THE INFLUENCE OF FLEDGLING NUMBER AND HATCHING ORDER ON RETURN RATES OF COMMON TERNS *STERNA HIRUNDO*

T. DITTMANN, J.-D. LUDWIGS & P. H. BECKER

Dittmann, T., Ludwigs J.-D. & Becker P.H. 2001. The influence of fledgling number and hatching order on return rates of Common Terns *Sterna hirundo*. Atlantic Seabirds 3(4): 179-186. *Natal characteristics of Common Terns* Sterna hirundo *that returned as prospecting pre-breeders to their home colony in a coastal brackish water lake in North-western Germany were compared with those that did not return. No influence of either fledgling number or hatching order on return rates (mean 41%) could be found. These findings indicate that during the stage of post-fledging care, individual parental quality becomes less important for the survival of the offspring.*

Institut für Vogelforschung "Vogelwarte Helgoland", An der Vogelwarte 21, D-26386 Wilhelmshaven, Germany; E-mail: tobias.dittmann@ifv.terramare.de

INTRODUCTION

In semi-altricial seabirds, including the Common Tern *Sterna hirundo*, both hatching order and number of siblings within a brood have proved to be important factors affecting chick survival until fledging (e.g. Parsons *et al.* 1976; Spear & Nur 1994; Nisbet *et al.* 1995; Royle & Hamer 1998). In contrast, knowledge about the influence of both factors on post-fledging survival is limited, mainly due to methodological problems. Young Common Terns depend entirely on being fed by their parents until fledging and are still provided with food for some weeks thereafter, and possibly also during autumn migration as in larger tern species (Burger 1980). Hence, siblings within a brood may compete for food even for some time after fledging. Nisbet (1996) investigated the influence of hatching order on post-fledging survival of Common Terns, based on a small sample size, and found no effect. Most surviving Common Terns explore their home colony site as subadults when 2 years old, arriving several weeks later than breeding birds (Becker *et al.* 2000) and breed for the first time at an age of 3 years (Wendeln & Becker 1998; Becker *et al.* 2000). Return rates to their natal colony site of Common Terns in Wilhelmshaven, Germany, vary between 22% and 46% among different year classes (Wendeln & Becker 1998). The aim of the present study was to investigate effects of both hatching order and number of siblings fledged on individual survival from fledging until return to the natal colony using a large sample.

Common Tern feeding young, Banter See study colony, 13 July 2000 *Adulte Visdief voert jong, Banter See onderzoekskolonie, 13 juli 2000* (J-D. Ludwigs)

STUDY AREA AND METHODS

In 1992-1999 studies were conducted in a Common Tern colony situated in the *Banter See*, a brackish water lake on the German Wadden Sea coast in the harbour area of Wilhelmshaven, Lower Saxony (53°27'N, 08°07'E). The colony site consisted of six rectangular concrete islands each measuring 10.7 x 4.7 m. All of these islands were surrounded by a low wall (60 cm high) with 42 elevated places for landing and resting (resting platforms, Becker 1996; Becker & Wendeln 1997). During the study period the colony increased from 90 to 250 breeding pairs.

All nests were visited at intervals of 2-3 days to record the fate of eggs and chicks. After hatching, chicks were ringed with steel rings from the ringing centre "Vogelwarte Helgoland". If two or three siblings were found in a nest on the same day the hatching order was determined from the size of the remains of the yolk sac on the chick's belly, which becomes smaller with age (Wagener 1998). In this paper the hatching order is denoted by A (first), B (second) and C (third chick). Chicks were considered to have fledged if they were encountered alive for the last time at least 18 days old and not found dead later in the same season. Mean fledging age was 26 days.

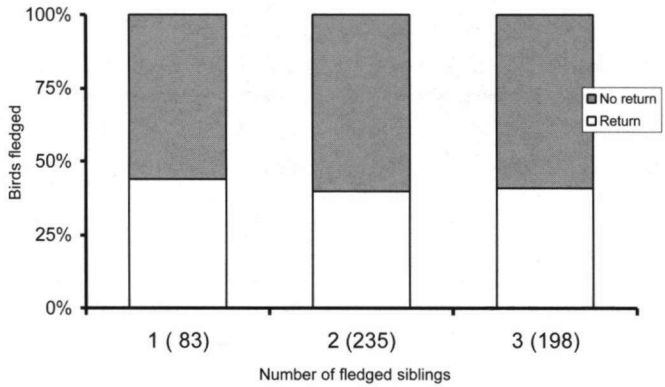

Figure 1. Proportion of fledged Common Terns with known number of fledglings per brood that were resighted in the natal colony (absolute numbers of returned and non-returned birds in brackets).

Figuur 1. Percentage uitgevlogen jonge Visdieven met bekend aantal uitgevlogen nestgenootjes dat na verloop van tijd terugkeerde als hoopvolle broedvogel in de kolonie (totale aantallen teruggekeerde en niet-teruggekeerde aantallen vogels).

From 1992 onwards, all chicks were marked with subcutaneously injected passive transponders before fledging (Becker & Wendeln 1997). These transponders sent an individual alphanumeric code when activated by special antennae placed on resting platforms (see above) around the colony, thereby allowing identification of birds for their whole life without retrapping (Becker & Wendeln 1997). The antennae were active continuously throughout the seasons. All antennae (1993-94: 12; 1995-96: 22; 1997-98: 30; 1999-2000: 35) were distributed equally among the platforms and their positions were changed regularly at intervals of 2-3 days in order to record the presence of marked birds at all platforms. Using these methods we recorded with a high probability all marked birds that returned to their home colony. Only chicks from broods in which three chicks hatched were used for the analysis, so that the number of chicks raised to fledging would serve as an index of parental quality. In this study, 215 fledglings from the years 1992-1997 with known information about hatching position or the number of fledged siblings and re-encountered up to the end of the breeding season in 2000 were compared with 307 fledglings that did not return to date. To test for an influence of either hatching order or of number of fledged siblings on return rates we performed two-tailed Chi-square tests. For testing for combined effects on return rates of both hatching order and number

Table 1. Proportion of fledged Common Terns of known hatching order in broods of different sizes that returned to the natal colony.

Tabel 1. Percentage uitgevlogen jonge Visdieven met bekende volgorde van uitkomst in broedsels van verschillende grootte dat na verloop van tijd terugkeerde als hoopvolle broedvogel in de kolonie.

Fledglings	Hatching order						Total	
	A		B		C			
	%	*n*	%	*n*	%	*n*	%	*n*
one	48.8	20	48.0	12	100	1	49.2	33
two	41.5	37	41.8	33	47.6	10	44.1	80
three	44.2	23	43.1	22	42.1	24	43.1	69
Total	44.0	80	46.2	67	44.3	35	43.8	182

of fledged siblings with and without respect to the study year we used a multiple logistic regression because outcomes were binary (the birds either returned or not) and binomially distributed. All statistics were performed using SPSS 8.0 (level of significance $P \leq 0.05$). All fieldwork was conducted under licences of the Niedersächsisches Landesverwaltungsamt, Hannover, and of the Bezirksregierung Weser-Ems, Oldenburg (Nationalparkverwaltung; Tierschutzangelegenheiten).

RESULTS

From 516 chicks with known fledgling brood size that fledged between 1992 and 1997, 212 (41%) were recorded again at the colony up to 2000 (Fig. 1). Return rates of young birds were independent of the number of siblings that had survived to fledging in the same brood ($\chi^2_2 = 0.910$, n.s.). From 442 chicks with known hatching order that fledged between 1992 and 1997, 185 (42%) birds were re-encountered in their natal colony (Fig. 2). No effect of hatching order on post-fledging survival could be found ($\chi^2_2 = 0.032$, n.s.).

For 416 birds fledged between 1992 and 1997 both the number of fledged siblings and hatching order were known. 182 (44%) of them returned to their home colony as subadults. Return rates varied only slightly between the chick groups (Table 1): lowest return rate was found in A-chicks of broods with two fledglings (41.5%), highest rate (48.8%) in A-chicks fledged without siblings. The only C-chick fledged alone returned to the colony. In total, in a logistic regression analysis, whether or not including year class as a factor, no combined effects of both number of fledged siblings and hatching order on return rates were detectable (Table 2).

Table 2: Test for combined effects of hatching order HO, number of fledged siblings NFS and study year SY (Logistic regression models, likelihood ratio statistic LRS (-2 log likelihood) (n = 416).

Tabel 2. Test voor de gecombineerde effecten van uitkomstvolgorde (HO), het aantal uitgevlogen nestgenootjes (NFS) en het jaar van onderzoek (SY).

Term	Adjusted for:	LRS	df	*P* value	Regression coefficient	SE
NFS	HO	570.06	1	0.723	-0.0014	0.004
NFS	SY	698.78	1	0.552	-0.0003	0.0013
HO	SY	578.59	1	0.952	0.0000	0.0001

DISCUSSION

In the Common Terns studied, neither hatching order nor number of fledglings per brood influenced return rates of prospecting individuals. This is in accordance with the findings of Nisbet (1996) whose study was based on a much smaller number of birds that returned. In this study we also found no evidence that potential effects of hatching order and sibling number on fledgling survival might mask each other. But why do both natal characteristics lose their importance after fledging?

In the pre-fledging stage, many studies document the importance for survival of intrinsic factors such as body weight at hatching and of extrinsic factors such as hatching order or brood size (Parsons 1970; Becker & Finck 1985; Rhymer 1988; Sydeman & Emslie 1992; Nisbet *et al.* 1995). In several seabird species last-hatched chicks suffer higher mortality (e. g. Parsons 1970; Becker & Finck 1985; Sydeman & Emslie 1992). However, the importance of these factors for pre-fledging survival depends strongly on parental quality, as shown by studies of Bolton (1991), Nisbet *et al.* (1998) and Wendeln & Becker (1999). During the post-fledging stage, some studies show effects of hatching position or brood size on survival (Nisbet & Drury 1972; Coulson & Porter 1985; Viksne & Janaus 1993). Other investigations, including this study, found that these factors are no longer important after fledging (Spear & Nur 1994; Nisbet 1996).

In species whose young depend on being fed by the parents for a long time after fledging, as in the Common Tern (Burger 1980), parental quality is expected to be of particular importance also for post-fledging survival. At our study site, fledglings are fed by their parents up to an age of at least 64 days, that is about six weeks after fledging (Kühn & Becker, unpubl. data). Watson & Hatch's (1999) data support the idea that parental care in the Roseate Tern *Sterna dougalli* may extend through the migration period as documented for the

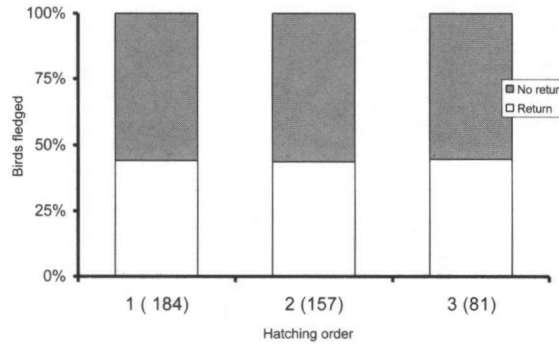

Figure 2. Proportion of fledged Common Terns with known hatching order that were resighted in the natal colony (absolute numbers of returned and non-returned birds in brackets).

Figuur 2. Percentage uitgevlogen jonge Visdieven met bekende volgorde van uitkomst dat na verloop van tijd terugkeerde als hoopvolle broedvogel in de kolonie (totale aantallen teruggekeerde en niet-teruggekeerde aantallen vogels).

large tern species (Burger 1980). In the Common Terns studied, a higher number of fledged siblings did not result in increased mortality after fledging despite the possibility that competition for food might continue into the post-fledging period. Viksne & Janaus (1993) even found greater survival of fledglings from large broods of Black-headed Gulls. Similarly, after fledging, hatching position of the Common Terns studied had no effect on survival. This is in contrast to the findings of Coulson & Porter (1985) in the Black-legged Kittiwake *Rissa tridactyla,* and may indicate that effects of hatching position on Common Tern chick survival that are known to occur in the first days of life have been balanced already at the age of fledging by other factors.

As in other seabird species, recent investigations have shown that Common Tern adults differ greatly in quality, with consequences for their reproductive performance (Wendeln & Becker 1999). Many authors studying long-lived seabirds report that older birds have a higher breeding success (Coulson & Thomas 1985; Ollason & Dunnet 1988; Clutton-Brock 1988; Forslund & Pärt 1995). In the Common Tern, reproductive success seems to increase with age only during the early years of reproduction (Nisbet *et al.* 1984). Besides age, individual body condition may reflect bird quality, and the breeding success of Common Terns strongly depends on the parents' body masses, a constant individual trait with low intra-individual variation between years and mostly independent of age (Wendeln & Becker 1999; Becker *et al.* 2000).

Consequently, hatching order and sibling number may be important factors during the first days in the life of a chick. But the number of chicks that can be reared successfully under the prevailing environmental conditions mainly depends on the quality of the parents. At fledging, possible effects of hatching order have been balanced by parental quality, and brood size has been adapted to the parental capacity for rearing chicks (see also Becker *et al.* 2000). The lack of influence of both hatching order and sibling number on post-fledging survival of Common Terns indicates that the quality of a pair that is reflected already in the number of fledglings, loses much of its importance after their young fledge. Probably post-fledging care is much less demanding than pre-fledging care because the fledglings accompany their parents to the feeding grounds within a few days after fledging (Nisbet 1976; own unpubl. data). Furthermore, parents are able to exploit additional feeding resources that are situated beyond the feeding range during the pre-fledging stage. Both factors might minimise the competition between siblings.

ACKNOWLEDGEMENTS

We are indebted to M. Wagener and H. Wendeln for their help in the field as well as with data management. Many thanks to many other voluntary fieldworkers. We thank H. Wendeln and the reviewers I.C.T. Nisbet and N. Ratcliffe for commenting on the manuscript. This study was supported by the Deutsche Forschungsgemeinschaft (Be 916/3 and 916/5).

DE INVLOED VAN DE VOLGORDE VAN UITKOMEN EN UITVLIEGEN OP HET PERCENTAGE TERUGKERENDE JONGEN BIJ DE VISDIEF *STERNA HIRUNDO*

Bij dit onderzoek werden uitgevlogen Visdieven die als hoopvolle broedvogels terugkeerden op de onderzoekskolonie in de Banter See (havengebied Wilhelmshaven, Duitsland), vergeleken met vogels die niet terugkeerden. Bij ieder legsel werden de jongen gemerkt en werd bepaald in welke volgorde de eieren uitkwamen. Vervolgens werd gekeken in welke volgorde de jongen de kolonie als vliegvlugge juvenielen verlieten. Er bleek geen enkel verband te bestaan tussen de volgorde van uitkomen en uitvliegen en de kans dat een dergelijk jong in de kolonie werd teruggezien. De gegevens suggereren dat gedurende de jongenzorg ná het uitvliegen van de jongen (rond de kolonie en onderweg naar de overwinteringsgebieden) de individuele verschillen in kwaliteit van de ouders een ondergeschikte rol spelen op de overlevingskansen van het jong.

REFERENCES

Becker P.H. 1996. Flußseeschwalben (*Sterna hirundo*) in Wilhelmshaven. Oldenb. Jahrbuch 96: 263-296.

Becker P.H. & Finck P. 1985. Witterung und Ernährungssituation als entscheidende Faktoren des Bruterfolgs der Flußseeschwalbe (*Sterna hirundo*). J. Ornithol. 126: 393-404.

Becker P.H. & Wendeln H. 1997. A new application for transponders in population ecology of the Common Tern. Condor 99: 534-538.

Becker P.H., Wendeln H.& González-Solís J. 2000. Population dynamics, recruitment, individual quality and reproductive strategies in Common Terns marked with transponders. Ardea: 89: 241-252.

Bolton M. 1991. Determinants of chick survival in the Lesser Black-backed Gull: relative contributions of egg size and parental quality. J. Anim. Ecol. 60: 949-960

Burger J. 1980. The transition to independence and post-fledging parental care in seabirds. In: Burger J., Olla B.L. & Winn H.E. (eds) Behaviour of marine animals, 4; marine birds: 367-447. Plenum Press, New York.

Clutton-Brock T.H. 1988. Reproductive success. University of Chicago Press, Chicago.

Coulson J.C. & Thomas C.1985. Differences in the breeding performance of individual Kittiwake Gulls, *Rissa tridactyla*. In: Sibly R.M. & Smith R.H. (eds.): Behavioural Ecology: 489-503. Blackwell Science, Oxford.

Coulson J.C. & Porter J.M. 1985. Reproductive success of the Kittiwake *Rissa tridactyla*: The roles of clutch size, chick growth rates and parental quality. Ibis 140: 315-322.

Forslund P. & Pärt T.1995. Age and reproduction in birds–hypotheses and tests. TREE 10: 374-378.

Nisbet I.C.T. 1976. Early stages in post-fledging dispersal of Common Terns. Bird-Banding 47: 163-164.

Nisbet I.C.T. 1996. Post-fledging survival in Common Terns in relation to brood order, hatching date and parental age. Col. Waterb. 19: 253-255.

Nisbet I.C.T., Winchell J.M. & Heise A.E. 1984. Influence of age on the breeding biology of Common Terns. Col. Waterb. 7: 117-126.

Nisbet I.C.T., Spendelow J.A. & Hatfield J.S. 1995. Variation in growth of Roseate Tern chicks. Condor 97: 335-344.

Nisbet I.C.T., Spendelow J.A., Hatfield J.S., Zingo J.M. & Gough G.A. 1998: Variation in growth of Roseate Tern chicks: II. Early growth as an index of parental quality. Condor 100: 305-315.

Nisbet I.C.T. & Drury W.H. 1972. Post-fledging survival in Herring Gulls in relation to brood-size and date of hatching. Bird-Banding 43: 161-172.

Ollason J.C. & Dunnet G.M. 1988. Variation in breeding success in Fulmars. In: Clutton-Brock T.H. (ed.) Reproductive success: Studies of individual variation in contrasting breeding systems: 263-278. Univ. Chicago Press, Chicago.

Parsons J. 1970. Relationship between egg size and post-hatching mortality in the Herring Gull (*Larus argentatus*). Nature 228: 1221-1222.

Parsons J., Chabrzyk G. & Duncan N. 1976. Effects of hatching date on post-fledging survival in Herring Gulls. J. Anim. Ecol. 45: 667-675.

Rhymer J.M. 1988. The effect of egg size variability on thermoregulation of Mallard (*Anas platyrhynchos*) offspring and its implications for survival. Oecologia 75: 20-24.

Royle N.J. & Hamer K.C.1998. Hatching asynchrony and sibling size hierarchies in gulls: effects on parental investment decisions, brood reduction and reproductive success. J. Avian Biol. 29: 266-272.

Spear L. & Nur N. 1994. Brood size, hatching order and hatching date: effects on four life-history stages from hatching to recruitment in western gulls. J. Anim. Ecol. 63: 283-298.

Sydeman W.J. & Emslie S.D. 1992. Effects of parental age on hatching asynchrony, egg size and third-chick disadvantage in Western Gulls. Auk 109: 242-248.

Viksne J. & Janaus M. 1993. Post-fledging survival of the Black-headed Gull (*Larus ridibundus*) depending on hatching parameters. Ring 15: 387-389.

Wagener M. 1998. Praktische Hinweise für brutbiologische Untersuchungen an der Flußseeschwalbe *(Sterna hirundo)*. Vogelwelt 119: 279-286.

Watson M.J. & Hatch J.J. 1999. Difference in foraging performance between juvenile and adult Roseate Terns at a pre-migratory staging area. Waterbirds 22: 463-465.

Wendeln H. & Becker P.H. 1998. Populationsbiologische Untersuchungen an einer Kolonie der Flußseeschwalbe *Sterna hirundo*. Vogelwelt 119: 209-213.

Wendeln H. & Becker P.H. 1999. Effects of parental quality and effort on the reproduction of Common Terns. J. Anim. Ecol. 68: 205-214.