SUBTROPICAL ROSEATE TERNS DELIVER MORE APPROPRIATE SIZED PREY TO THEIR CHICKS THAN COMMON TERNS

José C. Pereira[1] and Jaime A. Ramos[2,3]

[1]SILPERMAR – Aquaculture. Avenida Humberto Delgado 6, Alhos Vedros

[2]Institute of Marine Research (IMAR), Departamento de Zoologia, Universidade de Coimbra, 3004-517 Coimbra, Portugal

[3]Corresponding author. Email: jramos@ci.uc.pt

ABSTRACT. We compared chick food provisioning between Roseate Tern (*Sterna dougallii*) and Common Tern (*Sterna hirundo*) on Vila, an islet offshore Santa Maria

Island (36.9ºN, 25ºW), Azores in 1996. Twelve nests of each species were fenced and prey deliveries to chicks of both species were observed during three diurnal periods each day for 35 days. We identified all prey offered to chicks, registered whether chicks ingested prey or not and weighed chicks daily. Blue jack mackerel (*Trachurus picturatus*) and Atlantic sauri (*Scomberosox sauri* and *Nanicthys simulans*) were the main prey items offered to chicks by Roseate Terns, whereas Common Terns offered mainly blue jack mackerel and boarfish (*Capros aper*). The number of Atlantic sauri offered to chicks with more than 6 days old by both tern species decreased markedly, and the inverse occurred for blue jack mackerel and boarfish. Overall, non-ingested prey items were larger than those that were ingested, especially for chicks aged 1-12 days. Roseate Tern chicks showed a higher acceptance rate (frequency of prey ingested/frequency of prey offered) than did the Common Tern chicks. Acceptance rate of the chicks increased with chick age for both tern species but, overall, Roseate Tern adults made a better adjustment of prey delivered to chicks (in particular those aged 1-12 days) than did the Common Terns. The breeding strategy of the Roseate Tern might reflect a greater specialization on favourable marine fish species.

Variation in food supply around the breeding colonies has a strong impact on breeding success of small seabirds such as terns (Monaghan et al. 1989, 1992) because they forage close to the nest, and allocate a greater proportion of available time to foraging and carrying food items in the bill to provisioning their chicks (Pearson

1968). Therefore, terns are very vulnerable to food shortages that occur around the breeding colonies (Monaghan et al. 1989, Ramos 2000, Ramos et al. 2002). More distant foraging sites may be utilized, especially by larger species (McGinnins and Emslie 2001), if they are particularly profitable because of greater prey availability, greater prey energetic value or when the forager possesses a specific knowledge of the foraging site (Massias and Becker 1990, Lyons et al. 2005).

In order to ensure a normal development of their chicks parent terns must provide them with a good supply of prey of adequate quality (Massias and Becker 1990, Dahdul and Horn 2003, Martins et al. 2004) and, therefore, should be adapted to environmental conditions around the colonies. Diet and chick provisioning has been well studied in terns (Monaghan et al. 1989, Ramos et al. 1998a, Paiva et al. in press). Most studies showed that tern nestling growth, breeding success and reproductive effort is often affected by variation in food provisioning (Monaghan et al. 1989; Massias and Becker 1990; Monaghan et al. 1992, Ramos et al. 2002, Shealer et al. 2004), but, the ability of the parents to deliver prey of appropriate sizes to their growing chicks has received little attention.

This study examined in detail the characteristics of prey, offered by parents and ingested by growing chicks of Common Terns (*Sterna hirundo*) and Roseate Terns (*Sterna dougallii*) breeding in mixed colonies in the Azores (Ramos and del Nevo 1995). Foraging Roseate Terns usually feed in smaller flocks over more dispersed prey (Duffy 1986), are more associated with particular physical features of the ocean such as shoals and tidal rips (Safina 1990, Monticelli and Ramos 2006), and seem to dive deeper than Common Terns (Nisbet 1981). Their foraging may be depressed when feeding within larger flocks with Common Terns (Safina and Burger 1985; Safina 1990). However, studies translating such differences in foraging habitat partitioning and feeding techniques into provisioning of chicks are lacking.

Ramos et al. (1998a, 1998b) and Granadeiro et al. (2002) showed that the diet of Roseate and Common tern chicks in the Azores overlapped to a great extent. Roseate Tern adults were obliged to switch between prey types along the chick rearing period, because deep bodied species, such as boarfish (*Capros aper*) and trumpet fish (*Macroramphosus scolopax*) were too wide for young chicks to swallow. Modelling suggests that Azores Roseate Tern chicks fed on prey with a favourable length-weight relationship, such as blue jack mackerel (*Trachurus picturatus*), have a higher growth efficiency (Martins et al. 2004). To understand how differently Roseate Terns and Common Terns deal with chick food provisioning, we made daily observations of the species and sizes of prey delivered by parents of both tern species to their chicks.

METHODS

We studied chick provisioning of Roseate and Common Terns on Vila, an islet off Santa Maria Island (36.9ºN, 25ºW), Azores, in 1996. Vila is a mixed Roseate and Common Tern colony. Roseate terns nested in areas with higher relief and/or tall vegetation, and Common Terns nested immediately around the Roseate Terns in more open areas (Ramos and del Nevo 1995). In the Azores, Roseate Terns typically nest earlier than Common Terns, including on Vila Islet (Ramos and del Nevo 1995), where, in 1996, Roseate Tern chicks began hatching about one week earlier than Common Tern chicks. Both species had equal access to foraging waters surrounding the islet.

Two portable hides were erected on the 8 June, one overlooking 35 Roseate Tern nests (0.18 nests/m^2) and the other, about 80 m away, overlooking 45 Common Tern nests (0.13 nests/m^2). Twelve nests of each species, situated 4 – 10 m away from the hides, were fenced with 0.5 m high, 2.5 cm diameter hexagonal mesh wire net.

Each fence was 1.5 m in diameter and included cover (rocks and grass) so chicks could hide and find protection from inclement weather. To keep young chicks inside, 1.5 cm^2 mesh plastic net 10 cm high, was added around the fence.

Fenced broods of Roseate Terns were watched from 9 June to 3 July 1996 and those of Common Terns from 22 June to 14 July. Three to 12 (median = 7) Roseate Tern chicks and two to 30 (median = 8) Common Tern chicks were watched from one to 24 days of age. For Roseate Terns, we watched only broods of one chick. For Common Terns, we watched six broods of two and six broods of three chicks. Common Tern chicks were designated has a, b or c according to hatching order, and were colour-marked on the head with different colours.

Prey items brought to chicks were observed daily from 7:00 - 9:30, 11:45 - 14:15 and 17:00 - 19:30 by two observers to allow simultaneous observations of both species. We used these three diurnal periods to account for the daily variation in chick provisioning (Ramos et al. 1998a). Each observer watched the same species for a whole day and observers switched between species on consecutive days. We observed all prey offered to chicks and registered whether chicks ingested the prey or not. We were familiar with the main fish species taken by terns: blue jack mackerel (*Trachurus picturatus*), trumpet fish (*Macroramphosus scolopax*), Atlantic sauri (*Scomberesox saurus saurus*) and boarfish (*Capros aper*; Ramos et al. 1998a; 1998b). We identified most prey species and estimated their size relative to the bill length of adult terns (in 0.5 bill units). In the Azores, bill length (mean ± SD) of Common Terns (37.54 ± 1.72 mm, N = 33) is similar to that of Roseate Terns (38.93 ± 1.56 mm, N = 30; Monteiro et al. 1996). We had a good view over the area with fenced nests and controlled for situations where a prey was offered multiple times (this was more frequent in Common Terns), because the adults performed small flights in the area within view, before offering the same prey.

Chicks were divided into four age groups (1-6, 7-12, 13-18, 19-22 days of age) and prey offered, ingested and not ingested by each tern species were compared among these age groups. Prey diversity index was computed using $B = 1/\sum p_i^2$, where p_i is the proportion of a given species in the diet (Levins, 1968). We transformed bill-length units into length of fish (L, mm) and then into mass (W, g) using the length-weight relationships for the main prey delivered (blue jack mackerel: W = 0.00819 x $L^{3.11}$, Atlantic sauri: W = 0.0079 x $L^{2.54}$, boarfish: W = 0.0282 x $L^{2.81}$, trumpet fish: W = 0.0040 x $L^{3.15}$, *Pagellus bogaraveo*: W = 0.00819 x $L^{3.11}$; see Martins et al. 2004 and http://www.fishbase.org). The mass of unidentified prey and prey for which we had no length-weight relationship (less than 15% of all prey items) was assumed to be the same as blue jack mackerel because this was the most abundant prey species. We calculated the mean mass of each fish species, ingested and non-ingested, and compared it among chick age groups with non-parametric tests (Mann-Whitney U-test, Kruskal-Wallis and Multi-sample Q test), because variance was not homogeneous among age groups.

The ratio between frequency of prey ingested and frequency of prey offered was named acceptance rate of the chicks, and compared between tern species and age groups. This can be viewed as a measure of inter-specific parental performance because this parameter reveals the capacity of the parents to match prey delivered with the need of their chicks.

Except otherwise stated data is presented as mean ± SE.

RESULTS

Diet composition and prey destiny of Roseate and Common Tern chicks

The diversity of prey offered and ingested by chicks of each age-class (1-6, 7-12, 13-18, 19-24 days of age, respectively) was generally lower for Roseate Terns than for Common Terns (offered: B = 2.82, 4.45, 2.99, 3.14 and B = 3.97, 3.12, 3.92, 3.93; ingested: B = 2.35, 4.56, 3.00, 3.19 and B = 3.81, 3.42, 4.10, 4.12, for Roseate and Common terns, respectively). Blue jack mackerel and Atlantic sauri were the main prey offered to chicks by Roseate Tern adults, whereas Common Tern adults carried mainly boarfish and blue jack mackerel (Table 1). The number of Atlantic sauri (elongated fishes easier to swallow by young chicks) offered to chicks by adults of both tern species decreased as chicks aged (Table 1). The mass of each individual ingested Atlantic saury also increased with chick age for both tern species (Table 1). The number of blue jack mackerel offered to and the % ingested by Roseate Tern chicks increased with chick age, but the mean mass of each individual blue jack mackerel ingested did not (Table 1).

Overall, the % of ingested prey items by Roseate Tern chicks was always greater than the % of non-ingested prey items. For Common Terns, the number of ingested prey items was higher than that of non-ingested items only for old chicks (Table1).

Differences in prey offered and ingested by chicks

Overall, Roseate Terns parents offered longer prey (in bill-length units) to their chicks than did Common Terns (1.96 ± 0.02, N = 908 and 1.59 ± 0.02, N = 1301; Mann-Whitney test: z = 11.6, P = 0.000). No significant differences were found between the length of ingested (1.96 ± 0.03, N = 570 and non-ingested (2.00 ± 0.07, N = 118) prey for Roseate Terns (Mann-Whitney test: z = -0.45, P = 0.650). However, for Common Terns, a significant difference was found between the length of ingested (1.50 ± 0.03, N = 683) and non-ingested (1.68 ± 0.03, N = 582) prey (Mann-Whitney test: z = 4.22, P = 0.000). This was explained by the fact that individual prey items offered to the youngest Common Tern chicks (1-6 days) that were not ingested (mean

= 4.6 g), were larger than individual ingested prey items (mean = 2.2 g; Table 1). In general, Table 1 shows that, with the exception of boarfish for Common Terns, non-ingested prey items were larger than ingested prey items. The proportion of fish stolen by kleptoparasites was negligible (1% and 2% of prey offered to Roseate and Common Tern chicks, respectively).

The acceptance rate of the chicks (frequency of prey ingested /frequency of prey offered) is presented in Figure 1 for both tern species. There was a significant difference in the acceptance rate of the chicks between age groups for both Roseate Terns (Kruskal Wallis test: $H_{3, 214} = 48.1$, P = 0.000) and Common Terns (Kruskal Wallis test: $H_{3, 157} = 28.5$, P = 0.000). The overall acceptance rate by the chicks was significantly higher for Roseate Terns than for Common Terns (Mann-Whitney test: $z = 9.13$, P = 0.000), but increased with age at an approximately equal rate for both species (Figure 1). Nevertheless, Common Terns showed a more marked difference between young (1-12 days) and old (>12 days) chicks than did the Roseate Terns (Figure 1).

DISCUSSION

In this study the diet of Roseate Tern chicks was less diverse than that of Common Terns, which agrees with other studies of these two species breeding in the same colony or area (Gochfeld et al. 1998, Nisbet 2002). However, the diversity of prey ingested by Roseate and Common terns on Vila Islet in 1996 was greater than reported for other coastal marine areas. In 1995, also in Vila islet, Trumpet fish was the main prey species delivered to Roseate Tern chicks, with a diversity index of 2.61 (calculated from table 2 of Ramos et al. 1998b). The prey diversity index for Roseate Tern chicks breeding in temperate regions such as Cedar Beach, U.S.A (B = 1.81, Safina et al. 1990) and South Africa (B = 2.71, Randall and Randall 1978), or tropical regions such as Puerto Rico (*B* = 2.32, Shealer 1995) was also lower than that obtained in our study. Apart from a greater diversity of fish species, the diet of Common Terns usually includes variable numbers of invertebrates (Gochfeld et al. 1998, Granadeiro et al. 2002), although these were not recorded in our study. Differences in diet composition among areas and years should reflect variation in prey availability. The subtropical geographical location of the Azores, together with important physical and oceanographic features such as seamounts and upwellings (Santos et al. 1995), may be important in explaining the higher diversity of prey taken by Roseate and Common terns in the Azores when compared with other coastal marine areas (Ramos et al. 1998a, 1998b, Meirinho 2000, Granadeiro et al. 2002, This study).

The smallest size fish available to young Roseate Tern chicks may not have been equally available to Common Tern chicks because we began observing them about two weeks later. However, this does not explain the differences in chick provisioning between both species because: (1) there were consistent differences in the prey species delivered by Roseate and Common Terns to chicks of all age groups, and (2) non-ingested prey items were significantly larger than ingested items for young chicks (1-12 days) of both tern species. This and other studies (Shealer 1998a, Robinson et al. 2001) showed that chick age influenced the size and the species of fish offered by parent terns to their chicks. In particular, thin and relatively long prey items such as the Atlantic sauri were apparently targeted for the youngest chicks, which agrees with the hypothesis that seabird parents select higher quality prey for chick provisioning (Wilson et al. 2004, Catry et al. 2006). However, Roseate Terns were more efficient in delivering appropriate-sized prey than Common Terns, especially for chicks up to six days old.

The high percentage of boarfish, a wider prey species with acute dorsal fins, offered by Common Terns to their youngest chicks, explained most of the high percentage of not-ingested prey items by chicks of this tern species. Some chicks died with boarfish stuck in their mouths, a fact already reported by Ramos et al. (1998a). Our results suggest that some seabird species are more constrained than others in provisioning their chicks with prey of adequate quality. Most tern studies to date addressed only the impact of food shortage in chick growth and breeding success (Monaghan et al. 1989, Ramos 2001). This may be related to the fact that most studies were carried out in temperate coastal areas of Europe and North America, where *Ammodytes* sp are often the main prey species (Monaghan et al. 1989, Safina et al. 1990). In subtropical oceanic areas such as the Azores, prey diversity is higher and, therefore, prey quality may be increasingly important to explain chick provisioning patterns in marine terns.

Common Terns were unable to provide their young (1-12 days) chicks with appropriately-sized fish because their acceptance rate was lower than that of Roseate Tern chicks. Why did Common Terns offer such a high proportion of deep-bodied prey, such as boarfish, to young chicks, when more than 50% of these were rejected? These findings should be taken into account to explain the fact that the majority of tern chicks that die do so at ages 1-6 days (Nisbet 1978, 2002). The apparent inability of Common Terns to offer adequate prey for young chicks may be partly related to a larger brood size (Nisbet 2002). With more chicks to feed Common Terns presumably spent less time searching for fish and/or may have foraged closer to the colony. In fact, despite their larger clutch size, the overall productivity (fledgings/pair) of Common Terns is only significantly larger than that of Roseate Terns in some specific areas and years (Gochfeld et al. 1998, Nisbet 2002), with an apparent greater marine productivity (Rossell et al. 2000). The higher prey acceptance rate of Roseate Tern chicks might reflect the greater specialization of this tern species on specific foraging habitats (Safina 1990, Ramos 2000) and marine fish species (Safina et al. 1990, Shealer 1998b). This could be indicative of a better adaptation to a (sub)tropical marine situation, and contribute to explain the worldwide distribution of the Roseate Tern.

ACKNOWLEDGMENTS

We thank the Department of Oceanography and Fisheries of the University of the Azores, and the late Luís Monteiro for logistical facilities to carry out this study. The comments of Jeff Spendelow and Rachel Keedwell improved a previous version.

LITERATURE CITED

Burger, A. E., and J. F. Piatt. 1990. Flexible time budgets in breeding Common Murres. Buffers against variable prey abundance. Studies in Avian Biology 14: 71-83.

Burness, G. P., R. D. Morris, and J. P. Bruce. 1994. Seasonal and annual variation in brood attendance, prey type delivered to chicks, and foraging patterns of male Common Terns (*Sterna hirundo*). Canadian Journal of Zoology 72: 1243-1251.

T. Catry, J. A. Ramos, J. Martins, F. Peste, S. Trigo, V. H. Paiva, A. Almeida, A. Luís, J. Palma and P. Andrade. 2006. Inter-colony and annual differences in the diet and feeding ecology of Little Tern adults and chicks in Portugal. *Condor* 108: 366-376.

Dahdul, W. M. and M. H. Horn. 2003. Energy allocation and postnatal growth in captive Elegant Tern (*Sterna elegans*) chicks: response to high- versus low-energy diets. Auk 120: 1069-1081.

Duffy, D. C. 1986. Foraging at patches: interactions between Common and Roseate terns. Ornis Scandinavica 17: 47-52.

Gochfeld, M., J. Burger and I. C. T. Nisbet. 1998. Roseate Tern (*Sterna dougallii*). In the Birds of North America no. 370 (A. Poole and F. Gill, eds.). The birds of North America, Inc., PA.

Granadeiro, J. P., L. R. Monteiro, M. C. Silva, and R. W. Furness. 2002. Diet of Common Terns in the Azores, Northeast Atlantic. Waterbirds 25: 149-155.

Hamer, K. C., E. A. Schreiber and J. Burger. 2002. Breeding biology, life histories and life history-environment interactions in seabirds. Pp 263-305 *in* E. A. Schreiber and J. Burger (eds.), Biology of marine Birds. CRC Press, Boca Raton, Fl.

Klassen, M., B. Zwan, P. Heslenfeld, P. Lucas, and B. Luijckx. 1992. Growth rate associated changes in the energy requirements of tern chicks. Ardea 80: 19-28.

Langham, N. P. 1983. Growth strategies in marine terns. Studies in Avian Biology 8: 73-83.

LeCroy, M., and C. T. Collins. 1972. Growth and survival of Roseate and Common Terns chicks. Auk 89: 595-611.

Levins, R. 1968. Evolution in changing environments. Monography of Population Biology 2. Princeton University Press, Princeton, NJ.

Lyons, D. E., D. D. Roby and K. Collis. 2005. Foraging ecology of Caspian Terns in the Columbia river estuary, USA. Waterbirds 28: 280-291.

Martins, I., J. C. Pereira, J. A. Ramos and S. E. Jorgensen. 2004. Modelling the effects of different quality prey fish species and of food supply reduction on growth performance of Roseate Tern chicks. Ecological Modelling 177: 95-106.

Massias, A., and P. H. Becker. 1990. Nutritive value of food and growth in Common Tern *Sterna hirundo* chicks. Ornis Scandinavica 21: 187-194.

MCGinnis, T. W and S. D. Emslie. 2001. The foraging ecology of Royal and Sandwich Terns in North Carolina, USA. Waterbirds 24: 361-370.

Meirinho, A. 2000. Ecologia alimentar de Garajau-Comum (*Sterna hirundo*) e Garajau-Rosado (*Sterna dougallii*) nos Açores. Undergraduate thesis, Universidade do Algarve, Faro, Portugal.

Milton, D. A., G. C. Smith, and S. J. M. Blaber. 1996. Variable sucess in breeding of the Roseate Tern *Sterna dougallii* on the northern Great Barrier. Emu 96: 123-131.

Monaghan, P. J., J. D. Uttley, and M. D. Burns. 1992. Effect of changes in food availability on reproductive effort in Artic Terns *Sterna paradisaea*. Ardea 80: 71-81.

Monaghan, P. J., J. D. Uttley, M. D. Burns and C. Thaine. 1989. The relationship between food supply, reproductive effort and breeding success in Arctic Terns (*Sterna paradisaea*). Journal of Animal Ecology 58: 261-274.

Monteiro, L. R., J. A. Ramos, R. W. Furness and A. J. del Nevo. 1996. Movements, morphology, breeding, molt, diet and feeding of seabirds in the Azores. Colonial Waterbirds 19: 82-97

Nisbet, I. C. T. 1978. Dependence of fledging success on egg-size, parental performance and egg-composition among Common and Roseate terns *Sterna hirundo* and *S. dougallii*. Ibis 120: 207-215.

Nisbet, I. C. T. 1981. Biological characteristics of the Roseate Tern *Sterna dougallii*. Unpublished report to the U.S. Fish and Wildlife Service Office of Endangered Species.

Nisbet, I. C. T. 2002. Common Tern (*Sterna hirundo*). In the Birds of North America no. 618 (A. Poole and F. Gill, eds.). The birds of North America, Inc., PA.

Nisbet, I. C. T, and M. E. Cohen. 1975. Asynchronous hatching in Common and Roseate Terns, *Sterna hirundo* and *Sterna dougallii*. Ibis 117: 374-379.

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

Pearson, T. H. 1968. The feeding biology of seabird species breeding on the Farne Islands, Northumberland. Journal of Animal Ecology 37: 521-548.

Ramos, J. A. 2000. Characteristics of foraging habitats and chick food provisioning by tropical Roseate Terns. Condor 102: 795-803.

Ramos, J. A. 2001. Seasonal variation in reproductive measures by tropical Roseate Terns: previously undescribed breeding patterns in a seabird. Ibis 143: 83-91.

Ramos, J. A, and A. J. del Nevo. 1995. Nest site selection by Roseate Tern and Common Tern in the Azores. Auk 112: 580-589.

Ramos, J. A, E. Solá, and L. R. Monteiro. 1998a. Prey delivered to Roseate Tern chicks in the Azores. Journal of Field Ornithology 69: 419-429.

Ramos, J. A, E. Solá , F. M. Porteiro, and L. R. Monteiro. 1998b. Prey of Yellow-Legged Gull, Roseate Tern and Common Tern in the Azores. Seabird 20: 31-40.

Ramos, J. A, A. M. Maul, V. Ayrton, J. Hunter, J. Bowler, I. Bullock, G. Castle, R. Mileto, R. Lidstone-Scott, P. Lidstone-Scott and C. Pacheco. 2002. The influence of oceanographic conditions and timing of breeding on tropical

Roseate Tern reproductive parameters. Marine Ecology Progress Series 243: 271-279.

Randall, R. M., and B. M. Randall. 1978. Diet of Roseate Terns during the breeding season at St. Croix Island, Alagoa Bay. Cormorant 5: 4-10.

Robinson, J.A., K.C. Hamer, and L.S. Chivers. 2001. Contrasting brood sizes in Common and Arctic Terns: the roles of food provisioning rates and parental brooding. Condor 103: 108-117.

Rossell, C. R., Hamilton, C. D., L. M. Weber and S. W. Kress. 2000. Chick provisioning by Common Terns in the southern Gulf of Maine, U. S. A. Canadian Journal of Zoology 78: 158-160.

Safina, C. 1990. Bluefish mediation of foraging competition between Roseate and Common Terns. Ecology 71: 1804-1809.

Safina, C, and J. Burger. 1985. Common Tern foraging: seasonal trends in prey fish densities and competition with bluefish. Ecology 66: 1457-1463.

Safina, C, R. H. Wagner, D. A. Witting, and K. J. Smith. 1990. Prey delivered to Roseate and Common tern chicks: composition and temporal variability. Journal of Field Ornithology 61: 331-338.

Santos, R. S., S. J. Hawkins, L. R. Monteiro, M. Alves and E. J. Isidro. 1995. Marine research, resources and conservation in the Azores. Aquatic conservation: Marine and Freshwater Ecosystems 5: 331-354.

Shealer, D. A. 1995. Comparative foraging ecology of Roseate and Sandwich Terns in Puerto Rico and its relation to breeding performance. PhD thesis, The State University of New Jersey, New Brunswick, NJ.

Shealer, D. A. 1996. Foraging habitat use and profitability in tropical Roseate Terns and Sandwich Terns. Auk 113: 209-217.

Shealer, D. A. 1998a. Differences in diet and chick provisioning between adult Roseate and Sandwich Terns in Puerto-Rico. Condor 100: 131-140.

Shealer, D. A. 1998b. Size-selective predation by a specialist forager, the Roseate Tern. Auk 115: 519-525.

Shealer, D. A. 2002. Foraging behaviour and food of seabirds. Pp 137-177 *in* E. A. Schreiber and J. Burger (eds) *Biology of Marine Birds*. CRC Press, Boca Raton, Florida, USA.

Shealer, D. A. J. A. Spendelow, J. S. Hatfield and I. C. T. Nisbet. 2004. The adaptive significance of stealing in a marine bird and its relationship to parental quality. Behavioral Ecology 16: 371-376.

Stienen, E. W. M., and A. Brenninkmeijer. 2002. Foraging decisions of Sandwich Terns *Sterna sandvicensis* in the presence of kleptoparasitising gulls. Auk 119: 473-486

Visser, G. H. 2002. Chick growth and development in seabirds. Pp 439-465 *in* E. A. Schreiber and J. Burger (eds.), *Biology of marine Birds*. CRC Press, Boca Raton, Fl.

Wilson, L., F. Daunt and S. Wanless. 2004. Self-feeding and chick-provisioning diet differ in the Common Guillemot *Uria aalge*. Ardea 92: 197-207.

Zar, J. 1996. *Biostatistical analysis*. Prentice-Hall International, London.

Table 1. Comparison of the percentage of items ingested in relation to the total number of items offered (N) per prey species, for each age class. The mean mass of individual prey item ingested and non-ingested is compared between chick age classes for both Roseate and Common Terns. Roseate Tern data is referred to a-chicks and Common Tern data is referred to a - b - and c-chicks. Kruskal-Wallis K or Mann-Whitney U tests were used to compare fish mass among age classes (rows showing different letters are significantly different (non-parametric multisample *Q* test). The all prey category includes also Belone belone, Cubiceps gracilis, Pagellus bogaraveo, Ecletrona rissoi, Atherina presbyter, Argyropelecus aculeatus, Apogonon imberbis, Labridae, Blenidae, Squid and Shrimps (<0.1% to 5%) and unidentified prey (5 to 17%). - = prey species not taken

Roseate Tern

	Chick age (days)				Statistic
Prey	1-6	7-12	13-18	19-24	
Blue Jack Mackerel					
N	46	69	90	56	
Ingested (%)	59	77	92	93	
Ingested (g)	8.5 ± 1.1	8.3 ± 0.8	8.2 ± 0.7	9.0 ± 0.7	$H_{3,215} = 3.4$, $P = 0.30$
Non-ingested (g)	8.2 ± 1.4	8.8 ± 1.2	10.5 ± 3.3	10.7 ± 5.9	$H_{3,46} = 0.6$, $P = 0.90$
Atlantic Sauri					
N	108	43	18	14	
Ingested (%)	83	88	88	100	
Ingested (g)	1.1 ± 0.1[c]	2.0 ± 0.3[b]	3.4 ± 0.6[b]	5.1 ± 0.7[a]	$H_{3,158} = 46.5$, $P = 0.000$
Non-ingested (g)	1.5 ± 0.2	6.5 ± 1.8	2.8 ± 1.3	-	$H_{2,25} = 6.7$, $P = 0.035$
Boarfish					
N	13	37	24	11	
Ingested (%)	15	76	88	91	
Ingested (g)	1.3 ± 0.0	1.9 ± 0.4	2.1 ± 0.7	1.8 ± 0.4	$H_{3,61} = 2.9$, $P = 0.40$
Non-ingested (g)	2.7 ± 0.7	2.4 ± 0.9	1.3 ± 0.0	1.3	$H_{3,24} = 1.9$, $P = 0.60$
Trumpet fish					
N	6	15	-	2	
Ingested (%)	33	80	-	100	
Ingested (g)	0.7 ± 0.4	2.4 ± 0.3	-	2.6 ± 0.0	$H_{2,16} = 5.5$, $P = 0.06$
Non-ingested (g)	1.8 ± 0.4	2.6 ± 0.0	-	-	$U = 3$, $P = 0.30$
All prey					
N	202	191	169	118	
Ingested (%)	73	81	92	94	
Ingested (g)	3.4 ± 0.5[c]	4.7 ± 0.4[b]	6.3 ± 0.5[a]	6.4 ± 0.5[a]	$H_{3,568} = 84.4$, $P = 0.000$
Non-ingested (g)	4.5 ± 0.7[c]	6.7 ± 0.8[b]	6.8 ± 2.1[b]	7.1 ± 3.6[ab]	$H_{3,112} = 8.1$, $P = 0.044$

Common Tern

	Chick age (days)				Statistic
Prey	1-6	7-12	13-18	19-24	
Blue Jack Mackerel					
N	139	101	117	14	
Ingested (%)	27	39	69	79	
Ingested (g)	5.9 ± 0.5[b]	6.8 ± 0.5[ba]	8.9 ± 0.6[a]	10.6 ± 1.1[a]	$H_{3,169} = 18.9$, $P = 0.000$
Non-ingested (g)	7.5 ± 0.4[b]	9.5 ± 0.6[ba]	11.8 ± 1.1[b]	12.1 ± 2.5[ab]	$H_{3,202} = 18.8$, $P = 0.000$
Atlantic Sauri					
N	102	11	-	-	
Ingested (%)	83	36	-	-	
Ingested (g)	0.6 ± 0.1	2.5 ± 0.7	-	-	$U = 31.5$, $P = 0.006$
Non-ingested (g)	2.2 ± 0.6	4.2 ± 0.7	-	-	$U = 34.0$, $P = 0.10$

Boarfish					
N	86	168	123	42	
Ingested (%)	8	43	66	71	
Ingested (g)	1.6 ± 0.4	1.9 ± 0.3	2.1 ± 0.4	1.3 ± 0.1	$H_{3,229} = 5.8$, $P = 0.1$
Non-ingested (g)	1.6 ± 0.1	1.8 ± 0.1	2.1 ± 0.6	1.9 ± 0.6	$H_{3,190} = 2.1$, $P = 0.6$
Trumpet fish					
N	4	23	69	25	
Ingested (%)	25	17	36	48	
Ingested (g)	1	1.4 ± 0.7	1.3 ± 0.2	0.9 ± 0.2	$H_{3,42} = 1.1$, $P = 0.8$
Non-ingested (g)	2.1 ± 0.5[a]	2.5 ± 0.4[a]	1.1 ± 0.1[b]	0.7 ± 0.1[c]	$H_{3,79} = 24.1$, $P = 0.000$
All prey					
N	407	374	376	108	
Ingested (%)	45	47	65	73	
Ingested (g)	2.2 ± 0.3[c]	3.1 ± 0.3[a]	4.5 ± 0.4[a]	2.8 ± 0.4[b]	$H_{3,683} = 60.2$, $P = 0.000$
Non-ingested (g)	4.6 ± 0.3[a]	4.7 ± 0.4[a]	4.6 ± 0.6[b]	2.5 ± 0.7[b]	$H_{3,582} = 30.0$, $P = 0.000$

Figure 1. Variation in the prey acceptance rate of the chicks (prey ingested/prey offered) for both Common and Roseate Terns in relation to chick age. Age groups sharing the same latter did not differ significantly (Nemenyi test: P < 0.01). Vertical bars indicate standard error. Sample size indicated in parenthesis beside the bars.