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Published in:
The Wilson journal of Ornithology

DOI:
10.1676/13-133.1

The Wilson Journal of Ornithology 127(3):467–476, 2015

MODERATE LIVESTOCK GRAZING OF SALT, AND BRACKISH MARSHES BENEFITS BREEDING BIRDS ALONG THE MAINLAND COAST OF THE WADDEN SEA

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ABSTRACT.—Our study investigated how bird species richness and abundance was related to livestock grazing on salt, and brackish marshes, with an emphasis on songbirds, and shorebirds. Survey areas with a high percentage cover of tall vegetation were assumed to have experienced lower livestock grazing intensities than survey areas with a low percentage cover of tall vegetation. This relationship was verified for the tall grass *Elytrigia atherica*. The species richness, and abundance of birds was related to the percentage cover of tall vegetation on the survey areas. We found that total bird species richness was positively related to the percentage cover of tall vegetation. We also found that all of the investigated species, except Pied Avocet (*Recurvirostra avosetta*), showed a positive relation to the percentage cover of tall vegetation up to a specific percentage of cover. The abundance of investigated songbird species increased up to an intermediate percentage cover of tall vegetation, and decreased at higher percentage cover of tall vegetation, suggesting that moderate grazing of marshes may maximize the abundance of the investigated songbirds. Abundances of Common Redshank (*Tringa totanus*) and Eurasian Oystercatcher (*Haematopus ostralegus*) were positively related to the percentage cover of tall vegetation on salt marshes, but negatively related to the percentage cover of tall vegetation on brackish marshes. With intermediate livestock grazing species number, and abundance of most breeding birds can be maintained in coastal marshes. However, specific goals for management should be set before applying a grazing regime to a marsh. *Received 24 August 2013. Accepted 24 December 2014.*

Key words: bird diversity, brackish marsh, *Elytrigia atherica*, *Phragmites australis*, salt marsh, songbirds, shorebirds.

Several studies have shown the importance of moderate grazing in creating and maintaining habitat heterogeneity for birds on salt marshes (e.g., Norris et al. 1997, 1998), and other grassland systems (e.g., Tichit et al. 2005, Sirami et al. 2008, Nikolov 2010). Livestock grazing has also been shown to facilitate foraging by geese in winter (Bos et al. 2005). In the last decades, livestock grazing of salt and brackish marshes has become less economically viable in the Netherlands, leading to a decrease of livestock grazing on coastal marshes (Bakker et al. 1993, Dijkema et al. 2010). On some marshes, livestock densities have decreased, while other marshes have been completely abandoned. Abandonment of salt and brackish marshes has led to an increase in cover of tall climax plant communities such as those dominated by *Elytrigia atherica* in salt marshes and *Phragmites australis* in brackish marshes (Bakker et al. 1993, Esselink et al. 2002, Sammul et al. 2012). With an increase in homogeneous tall vegetation, habitat heterogeneity is lost. Livestock grazing retards the succession of salt-marsh vegetation (Olff et al. 1997, Bakker et al. 2003), leading to a more heterogeneous habitat for birds on marshes. In the Wadden Sea area, the numbers of shorebirds have been declining or have been stable (Koffijberg et al. 2006), while livestock grazing of marshes has decreased, leading to a higher percentage cover of tall homogeneous vegetation on these marshes (Bakker et al. 1993, Dijkema et al. 2010). Salt and brackish marshes are under threat from climate-change driven sea level rise (Dijkema et al. 2010). Grazing management which might increase densities of bird species on the remaining areas of these habitats can potentially help offset reductions in their populations caused by a reduction in the total area of these habitats.

Habitat heterogeneity is deemed an important factor in creating high levels of bird species richness (e.g., Atauri and de Lucio 2001, Cerezo et al. 2011). Grazing, which changes vegetation structure (Bakker et al. 1993), is likely to lead to

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changes in the community composition of breeding birds (Oltmanns 2003). This will be reflected in the species richness and bird abundance. The effects of livestock grazing of salt and brackish marshes on shorebirds are still under debate. Songbird species are generally found to benefit from an increase in tall vegetation (e.g., Oltmanns 2003, Thyen and Exo 2003, Darnell and Smith 2004), but the effect on shorebirds is still unclear. Thyen and Exo (2003) state that increasing livestock grazing may lead to lower bird diversity, because there is a decrease in breeding densities of songbirds, without a parallel increase in shorebirds. They conclude that livestock grazing of saltmarshes is unnecessary and improper for the conservation of salt marsh breeding birds. Norris et al. (1997) found that maximum densities of Common Redshank (*Tringa totanus*) were found at grazed sites with up to 65% cover of *Elytrigia atherica.* This percentage cover was an indication of moderate grazing. Norris et al. (1997) investigated saltmarsh sites where up to a maximum of 65% of the marsh is covered with plant communities dominated by *Elytrigia atherica*. It remains unclear what happens at sites where the percentage cover of *Elytrigia atherica* exceeds 65%. In the Northern Baltic Sea area it was found that the number of breeding shorebirds decreased with increasing cover of reeds that occurred after abandonment of coastal marshes (Helle et al. 1988).

To facilitate management decisions, this study aimed to investigate how bird species richness and abundance is related to livestock grazing on salt, and brackish marshes. Based on the habitat requirements of several shorebird species (Beintema et al. 1995, Thyen 2000, van de Kam et al. 2004), we expected that the highest densities of breeding pairs for many shorebird species would be found at intermediate grazing intensities, ergo at an intermediate percentage cover of tall vegetation. If the percentage cover of tall plant communities increases over time, we expected a subsequent increase in the songbird abundance, and species richness. We estimated livestock density on salt and brackish marshes from the percentage cover of tall plant communities. We verified the relation between livestock density, and the percentage cover of tall plant communities on salt marshes for *Elytrigia atherica*.

METHODS

Study Area.—The study was carried out on salt and brackish marshes located along the Netherlands Wadden Sea coast (53° 23′ N, 5° 49′ E). The Wadden Sea is one of the largest, and most important intertidal systems in the world. The mainland salt marshes of the Netherlands Wadden Sea are largely of anthropogenic origin, because their development has been promoted by ditching and construction of sedimentation fields, from at least the 17^{th} century onwards (Verhoeven 1980, Esselink et al. 2009). These salt marshes, which are important areas for breeding birds, are now part of the Wadden Sea World Heritage site.

There were 30 survey areas total, with seven of the survey areas in brackish marshes located in the Dollard-area and the remaining 23 sites in salt marshes located along the coast of the provinces of Groningen and Friesland. The tidal marshes in the Dollard bay may be inundated by brackish water of the Ems estuary. The vegetation on the Dollard marshes consists mostly of the grass *Puccinellia maritima* on the high marsh, close to the sea wall, and *Aster tripolium*, *Scirpus maritimus*, and *Phragmites australis* among others closer to the sea side of the marsh (Esselink et al. 2000, 2002). The vegetation on the salt marshes consists mainly of grasses such as *Elytrigia atherica*, *Festuca rubra*, and *Agrostis stolonifera* on the high marsh. The lower marsh is dominated by *Pucinellia maritima*, and *Aster tripolium*. The survey areas ranged in size from 21 ha to 447 ha, and they were separated by water-filled ditches. Livestock densities on the survey areas during the study ranged from no livestock to $>$ 1 livestock unit/ha.

Cover Percentage of Tall Vegetation as a Proxy for Stocking Density.—The cover of tall plant communities on marshes is affected by livestock grazing (Olff et al. 1997, Bakker et al. 2003). The cover of these plant communities therefore indicates to what extent a salt or brackish marsh has been grazed (stocking density) in previous years. A higher cover of these communities indicates a low stocking density. We checked this assumption for the tall grass *Elytrigia atherica* (salt marshes only).

On salt marshes along the Wadden Sea coast we placed a total of 50 transects (different from the survey areas where birds were counted). Transects were spread evenly across the length of the salt marshes along the Netherlands Wadden Sea coast. On these transects the percentage cover of *Elytrigia* *atherica* was estimated visually each year from the sea wall to the intertidal flats from 1960 to 2010 by *Rijkswaterstaat* (part of the Netherlands Ministry of Infrastructure and the Environment). Transects were grazed most frequently by cattle but also by horses and sheep. Livestock densities were standardized to livestock units (LU). The livestock grazing density of each transect was classed as ungrazed (0 livestock unit/ha), intermediately grazed ($\leq$ 1.0 livestock unit/ha) or intensively grazed ($>$ 1.0 livestock unit/ha). These classifications were based on literature data for salt marshes in Germany (Andresen et al. 1990, Kleyer et al. 2003), Netherlands (Esselink et al. 2000), and in the UK (Norris et al. 1997). Intensive grazing leads to a very short uniform sward, whereas intermediate or light grazing results in a more uneven patchy vegetation canopy with diverse heights.

The average cover of *Elytrigia atherica* for each stocking density was calculated for every year from 1960 to 2010. To test for a relation between time and the cover of *Elytrigia atherica* at different livestock grazing intensities, the natural log of the average cover + 0.5 was used as the response variable in a linear model with year as a continuous explanatory variable. Linear models were fitted using the base installation of R version 2.15.3 (R Core Team 2013).

Tall Vegetation and Breeding Bird Numbers.— In order to understand the relation between numbers of breeding birds on salt and brackish marshes and the percentage cover of tall vegetation we estimated the percentage cover of tall vegetation and the numbers of breeding birds on 30 survey areas, described in the study area section, between 1992 and 2008.

The percentage cover of tall vegetation in each survey area was estimated from vegetation maps in ArcGIS (ESRI 2009). On brackish marshes, we selected plant communities dominated by *Phragmites australis* or *Elytrigia repens* as tall plant communities (Esselink et al. 2002, Sammul et al. 2012).

Vegetation maps for the Wadden coastline were collected from *Rijkswaterstaat*. The vegetation maps followed the TMAP typology with respect to plant communities (Esselink et al. 2009). TMAP is an agreed vegetation typology used for the Wadden Sea area in all three Wadden Sea Countries (The Netherlands, Germany, and Denmark). For the salt-marsh survey areas vegetation maps were available for the years 1992, 1996, 2002, and 2008, and for the brackish survey areas for the years 1995, 1999, and 2006.

The relationship between livestock grazing and the cover of tall vegetation changes over time. The longer an area has not been grazed, the faster the increase in the percentage cover of tall vegetation. Salt marshes that are intensively grazed by livestock will not be completely overgrown with tall vegetation, while marshes that are not grazed will eventually have a 100% cover of tall vegetation. If no grazing (or other management) had been conducted on our study marshes we assume that they would be completely covered in tall vegetation. The actual percentage cover we estimated from vegetation maps for the different survey areas was therefore used to approximate grazer densities in the survey areas in the years between two vegetation maps.

The number of breeding pairs in each survey area was assessed annually by either territory mapping or counts of breeding pairs. Counts of breeding pairs were used for colony breeding birds where exact counts were possible. The counts followed standardized methods developed for surveys of breeding birds in the Netherlands by SOVON Dutch Centre for Field Ornithology (van Dijk and Boele 2011). With these counts, we calculated bird species richness (sum of species) and total bird abundance (sum of breeding territories) for the complete surface of each survey area in every year for which both breeding bird counts and vegetation maps were available. In addition, we calculated shorebird species richness, and songbird species richness separately. We also calculated the abundance of the three most common shorebird species (Pied Avocet [*Recurvirostra avosetta*], Eurasian Oystercatcher [*Haematopus ostralegus*], and Common Redshank) and the three most common songbird species (Meadow Pipit [*Anthus pratensis*], Eurasian Skylark [*Alauda arvensis*], and Reed Bunting [*Emberiza schoeniclus*]).

Analysis.—We used generalized estimating equations (GEE) with a log link and Poisson error structures to assess the relationship between breeding birds and the percentage cover of tall vegetation. GEEs are extensions of Generalized Linear Models that allow for modeling of correlated data, such as time series data (Hardin and Hilbe 2003). Bird counts in the same survey area at different times are not independent of each other. The closer two counts are in time, the higher the likelihood that similar numbers of birds are counted in the area. In this study, within-survey

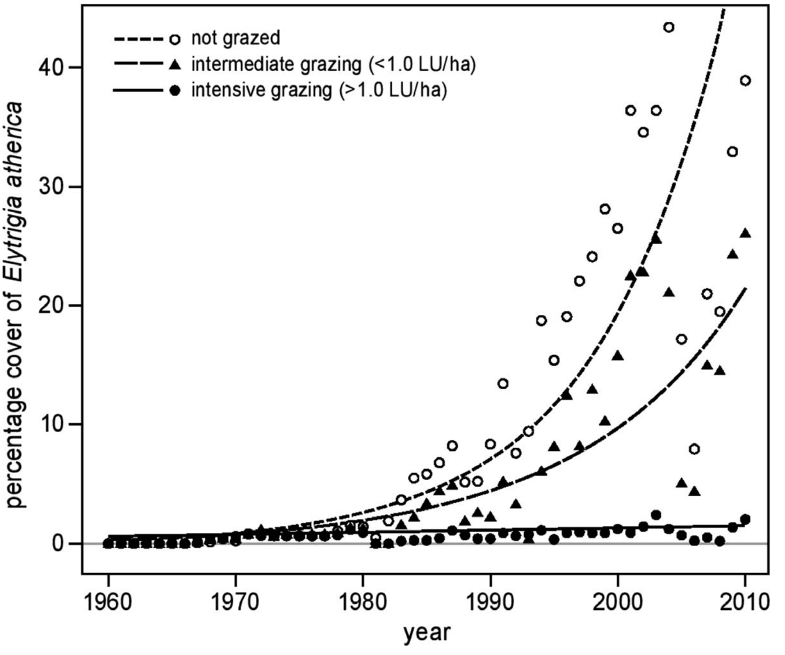

FIG. 1. The percentage cover of sea couch *Elytrigia atherica* on salt marshes along the Netherlands Wadden Sea coast from 1960 to 2010. For each year mean cover is calculated for 15 ungrazed transects, 19 intermediately grazed transects and 16 intensively grazed transects.

area bird counts can be modeled as a function of this 'time-distance' between years (Zuur et al. 2009). Hence, we used an auto-regressive correlation structure of order 1 (AR1) for the residuals to model our time series observations. An offset variable (the natural log of the surface area (ha) of each survey area) was included in the models to account for differences in size of the survey areas. Using an offset variable instead of analyzing densities has the advantage of allowing for heterogeneity within the context of a Poisson distribution (Zuur et al. 2009).

In a first series of statistical models, we used bird species richness and abundance as response variables, and percentage cover of tall vegetation and percentage cover of tall vegetation squared to allow for a polynomial effect of vegetation, as explanatory variables. As there are inherent differences in plant community types associated with salt and brackish marshes, we made a second series of statistical models to test for differences in the relation of bird abundance, and species richness with the cover of tall vegetation on salt and brackish marshes. In this second series of models, the bird species richness, and abundance were used as response variables. The explanatory variables in these models were: percentage cover of tall vegetation, marsh type (salt or brackish marsh), and the interaction between percentage cover and marsh type. A separate series of models was made to avoid over parameterization of the first series of models. Statistical models were reduced by backwards elimination and by an evaluation of models at every step on the basis of Wald statistics. Wald statistics are useful when comparing models with nominal variables (Zuur et al. 2009). Trends in the residuals were checked to make sure assumptions for the models were met for all models. GEEs were fitted using the geepack library (Højsgaard et al. 2006) in R, version 2.15.3 (R Core Team 2013).

RESULTS

Cover Percentage of Tall Vegetation as a Proxy for Stocking Density.—On the ungrazed transects we found a significant relation of the natural log of the percentage cover of *Elytrigia atherica* with time in years ($F = 576.37$, $P < 0.0001$; Fig. 1). On the intermediately grazed transects we also found a significant relation between the natural log of the percentage cover of *Elytrigia atherica*, and time in years ($F = 237.87$, $P < 0.0001$).

TABLE 1. Mean numbers (± SE) of species, and breeding bird pairs counted on all survey areas in the years that vegetation maps were available.

Species	Mean
Species richness (number of species/survey area/year)	
Total species richness	12.5 ± 0.5
Shorebird species richness	4.2 ± 0.3
Songbird species richness	4.5 ± 0.1
Bird abundance (number of birds/survey area/year)	
Total bird abundance	541.0 ± 79.9
Pied Avocet abundance	69.1 ± 11.8
Eurasian Oystercatcher abundance	52.2 ± 4.9
Common Redshank abundance	24.2 ± 2.7
Meadow Pipit abundance	20.3 ± 3.7
Eurasian Skylark abundance	5.3 ± 1.3
Reed Bunting abundance	5.0 ± 1.0

However, the relation was not as strong as on the ungrazed marshes (Fig. 1). On intensively grazed marshes we again found a relation between the natural log of the percentage cover of *Elytrigia atherica*, and time in years ($F = 25.879$, $P < 0.0001$), but this relation again was not as strong as on the ungrazed or the intermediately grazed transects (Fig. 1).

After approximately 50 years the cover of tall vegetation on an ungrazed marsh may reach 100%. On intermediately grazed marshes, the cover of tall vegetation grows less quickly and only reaches about 30% after 50+ years of grazing. Although this may grow to a higher percentage, livestock will prevent the cover of tall vegetation reaching 100%. On the intensively grazed marshes the cover of tall vegetation does grow, but to less than 10% after 50+ years of grazing (Fig. 1).

Tall Vegetation and Breeding Birds.—Mean bird species richness over all survey areas for all years was 12.5 ± 0.5 (mean ± SE). Bird species richness was relatively evenly distributed between shorebirds (4.2 ± 0.3) and songbirds (4.5 ± 0.1; Table 1).

There was a significant positive relationship between total species richness and the percentage cover of tall vegetation, but the slope of this relationship decreased over time (Fig. 2). This positive relationship was mainly driven by the species richness of songbirds. Shorebird species richness exhibited a significant positive relationship with the cover of tall vegetation in the early years of this study, but no trend was found in the later years (Fig. 2, Table 2).

The abundance of all investigated bird species, except Pied Avocet, was significantly positively related with the cover of tall vegetation. The three focal songbird species all showed maximum densities at an intermediate cover of tall vegetation, while Eurasian Oystercatchers and Common Redshanks showed a general positive relationship with the cover of tall vegetation (Fig. 3, Table 2).

The abundance of birds was not just explained by the cover of tall vegetation. The total bird abundance, and the abundance of Pied Avocets both declined over time, while the number of Eurasian Skylarks increased with time. The relation between the cover of tall vegetation and species richness or abundance of Eurasian Skylarks or Eurasian Oystercatchers also weakened with time (Figs. 2–3, Table 2).

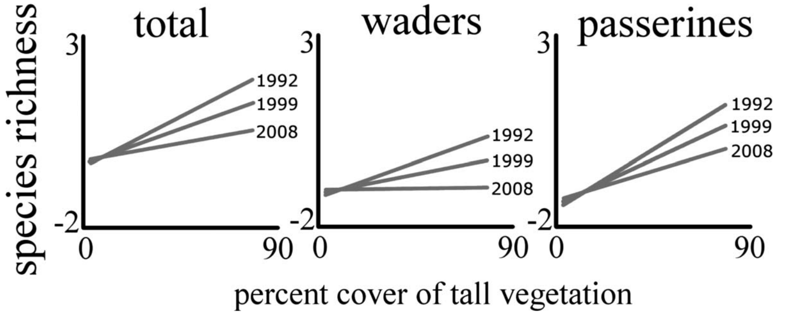

FIG. 2. Fitted lines modeling species richness as a function of cover of tall vegetation and year. On the x-axes of the plots is the cover of tall vegetation as a percentage of the total vegetated area, from 0% to 90%. The y-axis shows the estimates of the model on a log scale. Note that the number of breeding pairs is offset in the model based on the size of the survey areas. This allows the model to take into account the different sizes of the survey areas. When a significant year effect, and/or an interaction between year and cover of tall vegetation was found in our statistical model, three years have been plotted to understand the change in intercept and/or slopes over the years of this study.

TABLE 2. Results of a GEE for the relation between the percentage cover of tall vegetation, and species richness, and abundance (first series of models).

	Vegetation			Year			Vegetation^2			Vegetation:year		
		X^2	*P*		X^2	*P*		X^2	*P*		X^2	*P*
species richness	+	5.22	0.02	+	0.34	0.56		0.89	0.34	–	4.79	0.03
shorebird species richness	+	6.73	0.01	+	0.64	0.42		1.15	0.28	–	6.32	0.01
songbird species richness	+	4.5	0.03	+	0.68	0.41		0.054	0.82	–	3.94	<0.05
species abundance	+	10.1	<0.01	–	43.4	<0.0001		1.12	0.29		0.18	0.67
Pied Avocet	–	4.24	0.04	–	9.66	<0.01		0.15	0.69		1.64	0.2
Eurasian Oystercatcher	+	13.9	<0.001	–	1.7	0.19		1.4	0.24	–	14.5	<0.001
Common Redshank	+	21.1	<0.0001		0.18	0.67		2.34	0.13		3.59	0.06
Meadow Pipit	+	19.1	<0.0001		0.89	0.35	–	14.1	<0.001		0.06	0.79
Eurasian Skylark	+	9.22	<0.01	+	20	<0.0001	–	6.38	0.01	–	9.2	<0.01
Reed Bunting	+	20	<0.0001		0.016	0.9	–	4.84	0.03		0.60	0.44

Salt and Brackish Marshes.—For the species richness and the total species abundance, we did not find that the relation with the cover of tall vegetation differed on salt or brackish marshes. However, on brackish marshes we found that the positive relation of abundance of Meadow Pipits and Reed Buntings with the cover of tall vegetation was stronger than on salt marshes. For Eurasian Oystercatchers and Common Redshanks on the other hand, we found there was a positive relationship with the cover of tall vegetation on salt marshes, but a negative relationship with brackish marshes (Table 3).

DISCUSSION

Cover of Tall Vegetation as a Proxy for Stocking Density.—Our results show that the cover of the tall grass *Elytrigia atherica* increased over time on salt marshes. This increase is much more rapid on ungrazed marshes than on intermediately or intensively grazed marshes (Fig. 1). This agrees with studies by Bakker et al. (1993) and Olff et al. (1997) who found that livestock grazing retards vegetation succession on salt marshes. We therefore conclude that the percentage cover of *Elytrigia atherica* on a salt marsh can be used as an approximation of grazer density on a salt marsh in previous years, provided the salt marsh has existed for several decades and tall vegetation has had the opportunity to spread over the marsh if not managed. We extend this assumption to other tall plant communities affected by livestock grazing, such as communities dominated by *Phragmites australis* on brackish marshes or *Atriplex portulacoides* on salt marshes.

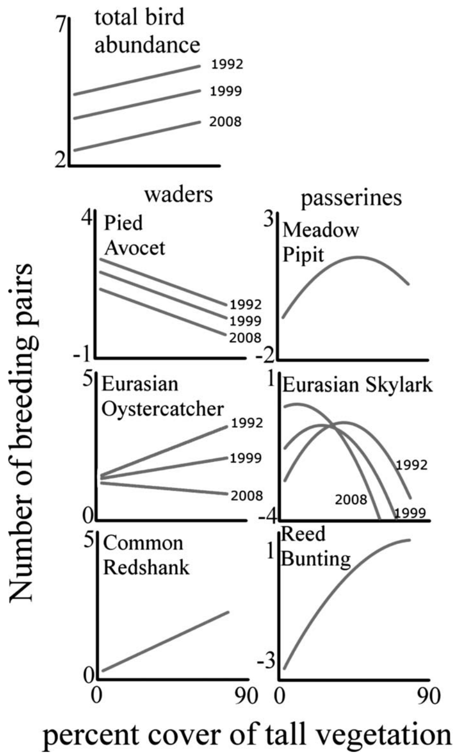

FIG. 3. Fitted lines modeling number of birds as a function of cover of tall vegetation + cover of tall vegetation squared + year + cover of tall vegetation*year. On the x-axes of the plots is the cover of tall vegetation as a percentage of the total vegetated area, from 0 to 90%. The y-axis shows the estimates of the model on a log scale. Note that the number of breeding pairs is offset in the model based on the size of the survey areas. When a significant year effect, and/or an interaction between year and cover of tall vegetation was found in our statistical model, three years have been plotted to understand the change in intercept and/or slopes over the years of this study.

TABLE 3. Results of a GEE for the interaction between the percentage cover of tall vegetation with marsh type (salt marsh or brackish marsh) (second series of models). In the table 'vegetation' is the percentage cover of tall vegetation, and 'marsh type' is a factor with two levels, salt or brackish marsh. 'Brackish', and 'salt' indicate the direction of the relation between species richness and abundance when there was a significant difference in the relation of species richness, and abundance with the percentage cover of tall vegetation between the two marsh types.

	Vegetation: marsh type			
	X^2	P	Brackish	Salt
species richness	0.484	0.49		
shorebird species richness	1.59	0.21		
songbird species richness	0.518	0.47		
species abundance	0.107	0.74		
Pied Avocet	0.11	2.58		
Eurasian Oystercatcher	20.3	<0.0001	–	+
Common Redshank	32.3	<0.0001	–	+
Meadow Pipit	8.85	0.0029	+	++
Eurasian Skylark	1.49	0.22		
Reed Bunting	7.7	0.0055	+	++

Tall Vegetation and Breeding Birds.—The total species richness as well as shorebird species richness and songbird species richness increased with increasing cover of tall vegetation. This agrees with the study by Thyen and Exo (2003) who concluded that decreasing management of salt marshes has a positive effect on shorebirds. However, the abundance of all three of the focal songbird species increased up to an intermediate percentage cover of tall vegetation (Fig. 3), suggesting that some grazing may have a positive effect on these songbird species, because it will prevent marshes from being completely overgrown with tall vegetation. Only for the abundance of Pied Avocets did we find a negative relation with the percentage cover of tall vegetation, indicating that grazing or other management is necessary for this species.

The positive relation found for Reed Buntings with cover of tall vegetation may be explained by the dead stems of tall vegetation providing these birds with song perches. Additionally tall vegetation provides concealment of their nests in *Phragmites australis* tussocks or *Elytrigia atherica* (Bauer and Glutz von Blotzheim 1966). Survival of nests at the egg stage is positively related to the extent of concealment of nests in Reed Buntings (Brickle and Peach 2004). Maximum numbers of breeding Eurasian Skylarks were reached on marshes with an intermediate percentage cover of tall vegetation. However over the course of the years, the maximum numbers of Eurasian Skylarks were found at a lower percentage cover of tall vegetation, ergo at more intensively grazed marshes (Fig. 3). Spring has commenced earlier in Europe the past decades (Sparks and Menzel 2002); therefore, the structural diversity of salt and brackish-marsh plant communities at the time of arrival of Eurasian Skylarks may have changed over time. For Eurasian Skylarks, this may lead to a change in the preferred plant communities to breed in, and they may shift to sites with a lower cover of tall plant communities. The positive relation we found for Common Redshanks with the cover of tall vegetation complies with the findings by Norris et al. (1997) who found that breeding Common Redshanks were most abundant in grazed marshes with *Elytrigia atherica* where the vegetation was structurally diverse. Our results show that structural habitat heterogeneity can be increased on marshes with livestock grazing. With moderate livestock grazing and increased habitat heterogeneity the abundance of several songbird, and shorebird species was increased.

The percentage cover of tall plant communities over a marsh can be reduced with livestock grazing (Bakker et al. 1993, Fig. 1). The investigated songbirds in this study decreased in abundance when the cover of tall vegetation became too great. The waders increased with increasing cover of tall vegetation, but previous studies showed that habitat heterogeneity is an important factor for breeding shorebirds (e.g., Norris et al. 1997). We found that some livestock grazing of salt, and brackish marshes is, therefore, appropriate to manage the cover of tall vegetation of a marsh, increasing habitat heterogeneity for songbirds as well as shorebirds. Our findings contradict the conclusions by Thyen and Exo (2003) who stated that management of salt marshes is unnecessary and improper for the conservation of salt-marsh breeding birds.

Trends in Time.—For two individual species we found a significant change in abundance over time (Table 2). Pied Avocets declined over time. This is a colonial breeding species, which is particularly vulnerable to predation. Our results suggest that apart from the cover of tall vegetation, there are other important factors determining the number of breeding pairs for this species. One possibility that has been suggested is increased predation by foxes as a major influence on the decline of colonially breeding bird species (van Dijk et al. 2009, van Dijk and Oosterhuis 2010, van Kleunen et al. 2010). For Eurasian Skylarks, we found a positive trend over time on salt and brackish marshes. Eurasian Skylarks may not be affected by foxes as much as Pied Avocets, because they do not form the close-knit colonies with open nests like Pied Avocets. For Eurasian Skylarks the increase in abundance found is especially interesting, because the total number of breeding Eurasian Skylarks in the Netherlands has declined (Boele et al. 2012).

Salt and Brackish Marshes.—For two shorebird species (Eurasian Oystercatcher and Common Redshank), and two songbird species (Meadow Pipit and Reed Bunting) we found that the relation between the abundance of these species and the percentage cover of tall plant communities was significantly different on brackish marshes, and salt marshes. Meadow Pipits and Reed Buntings showed a positive relationship with the percentage cover of tall vegetation, but the relationship was significantly stronger on salt marshes than on brackish marshes. Nests of these songbird species may be more easily concealed in dense *Elytrigia atherica* on salt marshes, compared to the more open *Phragmites australis* on brackish marshes. Eurasian Oystercatchers and Common Redshanks showed a positive relationship with the percentage cover of tall vegetation on salt marshes, but a negative relationship on brackish marshes. The preferred breeding sites of Eurasian Oystercatchers are close to the intertidal flats (Ens et al. 1992). On brackish marshes tall vegetation, consisting predominantly of *Phragmites australis*, spreads from the water's edge onto the marsh. On salt marshes the predominant tall vegetation (*Elytrigia atherica*) spreads from the landward side onto the marsh. We therefore speculate that the tall vegetation that negatively affects Eurasian Oystercatchers is more dominant at the preferred breeding sites on brackish marshes than on salt marshes.

Conclusions.—We conclude that abandonment of brackish marshes and salt marshes (ceasing livestock grazing), which lead to an increasing cover of tall plant communities, did not cause a decline in species richness or a decline in 'typical' marsh species such as Eurasian Oystercatcher and Common Redshank. The findings of Thyen and Exo (2003) agree with our conclusions, but we recommend that the complete abandonment of grazing of marshes is inappropriate because abandonment will lead to a homogeneous tall vegetation structure and less habitat heterogeneity.

For managers of salt and brackish marshes, not all species may have equal conservation interest (Baudry 1991, Suárez-Seoane et al. 2002). Pied Avocets, for example, are listed as species to be protected by the European birds directive which was updated in 2009 (European Parliament and the Council of the European Union 2009) and a substantial part of the world's population of Pied Avocets breeds in the Wadden Sea area (Koffijberg et al. 2006). Abundance of Eurasian Skylarks decreased nationally in the Netherlands (Boele et al. 2012), while we found an increase on salt marshes.

At a high cover of tall vegetation, however, we found that several bird species are negatively affected (e.g., Pied Avocet, Meadow Pipit, and Eurasian Skylark) by an increasing cover of tall vegetation. Hence, abandonment of all livestock grazing may be detrimental for some breeding bird species on a longer term. Therefore, marsh managers should set clear goals before applying a grazing regime to a marsh.

Our results indicate that moderate livestock grazing can be used to limit the spread of tall vegetation over salt and brackish marshes (Fig. 1), as well as changing the structural diversity within tall plant communities. With moderate livestock grazing, species number, and abundance of most breeding birds can be maintained in coastal marshes. Large parts of the salt, and brackish marshes along the Netherlands Wadden Sea coast are owned by nature conservation organizations. Other marshes are often managed with the prescriptions of agri-environment schemes. Agri-environment schemes that have the goal to protect specific bird species should investigate the grazing management best suited to specific species.

ACKNOWLEDGMENTS

We would like to thank the members of the FFF (*Fryske Feriening foar Fjildbiology*), and *Avifauna Groningen* for collecting data on breeding bird territories. *It Fryske Gea*, *Stichting Het Groninger Landschap* and private landowners allowed us to survey breeding birds on their properties. We thank *Rijkswaterstaat*, especially Bas Kers, for providing vegetation maps, and the *Waddenfonds* for funding this study. We also like to thank several reviewers for comments on earlier versions of this manuscript.

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