Black Terns Chlidonias niger and Their Dietary Problems in Dutch Wetlands

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Black Terns *Chlidonias niger* and their dietary problems in Dutch wetlands

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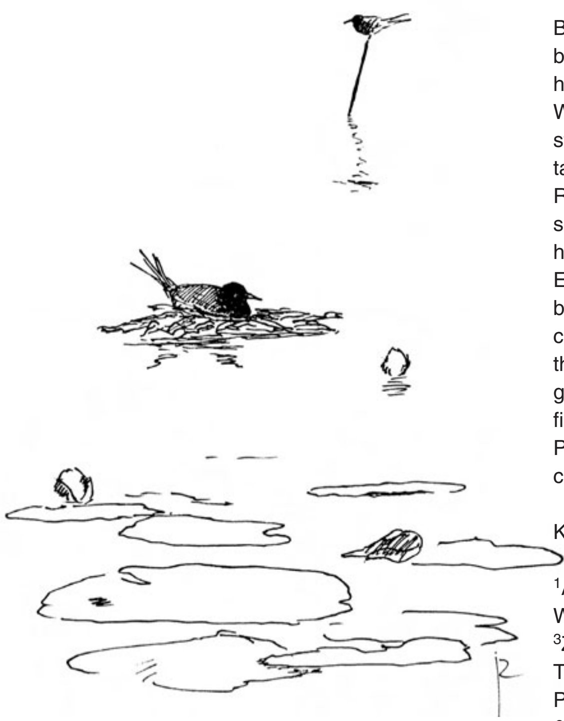

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Black Terns *Chlidonias niger* have shown a decrease of well over 90% as a breeding bird in The Netherlands during the twentieth century. Two hypotheses have been put forward for this decline: the disappearance of the floating plant Water Soldier *Stratiotes aloides*, which used to be the favourite nesting substrate of the terns, and a decrease of available insect food for the chicks, notably dragonflies. Both effects are attributed to eutrophication of surface waters. Reproductive bottlenecks vary greatly among areas and habitats. In river landscapes, no signs of food shortage could be found, and loss of nesting substrate has been successfully compensated for by offering artificial nest rafts. Extremely low fledging success in moors and in lowland grasslands is caused by food problems. In this case, artificial rafts are less successful. With decreased insect availability, fish and earthworms have become more important in the chicks' diet, but these are less reliable as a food source. Fledging success greatly depends on the amount of fish in the diet. Also, a minimum amount of fish is always needed to cover the calcium need of the chicks. In north-eastern Poland, there were no problems with either nesting places or food for the chicks.

Key words: Black Tern, *Chlidonias niger*, prey availability, growth, starvation

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Black Terns *Chlidonias niger* have decreased over most of their range in Europe, but most strongly so in western Europe (Tucker & Heath 1994). In The Netherlands, formerly with 15,000–200,000 pairs one of the strongholds of the species, the decline has been more than 90% this century (van der Winden *et al.* 1996). Presently, Russia and Belarus are the only European countries with populations of over 10,000 pairs (Tucker & Heath 1994). Similar decreases have also been reported for the American subspecies *Chlidonias niger surinamensis* by the North American Breeding Bird Survey, especially from the prairie region and the north-eastern states (B.G. Peterjohn & J.R. Sauer, pers. comm.).

Black Terns not only suffered from habitat loss due to drainage and conversion of wetlands, but also from deterioration of quality within their remaining habitats. An important factor specific for western Europe is the large-scale disappearance of Water Soldier *Stratiotes aloides*, due to eutrophication of surface waters (Smolders 1995). Dense floating mats of Water Soldier used to be a favourite nesting substrate for Black Terns (Haverschmidt 1933, 1978, Baggerman *et al.* 1956, Spillner 1975, Hahnke 1992), and loss of such nesting places has often been considered a major factor in the decline of the species (Haverschmidt 1978, Litzkow 1992, Schröder & Zöckler 1992, Dittberner &

Dittberner 1993), To compensate for this loss, Black Terns have often been offered artificial rafts to nest on, with a varying degree of success (Timmerman 1961, Haverschmidt 1978, Hahnke & Becker 1986, Steen 1987, van der Winden *et al.* 1996).

Although there is little quantitative evidence, there is also a general belief that eutrophication and pollution have led to a decrease in insects, notably the large insects which form the major food for the chicks (Glutz von Blotzheim & Bauer 1982, Cramp 1985). Impoverishment of insect fauna within the Odonata family (dragonflies and damselflies) has been documented for The Netherlands by Wasscher & van Tol (1993).

This paper concentrates on the hypothesis that decreased food availability has been a major factor in the decline of the Black Tern. Breeding success and the impact of nest substrate on clutch survival are dealt with by van der Winden *et al.* (2001).

METHODS

From 1992–1996 we observed various colonies in The Netherlands and, as a reference, in 1994 also one in a rather undisturbed habitat in Poland. Observations on feeding of the chicks were made in the four main habitats of the species (Beintema 1993, van der Winden *et al.* 1996, 2001), i.e.:

(1) River landscapes (oxbows, gravelpits etc.): Ooypolder (Province Gelderland), Biebrza Marshes (Poland).
(2) Lowland peat lakes and fens: Ankeveen (Province Noord-Holland), Vuntus, Tienhoven (Province Utrecht).
(3) Lowland meadow polders: Demmerik, Kockengen (Province Utrecht), Krimpenerwaard (Province Zuid-Holland).
(4) Moorland pools: Bargerveen (Province Drenthe).

Depending on accessibility, nests were visited by boat or on foot, or were only observed through a telescope from the shore or from a boat keeping a distance. Observations on parents feeding their chicks were made with 10 × binoculars from a hide at 6–10 m from the colony, or with a 20–40 × telescope from a greater distance. Black Terns bring food items to the chicks one by one. Each food item was recorded, and, if possible, the parent which brought it was identified. Males and females slightly differ in coloration, but feeding occurs very quickly. Often the parent does not even land, but feeds the chick while hovering over it. In a few cases it could also be recorded which chick was being fed.

Over 10,000 food items were recorded (634 observation hours). Usually, the following categories could be distinguished: fish, earthworms, slugs, dragonflies (Anisoptera, *e.g. Orthetrum* sp.), damselflies (Zygoptera, *e.g. Lestes* sp.), moths, aquatic beetle larvae (*e.g. Dytiscus* spec.), unidentified insects (in various size classes, down to 'invisible').

In some colonies, small wire mesh enclosures (30 cm high and 1 m diameter) were built around individual nests, to enable recaptures of individual chicks, to monitor body mass development. Where possible, enclosures were built around all available nests in a colony to avoid chaos due to disturbance during weighing. Chicks were weighed to the nearest gram using Pesola spring balances.

RESULTS

Food types

Food types fed to the chicks, and their relative frequency in the chicks' diet in different habitats, are summarised in Table 1 and Figure 1. Larger prey items are shown in the left-hand side of the diagrams.

Where fish were available (all areas except Bargerveen), fish were being fed to the chicks most often by the males (Fig. 2, $P < 0.001$, Chi-square test with Yates correction).

There were large individual differences within colonies. Some males and females specialised in earthworms. In Ooypolder there was one male specialising in stealing food from the neighbours, with a high preference for neighbours which were good at fishing (Beintema 1997a).

Table 1. Food types brought to Black Tern chicks in The Netherlands, all habitats, 1992–96 (n = 10,334 preys).

Food item	Percentage
Fish	8.60
Earthworms	2.78
Slugs	0.19
Aquatic larvae	10.95
Dragonflies	3.56
Damselflies	8.57
Moths	0.94
Other insects	10.84
Tiny objects	48.95
Unknown	4.61
Total	99.99

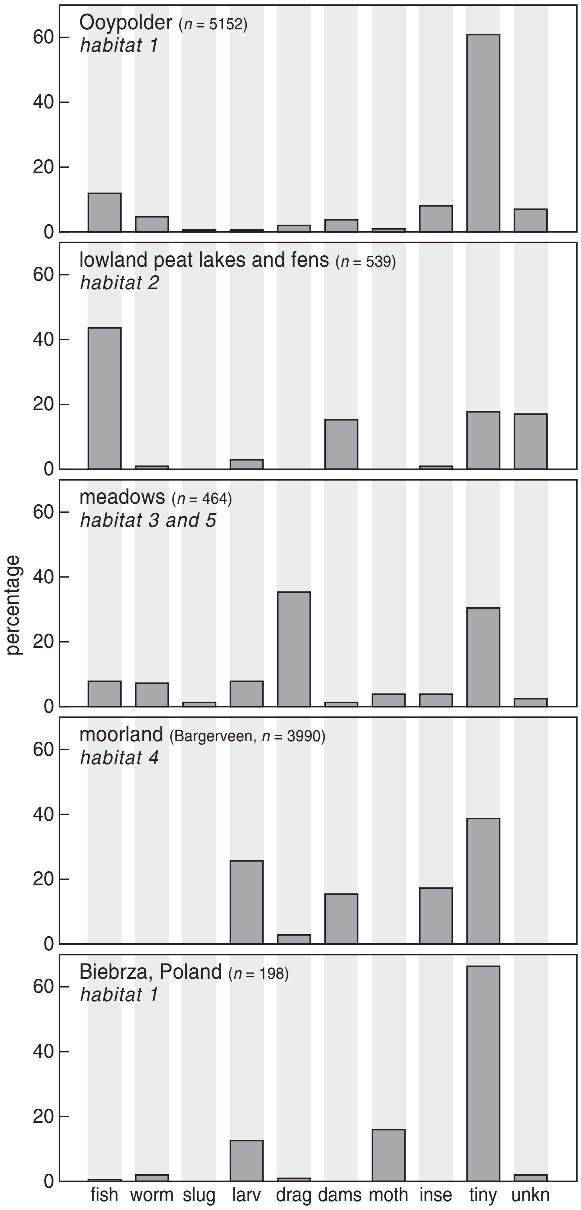

Figure 1. Contribution of different prey types (percentages) to the food brought to Black Tern chicks in different habitats. Worm = lumbricid earthworms, larv = aquatic larvae of Odonata and *Dytiscus* sp., drag = dragonflies, dams = damselflies, inse = other insects, tiny = unidentified tiny prey, unkn = unknown.

Black Terns in river landscapes

Black Terns in the study colony in Ooypolder almost exclusively nest on artificial rafts. There had been a considerable decrease in numbers until rafts were presented in the 1980s. Since then, numbers have increased and are now stable (van der Winden *et al.* 2001).

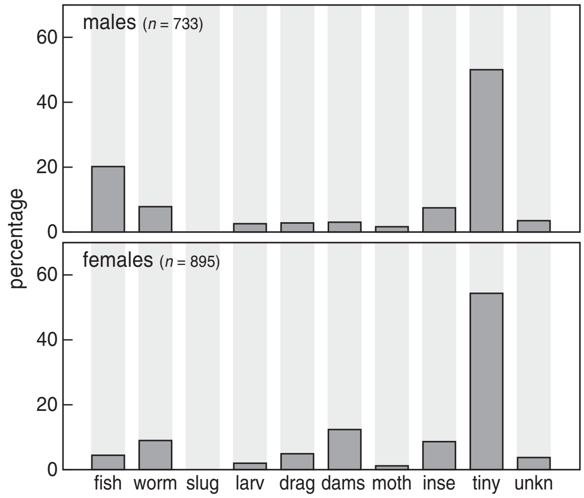

Figure 2. Prey brought to Black Tern chicks by males and females. Legend as in Fig. 1.

Figure 3 shows feeding frequencies for 1992 and 1995. In 1995, fewer fish were brought, which was compensated for by much higher frequencies of (often tiny) insects. Feeding frequencies could reach 60 items per hour, in which case most prey were found within less than 50 m from the nest, where they were picked up from the water surface (probably emerging chironomids). During wet days earthworms were brought from nearby ploughed fields, especially early in the morning.

In the Biebrza, Poland, feeding was only observed for chicks up to three days of age. Frequencies were about 10 items per chick per hour, and very few fish were brought. Instead, there was a comparatively high percentage of large aquatic beetle larvae (Fig. 1), mainly *Dytiscus* sp.

Black Terns in lowland peat lakes and fens

In Ankeveen, Tienhoven and Vuntus, over 40% of the food items brought to the chicks were fish (Fig. 1). Under wet weather conditions, earthworms were taken in nearby meadows or grazed pasture.

In Ankeveen, like in Ooypolder, the proportion of fish in the chicks' diet was lower in 1993 than in 1992 (Fig. 4). In Ankeveen this coincided with a much lower fledging success in 1993 (van der Winden *et al.* 2001).

Black Terns in lowland meadows

In Demmerik feeding of the chicks was studied in 1996, because in 1995 it was reported that chicks were often found dead on the nests (L. Heemskerk, pers. comm.). During the first half of the season, all chicks grew well,

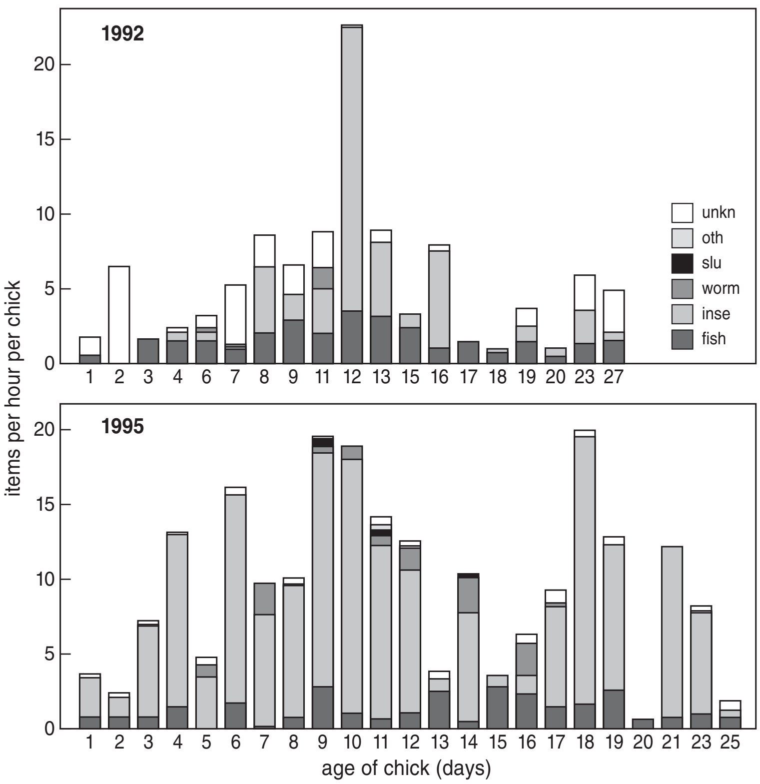

Figure 3. Feeding frequencies of Black Tern chicks at different ages in Ooypolder in two years. Ins = insects, wor = earthworms, slu = slugs, oth = other, unk = unknown.

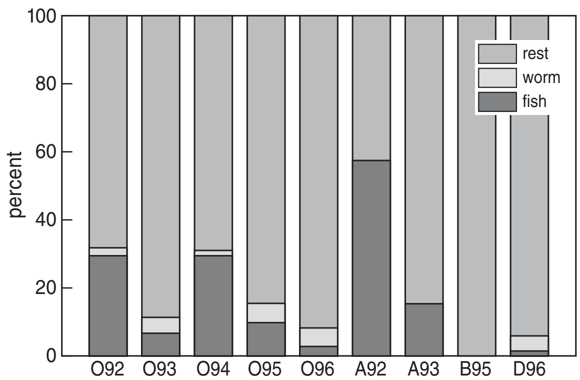

Figure 4. Contribution of fish and earthworms to the food brought to Black Tern chicks in Ooypolder in five years, 1992–1996 (O92-O96), Ankeveen in two years, 1992–1993 (A92-A93), Bargerveen 1995 (B95) and Demmerik 1996 (D96).

being mostly fed on freshly emerging dragonflies *Orthetrum cancellatum*. This was followed by a cold spell with frequent rain. The terns caught no more dragonflies, no fish, and only few other prey. All observed chicks started to lose weight and died. As an example, Figure 5 shows the nest of which the chicks survived the longest.

Black Terns in moors and heathland

Soft water bodies in moors and heathland were commonly inhabited by Black Terns in the past, but these waters have now almost completely been abandoned by the species (van der Winden *et al.* 1996).

Bargerveen is rich in large insects and their aquatic larvae, but there is no fish (Baarspul & de Krijger 1995). In spite of abundant food and high feeding frequencies, the Black Terns could not raise their chicks. After a week of rapid growth, the chicks started to lose weight and showed deformations of wings and legs. During this phase they often refused to take the insects offered to them by their parents. In 1995 all chicks observed died of what turned out to be severe calcium deficiency (Beintema *et al.* 1997).

In 1996 calcium pills were administered to a few chicks. These chicks fledged normally, while the others died (Beintema *et al.* 1997). Table 2 lists the calcium content of various prey items and some Black Tern chicks.

Growth and survival

Observations on chick growth were made in Ooypolder in 1993–94 and Ankeveen in 1992–93 (including Vuntus data for 1992).

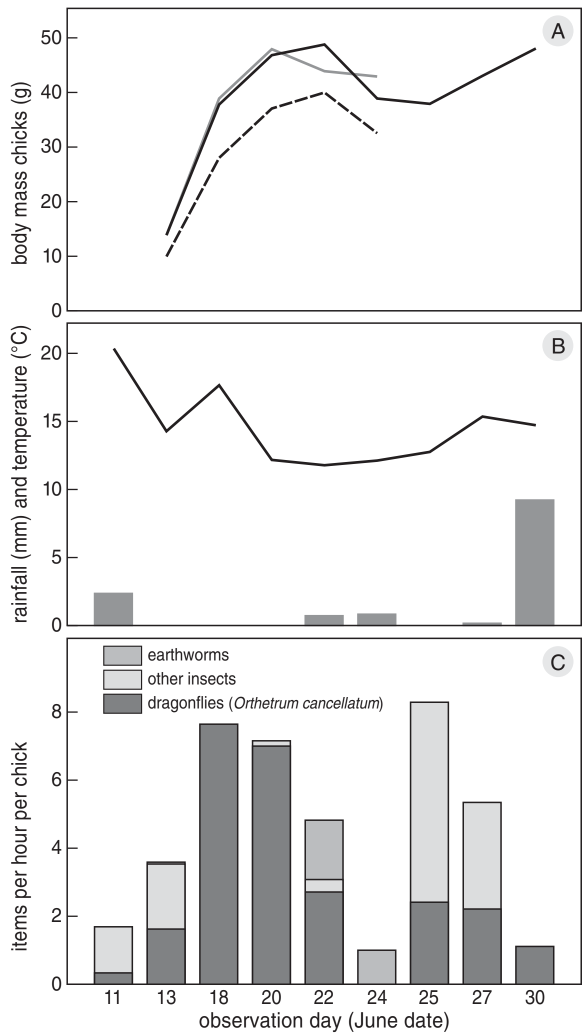

Figure 5. Body mass of three Black Tern chicks in nest 16 in Demmerik by date in 1996 (A); the average daily temperature in °C (line) and rainfall in mm by date (B); feeding frequencies at nest 16 by date (C).

Table 3 lists linear growth rates over the period up to day 11, for chicks surviving until fledging and those which did not survive. For each chick, one estimate was used, based on the longest possible interval between measurements during this period. If a chick had been measured only once (at a known age >2 days) a birth mass of 9 g was assumed (mean birth mass = 9.10 g; SD = 1.59, n = 40). In Ooypolder, surviving chicks grew faster than chicks which died. In Ankeveen (including Vuntus data) this is less obvious. Figure 6 shows the average body mass development of chicks surviving until fledging.

In Ooypolder, A-chicks (first born) and A- and B-chicks combined survived better than C-chicks (Table 3, $P < 0.05$, Chi-square with Yates' correction); in Ankeveen this was not significant. Table 3 also suggests a difference in survival between A- and B-chicks, but this was not significant.

Table 3. Linear growth (g/d) during the first 11 days in A-, B-, and C-chicks (n = number of chicks). Asterisks indicate level of significance of difference in growth rates between fledged and lost chicks (Student's T-test; * $P < 0.05$, ** $P < 0.005$, *** $P < 0.001$, n.s. not significant).

		Fledged chicks		Lost chicks		
		g/d	*n*	g/d	*n*	
Ooypolder	A	4.73	23	3.30	7	**
	B	4.62	16	3.69	7	*
	C	4.44	2	1.01	5	**
Ankeveen	A	4.29	14	4.01	12	n.s.
	B	4.45	9	3.46	14	*
	C	4.58	3	2.72	5	n.s.
All chicks		4.56	67	3.32	48	***

Table 2. Calcium content (% Ca^{2+} dry matter) of some prey items and dead Black Tern chicks. Sources: 1 = Tim Bruynzeels (pers. comm.), 2 = Baarspul & de Krijger (1996).

Prey type	Area	Ca^{2+}	Source	Dead Black Tern chicks		Area	Ca^{2+}	Source
				Age (d)	Body mass (g)			
Dragonflies and damselflies[a]	Bargerveen	0.102	1,2	7	27	Bargerveen	0.51	1
Water beetle larvae[b]	Bargerveen	0.095	2	17	42	Bargerveen	0.99	1
Heteroptera aquatica[c]	Bargerveen	0.089	1	4	6	Demmerik	1.96	1
Heteroptera aquatica[c]	Ooypolder	0.238	1	5	12	Demmerik	1.82	1
Fish[d]	Ooypolder	3.512	1					

[a]*Aeschna* spec., *Libellula quadrimaculata, Sympetrum cyathigerum, Lestes sponsa* and *Lestes* spec.
[b]*Dytiscus* spec. [c]*Notonecta glauca* and *Corixa punctata*. [d]Young *Rutilus* spec.

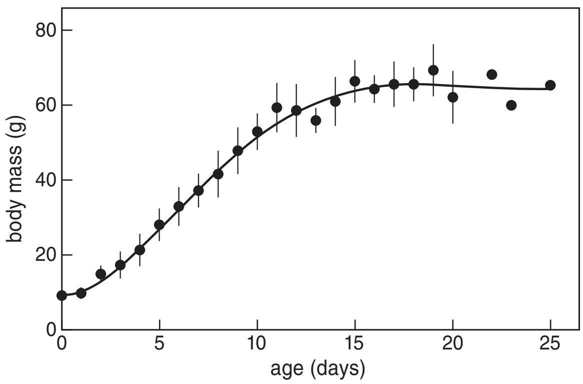

Figure 6. Body mass development of surviving Black Tern chicks; means and SD are indicated (n = 15, 9, 16, 8, 16, 12, 8, 10, 10, 15, 10, 17, 23, 12, 4, 12, 13, 10, 17, 10, 4, 1, 1). Data points are not independent because individuals have been weighed at different ages.

In Biebrza, Poland, no distinction could be made among A-, B- and C-chicks, or between surviving and dying ones. All chicks combined showed a linear growth rate of 4.24 g/day up to day 11 (SD = 1.09, n = 20).

DISCUSSION

Changes in diet

There is no quantitative information on the amount of food ingested by Black Tern chicks, allowing calculations of energy intake, because there is always a high proportion of unidentified prey items. However, the available information on relative frequencies of prey types fed to the chicks suggests a change in their diet. According to all sources prior to the 1980s (reviewed by Beintema 1997b), chicks were almost exclusively fed on insects. Cramp (1985) misquotes Baggerman *et al.* (1956) on a contribution of 58% fish in the diet in The Netherlands, as these observations referred to the so called 'fish flight', when males present shiny objects (preferably fish) to the females during courtship.

In 1981 and 1982 R. van Beusekom (pers. comm.) was the first to report a predominance of fish and earthworms in the food brought to Black Tern chicks, in a colony near Maarsseveen (lowland peat lake). Van Beusekom found 34% fish, 22% worms, 17% insects, 26% unidentified prey and 1% other items. Fish ranged from 18–60%, worms from 0–51%.

In Germany, Kisch (1992) observed diets very similar to our observations, with 13% fish, 12% earthworms, 6% aquatic larvae, 12% damselflies, 1% dragonflies, 4% moths, 36% tiny insects and 15% unidentified (n = 1542). Aquatic larvae were mostly fed during the earlier part of the season (the first three weeks of June), being virtually absent in July. The contribution of fish was very variable, ranging from 0–20% in June and early July, and reaching a peak of 60% in the third week of July. Damselflies showed a pronounced peak (44%) in the second half of June.

As there is no quantitative information on prey availability, it is impossible to say whether fish and earthworms are now taken more frequently because there are less large (profitable) insects, or because there are more fish (of the right size) and earthworms. Both effects could result from an increase in fertilisation levels in agriculture and eutrophication in general.

Assuming that fish and earthworms are profitable prey as compared to much smaller insects, it is also difficult to understand why the Black Tern did not utilise these resources more frequently in the past and why they are not more successful since they do take them. The answer may be that both fish and earthworms are too unpredictable in their occurrence to be a reliable food resource, although there are no data to substantiate this.

Patterns in prey availability

Although during autumn migration and winter Black Terns rely on fish as a food source (Cramp 1985), they may not be able to fish under all circumstances. They do not plunge-dive as deeply as *Sterna* species do and often take their prey by surface dipping from the uppermost water layer. It is insufficiently understood under what conditions fish of the right size come close enough to the surface, and what conditions are ideal for fishing by Black Terns. For instance, ripples caused by wind may decrease the visibility of tiny fish. Thus, the accessibility of fish resources may be limited and spells may occur during which no fish will be caught. A minimum amount of fish in the diet is indispensable to cover the calcium need of the growing chick (Beintema *et al.* 1997).

Our observations suggest that earthworms are also not always easily available, as they were mostly brought to the chicks during wet weather. Dragonflies, damselflies and water beetle larvae show distinct seasonal peaks in their occurrence (Kisch 1992, Baarspul & de Krijger 1995).

Irregular occurrence of prey types may depend on the reproductive cycles of individual prey species, on weather conditions, or on both.

The food situation in different habitats

In river landscapes no indications were found of periods of food shortage. There were marked differences among years in the relative frequencies of food types brought to the chicks, but this did not affect fledging success, which was generally high (van der Winden *et al.* 2001).

In lowland peat lakes the highest proportions of fish in the chicks' diet were found. Our data indicate that chick survival was negatively affected when less fish was caught by the parents, suggesting that the birds could not easily find alternative prey. Fledging success was lower and more variable than in river landscapes. In lowland meadows there were indications of low variability in food types and prolonged spells with serious food shortage, resulting in starvation of the chicks.

In moorland the variation in insect species was very high throughout the season, but the chicks could not grow up because they lacked a calcium source. A diet of 100% insects contains too little calcium to enable formation of the skeleton (Graveland 1995, Beintema *et al.* 1997).

It is not easy to understand why the Black Terns of Bargerveen did not take fish from nearby canals, which could be found within one km. They did not respond to aberrant behaviour of their chicks, or to their own needs during egg production, by developing a calcium-specific hunger and searching behaviour, like Great Tits *Parus major* do (Graveland 1995). Even when a locally nesting Common Tern *Sterna hirundo* flew through the colony with a fish in its bill, the Black Terns were not stimulated to go fishing. The birds seemed to be 'blinded' by the superabundance of large insects.

The risk of reduced variation

A high degree of diversity in the habitat seems to be of crucial importance for the Black Tern. If something goes wrong with the dragonflies, there will be fish. If there is no fish, there may be worms, etc. Reduction in the number of available prey types increases the risk that there will be periods with no prey at all.

Variation in prey items is not just a matter of the number of available prey species, but should be interpreted in terms of diversity in life strategies amongst prey species. Thus, a habitat with a limited number of species representing very different ecological groups offers better opportunities than a habitat with for instance an exceptionally large number of dragonfly species but not much else (as in Bargerveen). A good example is the availability of earthworms and dragonflies, which are virtually complementary in their occurrence in relation to the weather.

The risk of reduced variation may not show under average conditions, but under stress (*e.g.* extreme weather). The example of Demmerik illustrates this very well. At first sight one might conclude that all chicks died because of bad weather. But when it appears that at the same time chicks in Ooypolder fledged normally, one understands that the chicks in Demmerik died because in the impoverished habitat the birds were no longer able to cope with cold spells.

Reduced variation in the habitat due to agricultural and related hydrological developments may be the key problem for the Black Tern over most of Europe. The same may even be true for the declining Black Tern population in the North American prairie region.

The use of artificial rafts

At the onset of our research, the two main hypotheses for the decline of the Black Tern were the disappearance of suitable nesting places and the decline of food resources. It seems that both problems occur, but with large differences between places. Where nest places are limited and food supply is good, the birds readily accept rafts, as is the case in Ooypolder.

Where both nest places and food supply are lacking, rafts may have very little effect, and often are ignored by the birds. It seems as if the birds make a weighed decision, based upon measurement of different parameters. If one is below average quality, another must be above average to make a place acceptable. This may also explain why the birds often refuse to nest in re-established vegetations of Water Soldier; there may be too many other things still missing.

Rafts may be useful to help the last surviving colonies of the Black Tern to hold on, but at a population level the solution must come from improvement of their habitat, which is above all a matter of water quality. Incidentally, an improvement of water quality may also result in the return of Water Soldier and thus resolve the nest substrate problem as well…

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SAMENVATTING

De Zwarte Stern *Chlidonias niger* is in de 20ste eeuw in Nederland als broedvogel met 90% achteruitgegaan. De twee belangrijkste hypothesen ten aanzien van de oorzaken hiervan zijn: (1) vermindering van broedgelegenheid door het verdwijnen van drijvende vegetaties van Krabbenscheer *Stratiotes aloides* en (2) een vermindering van het voedselaanbod, vooral van grote libellen, voor de kuikens. Beide effecten worden toegeschreven aan verontreiniging en eutrofiëring van het oppervlaktewater. De problemen variëren per gebied. In het rivierengebied lijkt verlies van broedgelegenheid een belangrijke factor te zijn. Hier is aanbieden van kunstmatige nestvlotjes een effectieve manier om de stand op peil te houden. In hoogveenplassen en het veenweidegebied kan extreem laag broedsucces aan voedselproblemen worden geweten. Vlotjes hebben dan minder effect. Waar grote insecten schaars zijn, gaan vis en regenwormen een belangrijker plaats innemen in het menu van de kuikens, maar deze prooien lijken een onbetrouwbare voedselbron te zijn die niet altijd beschikbaar is. De hoeveelheid vis in het menu bepaalt in hoge mate het uitvliegsucces. Los daarvan is een minimale hoeveelheid vis noodzakelijk om de calciumbehoefte van de kuikens te dekken. Met een menu van alleen insecten lukt dat niet. In een referentiestudie in de Biebrzavallei in Polen deden zich geen problemen voor met nestgelegenheid of voedsel.