Native ant species *Myrmica rubra* affects Herring Gull *Larus argentatus* and Lesser Black-backed Gull *L. fuscus* chick survival at a North Sea island

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Abstract
Trischen island is located in the core area of the Schleswig Holstein Wadden Sea National Park, north of the Elbe estuary, and holds one of the largest colonies of Herring Gull *Larus argentatus* (1,781 pairs in 2013) and Lesser Black-backed Gull *L. fuscus* (1,838 pairs in 2013) on the German west coast. Productivity has been monitored for both species since 2010, and was low throughout 2010–13, averaging 0.26 ± 0.12 SD fledged/nest for Herring Gull and 0.32 ± 0.14 SD fledged/nest for Lesser Black-backed Gull. Since 2011 excessive ant activity has been noted at some nest sites, causing distress for freshly hatched chicks. In 2013 a total of 83 gull nests (40 Herring Gull, 33 Lesser Black-backed Gull, 10 unspecified) were monitored at 2–4 day intervals and ant activity was recorded. Ten nest sites with chicks that were obviously suffering from attacks by the European Fire Ant *Myrmica rubra* were noted; all of these chicks (n = 25) died before the age of 4 d (± 2 d), reflecting a chick loss of 14.5% within the study colony. At the end of the breeding season, ant densities were compared between these ten nest sites where ant attacks had been observed and ten out of the 15 nests sites where at least one chick lived to fledging age. Results showed a 12-fold higher ant density at nests where ant attacks had been observed and a distinctive ant density pattern within the colony, suggesting that location of nesting sites affected chick survival.

Introduction

Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* are among the most abundant breeding seabirds on the Dutch, German and Danish Wadden Sea islands. The island of Trischen holds the second largest population of Herring Gull and Lesser Black-backed Gull at the German coast, with 1,781 and 1,838 breeding pairs in 2013, respectively (Baer 2013). Trischen is also home to a large ant population, with especially dense colonies in dune and grassland *Elymus athericus* areas (pers. obs). In 2013 the ant species was identified as the European Fire Ant *Myrmica rubra*, a highly aggressive, polyphagous ant that may form supercolonies (Seifert 2007). *Myrmica rubra* is one of the most abundant native ant species in Europe, extending from Ireland and Portugal in the west across 8,000 km to central Asia and eastern Siberia (Wetterer & Radchenko 2011). The species is also currently increasing its range in North America, where it had been introduced in the early 20th century and is now considered a pest (Wetterer & Radchenko 2011).

Ants play a large role in terrestrial ecosystems. They act as predators, scavengers and herbivores, and constitute a great part of the animal biomass (Folgarait 1998; Holway *et al*. 2002). Ants have become inadvertently introduced to countless islands around the world, often causing widespread ecological damage (McGlynn 1999; Rabitsch 2011). There have been a number of cases in which invasive ant species are reported to have detrimental effects on ground-nesting birds, including seabirds. At Bird Island, Seychelles, Sooty Terns *Sterna fuscata* failed to nest in areas invaded by the Yellow Crazy Ant *Anoplolepis gracilipes* and White Terns *Gygis alba* suffered high chick mortality due to predation by the same ant species (Feare 1999). Suppression of the Red Imported Fire Ant *Solenopsis invicta* increased chick survival for the endangered Least Tern *Sterna antillarum* in Mississippi, USA (Lockley 1995). A similar problem was reported from the Hawaiian islands where booming populations of the Tropical Fire Ant *Solenopsis geminata* were expected to cause widespread damage to local seabird colonies; control of the ant populations resulted in temporary increase in the fledging success of Wedge-tailed Shearwaters *Puffinus pacificus* (Plentovich *et al*. 2009). Recently, *Myrmica rubra* has been reported to adversely affect Herring Gull reproduction on an island in the Gulf of Maine (DeFisher & Bonter 2013).

However, native ant species can also cause problems for nesting seabirds. Safina *et al*. (1994) reported that Roseate Tern chicks *Sterna dougallii* on Cedar Beach, New York, were more likely to die if the native ant species *Lasius neoniger* was found present on the chicks. Nisbet and Welton (1984) recorded ant predation on Common Tern chicks *Sterna hirundo* at a colony in Massachusetts between 1972 and 1981 and found that attacks by *Lasius neoniger* was one of the principal causes of egg and chick losses.

So far, most reported cases of ants affecting seabird reproduction have come from outside Europe. In Germany one incident was mentioned in 1938, where ants (species unknown) caused distress to seabird chicks on the island of Amrum (Emeis, in Schulz 1947). In 2011 and 2012 ants were observed attacking Herring Gull and Lesser Black-backed Gull chicks on Trischen (Philipps 2011; M. Mercker pers. comm.). During gull nest monitoring on Trischen in 2013, information on ant attacks and ant densities was collected in order to assess whether this had any effect on gull breeding success.

Methods

Study Site: Trischen island (54°03'N 8°41'E) is situated north of the Elbe estuary within the core protection area of the Wadden Sea National Park of Schleswig Holstein (Figure 1). Protection of the island dates back to 1910 and access is highly restricted, the sole inhabitant being a warden for seven months of the year. Trischen is about 180 ha in size and the main island habitats consist of dunes, beach and saltmarshes. Half of the island is prone to seasonal flooding, and wind and currents continuously shape the size and outline of the island (Kempf *et al*. 2000).

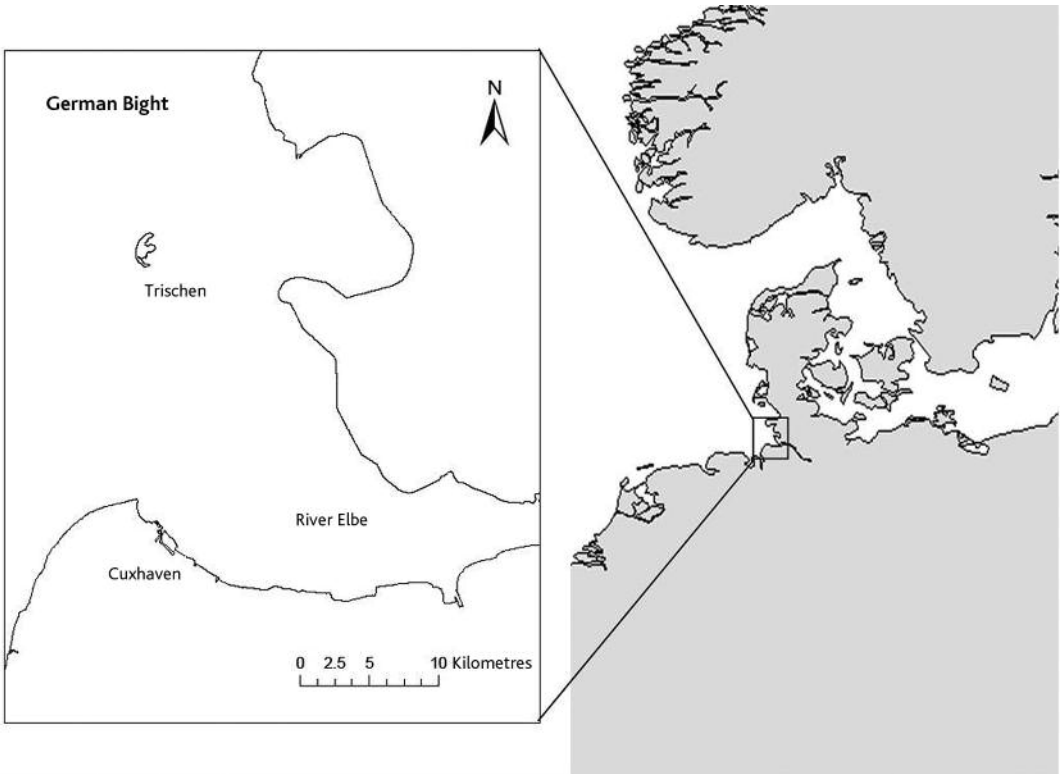

Figure 1. Location of Trischen island on the German west coast.

Gull productivity monitoring: The study site was located at the southern tip of Trischen, an area easily accessible and with a high gull nest density. There, both Herring and Lesser Black-backed Gulls breed in a mixed colony at the foot of a shallow chain of dunes, covered in patchy vegetation dominated by grasses *Ammophila arenaria, Elymus arenarius, E. athericus* and a number of large herbs such as *Oenothera oakesiana*, *Atriplex littoralis* and *Cakile maritima*.

On 30 May 2013, 83 gull nests were fenced with chicken wire before the main onset of egg laying. The colony was sub-divided into 11 fenced areas, containing between four and 12 gull nests each. Nests were individually marked and numbered and GPS coordinates were taken for each nest site. Because Herring Gulls and Lesser Black-backed Gulls breed in mixed colonies on Trischen, distant observations were necessary to determine the particular species for each nest site. The colony was visited every 2–4 days throughout the season, noting the nest contents during each visit. Chicks were metal-ringed while still at the nest site and also fitted with a coded colour ring shortly before fledging. Clutch size (eggs per nest), hatching success (chicks per egg) and fledging rates (fledgling per nest) were calculated for both species. The methodology was trialled in 2009 (Spalke 2009) and has been applied consistently since 2010 (Kronberg 2010), with minor variation in sample size and location, depending on annual colony density (Philipps 2011; Mercker 2012; Baer 2013).

Nest sites where live chicks were found suffering from attacks by *Myrmica rubra* (Figures 2 & 3) were recorded during each colony visit. Ants concentrated their attacks on the feet, nares, eyes and cloaca, and most ant-infested chicks were characterised by swollen eyes that appeared infected and sometimes glued shut by dried fluids. Infested chicks showed various signs of pain and distress, or apathy, calling continuously and writhing under the ant assault, or lying motionless showing only occasional signs of life. All chicks seen being attacked were so young that their efforts to rid themselves of ants appeared feeble and ineffective. Chicks found dead were recorded separately and not included in the analysis, as ants may have been attracted to the dead body without necessarily having been involved in the death.

Figure 2 and **Figure 3.** Examples of gull chicks suffering attacks by the European Fire Ant *Myrmica rubra*. June 2013, Trischen. © *Julia Baer*

Measuring ant density: At the end of the breeding season ant density was compared between those nest sites where ant attacks on chicks had been observed (n = 10) and nest sites where at least one chick had survived to fledging age (n = 15). Of these 15 nests from which young fledged, ten nests were chosen haphazardly so that both subject groups had equal sample sizes.

Differences in ant density were measured by placing food baits at each nest site and by counting the number of ants attracted to the bait, following Delabie *et al*. (2000). I had previously conducted trials with different baits (honey, jelly and sucrose water) and at different times of day (morning, midday, afternoon, evening) and found honey to be the most popular bait and late afternoon/evening as the time with most ant activity. Cardboard pieces of 10 cm^2 in size were therefore spread with honey and deployed at each nest site (n = 20) on 20 July at 16.00 h. After four hours the colony was visited again and a digital photo was taken of each bait station. The photos were uploaded, sub-divided with a 1 cm^2 grid and the total number of ants on each cardboard piece was counted.

Clutch size, hatching success and productivity were compared between nests with chicks attacked by ants and nests where at least one chick fledged; data were pooled for both gull species.

Results

Gull productivity monitoring: Of the 83 study nests 40 were occupied by Herring Gulls, 33 by Lesser Black-backed Gulls and 10 nests remained undefined. Average clutch size was 2.80 for Herring Gull and 2.78 for Lesser Black-backed Gull, with a hatching success of 81% and 88% respectively. Overall productivity was 0.18 fledglings per nest for Herring Gull and 0.52 fledglings per nest for Lesser Black-backed Gull.

Of the 83 study nests, five nests (6%) failed during the egg stage due to predation or infertility, ten (12%) failed at the small-chick stage due to obvious ant attack, 53 (63%) failed during various stages of chick rearing for largely unknown reasons (predation, starvation, etc.), and at the remaining 15 nests (18%) at least one chick grew to fledging age.

The ant *Myrmica rubra* was present throughout the gull colony, but active attacks on chicks were only observed at ten nest sites (seven Herring Gull, two Lesser Black-backed Gull, one species unknown). Ants became especially numerous in some areas of the colony during hatching, being particularly attracted to newly hatched and still damp chicks. In some cases ants were found to have entered pipped eggs.

Measuring ant density: *Myrmica rubra* densities at the nests where chicks were seen being attacked varied between 23 and 702 individuals per 10 cm^2 bait area, with an average of 271 (± 217 SD; n = 10; Table 1). At successful nest sites where at least one chick fledged, the ant density varied between 0 and 66 individuals

per 10 cm^2, with an average of 22 (± 26.5 SD; n = 10). The difference in ant numbers between the two groups of nests was highly significant (Mann Whitney U-test, U = 4, P < 0.01, independent two-sided test).

Table 1. Trischen island 2013: comparison of Herring Gull *Larus argentatus* (HG) and Lesser Black-backed Gull *L. fuscus* (LBBG) nests where ant attacks on chicks were observed (A) and nests from which gull chicks fledged (B). The number of ants were those attracted to baited card on 20 July, after chicks had fledged.

A. Nests where ant attacks were observed

Nest	Species	Clutch	Hatched	Fledged	No. ants
1	HG	3	3	0	199
2	HG	3	1	0	702
3	HG	3	3	0	533
4	HG	3	3	0	257
5	LBBG	3	3	0	439
6	HG	3	3	0	107
7	?	3	2	0	164
8	HG	1	1	0	23
9	HG	3	3	0	198
10	LBBG	3	3	0	91
Sum / Mean ± SD		**28**	**25**	**0**	**271 ± 217.5**

B. Nests from which gull chicks fledged

Nest	Species	Clutch	Hatched	Fledged	No. ants
1	HG	1	1	1	65
2	LBBG	3	3	1	66
3	LBBG	3	2	2	38
4	HG	2	2	2	0
5	HG	3	3	1	0
6	LBBG	3	3	2	20
7	LBBG	3	3	2	27
8	HG	3	2	1	0
9	LBBG	3	3	2	1
10	LBBG	2	2	2	3
Sum / Mean ± SD		**26**	**24**	**16**	**22 ± 26.5**

Average hatching success for the ten nests where ant attacks were observed was 89%; these chicks reached an average age of 4.1 days (± 2 days), none survived to fledging age, and the 25 chicks from these nests amounted to 14.5% of the chick loss within the study area. For the ten successful nests that were baited, hatching success was 92%, and 1.6 chicks fledged per nest. Nests in the two categories did not appear to occur at random locations; successful nests were clumped in the more densely populated central part of the study area whereas ant attack nests were scattered along the dune fringe to the northwest of this (Figure 4).

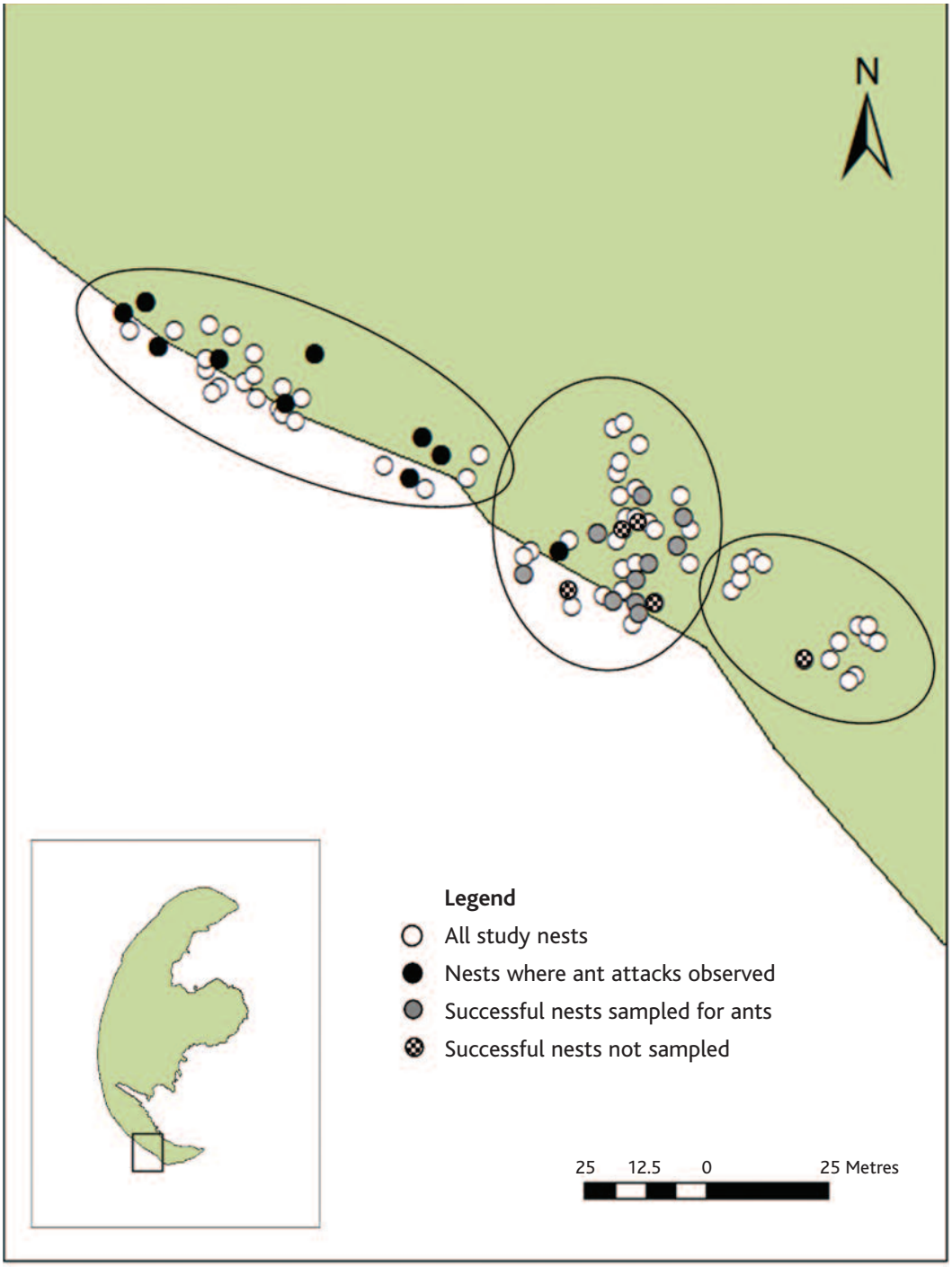

Figure 4. Trischen study site: location of Herring Gull *Larus argentatus* and Lesser Black-backed Gull *L. fuscus* nests. Also shown are nests where ant *Myrmica rubra* attacks on gull chicks were observed (black), and successful nests where ant densities were sampled (grey), and were not sampled (hatched).

Discussion

Trischen is located within the native range of *Myrmica rubra* and held a gull density in 2013 of 20 breeding pairs per ha (Baer 2013). This study found that both Herring Gull and Lesser Black-backed Gull chicks were affected by *Myrmica rubra* attacks, but despite long-term records of breeding birds on the island, there was no mention of ants causing a problem in the seabird colonies prior to 2011. One reason for this might be the high conservation status of the island; keeping disturbance to a minimum has been the main conservation priority on the island for the past 30 years and seabird colonies were generally not visited unless necessary (Kempf 2000). However, any negative effect of ants on seabird reproduction may be difficult to detect, as the mere presence of ants cannot automatically be attributed to the cause of chick death. Consequently ant interactions with gull chicks were first noticed with the start of intensive productivity monitoring and frequent colony visits, when ants were seen entering pipped eggs and attacking live chicks, leading to their death (Philipps 2012). However, ants were not reported as a problem in 2009 and 2010 (Spalke 2009; Kronberg 2010), the first two years of gull monitoring, which may indicate that ant presence and activity varies between years. Nisbet & Welton (1984) found that in four of the ten years 1972–81 there was heavy predation by the native ant *Lasius neoniger* on Common Tern eggs and chicks, whereas in the remaining years predation was light or absent. They also found that increased chick loss due to ant predation coincided with years of high Great Horned Owl *Bubo virginianus* activity, which kept adults off the nests and increased the chance of ants accessing eggs or chicks. This might also point to the importance of nest attendance and the quality of parental care in relation to ant attacks. DeFisher & Bonter (2013) found that nest site infestation by *Myrmica rubra* caused erratic incubation behaviour in Herring Gulls, possibly affecting embryonic development, and that chicks swarmed by ants either died quickly or had slower growth rates.

The role and reaction of adult gulls to ant presence, possible changes in nest attendance or chick desertion, were not investigated in this study. However in two cases very young (1–2 d) live chicks covered in ants were found outside the nest site, possibly dragged there by an adult and subsequently abandoned. Nest desertion apparently due to ants was not noticed and hatching success was relatively high (89%) despite observed cases of ants entering eggs. *Myrmica rubra* numbers seemed to increase during hatching, which was also found by Safina *et al*. 1994, where the incidence of ants (*Lasius neoniger*) in Roseate Tern nests increased from 9% to 78% after egg pipping. Liquid protein is a favourite food source that *Myrmica rubra* feeds its larvae (B. Seifert pers. comm.), which would explain their attraction to still moist and recently hatched chicks.

Holway *et al*. (2002) point out the vulnerability of island-breeding birds to invasive ants due to the often restricted choice of suitable nesting sites and the potential development of super-colonies once ants arrive at an island. This study also suggests that the choice of nesting sites can potentially be very important. The plotting of nest locations suggests higher ant numbers in the northwest part of the

study colony, where ant attacks were recorded at nine out of 30 nests and breeding success was zero, and lower numbers in the denser, central part of the colony, where ant attack was recorded at only one out of 39 nests, 14 of which fledged young (Figure 4). Competition for prime nest sites may force young or inexperienced pairs to breed at less suitable sites at the periphery of the colony (Patterson 1965; Coulson 1968; Aebischer & Coulson 1990), which in the case of the Trischen study colony may involve areas with higher ant densities. Such birds may also be less adept at chick care (Coulson & White 1958; Pugesek 1983), leaving chicks more vulnerable to ant attacks (Nisbet & Welton 1984). Whether any differences in ant densities were influenced by vegetation pattern was not apparent in this study.

The productivity monitoring shows that the breeding success of both gull species on Trischen was consistently low in 2010–13, with an average fledging success of 0.26 chicks/pair for Herring Gulls and 0.32 chicks/pair for Lesser Black-backed Gulls. A productivity protocol that aims to allow comparisons across larger geographical scales has been introduced by the World Seabird Union (Irons *et al*. 2011). The productivity index (PI: fledglings / clutch size*100) facilitates the classification of breeding success into different categories, with a PI of < 10% classified as poor, 10–50% as moderate and > 50% as good. With a four-year average PI of 9.8% for Herring Gulls and 11.9% for Lesser Black-backed Gulls, the breeding success has been rather poor throughout the study period. Since 2000, the number of Herring Gull breeding pairs on Trischen has declined on average by 5.3% p.a., and Lesser Black-backed Gulls by 0.8 % p.a. (Baer 2013). Other gull colonies in the Wadden Sea area have also experienced low breeding success in recent years, e.g. averages of 0.49 chicks/pair for Lesser Black-backed Gulls and 0.88 chicks/pair for Herring Gulls in 2006–12 on Texel, The Netherlands (Camphuysen 2013).

The consistently low breeding success on Trischen is likely to be due to a number of causes, and low food supply especially appears to have affected chicks near fledging age. However, chick losses of c. 11% attributed to ant attacks, as found in 2011 (Philipps 2012), and c. 15% in 2013 (this study), highlight the potential impact of *Myrmica rubra* on overall gull productivity. Furthermore, these figures are minima, referring only to live chicks actually seen being attacked by ants.

The overall low breeding success of gulls on Trischen suggests that the primary cause of the high chick mortality may be due to poor environmental conditions (e.g. low food supply), and that chicks attacked by ants could have been already weakened by food shortage. However, this is unlikely as the chicks observed being attacked were at such an early stage of development (during and just after hatching). The generally low productivity rate on Trischen also does not explain the patchy distribution of ant-infested nests and successful nests, which more likely reflects ant density patterns.

Myrmica rubra has been reported on a number of German islands such as Amrum, Mellum and some East Frisian islands (Haeseler 1981; Rose & Möhlmann 1993; Haeseler 2008). It is likely that the species also occurs on other islands, but detailed information on ants is rarely available. How *M. rubra* came to colonise Trischen is not clear, but it is unlikely that the species was introduced in the recent past. Trischen had a history of settlement and farming prior to its designation as a bird reserve (Kempf *et al.* 2000), and ants could have arrived at the island at any stage during the past 120 years, or earlier. However, if the high rate of gull chick mortality on Trischen is partially due to the large size of the resident ant population, as this study suggests, *M. rubra* may also affect seabird reproduction in other parts of its native range where conditions allow similarly high ant densities to occur.

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