Assessing Growth and Age of Whiskered Tern Chlidonias hybrida Chicks using Biometrics

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Short notes

Assessing growth and age of Whiskered Tern *Chlidonias hybrida* chicks using biometrics

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The growth of Whiskered Tern *Chlidonias hybrida* chicks was investigated in Lake Grand-Lieu, western France. Body mass, tarsus, culmen and wing lengths of 33 chicks from 19 nests held in enclosures were measured at intervals of 2–3 days during the rearing period (0–20 days). The repeatability between two observers in chick body size measurements was generally high (overall 0.94), with the highest value for the wing length. Tarsus length and body mass increased fast and reached asymptotic values at about 14 (23.23 mm ± 0.18 SE) and 16 days (92.35 g ± 1.82 SE). The body mass growth rate (K, resulting from a logistic model) was 0.294 g day^{-1} ± 0.016. The linear growth rate at age 3–9 days was 6.32 g day^{-1} ± 0.28 SE. The standardized linear growth rate was 7.0% of adult body mass, which was in the range of values recorded for the closely related Black Tern *Chlidonias niger* (6.5–7.9%). The culmen and wing were still growing at fledging (age 20 days), asymptotic values had clearly not been reached. Before fledging, chicks were better aged by wing length (logistic model) than by any of the other body measurements. Given the geographic variation in bird morphometry, the applicability of our growth curves to disjoint populations of whiskered terns may be restricted. We encourage therefore new studies on chick growth in other European breeding populations.

Key words: Whiskered Tern, *Chlidonias hybrida*, chick, biometrics, growth curves, ageing

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Introduction

Management of endangered bird species requires accurate knowledge of specific breeding events such as hatching dates and growth of chicks. These data are useful to investigate the performance of chicks or parents in response to local environmental conditions (Ricklefs 1968, Nisbet *et al.* 1995, Stienen & Brenninkmeijer 2002), which are important to understand local patterns in demography and the suitability of breeding sites.

Indeed, poor body growth may have significant consequences on fitness, such as increased chick mortality, reduced fledging body mass and reduced post-fledging survival and recruitment (e.g. Gebhardt-Henrich & Richner 1998, Nisbet *et al.* 1999). However, collecting detailed growth data is often limited by undesirable levels of disturbance induced by repeated nest visits, especially in colonial species with high nest density and high degree of reproductive synchrony between colony members.

The Whiskered Tern *Chlidonias hybrida* is a species with an unfavourable conservation status in Europe. It is declining and currently listed as a conservation priority in the EU Wild Birds Directive (BirdLife 2004). The species requires particular surveillance in several European countries (Rocamora & Yeatman-Berthelot 1999). However, it remains a very poorly studied species (e.g. Tomialojc 1994). A few study programs have been carried out in Europe (France, Croatia, Poland) in order to define conservation measures, but they suffer from a lack of data on important breeding aspects of the species. It would be particularly useful to develop methods for assessing chick growth and age. In the present paper, we report the first data on growth of Whiskered Tern chicks. We provide models based on various biometric parameters for ageing chicks. We also checked the morphometric measurements in the field for consistency between observers, in order to recommend a limited number of morphometric measurements to collect in circumstances where high disturbance level is to be avoided, like in dense colonies.

Study species and study site

The Whiskered Tern is a Eurasian species, distributed throughout southern and central Europe. Its breeding distribution is scattered, and the species is usually restricted to small colonies established on floating vegetation in lacustrine systems (van der Winden 1997, Latraube 2006, Paillisson *et al.* 2006). The study was carried out in 2006 (4 July to 10 August) at Lake Grand-Lieu (47°05'N, 1°39'W), in western France. Lake Grand-Lieu is one of the main breeding sites of the species in France. It is covered with extensive beds of floating plants (varying among years at 743–804 ha), mainly White Waterlily *Nymphaea alba*. Whiskered terns nest on the floating plants in loose colonies (Fig 1; 27.1 nests $ha^{-1} \pm 4.5$ SE, unpubl. data).

Methods

Because Whiskered terns are sensitive to disturbance in particular during the laying period (pers. obs.), an enclosure experiment was carried out after clutch completion (the synchrony in laying dates and incubating within colonies is high, Paillisson *et al.* 2007). In several colonies, a total of 19 nests were randomly selected and each enclosed using wire mesh fencing (20–40 cm high and 2 m in diameter) to prevent chicks from swimming away from the nest-site. The average clutch size (2.16 eggs ± 0.14 SE) of the fenced nests was representative of the average clutch size observed that season at the site (2.35 ± 0.05 SE, $n = 207$ clutches: two-sample t-test, $t_{224} = 1.006$, $P = 0.315$). The average hatching date was 10.5 days ± 0.9 SE (range: 0–18 days, $n = 33$ chicks) after enclosure construction, which was halfway the incubation period of 20 days (Cramp 1985; Bakaria *et al.* 2002). When undisturbed, chicks usually remain on their nest until fledging (pers. obs.), so the enclosures did not affect their normal behaviour. Field observations also showed that incubating parents were not affected by the enclosures, since adults came back to the nest within 1–10 min after enclosure construction. Nevertheless, one pair abandoned their nest immediately after enclosure construction. It cannot be excluded that the birds deserted the nest because they were early in the incubation phase when the nest was fenced in. Two others nests were deserted at 6 and 20 days after the beginning of the study; in these cases it was less likely that the enclosure was the cause of nest desertion. Since daily visits were not desirable due to risk of disturbance, nests were checked at intervals of 2–3 days (between 6–11 pm) to determine hatching dates and to measure chicks. The age of the chicks was estimated from the state of the egg during the visit, feather characteristics of the chick, whether the chick was still wet or had eggshell remains on its

Figure 1. Whiskered tern with chicks on nest within White Waterlily beds in Lake Grand-Lieu, France (photo J-M. Paillisson).

back. As hatching is synchronous within a clutch (Cramp 1985, pers. obs.), we suppose that hatching dates were correctly assigned for all chicks (n = 33). The day of hatching was denoted as day 0, and the average value of chick age at first encounter was 1.2 days ± 0.2 SE (range: 0–3 days, n = 33 chicks). Within the enclosures, at first encounter all chicks were marked with a paint mark on their heads, and then ringed within 4.9 days ± 0.3 SE (range: 2–8 days, n = 33 chicks) from hatching with a metal ring provided by the CRBPO. Each chick was weighed to the nearest 0.1 g using an electronic balance. The tarsus and culmen (from the tip of the bill to the base of the feathers) lengths were measured with a Vernier calliper to the nearest 0.1 mm, and the wing length (from the carpal joint to the top of the wing) was measured to the nearest 1 mm using a metallic stop ruler until chicks fledged, disappeared or died. When possible, chicks were measured by two observers in order to check for consistency (i.e. repeatability) in body size measurements.

Statistical analysis

Repeatability was calculated following Lessells & Boag (1987). To investigate the influence of age (i.e. body size) on the consistency of measurements between observers Whiskered Tern chicks were classified in three age classes of approximately similar sample sizes (<5 days, 5–9 days and >9 days). Two non linear growth curve models (logistic and Gompertz (Ricklefs 1968, Starck & Ricklefs 1998)) were used (least square procedure in STATISTICA, version 6.0), and the best fitting function (highest R^2) was retained. Means ±

SE of the three parameter estimates of the model are reported: asymptotic value A, growth rate constant K and time inflection of the growth curve Ti. Growth rate constants are not always provided in studies. For comparison with other *Chlidonias* species, the mean linear growth rate (LGR, defined as the slope of a regression line fitted to morphometric data during the linear part of the growth curve; see ranges of chick age in Table 1) was calculated.

Results

Repeatability of body measurements

Repeatability of morphometric measurements was generally high (overall 0.94), although it varied among measurements and age classes. The highest repeatability (0.98) was found for the wing length, and repeatability of wing length increased slightly with age (0.97 to 0.99). Conversely, repeatability of tarsus (0.91) and culmen (0.93) measurements tended to decrease with age. As the overall repeatability was high, average measurements of the two observers were used to compute growth models.

Growth curve and chick ageing

Growth patterns differed between the morphometric measurements (Fig. 2, Table 1). Body mass, tarsus and culmen were characterized by a period of rapid increase followed by asymptotic values until fledging. Tarsus and body mass grew more quickly than culmen, attaining asymptotic values at about 14 and 16 days, respectively (Fig. 2). In contrast, asymptotic values were not reached for wing length at the age of 20 days (Fig. 2). Consequently, wing length was the only parameter that allowed us to age chicks throughout the whole rearing period. Moreover, the variance in wing length explained by the model was very high compared to that found for the other measurements (Table 1). Chick age can be estimated from models obtained for each morphometric measurement (Table 1), but obviously wing length provided most accurate results with the following equation:
age (days) = –(ln((159.3/wing length) –1) –0.221 x 10.33)/0.221.

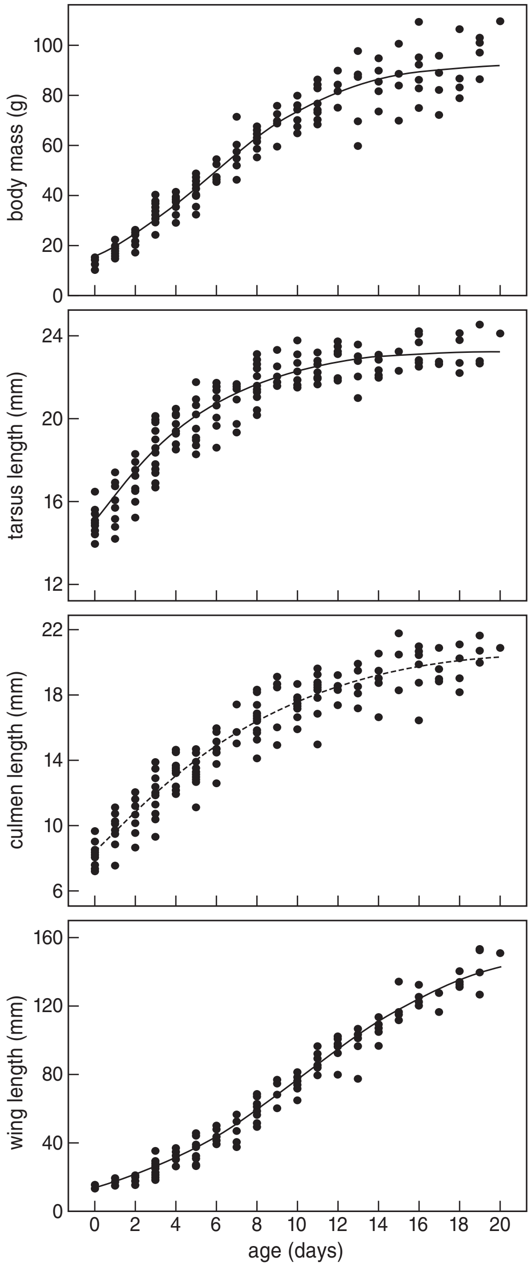

Figure 2. Changes in biometrics (body mass, tarsus, culmen and wing lengths, $n = 168$ for each biometric) of Whiskered Tern chicks from hatching to fledging in Lake Grand-Lieu in 2006 with the best non linear growth model (highest R^2, see Table 1): logistic (full line) or Gompertz (dotted line).

Table 1. Fitted parameters (mean ± SE) of non linear growth models (logistic or Gompertz according to R^2 results) and linear growth rates (LGR (mean ± SE) expressed in g day^{-1}, mm day^{-1}) of the linear part of the growth curve (in days) applied to different biometrics of Whiskered Tern chicks at Lake Grand-Lieu in 2006. A is the asymptote (in g, mm), K the growth rate (in g day^{-1}, mm day^{-1}), Ti the inflection time (in days), R^2 the variance explained by the model and *n* the number of chick measurements.

Biometric	Model	Parameter estimates					Linear part of the growth curve			
		A	K	Ti	R^2	*n*	Period	LGR	R^2	*n*
Body mass	Logistic	92.35 ±1.82	0.294 ±0.016	5.51 ±0.20	0.941	168	3–9	6.32 ±0.28	0.869	75
Tarsus length	Logistic	23.23 ±0.18	0.251 ±0.017	2.32 ±0.24	0.895	168	0–5	1.02 ±0.07	0.761	71
Culmen length	Gompertz	20.87 ±0.47	0.165 ±0.014	0.45 ±0.16	0.918	168	0–6	1.06 ±0.06	0.801	81
Wing length	Logistic	159.31 ±4.30	0.221 ±0.007	10.33 ±0.31	0.977	168	6–15	7.99 ±0.28	0.911	77

Discussion

In the present study, we provide the first published growth curves for Whiskered Tern chicks. We selected nests with birds incubating since several days to reduce chances of nest desertion. We have no evidence that the experiment alone contributed to nest desertion, since all incubating birds came back to the nest rapidly after enclosure construction. Moreover, chicks held in enclosures can hide under Waterlily leaves near the nest when disturbed, and one can suppose that the behaviour of chicks was not affected by the enclosure experiment. Nevertheless, Stienen & Brenninkmeijer (1999) found that enclosure experiments affected growth and survival of Sandwich Tern *Sterna sandvicensis* chicks (but see Eyler *et al.* 's (1999) study on Gull-billed terns *Sterna nilotica*). Further studies are needed to evaluate the extent of all possible effects of enclosures on Whiskered Tern chicks. We recommend, if this experiment was to be repeated, to construct enclosures around nests incubated since about 10 days (i.e. the average value in the present study) to prevent nest desertion and not in dense colonies that would induce undesirable levels of disturbance.

The Whiskered Tern chicks invested mainly in a rapid tarsus and body mass growth. For this semi-nidifugous species, the rapid growth of tarsus may reflect the high adaptive value of strong legs, allowing the chicks to move away from their nest and hide in vegetation when disturbed. Asymptotic values for tarsus and body mass were reached at fledging (23.23 ± 0.18 mm and 92.35 ± 1.82 g, respectively) and were comparable to values measured in breeding adult birds (tarsus: 23.44 ± 0.13 mm, *n* = 93, and body mass: 91.08 ± 0.97 g, *n* = 91, unpubl. data). Despite an apparent asymptotic length of culmen for chicks at 20 days old (20.87 ± 0.47, Fig. 2), the culmen is still growing after fledging, since in adults it is considerably larger (30.22 ± 0.29 mm, *n* = 95, authors unpubl. data). The wing grew most slowly. Asymptotic values were not reached when the chicks fledged: 163.35 ± 4.59 mm at 20 days old compared to 242.2 ± 0.69 mm in adults (*n* = 95). Consequently the wing length appeared to be the most reliable morphometric variable to assess the age of chicks until fledging, whereas the other variables were only useful for young chicks. Moreover, the consistency between observers in morphometric measurements was highest for the wing whatever the chick age, indicating that measuring the wing was better reproducible than other body size variables. As a non-skeletal variable, body mass had the highest variation during growth, which makes this biometric less appropriate for ageing chicks correctly.

Growth of chicks of *Chlidonias* species has been little studied, and the only data published dealt with LGR of body mass in the Black Tern *Chlidonias niger*. When standardized for adult body mass (90 g: Cramp 1985, Latraube 2006, unpubl. data) the average daily LGR of body mass of Whiskered Tern chicks (7.0%) was in the range of values calculated for Black Tern chicks: 6.5–7.9% (Bailey 1977, Dunn 1979, Beintema 1997, Chapman-Mosher 1986, Gilbert & Servello 2005), using an average adult body mass of 65 g (van der Winden 2002). Thus overall, body mass growth of Whiskered Tern chicks was comparable with growth of Black Tern chicks.

The applicability of growth rates and morphometry of whiskered terns for accurately ageing chicks to different populations may be restricted, due notably to geographic variation (e.g. Ricklefs 1968, Demongin *et al.* 2007, Dmitrenok *et al.* 2007, Shealer & Clearly 2007). We suggest that enclosure experiments should be carried out at other European Whiskered Tern colony sites to obtain additional growth rates and biometrics of chicks. This would add to a better understanding of the reproductive strategy of the Whiskered Tern, and moreover provides a way to study mortality and growth of chicks in relation to brood size and chick rank within the brood (e.g. Stienen & Brenninkmeijer 2006). However, pending such investigations on the Whiskered Tern, we recommend to assess the age of chicks with the equation defined in the present study based on wing length.

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SAMENVATTING

De Witwangstern *Chlidonias hybrida* is een kwetsbare soort die vooral in Europa langzaam maar gestaag achteruitgaat en dus meer aandacht verdient. Dit artikel beoogt bij te dragen aan het beter bestuderen van de broedbiologie van de soort. De auteurs presenteren groeicurves van kuikens van Witwangsterns, die behulpzaam kunnen zijn bij het bepalen van de leeftijd van nestjongen. Het onderzoek werd uitgevoerd in het Grand-Lieu Meer in West-Frankrijk. Negentien nesten werden omheind en van 33 kuikens uit deze nesten werd de groei gevolgd. Daartoe werd gedurende de nestperiode elke 2–3 dagen het lichaamsgewicht bepaald en de tarsus-, snavel- and vleugellengte gemeten. De consistentie in metingen tussen twee onderzoekers bleek hoog (gemiddeld 0,9). Tijdens de nestperiode namen de tarsuslengte en het lichaamsgewicht snel toe en bereikten plafondwaarden van respectievelijk 23,23 mm (± 0,18 SE) in 14 dagen en 92,35 g (± 1,82) in 16 dagen. De logistische toename in lichaamsgewicht (K) was 0,294 g dag^{-1} (± 0,016). De snelste lineaire toename in gewicht tussen dag drie en dag negen was 6,32 g dag^{-1} (± 0,28). De gestandaardiseerde lineaire groeisnelheid (LGR) was 7,0% van het lichaamsgewicht van een volwassen Witwangstern en is daarmee vergelijkbaar met waarden in de literatuur voor de nauw verwante Zwarte Stern *Chlidonias niger* (6,5–7,9%). Na 20 dagen, toen de kuikens op het punt van uitvliegen stonden, groeiden de snavel en de vleugel nog steeds. Tot het moment van uitvliegen was het logistische groeimodel van de vleugellengte de beste biometrische maat om de leeftijd te bepalen. Omdat de biometrie van vogels vaak geografische verschillen vertoont, zijn de resultaten misschien beperkt bruikbaar voor andere populaties. Er wordt dan ook voor gepleit om de kuikengroei van Witwangsterns ook in ander Europese broedpopulaties te bestuderen. (YIV)

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