Kentish Plovers and tourists: competitors on sandy coasts?

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Schulz, R. & Stock, M. 1993. Kentish plovers and tourists: competitors on sandy coasts? *Wader Study Group Bull.* 68: 83-91.

The effects of human-related disturbances in a breeding colony of Kentish plovers were investigated. Nest searches revealed a maximum of nearly 200 nests in the foreland of St Peter in Schleswig-Holstein. The breeding colony thus accounts for 10% of the entire north-west European breeding population and contains nearly 50% of the German population. Large parts of the potential breeding habitat could not be colonised because they were occupied by tourists sun-bathing and resting in the primary dunes. Furthermore, the birds showed reduced hatching success. Nest failures from various causes amounted to 52.1% on average. A strong relationship between the disturbance intensity and the rate of clutch losses was found. Habitat characteristics such as vegetation cover and the vegetation structure around the nests, expressed as the view obstruction, can reduce these losses. Possible disturbance-related and disturbance-independent reasons for nest failures are discussed.

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INTRODUCTION

The Kentish Plover *Charadrius alexandrinus* is one of the most widespread waders in the world. Different subspecies are found on five continents. The Kentish Plover was once widely distributed along most European coasts, from Scandinavia to southern Iberia, on the coasts of southern England as well as in the Mediterranean and the Black Sea areas. Formerly large inland breeding areas also existed in Spain and in the Pannonic region in south-east Europe. The northern-most populations breed along the coasts of the Wadden Sea and the south-west Baltic Sea (Glutz *et al.* 1975; Cramp & Simmons 1983).

At present the nominate form (European Kentish Plover) appears to be among of the most rapidly disappearing waders in Europe. Breeding populations have declined in many regions, e.g. in Sweden, Hungary and the Wadden Sea, or have disappeared from many areas in recent years, e.g. from breeding habitats in Norway, Great Britain, Denmark, Hungary and the Baltic area. Increasing tourism and the destruction of natural habitats are considered the main reasons for the decline (Bauer & Thielcke 1982), despite the fact that the species is often regarded as adaptable and insensitive to human disturbance. An international working group established in response to this rapid decline hopes to enlighten questions concerning the ecology and status of Kentish Plovers and to find evidence supporting the need for species conservation (Jönsson *et al.* 1990). As a part of the Ecosystem Research Project in the Schleswig-Holstein part of the Wadden Sea we studied the effects of tourism on colonisation, distribution and hatching success of Kentish plovers. The natural breeding areas of the species, such as primary dunes, sandy coastal areas and exposed washed-up shell fragment areas are simultaneously the preferred habitats of tourists during the summer months. Tourist activities are a major source of disturbance to large portions of these areas.

This investigation is part of an applied ecosystem research project in the Wadden Sea area of Schleswig-Holstein and deals with the effects of human disturbances to birds. Aims, content and the structure of the interdisciplinary project are described by Leuschner (1988) and Leuschner & Scherer (1989).

STUDY AREA

The westernmost parts of the Eiderstedt peninsula, the sandy shores of St Peter-Ording (Figure 1), form an exception to the geomorphology of the west coast of Schleswig-Holstein. The peninsula is the only area between Blåvandshuk in Denmark and Den Helder in the Netherlands where the sandy barrier coast lines the mainland. This coastal stretch is dominated by a large system of barrier beaches of different ages, composing a mosaic of pleistocene dunes, saltmarshes, tidal sand flats and higher sand flats. On some restricted sites primary dunes have built up. Elongated lagoons have

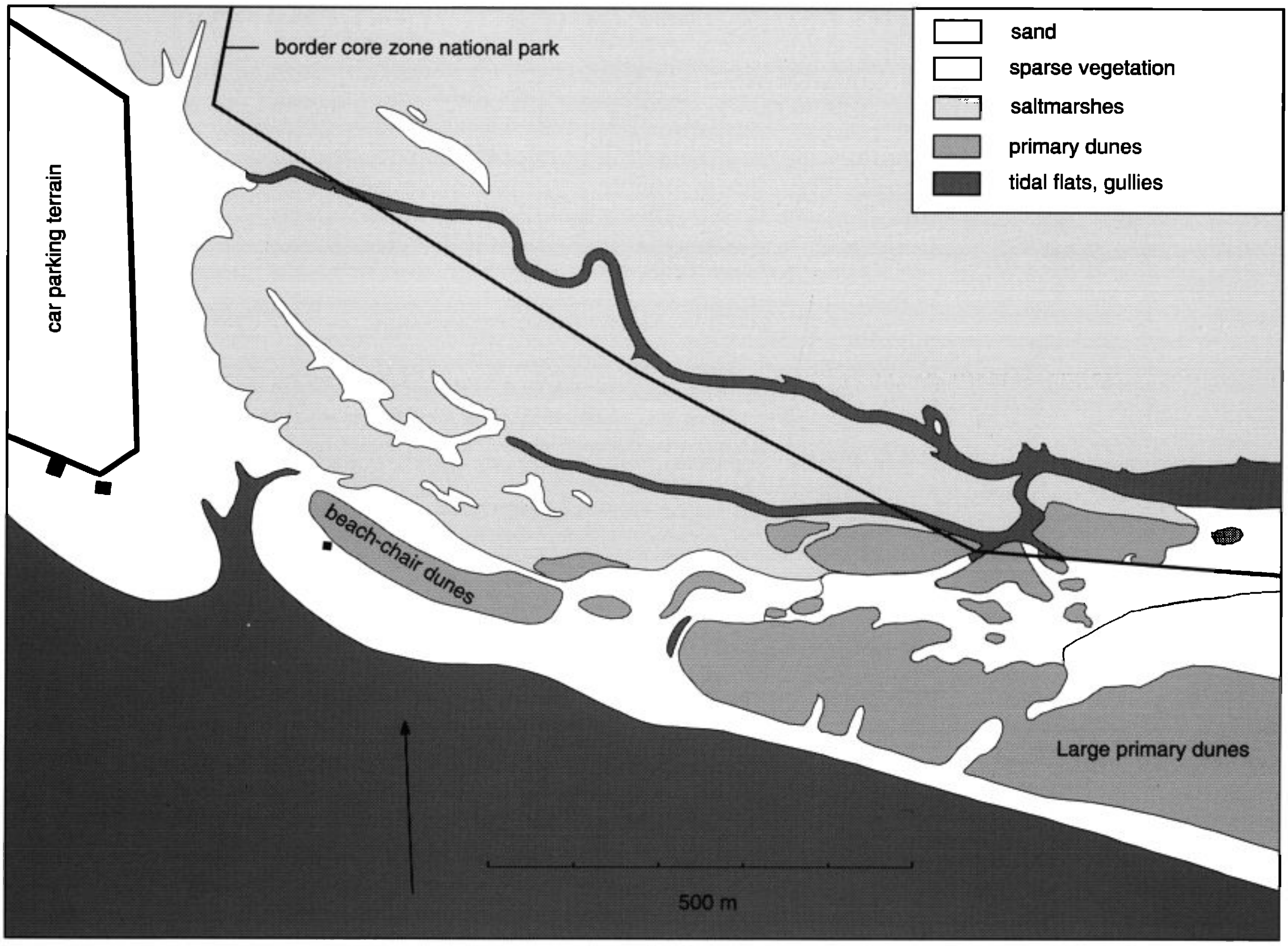

Figure 1. Habitat map of the study area in the foreland of St Peter-Böhl. The potential breeding habitat is shaded medium-grey (beach chair dunes and large primary dunes). The border of the core zone of the national park is indicated.

developed behind the barriers. The total area is traversed by an extensive natural gully system (Ehlers 1988).

In the south-east part of the coast - at St Peter-Böhl - the oldest and thus innermost barrier beach supports a most remarkable natural sandy saltmarsh. A succession of different vegetation communities from a *Puccinellion maritimae* to an *Armerion maritimae* can be found. This vegetation is protected by a younger barrier covered with a mixture of different plant species characteristic of salt-marshes as well as primary dunes. The outermost barrier forms an extended sea-wall covered by an *Elymo-Agropyretum juncei* with *Agropyron junceum* predominating. The vegetation cover reaches a height of nearly 50 cm and is denser on the seaward side of the barrier beach than on the lee side. The sea-wall is 1.5 km long and nearly 250 m wide. The dunes vary in height between 0.5 and 1.5 m and are not flooded during normal high tides. Only the gullies and an extended lagoon regularly flood. The study area (Figure 1) includes parts of the more open saltmarsh vegetation within the totally protected core zone of the National Park 'Schleswig-Holsteinisches Wattenmeer' as well as the primary dunes on the youngest sea-wall. The potential breeding habitat is thus characterised mainly by the primary dune area (Figure 1). The total area comprises 90 ha, of which 12 ha are not accessible to the public. The entire area - except the well-protected core zone – is heavily disturbed by walking tourists. Parts of the primary dunes are used by nudists.

METHODS

Preliminary investigations began in 1989, when 113 Kentish Plovers were individually marked with colour-rings. Since the beginning of the study a set of parameters outlined below were investigated as part of a long-term study on the population ecology of Kentish Plovers. Results presented here reflect only data concerning the effects of disturbances on colonisation, distribution and hatching success of the 1990 season.

Breeding bird numbers were assessed using the method described by Brunckhorst *et al.* (1988), by searching for nests, by calculating the proportion of ringed to unringed birds, and by determining the percentage of birds ringed the previous year and by birds caught on the nest this season. Every nest was mapped on an infra-red photograph of the area; the exact position was described by triangulation.

To describe nest habitat characteristics, we measured the vegetation cover (in steps of 10%) within a circle of 50 cm and 200 cm around the nests after hatching. The vegetation height was measured within the smaller circle.

Kentish Plovers often select nest sites in close proximity either to individual plants or to clumps of loose vegetation. We quantified the degree of view obstruction from the perspective of the incubating birds by measuring the width of tufts of vegetation higher than 15 cm within a radius of 100 cm around the nest. This translated easily to an angle describing the view from the nest: a view angle of 0° was characteristic of nests located within plant groups - total obstruction – and an angle of 360° described nest sites with an unobstructed view.

The relative density of the nests was established by counting the number of nests in an area of 1 ha surrounding a certain nestcup. This was only applied to nests under active incubation at the end of May after most of the eggs had been laid. The age of newly found eggs was estimated by measuring their floating characteristics following the procedure described by Hays & LeCroy (1971) and Van Paassen *et al.* (1984). Assuming an incubation period of 30 days (Rittinghaus, 1961; pers. obs.) the laying date for successful nests can be calculated from the hatching date. The hatching success was corrected using the formula of Mayfield (1961, 1975). The fate of the clutches was examined by visual observations and by reading tracks and footprints. A clutch was assumed to be successful if hatching chicks were heard in the egg or if at least one chick hatched. A clutch was presumed lost to predation if yolk and/or egg-shell fragments were found. In some cases clutches were collected by humans or flooded by extremely high tides.

The disturbance intensity in the study area was measured by counting and mapping the number of tourists (walking and resting people were considered separately) on 50 days from April to July. Tourist counts were made during times of peak activity in the area, between 15.00 and 16.00 hours as well as on individual days throughout the whole day in intervals of 30 minutes. To assess the influence of disturbance intensity on hatching success an index (person-hours/10 ha/day) was calculated by multiplying the number of people in the surrounding area of a certain nest with the mean length of stay of the people in each spot, summed over the entire breeding period.

RESULTS

Total bird numbers

Following the standard procedure described by Brunckhorst *et al.* (1988) a total of 70 breeding pairs were counted in the study area in 1990 (Hälterlein, unpubl.). This number is quite low in comparison with the corrected actual number of breeding pairs.

A maximum of 236 to 239 Kentish Plovers present at the same time was examined in the middle of June by means of two different methods. Nest searches revealed a total of 130 clutches with 77 nests present at the same time at the end of May. Applying Mayfield's correction factor to these numbers implies a total of 178 breeding attempts in the 1990 season. This can be translated to a total number of 120 pairs.

The course of the breeding season is given in Figure 2. The graph shows the start of the laying period with a median laying date of 18 May, a maximum number of nests simultaneously present on 29 May and a median hatching date of 16 June.

Overall hatching success

Table 1 presents the overall hatching success for the 1990 season with and without the Mayfield correction factor. A total of 130 nests was found; the fate of 101 of these nests is known: 65% were successful and 35%

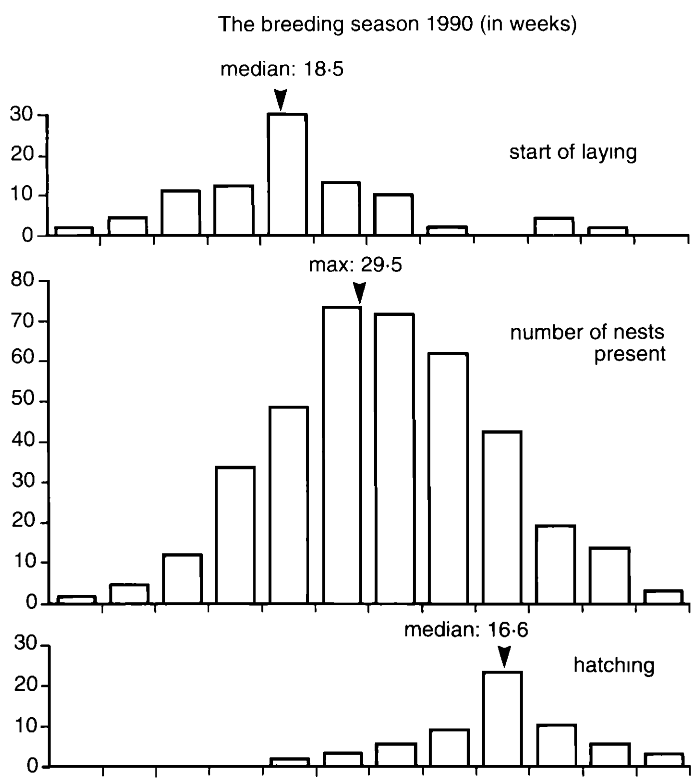

Figure 2. The course of the breeding season in the study area of St Peter-Böhl.

Table 1. Overall hatching success of Kentish Plovers, 1990, with and without Mayfield correction factor.

Parameter	found	calculated
fate known (n)	101	138
successful nests (n)	66	66
losses (n)	35	72
rate of losses (%)	34.7	52.1
number of nests (n)	130	178

were lost due to various causes (7% destroyed by high tides, 9% taken by egg collectors, the remaining 19% were taken by predators or were lost due to unknown causes). No significant correlations could be found between weather data and the amount or the percentage of clutch losses. The maximum number of losses occurs within the first 10 days after laying (Figure 3). 78.8% of clutch losses occurred within the first 15 days.

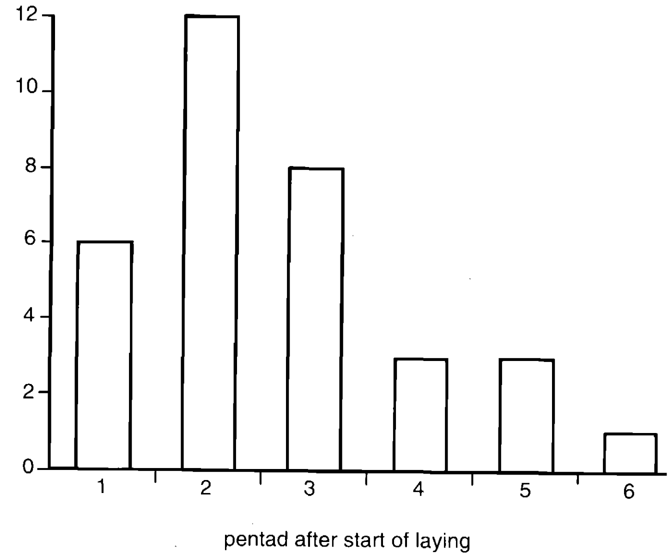

Figure 3. Number of clutch losses - due to various causes - in pentads after the start of laying.

Spatial distribution of nests in relation to tourist activities

Kentish Plovers prefer to breed in areas with sparse vegetation on primary dunes. The spatial distribution of the nests, the fate of the nests and the use of the area by humans are shown in Figure 4. The upper part of the map shows the first two parameters in relation to sun-bathing and resting people, the lower part in relation to beach-walkers. Sun-bathing and resting people were concentrated on the westernmost, the so-called 'beach-chair' dune and at the tip of the large primary dune in the east. The more plant-covered salt-marshes were less regularly occupied. Walking people concentrated at the parking lot and along the high-tide line, with most of the people walking to the tip of the sea-wall at the end of the study area.

Most of the nests were found in the eastern part of the potential breeding habitat. Heavily disturbed areas, which include the westernmost part of the large primary dune and the smaller 'beach-chair' dune next to it, were not colonised, as these potential breeding habitats were occupied by resting tourists. The birds were only able to settle in the remaining undisturbed areas. Most of the successful nests were found in remote areas which lie off the places of main touristic activities and walking routes or within the well-protected core zone of the national park. Even on a small scale, e.g. on the westernmost tip of the large primary dune (Figure 4) it is obvious that potential breeding places are pre-empted here mainly by sun-bathers and resting people. As may be derived from our distribution maps (Figure 4), their influence seems to be more important than the influence of walking people. The latter mostly follow the high-tide line and were rarely seen within the breeding area.

The effect of human disturbance on hatching success

There was a clear relationship between the disturbance intensity and the number of clutches lost - excluding losses due to egg-collectors and flooding - during the breeding season (Table 2). The rate of losses increased with increasing disturbance intensity in the

Table 2. Relationship between the disturbance intensity and the number of clutches lost.

Parameter	disturbance intensity (person-hours/10ha/day)			
	0–2	2–4	4–10	>10
number of nests *	20	21	22	22
clutch losses *	10.0	13.6	28.6	36.4
number of nests [1]	22	24	30	25
clutch losses found [1]	18.2	25.0	46.7	44.0
clutch losses calculated [1]	27.6	43.4	68.0	59.0

* excluding collected and flooded eggs [1] all nests.

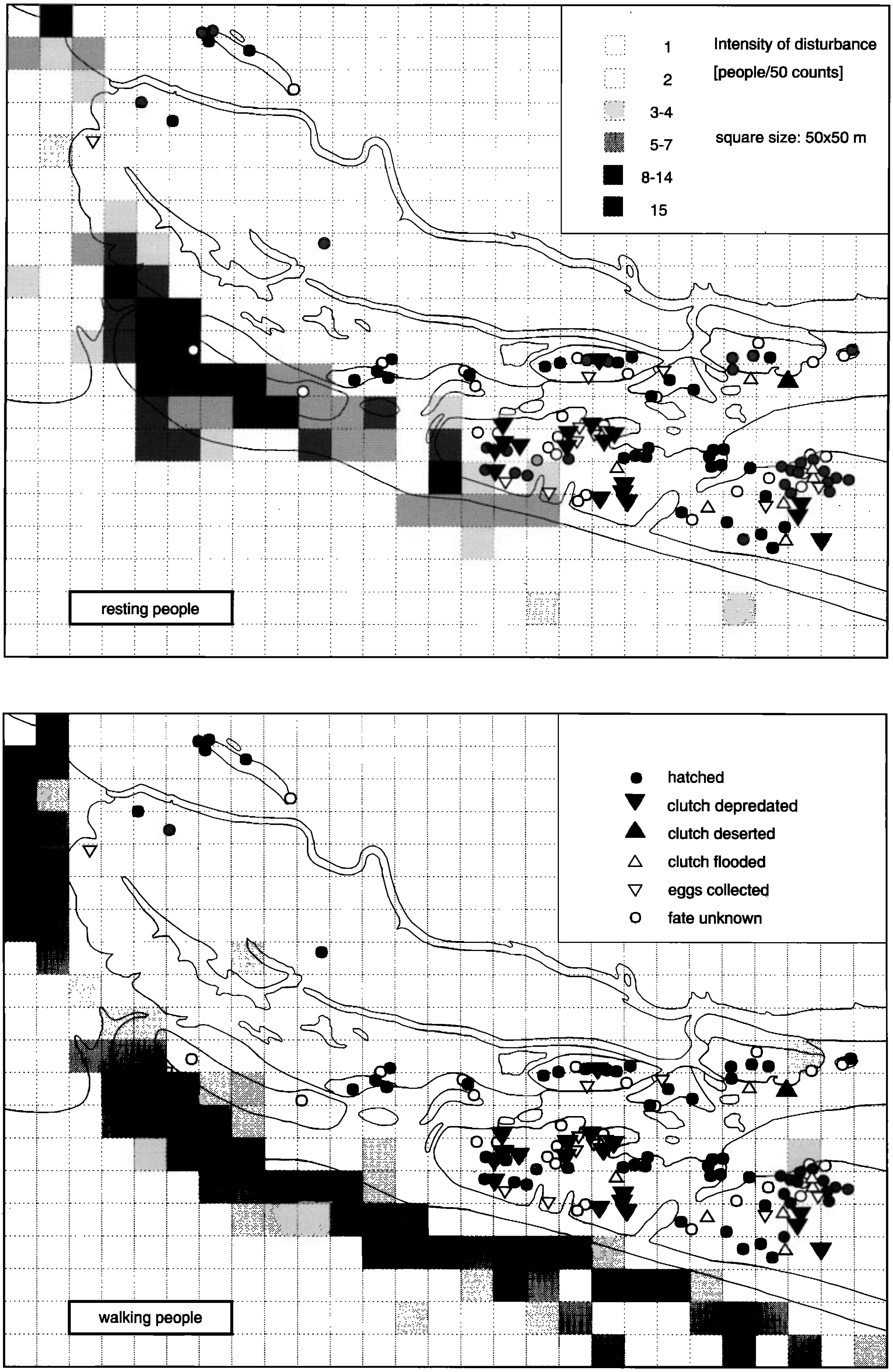

Figure 4. The distribution and the fate of Kentish Plover nests within the study area in relation to the tourist use of the area: a) resting and sunbathing people, b) walking people. The grid indicates the intensity of tourist usage of the respective squares.

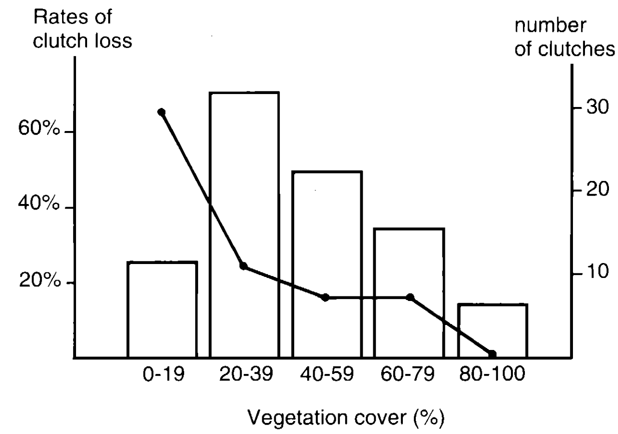

Figure 5. Number of clutches found (columns) and the rate of clutch losses in relation to extent of vegetation cover.

nest surroundings (person-hours/10 ha/day). Clutch losses were lowest (10.0%) in areas with little disturbance but increased steadily with increasing disturbance level up to 36.4% in heavily disturbed areas. The differences in clutch losses between a low disturbance intensity (< 4person-hours/10ha/day) and a high disturbance intensity (> 4 person-hours/10 ha/day) were significant (Chi-Square = 4.71, $p < 0.05$). In the corrected data (after Mayfield 1975) clutch losses account for 27.6% of nests in low disturbance areas and increase to 59% under a high disturbance level.

Clutch losses in relation to vegetation cover

Kentish Plovers are not equally distributed within the study area. Tourist use of parts of the primary dune is one of the reasons. In general, plovers mainly colonise areas with sparse vegetation. Most of the nests are found in zones with a vegetation cover of less than 40% (Figure 5). Hatching failure in such areas is 22.6% on average. The rate of clutch loss in open habitat is the highest value found accounting for 63.6%. Increased vegetation cover lowers clutch losses toward 0%. This relationship is little influenced by the fact that less vegetated dunes are more often used by resting and sun-bathing people than the more heavily vegetated ones. The log disturbance intensity is in fact only slightly negatively correlated with the vegetation cover ($r^2 = -0.09$; df = 129; p = 0.006).

Combined effects

To determine both the effect of disturbance intensity and the influence of the vegetation cover on hatching success we divided all clutches into four classes. This was done using the disturbance intensity (> or < 180°) of the nestcups as the criteria for the division (Figure 6). Thirty-four per cent of all nests were hidden (view angle < 180°). In less disturbed areas all these birds were successful. Even in more disturbed places the losses in hidden nests were low (14.3%). But 50% of the clutches were lost at high levels of disturbance and where nests were situated on open ground. Losses were thus lower in areas with dense vegetation and low levels of disturbance ($p > 0.05$, χ^2- test). This clearly indicates that hatching success in highly disturbed areas even with optimal habitat is as low as in poor habitat with a low level of disturbance.

Figure 7 summarises the effects of different parameters on the fate of the nests. Differences were tested with the Mann-Whinney U-test. Nests were more often successful in places with a higher vegetation cover, on less open sites and on spots with a low disturbance intensity. No differences between successful and failed nests could be detected in different vegetation heights and different relative abundances of nests per 10 ha.

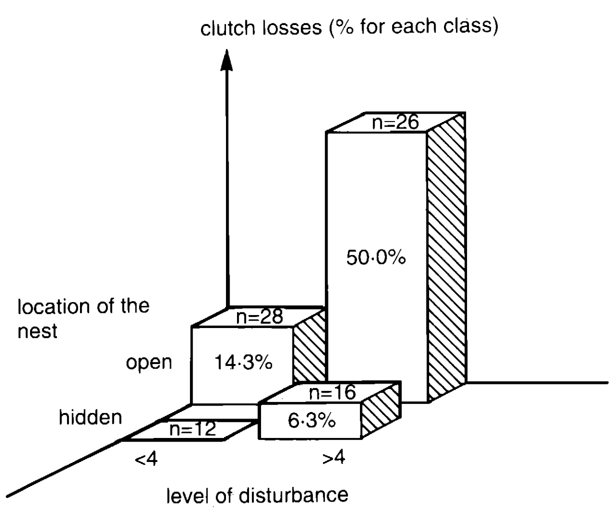

Figure 6. Clutch losses (% for each class) in relation to the location of the nest and the level of disturbance. See text for explanation.

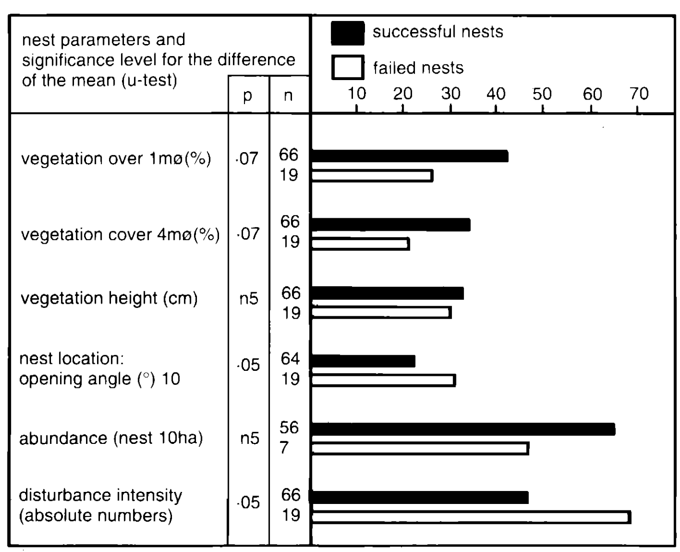

Figure 7. Differences of the mean of certain parameters between successful and failed nests.

DISCUSSION

The study in the foreland of the whole coastline in St Peter revealed a breeding population of nearly 200 pairs in 1990. This area thus holds the largest concentration of Kentish Plovers in north-western Europe. The population accounts for nearly 10% of the N W European and for nearly 50% of the German breeding population (Hälterlein unpubl.). Similar numbers were also reported in the 1970s for this specific area (Glutz *et al.* 1975). In the 1980s Hälterlein (1986) and Kempf *et al.* (1989) reported less than 50 pairs. These low numbers are partly due to different methods. Rittinghaus' data were based on nest counts whereas the more recent data were gained by counting territorial birds following the method described by Brunckhorst *et al.* (1988). Despite these difficulties there is evidence that an enormous reduction in numbers has occurred. Between 1970 and 1990 the German Kentish Plover population has dropped from 900 to 412 pairs. As recently stressed by Smit & Visser (1990), Kentish Plovers and Little Terns belong to the most threatened breeding species in the Wadden Sea area. Their populations have decreased dramatically during the last decades. The authors concluded that this decline of the breeding population is due to loss of suitable breeding sites and to disturbances from tourists.

The distribution of Kentish Plovers within the study area is strongly influenced by tourist use of the area. The potential breeding habitat in the westernmost part of the area, the so-called 'beach-chair dune', and other parts of the area cannot be used by the birds. It can be concluded that disturbances reduce the size and the value of the foreland area in St Peter-Böhl. Resting people and sun-bathers have a greater influence than do beach-walkers. This may be attributable to habitation to beach-walkers as recently found by Hüppop & Hagen (1990) in breeding Oystercatchers but is surely also affected by habitat features like vegetation cover and/or openness of the nest-site.

When studying the effects of disturbances, one of the major questions to be answered is whether or not a disturbance is significant to a bird. In population terms this means whether or not the population can withstand a certain reduction in productivity to secure a certain population level or not.

Rittinghaus (1961) reported a very low rate of egg losses (6%, only data for one year published) for the population he studied on the undisturbed island of Oldeoog, Niedersachsen. Unfortunately, he did not comment on the population development. In recent years Székely (1991) found a clutch loss rate of between 56.7 and 79.3% for a small breeding population in Hungary, and Jönsson (1991) reported losses up to 60% for Kentish Plovers in S-Sweden. Both populations are decreasing. The overall loss rate in our study area accounted for 52.1% and is thus comparably high. Furthermore, plovers are very sensitive to disturbances during rearing. Yalden & Yalden (1990) could show that the time juvenile Golden Plovers *Pluvialis apricaria* spent feeding was significantly reduced under disturbed conditions. Flemming's *et al.* (1988) study yielded similar results in Piping Plovers *Charadrius melodus*. Disturbances resulted in a lower survival rate of chicks up to an age of 17 days. By altering chick behaviour, disturbances led to a 50% reduction in the rearing success. Whether this affects the long-term population level is not yet known but currently under investigation.

WHAT ARE THE REASONS FOR CLUTCH LOSSES?

In addition to collecting, flooding and crushing, the reason for losses in some circumstances was discovered. Losses directly attributed to human activities are in general low, e.g. Pienkowski (1984) for Ringed Plovers *Charadrius hiaticula*. Indirect effects are more often responsible, often through an increase in predation pressure. The fact that open nests fail more often than hidden ones is an indication that aerial, visually-searching avian predators are more likely to cause losses than nocturnal mammalian predators. To what extent dogs are predators of plovers' eggs in the study area is unclear, but dogs are well known as predators of eggs and young of various plover species, e.g. Killdeer *Charadrius vociferus*, Ringed and Kentish Plovers (Nol & Brooks 1982, Pienkowski 1984, Székely unpubl.).

It is very likely that avian predators, mostly gulls, less often crows, are responsible for many losses. Although we do not know exactly what role mammalian predators play, there is a fox den near the colony and many traces have been found. An increase in predator density due to an elevated tourist use of an area is a well-known effect (Watson 1982, Pienkowski 1984). Götmark & Åhlund (1984) found that human-related disturbances in an Eider colony *Somateria mollissima* led to increased predation shortly after the disturbance compared with the predation rate before. This may explain why clutch losses in our study area seem to occur more often on days with a very high disturbance pressure. Avian predators like gulls can probably find disturbed nests more easily through the movements of disturbed plovers. Other circumstances, such as an increase in plover footprints in a sandy area as a consequence of repeated disturbances, are likely to attract gulls. Similarly, Pienkowski (1984) considers both disturbed movements of parents and footprints reasonable marks for predatory gulls. Furthermore if the predators tolerate a closer approach of tourists than do plovers, the losses can be very high as found by Anderson & Keith (1980) in a seabird colony. Specialisation of individual birds on certain cues can increase their predatory effectiveness considerably. As well as gulls, Oystercatchers are also known as predators of plover and tern nests (pers. obs., Haddon & Knight 1983.) Haddon & Knight (1983) observed an individual Oystercatcher depredating 12 nests of Little Terns within 30 minutes.

Nol & Brooks (1982) propose a relationship between clutch losses in a Killdeer colony and the number of roosting gulls nearby. Although we have only little evidence supporting this assertion, it is very likely that gulls flying to their roost search for nests as we observed in the same area in the case of Little Terns.

DISTURBANCE-INDEPENDENT FACTORS

Gulls foraging along a high tide waterline could be responsible for the larger amount of clutch losses at the outer ridge of the sea-wall, as found in our study. A larger number of losses in such areas is thus the direct consequence of the nest site location.

A high density of breeding birds in a colony can subsequently increase the predator density and thus lead to a higher predation pressure. However, it is also possible that a common antipredator behaviour of the nesting birds serves as a precaution for the whole colony (Göransson *et al.* 1975). A density-dependent higher rate of clutch losses as found by Page *et al.* (1983) in Snowy Plovers *Charadrius alexandrinus* could not be observed in our study area. The highest plover density in our study plot was found in an area with high *Agropyron junceum* vegetation and most of the nests were hidden. Habitat factors can thus inhibit the negative effects of a higher breeding density.

We can conclude that tourist-induced disturbances reduce the effective size and the value of the potential breeding habitat in our study area. Large areas are not colonized or breeding success in such areas is very low. Plovers and tourists are indeed competitors for rare resources. This already has led to conservation efforts as suggested by Schulz & Stock (1991). Large parts of the entire breeding area are now protected during the breeding season. The effects of these measures on the breeding success of Kentish Plovers and Little Terns are currently under investigation.

ACKNOWLEDGEMENTS

We would like to thank H. Hötker, P. E. Jönsson, P. Meininger, H. U. Rösner and T. Székely for valuable discussions during the course of the project. We thank T. Székely for allowing us to use his unpublished data. D. Fröhlich kindly corrected our English. The 'Wetteramt Schleswig' allowed us to make use of unpublished data from a nearby weather station.

This work was financially supported by the Federal Environment Agency and the Umweltbundesamt as part of the project: 'Ecosystem Research Wadden Sea . This is contribution no. 13.

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Kentish Plover