

Uniformity of diet composition of Brown Skua chicks at different ages and between siblings

Maricel Graña Grilli^{1,4}, Lucas J. Marti² and Diego Montalti^{1,3}

¹ Instituto Antártico Argentino, Balcarce 290, C1064AAF, Ciudad Autónoma de Buenos Aires, Argentina – Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET).

² Universidad CAECE, Av. de Mayo 866, C1084AAQ-Ciudad Autónoma de Buenos Aires, Argentina.

³ División Zoología Vertebrados, Museo de La Plata, Paseo del Bosque, B1900FWA-La Plata, Argentina.

⁴ Corresponding author: gmaricel@gmail.com

Received on 14 May 2014. Accepted on 17 September 2014.

ABSTRACT: The diet of chicks may change according to their growth and also vary between siblings due to their competitive relationship. Diet composition of 81 Brown Skua (*Stercorarius antarcticus lonnbergi*) chicks was analysed from regurgitated stomach contents in order to determine changes in diet composition related to chick age and differences between siblings. Fifty-nine of the samples belonged to chicks whose age was estimated by applying culmen measurement to a regression function. The remaining 22 samples belonged to 11 sibling pairs whose stomach contents were simultaneously sampled. The diet was constituted mostly by soft tissues of penguins. Marine resources were a minor part of the diet of chicks, appearing in the third week of their life. The qualitative composition of the stomach content of siblings was similar in most cases, but mass of regurgitates differed between siblings (1.3–90.0% = 0.5–9 g), which suggests the potential existence of aggressive food monopolization by one sibling, an issue to be elucidated with further research.

KEY-WORDS: Chick growth, sibling competition, *Stercorarius antarcticus lonnbergi*, stomach regurgitate.

INTRODUCTION

The food delivered to chicks by their parents may be influenced by many factors, such as changes in food availability, the status of dominance of parents or changes on their ability or opportunity to get different kinds of resources. Changes in the nutritional requirements due to chick growth, as well as their acquisition of the ability to feed on new kinds of food and larger meals can also lead to variations in the food delivered to chicks (Shealer 1998, Smiseth & Amundsen 2002), not only in quantity, but also to its qualitative characteristics (Moorer 1986, Hill & Hamer 1994, Robinson & Hamer 2000, Mitrus *et al.* 2010).

Hatching asynchrony gives the older chick a higher ability to compete for food delivered by parents (Braun & Hunt 1983, Smiseth & Amundsen 2002, Smiseth *et al.* 2003). This higher competitiveness added to the initial difference in size at the time the second chick hatches, may determine a progressive increase in the difference in size between siblings (Pugesek 1993). In turn, this reduces the probability of survival of the younger chick either during its rearing, leading to brood reduction (Seddon & van Heezik 1991, Royle & Hamer 1998, Maddox & Weatherhead 2008), or after fledging (Ploger & Mock 1986, Stenning 1996).

The Brown Skua (*Stercorarius antarcticus lonnbergi*) breeds on the Antarctic Peninsula and in Antarctic and Sub-Antarctic islands (Ritz *et al.* 2008). It has opportunistic feeding habits taking advantage of a broad variety of available resources. Its main food resources during the breeding period are penguins from nearby colonies, and flying seabirds (Trivelpiece *et al.* 1980, Graña-Grilli & Montalti 2012). During the rearing period, lasting around 60 days, both parents feed chicks (Young 1994) and the hatching asynchrony between siblings, of between 1 and 4 days, is reflected in a bigger body size of the older one (Montalti 2005, Ritz *et al.* 2005).

The aim of this study was to describe the diet of Brown Skua chicks while looking for differences in its composition at different ages and between siblings.

METHODS

Study area

Sampling was carried out at Harmony Point (62°17'60"S, 59°15'0"W), Nelson Island, South Shetland Islands, Antarctica, where Brown Skuas breed in sympatry with South Polar Skuas (*S. maccormicki*). Breeding colonies of

Chinstrap Penguins (*Pygoscelis antarcticus*) and Gentoo Penguins (*P. papua*) are located at this site, which in 1995 had 89,700 and 3,347 pairs, respectively (Silva *et al.* 1998). During the 2002–2003 season, 79 pairs of Brown Skua bred at Harmony Point (Author's unpubl. data).

Sampling and sample analysis

Between 19 January and 11 February 2003, samples of stomach content were obtained from 81 Brown Skua chicks by stimulating their regurgitation reflex through abdominal massage. Samples were analyzed to identify food items and classify them by comparison with reference material.

Diet according to chick age

Fifty-nine samples were obtained from chicks for which their culmen was also measured (precision 0.01 mm). That measurement was later used for age estimation by means of a regression model developed from culmen measurements taken from 15 known-age Brown Skua chicks, between 1 and 57 days old, from Laurie Island (South Orkney Islands), whose growth was monitored every three days during the 1993–1994 breeding season (Montalti 2005). From a total of 206 measurements, the regression function obtained was:

$\text{Age} = 2.240170 - 0.420258 * \text{Culmen} + 0.026932 * \text{Culmen}^2$ and showed good fit to the data ($R^2 = 0.97$). The application of the function on the same data that generated it gave a correct age assignment to 15.3% of the measurements and a difference between the calculated and actual age of 1 and 2 days to 32.6% and 23.7% of measurements, respectively (difference mean = 2 d, SD = 1.74 d). The largest differences between calculated and actual ages were 8 and 9 days for 2 and 1 measurements, respectively, the three cases belonging to chicks over 50 days old. This model allowed determining that ages of chicks sampled at Harmony Point were between 4 and 43 days old.

Samples were grouped according to the age of chicks, defined in weeks, covering a total of six weeks. The frequency of occurrence of resources in stomach contents was calculated for the following categories: penguin colonies – soft tissue, indigestible remains of penguin chicks, feathers, bone and egg; eggs of flying seabirds; and marine resources – including krill (*Euphausia superba*), fish, and cephalopods.

Data analysis was carried out by contingency tables, grouping data for two consecutive weeks, obtaining three age categories defined by fortnights: first ($n = 14$), second ($n = 25$), and third fortnight ($n = 20$). Fortnight blocks were used because the condition of 20% of the expected frequencies higher than 5 at every class was not fulfilled for chi-squared test (Quinn & Keough 2002), precluding analysis in weekly blocks. For the same reason, eggs of

penguins and flying seabirds were pooled for analysis, despite being possible to identify them as belonging to each category. Similarly, krill, fish and cephalopods remains were combined in a single category named “marine resources”.

Diet of sibling chicks

Regurgitated stomach contents were sampled from 11 pairs of sibling chicks, in both chicks simultaneously. Culmen measurements were not recorded for these chicks precluding us from estimating their ages. Samples obtained were weighed and their qualitative composition was examined and both mass and composition were compared between siblings.

Temporal change in diet

In order to test for changes in diet throughout the study period, regardless of chick age, all 59 samples took from chicks of different ages were classified in three groups, covering eight consecutive calendar days each (19/01–26/01, $n = 24$; 27/01–03/02, $n = 15$; 04/02–11/02, $n = 20$) and an analysis of contingency was performed.

RESULTS

Diet according to chick age

Penguin remains found belonged to soft tissue (muscle and viscera), bone of chicks, complete body parts, and down feathers (all them grouped as indigestible chick remains); adult bones and skin with feathers, and egg. In the case of other seabird species, remains of egg and of a Greater Shearwater, *Chionis alba*, were found. The latter was found in a single sample and therefore, it was not included in the contingency table.

Soft tissue of penguins predominated in all age classes (Figure 1). There was an exclusive presence of penguin remains during the first week, with a progressive appearance of other items in the following weeks, and the incorporation of marine resources in the third week of life of chicks (Figure 1). Those marine resources were found in the stomach content of 6 chicks sampled in dates that covered all the sampling period (between 20 January and 4 February). In 4 of those samples the marine remains belonged to krill in advanced digestion condition.

There were no significant differences in the composition of the diet in the three chicks' stages ($\chi^2 = 6.74$, $df = 10$, $P = 0.75$).

Diet of sibling chicks

Regurgitated wet mass obtained was variable between

sibling chicks. In five of the pairs of siblings, the difference was between 60.9% (9–23 g) and 90.0% (1–10 g), while in the other four pairs it was between 1.3% (38–38.5 g) and 13.3% (26–30 g).

Penguin remains were almost the only food item found in stomach contents of siblings and in 8 out of 11 pairs, the items found were coincident in both siblings (Table 1).

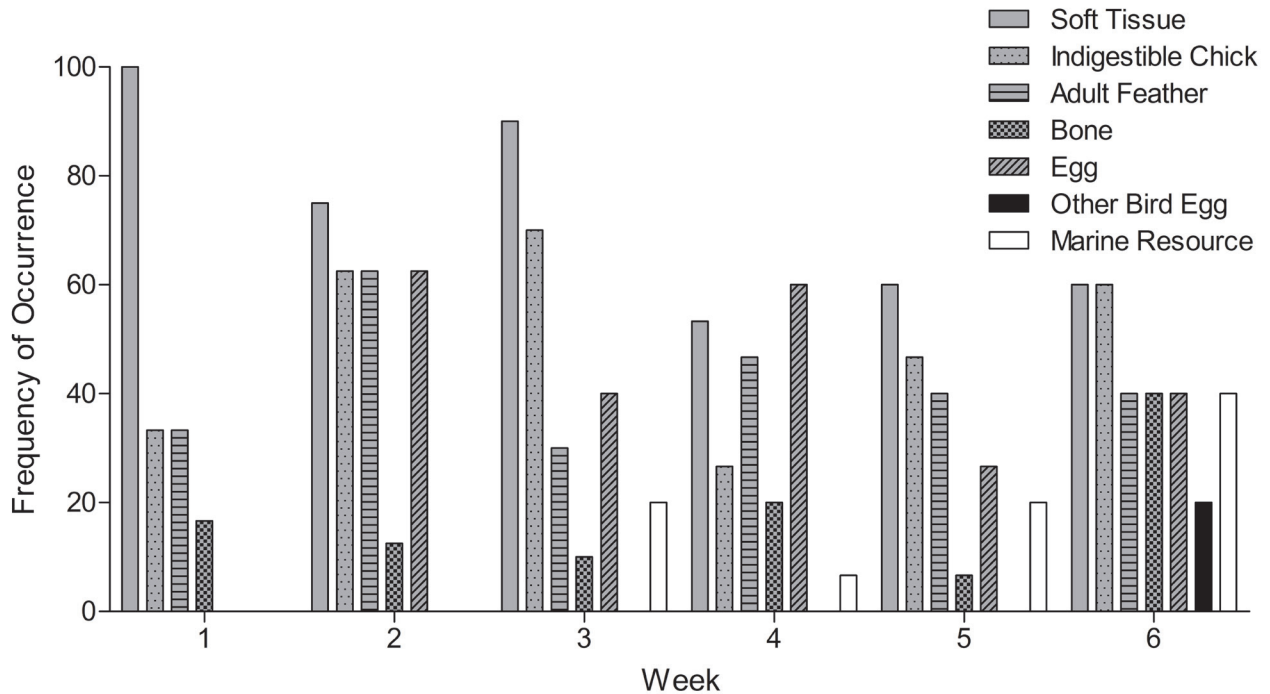


FIGURE 1. Frequency of occurrence of food items found in stomach contents ($n = 59$) of Brown Skua chicks (*Stercorarius antarcticus lonnbergi*) of different weeks of age.

TABLE 1. Food items found in the stomach contents of sibling Brown Skua chicks (*Stercorarius antarcticus lonnbergi*) from Nelson Island, South Shetland Islands during the 2002-2003 breeding season. A and B denote different chicks in the same brood.

| Nest | Chick | Food items | | | | | | |
|------|-------|-------------|---------------|------------|---------------|------|-----|-------|
| | | Soft Tissue | Chick Feather | Chick Bone | Adult Feather | Bone | Egg | Algae |
| 1 | A | x | | | | | | x |
| | B | x | | | | | | x |
| 2 | A | | | x | | | | |
| | B | x | | x | | | | |
| 3 | A | x | x | | x | | | |
| | B | x | x | | x | | | |
| 4 | A | x | x | | | x | x | |
| | B | x | x | | | x | x | |
| 5 | A | x | x | | | x | x | |
| | B | x | x | | | x | x | |
| 6 | A | x | | | x | x | | |
| | B | x | | | x | x | | |
| 7 | A | | | x | | | x | |
| | B | x | | x | | | x | |
| 8 | A | x | | | x | | | |
| | B | x | | | x | | | |
| 9 | A | x | x | | | | | |
| | B | x | x | | | | | |
| 10 | A | x | | | x | | | |
| | B | x | | | x | | | |
| 11 | A | x | x | x | | | | |
| | B | | x | x | | | | |

Temporal change in diet

The comparison of items found when samples were classified according to calendar date did not show significant differences between the three periods sampled ($\chi^2 = 8.60$, $df = 10$, $P = 0.57$).

DISCUSSION

We addressed in the current study only one aspect among several ones that can determine changes in diet of chicks, such as changes in food availability or feeding status of parents. The lack of differences among the three compared periods sampled would suggest that the kind of food that skuas offer to their chicks would be determined by the availability more than by changes in the specific needs of chicks related to their age.

In agreement with previous studies, remains of soft tissue of penguins predominated in the diet of Brown Skua chicks throughout their nesting period (Reinhardt 1997, Graña-Grilli *et al.* 2011). Sampling covered a period of 24 days in which penguin chicks would be at the crèche stage (chicks are big and get grouped under the care of a few adults while other parents forage at sea) and at the onset of the fledging stage (Williams 1995). At those stages, penguin chicks have low vulnerability to the attack of skuas due to their big size and self-defense ability (Burton 1968). However, the occurrence of viscera and muscle in stomach contents would indicate that parent skuas were able to get high quality food from nearby penguin colonies. Viscera and muscle are the first parts ingested by skuas (Young 1994) and may be selected as high quality food to be given to chicks.

The appearance of marine resources in stomach contents of older chicks only would suggest that there is a need for supplementation of the diet that may lead parents to look for other kinds of food, apart from the ones obtained at the penguin colonies, or that availability of marine foods changed through the season. However, the high degree of digestion of krill remains suggests that its occurrence may be due to secondary ingestion, i.e. from digestive tracts of penguins on which the skuas fed.

The lack of information about feeding status of parents, as owners of feeding territories or not, which can be a determinant of breeding success (Ens *et al.* 1992), precludes us from making inferences about the possibility that no territorial pairs may need to look for food sources other than penguins. In the same way, the age of parents, which also has an influence on breeding success (Pugesek 1993), is not known in this work.

Aggression of the older sib towards younger ones has been reported for other skua species, especially when the food availability is reduced (Procter 1975, Wang & Norman 1993, Young & Millar 2003). Aggressive

behaviour consists of older chick throwing out the younger sib from the territory, causing its death by predation or starvation (Young & Millar 2003). However, parents can control food delivered to chicks, either by reducing the effects of competition between siblings (Ricklefs 1982), or enhancing differences in food acquisition by selecting the older one during feeding (Braun & Hunt 1983). Sampling of siblings was carried out on both chicks at a nest, therefore ejection from the nest is not an option in our study, and the similarity in the kind of items found between siblings would suggest that there is no parent discrimination between them when delivering food. This rose the possibility of parents intervening to reduce the effect of competition between chicks, thus increasing fledging rates and consequently their own fitness

On the other hand, the stomach contents obtained from many sibling pairs had important differences in mass. Unfortunately, our work does not allow us to determine the amount of food delivered to each chick after each foraging trip and whether the feeding frequency is similar for both chicks or not. Those differences in mass found in the stomach contents could be the result of aggressive food monopolization by one of the siblings, or differences in the period elapsed since the last time each chick was fed. Alternatively it could result from sampling biases, such as obtaining an incomplete sample of the total stomach content (Barrett *et al.* 2007). Dietary differences between chicks would be most likely reflected in its quantity rather than quality, but the impossibility to distinguish among those possible causes for mass differences leaves the question open about food monopolization by older siblings in skuas. Further research on the feeding of chicks could clarify the characteristics of the relationship between siblings and the role of parental provisioning on them.

ACKNOWLEDGEMENTS

The sampling for this study was done thanks to the financial support of the Instituto Antártico Argentino and under the permits given by the Program of Environmental Management and Tourism, observing the guidelines of the Madrid Protocol. We thank to J. Harada for improving the English.

REFERENCES

- Barrett, R. T., Camphuysen, C. J., Anker-Nilssen, T., Chardine, J. W., Furness, R. W., Garthe, S., Hüppop, O., Leopold, M. F., Montevicchi, W. A. & Veit, R. R. 2007. Diet studies of seabirds: A review and recommendations. *ICES Journal of Marine Science*, 64: 1675-1691.
- Braun, B. M. & Hunt, G. L. 1983. Brood reduction in Black-legged Kittiwakes. *Auk*, 100: 469-476.

- Burton, R. W. 1968. Breeding biology of the Brown Skua, *Catharacta skua lönnerbergi* (Mathews), at Signy Island, South Orkney Islands. *British Antarctic Survey Bulletin*, 15: 9-28.
- Ens, B. J., Kersten, M., Brenninkmeijer, A. & Hulscher, J. B. 1992. Territory quality, parental effort and reproductive success of Oystercatchers (*Haematopus ostralegus*). *Journal of Animal Ecology*, 61: 703-715.
- Graña-Grilli, M., Libertelli, M. & Montalti, D. 2011. Diet of South Polar Skua chicks in two areas of sympatry with Brown Skua. *Waterbirds*, 34: 495-498.
- Graña-Grilli, M. & Montalti, D. 2012. Trophic relationships between Brown and South Polar Skuas at Deception Island, Antarctica. *Polar Biology*, 35: 299-304.
- Hill, J. K. & Hamer, K. C. 1994. Do Great Skuas *Catharacta skua* respond to changes in the nutritional needs of their chicks? *Seabird*, 16: 3-7.
- Maddox, J. D. & Weatherhead, P. J. 2008. Egg size variation in birds with asynchronous hatching: Is bigger really better? *American Naturalist*, 171: 358-365.
- Mitrus, C., Mitrus, J. & Sikora, M. 2010. Changes in nestling diet composition of the Red-breasted Flycatcher *Ficedula parva* in relation to chick age and parental sex. *Animal Biology*, 60: 319-328.
- Montalti, D. 2005. *Morfología y biología reproductiva de las especies del género Catharacta (Aves, Stercorariidae) de la Antártida*. PhD Dissertation. La Plata: Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata.
- Moorer, J. 1986. Dietary variation among nestling starlings. *Condor*, 88: 181-189.
- Ploger, B. J. & Mock, D. W. 1986. Role of sibling aggression in food distribution to nestling Cattle Egrets (*Bubulcus ibis*). *Auk*, 103: 768-776.
- Procter, D. L. C. 1975. The problem of chick loss in the South Polar Skua *Catharacta maccormicki*. *Ibis*, 117: 452-459.
- Pugesek, B. H. 1993. Chick growth in the California Gull: relationships with hatching asynchrony and parental age. *Colonial Waterbirds*, 16: 183-189.
- Quinn, G. & Keough, M. 2002. *Experimental design and data analysis for biologists*. Cambridge: Cambridge University Press.
- Reinhardt, K. 1997. Nahrung und Fütterung der Küken antarktischer Raubmöwen *Catharacta antarctica lonnbergi* und *C. maccormicki*. *Journal of Ornithology*, 138: 199-213.
- Ricklefs, R. E. 1982. Some considerations on sibling competition and avian growth rates. *Auk*, 99: 141-149.
- Ritz, M. S., Hahn, S. & Peter, H.-U. 2005. Factors affecting chick growth in the South Polar Skua (*Catharacta maccormicki*): Food supply, weather and hatching date. *Polar Biology*, 29: 53-60.
- Ritz, M. S., Millar, C., Miller, G. D., Phillips, R. A., Ryan, P., Sternkopf, V., Liebers-Helbig, D. & Peter, H.-U. 2008. Phylogeography of the southern skua complex-rapid colonization of the Southern Hemisphere during a glacial period and reticulate evolution. *Molecular Phylogenetics and Evolution*, 49: 292-303.
- Robinson, J. A. & Hamer, K.C. 2000. Brood size and food provisioning in Common Terns *Sterna hirundo* and Arctic Terns *S. paradisaea*: consequences for chick growth. *Ardea*, 88: 51-60.
- 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. *Journal of Avian Biology*, 29: 266-272.
- Seddon, P. J. & van Heezik, Y. 1991. Effects of hatching order, sibling asymmetries, and nest site on survival analysis of Jackass Penguin chicks. *Auk*, 108: 548-455.
- Shealer, D. A. 1998. Differences in diet and chick provisioning between adult Roseate and Sandwich Terns in Puerto Rico. *Condor*, 100: 131-140.
- Silva, M. P., Favero, M., Casaux, R. & Baroni, A. 1998. The status of breeding birds at Harmony Point, Nelson Island, Antarctica in summer 1995/96. *Marine Ornithology*, 26: 75-78.
- Smiseth, P. T. & Amundsen, T. 2002. Senior and junior nestlings in asynchronous Bluethroat broods differ in their effectiveness of begging. *Evolutionary Ecology Research*, 4: 1177-1189.
- Smiseth, P. T., Bu, R. J., Eikenæs, A. K. & Amundsen, T. 2003. Food limitation in asynchronous Bluethroat broods: effects on food distribution, nestling begging, and parental provisioning rules. *Behavioural Ecology*, 14: 793-801.
- Stenning, M. J. 1996. Hatching asynchrony, brood reduction and other rapidly reproducing hypotheses. *Trends in Ecology and Evolution*, 11: 243-246.
- Trivelpiece, W., Butler, R. G. & Volkman, N. J. 1980. Feeding territories of Brown Skuas (*Catharacta lonnbergi*). *Auk*, 97: 669-676.
- Wang, Z. & Norman, F. I. 1993. Timing of breeding, breeding success and chick growth in South Polar Skuas (*Catharacta maccormicki*) in the Eastern Lasermann Hills, Princess Elizabeth Land, East Antarctica. *Notornis*, 40: 189-203.
- Williams, T. D. 1995. *The penguins: Spheniscidae*. New York: Oxford University Press.
- Young, E. 1994. *Skua and penguin: predator and prey*. Cambridge: Cambridge University Press.
- Young, E. C. & Millar, C. D. 2003. Siblicidal brood reduction in South Polar Skuas. *New Zealand Journal of Zoology*, 30: 79-93.

Associate Editor: Leandro Bugoni