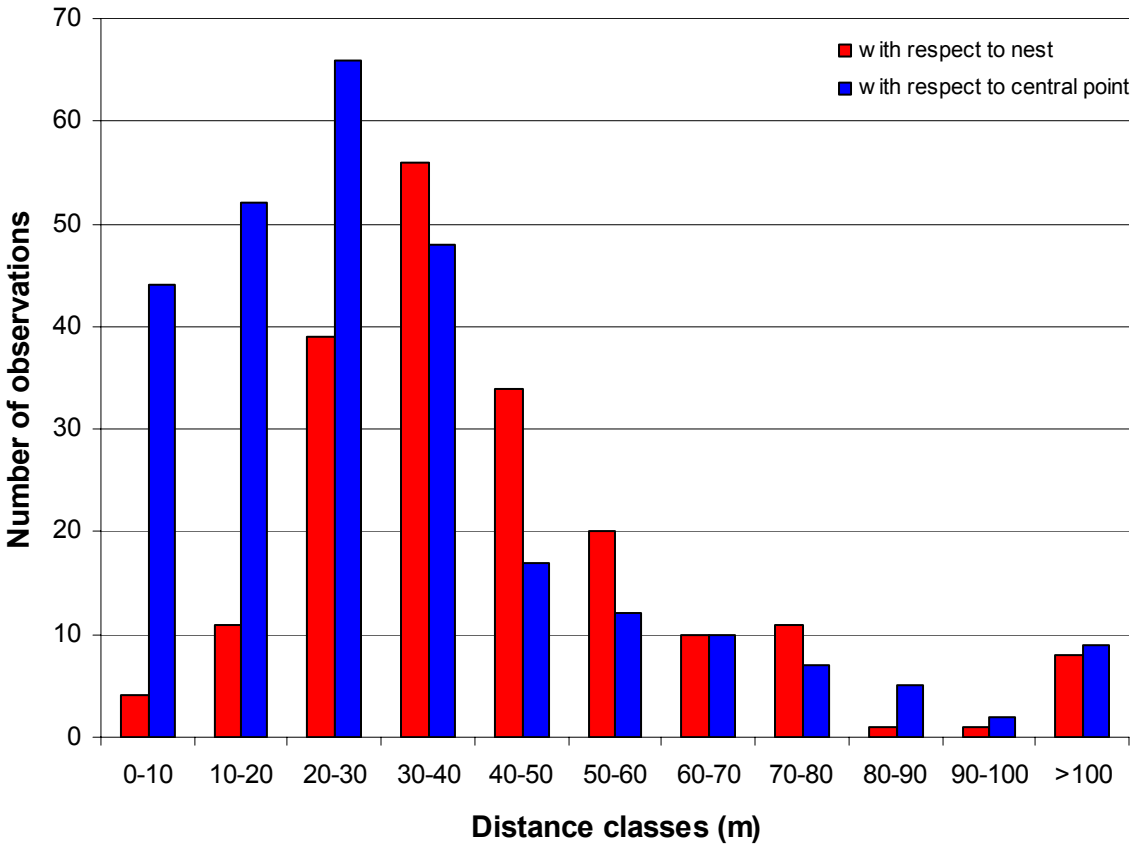

Figure 6: Distribution of observations over distance classes of 10 m in the chick phase with respect to nest (N=195) and central point N=272)

The distributions show a peak of observations in distance classes of 30-40 m for the nest method and 20-30 for the central point method. The method with respect to nest shows few observations near the nest, while the other method holds a lot of observations here. The number of observations is going down in classes further away for both methods. As explained

[2,3] Appendix B

above, class >100 m should be taken apart from the other classes because this class includes all observations more then 100 m away from the reference point, it is not a 10 m interval.

For the chick phase a weighed line has been introduced as well. In figure 5 the line is shown. The line shows that it is more likely that a redshank spends more time a little further away from the central point then in the nearest classes and the classes further away from the central point. This time significant differences were found (Tukey's Honestly Significant Difference). Two sets were created.

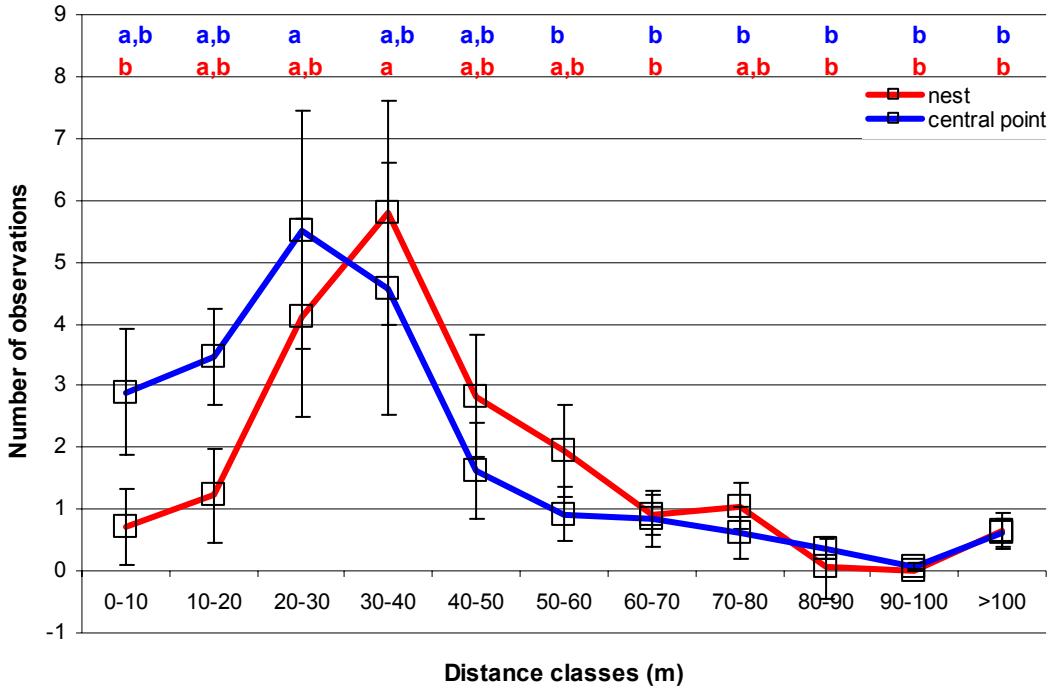

Figure 7: Distribution of average (weighed) observations (± standard error) in the chick phase with respect to nest location and central point

For the nest method, class 30-40 differs from class 0-10 m and most classes more than 60 m from the nest. For the central point method, class 20-30 differs from all classes above 50 m from the central point. It means that in this phase you expect to see a redshank in the classes in and around class 30-40 m, for the nest method. For the central point method this is in classes around class 20-30 m.

3.1.3 Observations at 'Het Wad' (Quarantaine)

On the mudflats near Quarantaine 10 birds were seen foraging, with 19 observations in total. One of these 19 observations was in the before-breeding phase, 13 observations in the breeding-phase, 3 observations in the chick-phase, and 2 observations of redshanks that failed hatching their eggs. Remarkable are the amount of observations of redshanks in the breeding period and in the after breeding period. On the mudflats most observations are in the breeding period with little observations in the chick phase, while most observations of the Westerlanderkoog are in the chick phase and little observations in the breeding period.

The fact that observations of redshanks were done at the mudflats indicates that redshanks may fly at least 1.5 km to forage at this high quality food source. Because of the difficulty of observing colour-ringed birds (short time and small place) it seems likely that these and other birds forage on the tidal flats more often.

3.2 Home-ranges

For the analyses on home-range sizes the data from all the colour-ringed redshanks were looked at. Only birds with more than ten observations in the chick phase were selected to use for analyses on home-ranges. This resulted in 11 individual redshanks. Observations then were plotted in a map.

3.2.1 Movements between nest and chick phase

At first thing checked was if birds stayed in the same area as the breeding area after the eggs hatched or that they moved with their chicks to another area. For seven birds this could be done, because they had observations in both the breeding and chick phase. Distribution of these observations is shown in figure 6. Six of the seven birds stayed in the same area as they had been nesting, one bird moved with its chicks about 200 m further.

Possible reason for this redshank to move could be that a group of about hundred greylag geese (*Anser anser)* were staying in its breeding area. The geese were very aggressive towards other animals and protective for their chicks and therefore it was safer for the redshank chicks to move. But still six other birds preferred to stay in their breeding area.

The other four birds with no observations in the breeding phase had a known nest location, so it was checked if they moved away from the area around the nest. But all four birds stayed close to the nest (not shown in figure).

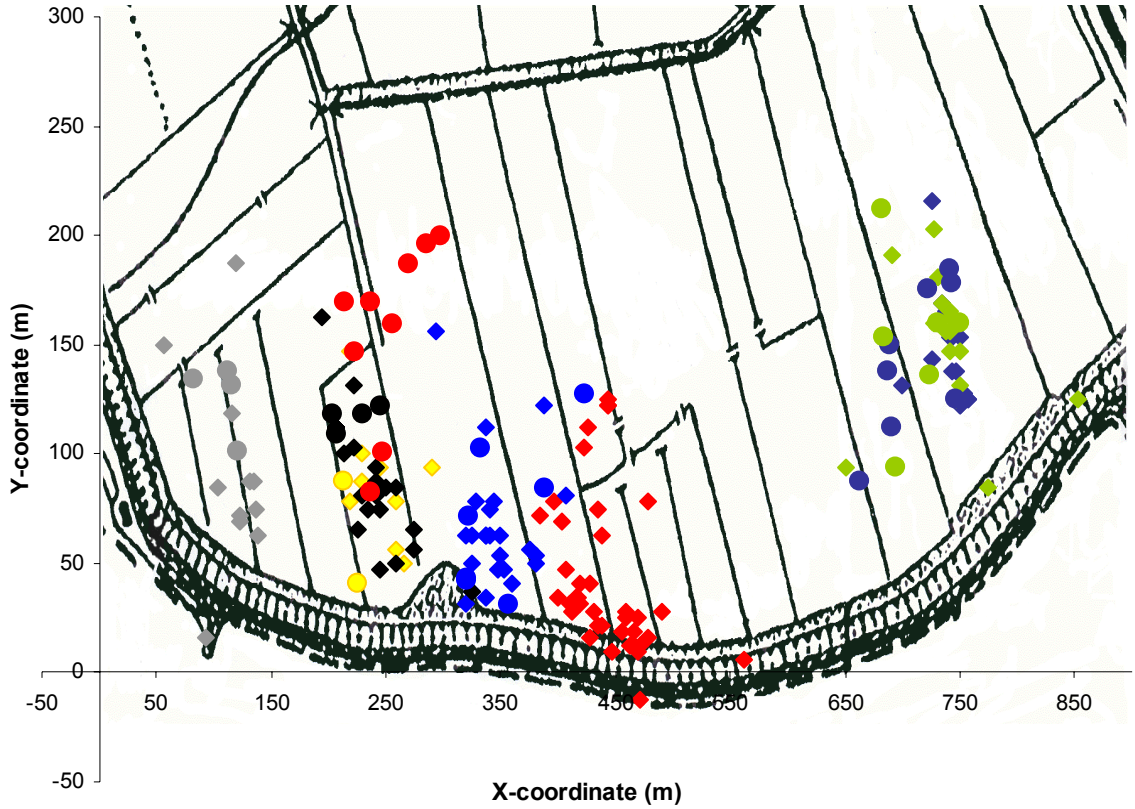

Figure 8: Spatial distribution of observations in the Westerlanderkoog during breeding period (circles) and chick phase (diamonds) of individual redshanks (different colours)

3.2.2 Home-range sizes

Home-range sizes[4] were calculated with two different methods. The first method was the Minimum Convex Polygon (MCP) and the second the Concave Polygon (CP). The home-range sizes with the MCP method were larger then the sizes with the CP method. Average size with the MCP method was 5626 ± 4018 m^2, while average size with the CP method was 2181 ± 1436 m^2.

[4] Appendix C

Table 2: Summary of home-range sizes, shape index and overlap

	MCP[1]	CP[2]
Home-range size (m^2) (N=11)	5626 ± 4018	2181 ± 1436
Shape Index (-) (N=11)	1.25 ± 0.13	-
Overlap (%) (N=24)	4.66 ± 6.73	0.47 ± 0.75

[1] Minimum Convex Polygon

[2] Concave Polygon

Results of the MCP method were 2.72 ± 1.06 times as big as the results of the CP method (table 2). The MCP method differs significantly from the CP method (Mann-Whitney-U: p=0.02, 2-tailed).

3.2.3 Home-range shape

When looking at the shape of the home-ranges, MCP home-ranges seem to be reflecting reality better then CP home-ranges. Average shape index value[5] for the 11 redshanks was 1.264 ± 0.127. To see if this systematically differs from 1 (i.e. perfectly circular), a One Sample T-test was used. This resulted in a significance of 0.000 and therefore home-ranges of individual redshanks are not round-shaped.

3.2.4 Overlap of home-ranges

Field observations indicated that redshanks did not enter a neighbouring home-range. However home-ranges of unpaired redshanks[6] coincided 4.66 ± 6.73 % with neighbouring home-ranges and this was significant from zero (T-Test; p=0.006 (2-Tailed)). This means that overlapping of home-ranges of adjacent redshanks occurs. A reason for this could be that the observations were done over a certain period and therefore the areas where redshanks stayed with their chicks could have shifted somewhat.

The hypothesis that paired redshanks would have a large part of their home-ranges overlapping was confirmed. Total percentage of overlap of paired redshanks with the MCP method was 60.7 ± 26.5 % and 39.8 ± 25.3 % with the CP method.

[5] Appendix C
[6] Appendix D

4. Discussion and conclusions

4.1 How do redshanks use their home-range throughout the breeding season?

The difference of about 30 meter between the two methods (i.e. nest and central point as a reference point) suggests that redshanks use their home-range not randomly or uniformly otherwise the central point would be near the nest location. Although the methods differed significantly, distribution patterns of observations over distance classes of 10 m are somewhat the same. Due to few observations in the breeding period, the distribution patterns in this period are irregular. About 50% of the observations were found within 40 m of the reference point (i.e. 48.4% for nest and 50.0% for central point) and more than 80% of all observations within 70 m (i.e. 80.7% for nest and 86.1% for central point).

Also in the chick period distribution of observations was done for the two methods. Enough observations for both methods resulted in smooth distributions patterns. Over 50% of the observations in this period were within 40 m (i.e. 56.4% to nest and 77.2% to central point) and about 90% within 70 m (i.e. 89.2% to nest and 91.5% to central point). The distribution of observations in both periods show that redshanks spent most time within the surroundings of their nest. With peaks in observations in 20-30 m and 30-40 m from the reference points, birds tend to be not immediately near the nest, but on a small distance from it. From the perspective of a redshank this seems logical, because you would not want to draw attention from predators while you are close to the nest.

Interesting is that families of redshanks stay in the same area as their breeding area. Only one pair of the redshanks we have been following moved about 200 m within one day, but they were probably chased away by greylag geese. The other redshanks all stayed in the near vicinity of their nesting area. So if there is no reason to move, they stay. This area is thus not only the preferred area to breed but also to stay and forage with the chicks.

No studies about territory use of redshanks have been done before, but studies on territory use of other wader species have been done. For lapwings (*Vanellus vanellus*) is known that females forage on average 170 m distance from their nest site in the week before laying, against on average 321 m in the week prior to this period (Blomqvist and Johansson, 1995); broods move 60-200 m (Redfern, 1982; Blomqvist and Johansson, 1995). Schekkerman and Müskens (2000) found all black-tailed godwit (*Limosa limosa)* broods

within 1.6 km, broods with chicks between 7 and 24 days old 50% within 250 m from their nesting site and 90% within 830 m.

Other studies on redshanks have been focusing on breeding site fidelity and reproduction success. Thompson and Hale (1989) found that redshanks were highly faithful to their natal area. Older, more experienced redshanks tended to pair with birds of similar breeding experience and generally nested early in the season (Thompson and Hale, 1991). We could not check for site fidelity but what we know from the ringing group we cooperated with was that more then 90 % of the colour-ringed redshanks seen in the previous year were seen this year. This was on Wieringen where their ringing activities concentrate.

4.2 Do redshanks make use of nearby high quality food sources?

Observations on the tidal mudflats indicate that redshanks fly at least 1.5 km to forage on high quality food sources. This means that if such a source is available in the area, redshanks make use of this and do not mind to cover this distance.

Most observations on the mudflats were done in the breeding period. A nearby high quality food source is especially of high importance for redshanks during the breeding period. Redshanks do not actively protect their nest against predators, but rely on the nest being well hidden and on the protection of other meadow birds breeding in the polder e.g. lapwings and black-tailed godwits. Therefore only one parent bird had to stay with the eggs. When the eggs hatched both parents were present to protect the chicks. Only two observations were done in this period on the mudflats.

4.3 What are the characteristics of home-ranges of redshanks?

Home-range sizes were on average 0.56 ha with the MCP method and 0.22 ha large with the CP method. Hale (1980) found the sizes of area defended by parental birds against potential predators 4-6 ha on rough moorland and 3-4 ha on salt marsh habitats. This is somewhat more then what we found for redshanks. But in our case we had a high density of redshanks (and other meadow birds) in the area. Lapwings, breeding in the same habitat as redshanks, were found to have territory sizes of 1.6 ha (Blomqvist and Johansson, 1995) and broods of lapwings 0.5-0.6 ha (Redfern, 1982). Lapwings are slightly bigger then redshanks and Hale (1980) stated that the defended area in case of larger birds is bigger.

Results from the shape index numbers indicate that the shapes of the home-ranges were irregular. The shapes of home-ranges tented to be more oval then round. However more observations might give slightly other results. Home-range borders will be less irregular and therefore shape index numbers lower (i.e. closer to one).

In the field it looked like that there was a border between home-ranges. However home-ranges were not bordered by parcels. Every family of redshanks seemed to have their own bordered area in the polder and these areas cross parcel boundaries. However from the spatial analyses this was not clear. Overlap of neighbouring home-ranges of redshanks occurred. On average 4.66 % of the home-range size was overlapping between adjacent redshanks. This number does not include paired redshanks, only unpaired birds. Possible cause for this was that observations were done over a range of time, so small movements of their area could have occurred. That way overlap of home-ranges can occur, because with the determination of the home-ranges movements through time have not been taken into account.

4.4 Final conclusions

In a nature reserve as the Westerlanderkoog, where a high number of meadow birds is present, redshanks adapt to a high density in breeding birds. As long as there is enough food for their chicks, they do not need a large area to move around in. The fact that some nests were found only 10 m apart from each other shows that redshanks do not mind to breed in high densities. Their nest does not have to be in the centre of their home-range and this makes it possible to breed close to each other.

Throughout the breeding season redshanks spent most of their time within the surroundings of their nest. Even in the chick rearing phase most redshank families stayed in the near vicinity of their nesting area. If possible this area is thus not only the preferred area to breed but also to stay with the chicks to forage. Apparently the Westerlanderkoog provided enough safety to rear their chicks and the polder provided parental and young birds enough food to stay in the same areas.

What does this all mean for implementation of protection measurements and at what spatial scale are agri-environment schemes effective in protecting redshanks? A matrix of swards of different heights at landscape scale, “mozaïekbeheer” does not seem to be of high importance, since most redshanks did well rearing chicks in the Westerlanderkoog. However this is a nature reserve for meadow birds and not normal farmland. Because redshanks rely

(partly) on the protection of other meadow birds it can indirectly be important. If lapwings or black-tailed godwits clearly benefit from this matrix of swards, redshanks can benefit from this as well.

Directly it is of high importance to have selected areas particularly good for meadow birds, where redshanks can stay throughout the breeding season. Because redshanks adapt well to high numbers in breeding birds, high densities seems no problem. A nearby high quality food source could be of importance as well, especially in the breeding period, because this way adult birds do not have to spent a lot of time for foraging. Protection measurements have to be applied on a larger scale than on parcel level, because home-ranges of redshanks were not bordered by parcels.

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Appendix A: Distribution of observations for individual redshanks in the breeding period

With respect to nest:

Code	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
A36	0	0	0	0	1	0	0	1	0	0	0
C23	0	0	0	0	0	1	0	0	0	0	1
C25	0	1	1	1	0	1	0	0	0	0	1
C40	1	0	2	0	1	1	1	1	0	0	1
C43	0	0	1	0	4	0	0	0	0	1	0
C58	2	0	0	2	0	0	0	0	0	0	0
C61	0	0	3	1	0	0	0	0	0	0	0
Total (N=31)	3	1	7	4	6	3	1	2	0	1	3

With respect to central point:

Code	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
A17	0	1	0	0	1	1	2	0	0	1	0
A36	0	0	2	0	0	0	0	0	0	0	0
A82	0	1	0	1	0	1	1	0	0	0	0
A85	0	0	0	0	1	2	0	0	0	1	1
C09	0	0	0	1	0	1	0	0	1	0	0
C19	1	1	0	3	0	2	1	1	0	0	0
C23	0	0	0	2	0	0	0	0	0	0	0
C25	0	1	2	0	0	1	0	1	0	0	0
C30	0	0	0	1	1	1	2	1	1	0	0
C40	0	0	2	2	2	1	0	1	0	0	0
C43	0	0	3	1	0	0	2	0	0	0	0
C46	0	0	1	2	3	0	0	0	1	0	0
C58	1	2	1	0	0	0	0	0	0	0	0
C61	1	1	2	0	0	0	0	0	0	0	0
Total (N=72)	3	7	13	13	8	10	8	4	3	2	1

Appendix B: Distribution of observations over distance classes of 10 m for individual redshanks in the chick phase

With respect to nest:

Code	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
A36	0	0	2	8	1	1	1	1	0	0	0
C23	0	0	1	8	1	0	0	0	1	0	0
C25	0	0	4	3	2	1	0	0	0	0	3
C40	0	0	3	3	3	3	3	2	0	0	0
C43	0	1	5	3	2	0	2	0	0	0	3
C55	0	0	3	2	12	0	0	2	0	0	0
C58	0	0	3	13	3	1	2	3	0	0	1
C61	0	0	1	1	2	4	1	1	0	0	1
C63	0	0	2	1	4	3	1	1	0	0	0
C65	0	3	1	5	2	1	0	1	0	0	0
C69	4	5	11	9	0	5	0	0	0	0	0
C81	0	2	1	0	1	1	0	0	0	0	0
Total (N=191)	4	11	37	56	33	20	10	11	1	0	8

With respect to central point:

Code	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
A17	1	0	0	0	0	0	0	0	0	0	0
A36	2	1	7	1	0	3	1	0	0	0	0
A82	0	0	0	2	0	0	0	0	0	0	0
A85	1	0	0	0	0	0	0	0	0	0	0
C19	0	3	9	10	5	3	3	3	1	0	1
C23	7	0	1	1	0	1	1	0	0	0	0
C25	0	1	2	3	0	1	2	1	1	0	2
C36	2	1	3	0	0	0	0	0	1	1	2
C40	3	6	6	0	1	0	0	1	0	0	0
C43	3	5	2	1	0	1	1	1	0	0	2
C46	4	4	6	5	2	0	2	0	0	0	1

With respect to central point: (continued)

Code	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100
C55	12	3	2	0	1	1	0	0	0	0	0
C58	2	5	4	8	4	1	0	0	1	0	1
C61	0	3	4	1	0	0	0	1	1	1	0
C63	1	7	3	0	1	0	0	0	0	0	0
C65	0	7	3	2	1	0	0	0	0	0	0
C69	5	3	13	12	1	0	0	0	0	0	0
C78	0	1	0	2	0	0	0	0	0	0	0
C81	0	2	1	0	1	1	0	0	0	0	0
C84	1	0	0	0	0	0	0	0	0	0	0
Total (N=272)	44	52	66	48	17	12	10	7	5	2	9

Appendix 3: Home-range sizes and shape indexes of individual redshanks

Code	MCP[1] (m^2)	CP[2] (m^2)	Shape Index (-)
A36	4272	1972	1.157
C19	11696	4324	1.216
C40	2736	598	1.327
C43	12812	2656	1.259
C46	8549	4412	1.141
C55	2194	672	1.277
C58	4794	2674	1.585
C61	8044	3460	1.271
C63	1397	646	1.208
C65	2045	982	1.210
C69	3352	1601	1.124
Average(N=11)	5626 ± 4018	2181 ± 1436	1.25 ± 0.13

[1] Minimum Convex Polygon

[2] Concave Polygon

Appendix 4: Overlap of home-ranges of individual redshanks

Code	Overlapping with	% of MCP[1]	% of MP[2]
A36	C46	0	0
”	C65	0	0
”	C69	7.21	0.20
C19	C46	2.24	0.19
C46	A36	0	0
”	C19	3.06	0.18
”	C58	0.75	0.36
C55	C61	0	0
C58	C46	1.34	0.60
”	C65	0	0
”	C69	6.55	0.97
C61	C55	0	0
”	C63	4.35	0
”	C65	2.04	0.69
”	C69	0	0
C63	C61	25.05	0
C65	A36	0	0
”	C58	0	0
”	C61	8.02	2.44
”	C69	20.29	2.34
C69	A36	9.19	0.25
”	C58	9.37	1.62
”	C61	0	0
”	C65	12.38	1.44
Average(N=24)		4.66 ± 6.73	0.47 ± 0.75

[1] Minimum Convex Polygon

[2] Concave Polygon