Wadden Sea saltmarshes: Ecological trap or hideaway for breeding Redshanks *Tringa totanus*?

STEFAN THYEN & KLAUS-MICHAEL EXO

Institut für Vogelforschung "Vogelwarte Helgoland", An der Vogelwarte 21, 26386 Wilhelmshaven, Germany, e-mail: stefan.thyen@ifv.terramare.de

Thyen, S. & Exo, K.-M. 2003. Wadden Sea saltmarshes: Ecological trap or hideaway for breeding Redshanks *Tringa totanus*? *Wader Study Group Bull.* 100: 43–46.

In contrast to Redshank populations at most other breeding sites in NW and central Europe, the Wadden Sea population is stable on a relatively high level. Nevertheless, Redshank breeding success in Wadden Sea saltmarshes is apparently insufficient, at least on a short-term and spatially restricted basis, to maintain the saltmarsh population. To determine the reason for this inconsistency, a project on the reproduction and population biology of Redshank breeding in the Wadden Sea saltmarshes was initiated in 2000. At Petersgroden, western Jadebusen, Germany, the effects of vegetational nest-site characteristics on hatching success and predation were studied in 2000 and 2001. Mean hatching success (10.6 % of clutches) was very low due to high clutch predation (mean daily predation rate: 7.4 % of clutches) probably by mammalian as well as avian predators. Redshank hatching success was higher at sites dominated by plant species characteristic of upper saltmarsh (*Elymus repens, Festuca rubra*), at sites with high vertical coverage of vegetation and at well-concealed nest-sites. Overall, hatching success was lower than that apparently required to maintain current population size. Besides themes for future research, recommendations on saltmarsh management and an integrated monitoring of coastal bird populations are derived from the presented results.

INTRODUCTION

The NW and central European Redshank breeding population has declined dramatically in recent decades, mainly the result of habitat loss and agricultural intensification at inland breeding sites (Tucker & Heath 1994, Bauer & Berthold 1996). For example, the inland population of NW Germany declined by about 35% between 1987 and 1997 (Melter & Welz 2001). Redshank declines have also been reported for saltmarsh habitats in Great Britain (Brindley *et al.* 1998). In contrast, the Wadden Sea breeding population is still stable on a comparatively high level and currently holds approx. 25% of the NW European Redshank population (*T. t. totanus*; Rasmussen *et al.* 2000). The status quo of the population on a biogeographic level is thus characterised by divergent population trends in different parts of the breeding range resulting in an increasing significance of the Wadden Sea population. In contrast, Thyen (1997, 2000) found evidence that the significance of Wadden Sea habitats for Redshank had potentially been overestimated, at least on a regional and short-term scale. Hatching success was very low suggesting that saltmarsh habitats are more likely to be population "sinks" rather than "sources". These apparently inconsistent phenomena of stable populations and low hatching success unfortunately did not lead to more detailed studies of Redshank reproduction and population dynamics. There are several studies on distribution and habitat selection in Redshank, often revealing a higher abundance of pairs in *Elymus*- and other upper saltmarsh plant communities compared to those of lower saltmarshes (Stiefel & Scheufler 1984, Thyen 1996, Norris *et al.* 1997, 1998, Thyen 2000, Esselink 2000). However, reproduction and fitness consequences of habitat and nest-site selection are as yet poorly understood (but see, e.g., Großkopf 1958, Thompson & Hale 1991, Thyen 1997, 2000). This has implications not only for understanding the population dynamics of Redshank, but also for planning and performing conservation management (Perrins *et al.* 1991, Tucker & Heath 1994, Thyen *et al.* 1998, Thyen 2000, Jones 2001).

Since 2000, Redshank reproduction and population biology has been investigated in the saltmarshes of the western Jadebusen, Germany. In this area, the Redshank breeding population has been stable since at least 1990 and the current population is among the highest in the Wadden Sea (Rasmussen *et al.* 2000, Thyen & Exo 2001). In view of the apparent inconsistency between the strength of the population and its low productivity, the main object of this study was to investigate variation in hatching success and predation of Redshank clutches in relation to vegetation and nest concealment, start of incubation and adult quality and behaviour. Some of the results are presented in this paper.

STUDY AREA AND METHODS

The study area (50 ha) is located at Petersgroden (53°26'N, 8°05'E), western Jadebusen, Germany. Searching and marking of clutches and regular nest inspections were carried out according to Thyen *et al.* (1998). For each nest site, the composition and vertical coverage of the surrounding vegetation was recorded (Oppermann 1989, Thyen 1997). Concealment of nests was ascertained by measuring luminous intensity within and 1 m above the nest. From these measurements, a "nest concealment index" was derived, defined as luminous intensity within nest as a percentage of that measured 1 m

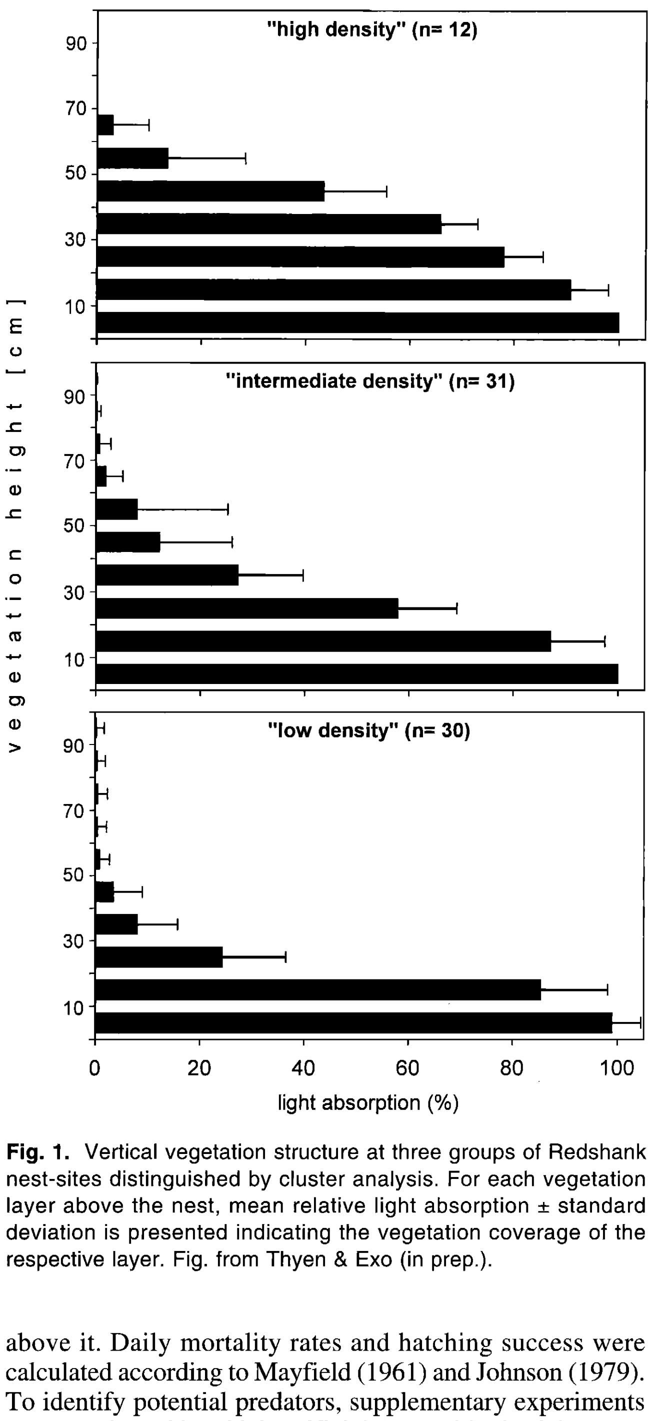

Fig. 1. Vertical vegetation structure at three groups of Redshank nest-sites distinguished by cluster analysis. For each vegetation layer above the nest, mean relative light absorption ± standard deviation is presented indicating the vegetation coverage of the respective layer. Fig. from Thyen & Exo (in prep.).

above it. Daily mortality rates and hatching success were calculated according to Mayfield (1961) and Johnson (1979). To identify potential predators, supplementary experiments were conducted in which artificial nests with plasticine eggs were monitored (Thyen & Exo in press).

RESULTS

Nest-site characteristics

41 out of 90 Redshank nest-sites studied (46%) were dominated by *Elymus repens*, 28 (31%) by *Festuca rubra* and 13 (14%) by *Puccinellia maritima*. The vegetation at the remaining nest-sites (9%) was dominated by *Plantago maritima*, *Triglochin maritimum*, *Aster tripolium* or *Elymus athericus*. By means of a cluster analysis (Ward method), three groups of significantly different vegetation structure could be distinguished (discriminant analysis, both functions $p<0.001$) (Fig. 1). Similarly, cluster analysis showed that 65 of 69 measured nests (95%) could be characterised as "well concealed" or "poorly concealed" ($p<0.001$) (Fig. 2).

Variation in hatching success

In 2000 and 2001, hatching success of Redshanks was low due to high clutch predation (Table 1). As revealed by artificial eggs, potential predators were mustelids (*Mustela* sp.; 26 % of artificial eggs), rodents (*Microtus/Apodemus* sp., *Rattus norvegicus*; 34 %) and Carrion Crows (*Corvus corone corone*; 34 %). On average, about 10 % of clutches produced chicks. However, clutch mortality, clutch predation and hatching success varied among nests with different vegetational characteristics. Mortality and predation rates were comparatively low at nest-sites dominated by *E. repens* or *F. rubra*, at sites with relatively high vertical coverage and at sites with well-concealed nests (Table 1).

DISCUSSION

British and central European saltmarshes are assumed to be high-quality habitats for breeding Redshank *Tringa totanus totanus* supporting superproportional shares of national populations (Brindley *et al.* 1998, Rasmussen *et al.* 2000). In the 1990's, Redshanks bred at densities of 0.5–40 pairs per 10 ha in the Wadden Sea saltmarshes (examples in Thyen 1996, Thyen 1997, Hälterlein 1998, Thyen 2000, Esselink 2000), whereas inland densities where less than a tenth as high (examples in Melter & Schreiber 2000, Nehls 2001). This difference can be explained mainly by landscape characteristics, the food supply available on the tidal mudflats and the effective conservation of the Wadden Sea. Therefore Wadden Sea saltmarshes appear to be highly attractive breeding habitats for Redshanks. However, little is known of their quality in terms of the fitness consequences of selecting saltmarsh habitats. Several studies show that breeding density does not always reflect habitat quality in terms of reproductive output due to mal-assessment of habitats by selecting birds, non-random distribution caused by the activity of predators, etc. (e.g. Galbraith 1989, Berg *et al.* 1992, Székely 1992, Exo *et al.* 1996, Thyen *et al.* 1998, Newton 1998, Misenhelter & Rotenberry 2000, Kokko & Sutherland 2001, Jones 2001, Tryjanowski *et al.* 2002).

The saltmarshes at Petersgroden support a stable Redshank population with a current breeding density of about 2 pairs/ha. They would therefore appear to be among the most attractive breeding sites of the Wadden Sea (Thyen & Exo 2001). However, assuming that a minimum breeding success of 0.7–1.0 fledglings/pair is required to maintain current population size (Boer 1995), pre-fledging mortality is 50%, as estimated by Großkopf (1959), and clutch size is 4 eggs, the minimum annual hatching success needed to maintain a stable population would be 35–50%. Therefore it appears that, as a result of high predation, Redshank hatching and breeding success in 2000/2001 was too low to maintain current population size on a long-term basis. Consequently the study area is probably a sink habitat where the population is maintained by immigration rather than by reproduction and recruitment. Nevertheless, it would seem unlikely that breeding in attractive saltmarshes under high predation pressure is some kind of "ecological trap".

Reproduction rates of saltmarsh-breeding Redshanks depend on seasonal and successive development of vegetation. Pairs breeding in well-structured and well-concealed nest-

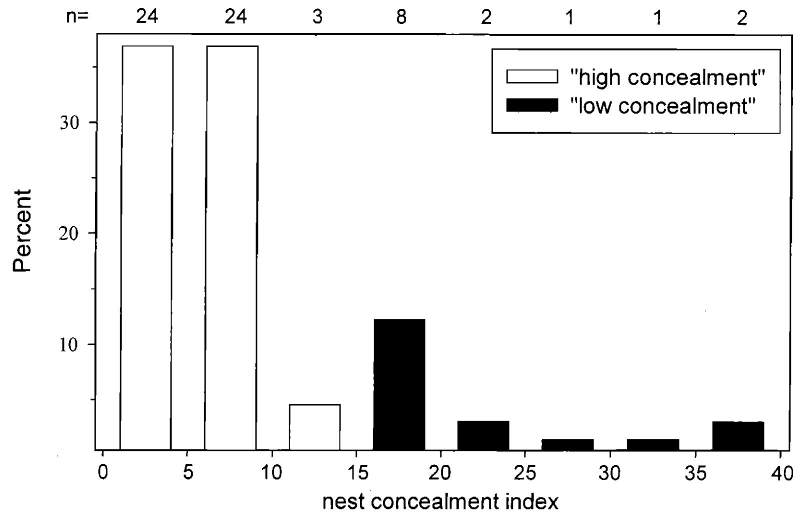

Fig. 2. Percent frequency distribution of Redshank nests with different degrees of concealment, discriminated by cluster analysis. Nests not classified by the analysis are not considered. Fig. from Thyen & Exo (in prep).

sites covered by vegetation of upper saltmarshes (*Elymus repens, Festuca rubra*) incubate more successfully than those that select other sites. Moreover, Thyen & Exo (in prep.) demonstrate a strong relationship between early breeding and successful incubation and conclude that successful reproduction of Redshanks in a predator-rich environment is based on the interaction between timing of breeding and the supply of concealed nest-sites. From these findings, several questions arise for future research and there are important implications for the management and conservation of saltmarshes if they really are such a poor breeding area for Redshank in the long-term.

In terms of research, the priority should be individual-based studies of the behavioural mechanisms that promote successful breeding under high predation pressure. It is also important to establish which habitats are "sinks" and which are "sources" of Redshank population. This will require the investigation of long-term temporal and spatial variability in reproduction as well as of recruitment and migration between breeding sites.

As discussed, for example, by Thyen (1996, 1997, 2000), managing saltmarshes by mowing or cattle-grazing, even at a relatively low level, should be detrimental to Redshank abundance as well as to reproductive success (but see Norris *et al.* 1997, 1998). As confirmed by the results presented here, Redshank hatching success should be higher in saltmarshes that are relatively undisturbed by man or grazing animals and support vegetation that has a structure that offers good concealment. Factors affecting seasonal and successional development of saltmarshes, such as agricultural usage (Bakker 1985, 1990, Thyen 1996), clay removal (Flemming 2001) or sea-level rise (Wijnen & Bakker 2001, Simas *et al.* 2001), are likely to impair Redshank reproduction, at least at sites with high predation pressure. Additionally, the need for implementing "Monitoring Breeding Success of Coastal Birds" within the "Trilateral Monitoring and Assessment Program" (Exo *et al.* 1996, Thyen *et al.* 1998) is confirmed by these results. A low rate of reproduction in apparently stable coastal bird populations, though surprising,

Table 1. Mortality and hatching success of Redshank clutches in 2000 and 2001 in relation to vegetation variables. Data from both breeding seasons were pooled for analyses. N = number of nests, DMR = daily mortality rate of nests including all causes of nest failure, DPR = daily predation rate of nests including exclusively depredated nests, HS = hatching success, SE = standard error. For classification of grouping variables see text and Figs. 1 and 2. Modified table from Thyen & Exo (in prep.).

Group	N_{total}	N_{failed}	DMR (%) ± SE	DPR (%) ± SE	HS (%)
Total	83	71	8.9 ± 1.0	7.4 ± 0.9	10.6
Dominant plant species at nest-site					
Puccinellia maritima	13	12	12.9 ± 3.5	10.8 ± 3.2	3.6
Festuca rubra	25	22	8.5 ± 1.7	6.6 ± 1.5	11.8
Elymus repens	37	29	7.0 ± 1.3	6.1 ± 1.2	17.4
other species	8	8	25.0 ± 7.7	21.9 ± 7.3	0.1
Vegetation coverage					
high	10	8	6.9 ± 2.4	6.0 ± 2.2	18.0
intermediate	29	25	9.7 ± 1.8	7.8 ± 1.7	8.7
low	29	26	10.3 ± 1.9	8.7 ± 1.8	7.4
Nest concealment					
high	49	41	9.2 ± 1.4	7.6 ± 1.3	9.8
low	12	12	14.5 ± 3.9	13.3 ± 3.7	2.4

might be more widespread, especially in habitats that are affected by varying amounts of human-induced interference, such as grazing. It is important to recognise these phenomena and to react with suitable counter-measures before populations decline. This requires an integrated approach to the population monitoring of coastal birds and their reproduction as well as the regular assessment of important demographic parameters, such as adult mortality, emigration and immigration. Within such a programme, the Redshank could be a very useful indicator of the effects of ecological changes in saltmarsh habitats on coastal bird populations.

ACKNOWLEDGEMENTS

The project was partially financed by the III. Oldenburgischer Deichband, Jever. The Nationalparkverwaltung "Niedersächsisches Wattenmeer", Wilhelmshaven, grants all authorisations needed to work in the saltmarshes of the national park. Field work was supported by B. Junge, K. Lehn, J. Leyrer, R. Nagel, M. Sass and S. Wenzel. F. Bairlein, J. Leyrer, H. Sitters and J. Smart gave useful comments on earlier drafts of the manuscript. Thanks to all institutions and persons involved!

REFERENCES

Bakker, J.P. 1985. The impact of grazing on plant communities, plant populations and soil conditions on salt marshes. *Vegetatio* 62: 391–398.

Bakker, J.P. 1990. Effects of grazing and hay-making on Waddensea saltmarshes. In: C.H. Ovesen (ed.) *Saltmarsh management in the Wadden Sea region*: 51–65. Denmark.

Bauer, H.-G. & Berthold, P. 1996. Die Brutvögel Mitteleuropas – Bestand und Gefährdung. Aula-Verlag, Wiesbaden.

Berg, A., Lindberg, T. & Gunnar, K. 1992. Hatching success of lapwings on farmland: differences between habitat and colonies of different sizes. *Journal of Animal Ecology* 61: 469–476.

Boer, T.E. den 1995. Weidevogels: feiten voor bescherming. *Technische Rapporten Vogelbescherming* 16. Vogelbescherming Nederland, Zeist.

Brindley, E., Cook, T., Babbs, S., Brown, C.F., Massey, P., Thompson, R. & Yaxley, R. 1998. The abundance and conservation status of redshank *Tringa totanus* nesting on saltmarshes in Great Britain. *Biological Conservation* 86: 289–297.

Esselink, P. 2000. Nature management of coastal salt marshes. Koeman en Bijkerk bv, Haren.

Exo, K.-M., Becker, P.H., Hälterlein, B., Hötker, H., Scheufler, H., Stiefel, A., Stock, M., Südbeck, P. & Thorup, O. 1996. Bruterfolgsmonitoring bei Küstenvögeln. *Vogelwelt* 117: 287–293.

Flemming, B.W. (ed.). 2001. Untersuchung der ökologischen Entwicklung einer Aussendeichskleipütte als Ergänzung der quantitativen Beweissicherung des Wiederverlandungsprozesses. *Bericht 01-1*. Senckenberg am Meer, Wilhelmshaven.

Galbraith, H. 1989. Arrival and habitat use by lapwings *Vanellus vanellus* in the early breeding season. *Ibis* 131: 377–388.

Großkopf, G. 1958. Zur Biologie des Rotschenkels (*Tringa t. totanus*) I. *Journal für Ornithologie* 99: 1–17.

Großkopf, G. 1959. Zur Biologie des Rotschenkels (*Tringa t. totanus*) II. *Journal für Ornithologie* 100: 211–236.

Hälterlein, B. 1998. Brutvogel-Bestände im Schleswig-Holsteinischen Wattenmeer. *UBA-FB 93-101, TEXTE 76/97*. Umweltbundesamt, Berlin.

Johnson, D.H. 1979. Estimating nest success: The Mayfield method and an alternative. *Auk* 96: 651–661.

Jones, J. 2001. Habitat selection studies in avian ecology: A critical review. *Auk* 118: 557–562.

Kokko, H. & Sutherland, W.J. 2001. Ecological traps in changing environments: Ecological and evolutionary consequences of a behaviourally mediated Allee effect. *Evolutionary Ecology Research* 3: 537–551.

Mayfield, H. 1961. Nesting success calculated from exposure. *Wilson Bulletin* 73: 255–261.

Melter, J. & Schreiber, M. 2000. Wichtige Brut- und Rastvogelgebiete in Niedersachsen. *Vogelkundliche Berichte aus Niedersachsen* 32, Special issue.

Melter, J. & Welz, A. 2001. Eingebrochen und ausgedünnt: Bestandsentwicklung von Wiesenlimikolen im westlichen Niedersachsen von 1987–1997. *Corax* 18, Special issue 2: 47–54.

Misenhelter, M.D. & Rotenberry, J.T. 2000. Choices and consequences of habitat occupancy and nest site selection in Sage Sparrows. *Ecology* 8: 2892–2901.

Nehls, G. 2001. Bestandserfassung von Wiesenvögeln in der Eider-Treene-Sorge-Niederung und auf Eiderstedt 1997. *Corax* 18, Special issue 2: 27–38.

Newton, I. 1998. Population limitation in birds. Academic Press, San Diego.

Norris, K., Brindley, E., Cook, T., Babbs, S., Brown, C.F. & Yaxley, R. 1998. Is the density of redshank *Tringa totanus* nesting on saltmarshes in Great Britain declining due to changes in grazing management? *Journal of Applied Ecolgy* 35: 621–634.

Norris, K., Cook, T., Dowd & Durdin, C. 1997. The density of Redshank *Tringa totanus* breeding on the salt-marshes of the Wash in relation to habitat and its grazing management. *Journal of Applied Ecolgy* 34: 999–1013.

Oppermann, R. 1989. Ein Meßinstrument zur Ermittlung der Vegetationsdichte in grasig-krautigen Pflanzengesellschaften. *Natur und Landschaft* 64: 332–338.

Perrins, C.M., Lebreton, J.-D. & Hirons, G.J.M. 1991. Bird population studies – Relevance to conservation and management. Oxford University Press, New York.

Rasmussen, L.M., Fleet, D.M., Hälterlein, B., Koks, B.J., Potel, P. & Südbeck, P. 2000. Breeding birds in the Wadden Sea in 1996. *Wadden Sea Ecosystem* 10. Common Wadden Sea Secretariat, Wilhelmshaven.

Simas, T., Nunes, J.P. & Ferreira, J.G. 2001. Effects of global climate change on coastal salt marshes. *Ecological Modelling* 139: 1–15.

Stiefel, A. & Scheufler, H. 1984. Der Rotschenkel. A. Ziemsen Verlag, Wittenberg Lutherstadt.

Székely, T. 1992. Reproduction of Kentish Plovers *Charadrius alexandrinus* in grassland and fish-ponds: the habitat mal-assessment hypothesis. *Aquila* 99: 59–68.

Thompson, P.S. & Hale, W.G. 1991. Age-related reproductive variation in the Redshank *Tringa totanus*. *Ornis Scandinavica* 22: 353–359.

Thyen, S. 1996. Auswirkungen landwirtschaftlicher Nutzungen auf Brutvögel in Salzrasen-Biotopen des Nationalparks "Niedersächsisches Wattenmeer". Unpublished report. Nationalparkverwaltung "Niedersächsisches Wattenmeer", Wilhelmshaven.

Thyen, S. 1997. Habitatwahl und Schlüpferfolg des Rotschenkels (*Tringa totanus*) in landwirtschaftlich genutzten Salzrasen der niedersächsichen Küste. *Vogelwarte* 39: 117–130.

Thyen, S. 2000. Verteilung und Schlupferfolg von Brutvögeln in landwirtschaftlich genutzten Außengroden Niedersachsens. *Seevögel* 21: 45–50.

Thyen, S., Becker, P.H., Exo, K.-M., Hälterlein, B., Hötker, H. & Südbeck, P. 1998. Monitoring breeding success of coastal birds. *Wadden Sea Ecosystem* 8: 7–55. Common Wadden Sea Secretariat, Wilhelmshaven.

Thyen, S. & Exo, K.-M. 2001. Ökofaunistik I: Brut- und Rastvögel. In: B. W. Flemming (ed.) *Untersuchung der ökologischen Entwicklung einer Aussendeichskleipütte als Ergänzung der quantitativen Beweissicherung des Wiederverlandungsprozesses*: 34–59. Senckenberg am Meer, Wilhelmshaven.

Thyen, S. & Exo, K.-M. in press. Die Bedeutung von Salzrasen des niedersächsischen Wattenmeeres für die Reproduktion von Rotschenkeln *Tringa totanus*. Conference proceedings "Schutz von Feuchtgrünland für Wiesenvögel in Deutschland, Rendsburg, 25.–26.02.2002". NABU, Bergenhusen.

Tryjanowski, P., Goldyn, B. & Surmacki, A. 2002. Influence of the red fox (*Vulpes vulpes*, Linnaeus 1758) on the distribution and number of breeding birds in an intensively used farmland. *Ecological Research* 17: 395–399.

Tucker, G.M. & Heath, M.F. 1994. Birds in Europe – Their Conservation Status. BirdLife International, Cambridge.

Wijnen, H.J. van & Bakker, J.P. 2001. Long-term surface elevation change in salt marshes: a prediction of marsh response to future sea-level rise. *Estuarine, Coastal and Shelf Science* 52: 381–390.