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Robert Simmons
University of Cape Town

BREEDING, FORAGING, TRAPPING AND SEXING OF DAMARA TERNS IN THE SKELETON COAST PARK, NAMIBIA

ROBERT SIMMONS & STEVE BRAINE[1]

Ornithology Section, Ministry of Environment & Tourism, P/Bag 13306, Windhoek, Namibia
[1] Present address: Hobatere Lodge, P.O. Box 110, Kamanjab, Namibia

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SUMMARY

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This paper details 6 years' monitoring of breeding Damara Terns *Sterna balaenarum* on Namibia's north-western coast. We report new breeding distribution records, factors limiting success on the desert coast and detail two new methods of catching terns and a new sexing technique. Nests occurred as far north as the Cunene River mouth and occurred mainly on open gravel plains up to 8 km from the coast. Eggs occurred over an 8 month period with a peak in January. Of 66 nests monitored on a daily basis, 72% successfully hatched, and most of those failing were taken by mammals. Incubation was slightly shorter than reported previously (19.2 d), and heavier chicks emerged from larger eggs. Adult plunge diving success was low and records indicate Skeleton Coast Damara Terns brought mainly needle fish *Tylosurus* sp. to their nestlings. Two new methods to capture adults were developed, noose catching and hand capture, both of which avoided nest desertions, and had success rates of up to 70%. Morphologically the sexes differed significantly in bill size, allowing a simple and efficient means to separate male and female terns. We conclude that Damara Tern populations are more extensive than previously thought and further ringing and monitoring of food resources is encouraged.

INTRODUCTION

As one of Africa's most vulnerable birds (Collar & Stuart 1985), and a near-endemic confined almost exclusively to the desert regions of Namibia, the Damara tern *Sterna balaenarum* has held special status among conservation bodies in Namibia. Low-key monitoring of this small tern was begun by Clinning (1978) north of Swakopmund in 1976, following the discovery of the first nest by SB in the early 1970s. Wading bird surveys between Cape Cross (21.75 °S) and the Cunene River (17.25 °S) (Ryan *et al.* 1984) and those specifically for Damara terns between Swakopmund (22.5 °S) and Möwe Bay (19.5 °S) (Clinning 1978) and Oranjemund (28.5 °S) and Luderitz (26.5 °S) (Frost & Johnson 1977; Siegfried & Johnson 1977), led to the first population estimates for the species in Namibia (2 000 birds: Clinning 1978). These and other studies (e.g. Frost & Shaugnessy 1976) added significantly to our understanding of Damara tern breeding, and chick development. They also underlined the difficulty in gaining accurate figures on the population numbers for this highly dispersed tern.

Since then, these populations and others farther north on the Namibian coast near the Ugab River mouth and Möwe Bay have been monitored more intensively and much new information obtained. Most of these data are contained in over 800 nest record cards held by the ornithology section of the Namibian Ministry of Environment and Tourism.

A new drive to publish this work with emphasis on factors limiting success was given impetus in 1991 with the chance finding of a single group of Damara Terns whose numbers (5 068) exceeded previous world population estimates (Braby *et al.* 1992). This paper re-examines Damara Tern breeding biology in the Skeleton Coast. We present new data on breeding distribution, incubation periods, egg and chick sizes, breeding success and foraging success. We also developed two new methods of trapping adults and present data on morphological sex differences between adults. Data were first gathered in a 5-year period between 1984 and 1988 in the Skeleton Coast Park by SB. Breeding success, egg size — chick size relationships and further morphological data were gathered by RS in 1993 following the development of additional trapping methods in Ugab and Möwe Bay. Other papers arising from this study provide details of new estimates on Damara Tern populations throughout Namibia (Simmons 1993a) as well as clutch size aspects (de Villiers & Simmons 1993).

STUDY AREA AND METHODS

The Skeleton Coast Park runs for approximately 495 km from the Ugab River (21 11.3 S; 13 37.8 E) north to the Cunene River (17 14.98 S; 11 45.20 E) on the Angolan border. The park encompasses approximately 16 000 km² of gravel and rocky plains, salt pans and dunes. Annual rainfall is highly variable, but averages just less than 20 mm (van der Merwe 1983). Fog is common, particularly in winter, and occurs once every three days on the Namibian coast (van der Merwe 1983).

During Damara Tern breeding seasons (October to June) regular patrols were undertaken to determine colony sizes and to plot nest sites. Year-round monthly coastal bird counts were also undertaken by conservation staff in the Skeleton Coast Park. While we admit to some bias in finding nests close to the only road that runs north-south through the park, once nests were found, intensive searches throughout the area

5,4 km from the coast and the average distance was much greater than previously found at 3,18 ± 0,95 km. This illustrates the suspected bias of monitoring nests mainly from the road that runs north-south through the park which rarely goes beyond 3 km from the ocean. In 1993 we monitored nests by fat-wheeled bike concentrating on all parts of a set study area 5,5 km in width. Nests elsewhere in Namibia occurred 500 m to 3 km inland (Clinning 1978), and averaged 1,9 km in the West Coast Recreation Area (P. Tarr unpubl. data). In South Africa the average distance was much smaller at 159 m (Randall & McLachlan 1982), where suitable habitat is limited to the coast (J. Cooper and R. Randall in litt.).

Closest nest spacing from 1984 to 1988 was 50 m, with nests most often 100–200 m apart, similar to that reported by Frost & Shaugnessy (1976) near Swakopmund, and Randall & McLachlan (1982) near Sundays River, South Africa. A total 62 nests were found in the 44 km^2 Mowe Bay study area in 1993, a density of 1,4 nests/km^2. Nest spacing varied greatly with obvious "hotspots" (typically on soft gravel plains) where up to eight pairs nested at an average nearest neighbour distance of ($\bar{x}$ ± 1.S.D.) 133 ± 50 m, with closest nests 80 m apart. More dispersed nests (typically in broken rocky country) averaged 365 ± 154 m (n = 10) apart. Least common were isolated nests averaging 900 ± 351 m (n = 5) and a maximum of 1 500 m apart. They occurred on featureless hard gravel plains. Elsewhere, nests averaged 57 m (range 32–96 m: Clinning 1978) and were closest (20 m) in the remote and completely undisturbed Hottentot Bay colony near Luderitz (de Villiers & Simmons 1993).

Close nest spacing may be associated with predator-free environments but the density of terrestrial predators such as Blackbacked Jackals *Canis mesomelas* has rarely been quantified. However, jackals do appear to have an effect on the distance inland that terns nest: Simmons & Heber-Percy (in prep.) showed that in four separate colonies the distance inland at which terns started nesting corresponded in all cases with a rapid decrease in jackal track densities. Since jackals and Brown Hyaenas *Hyaena brunnea* patrol mainly within 300 m of the coast (Simmons & Heber-Percy in prep.), this may explain why terns chiefly nest at least 1 km from their feeding grounds in all Namibian areas studied.

Predators and levels of predation

The Skeleton Coast Park has a high density of Blackbacked Jackals (pers. obs.) which have been observed depredating other ground-nesting birds (Braine 1987); they are thus potential predators of Damara Tern eggs and chicks. In an attempt to determine the impact of these predators, as well as that of Brown Hyaenas, Kelp Gulls *Larus dominicanus* and Pied Crows *Corvus albus*, 33 tern nests were monitored daily at Möwe Bay in 1987/88 and again in 1993. In 1987/1988 four nests (12%) were destroyed by jackals, as evidenced by fresh jackal tracks leading to the empty nests. Two eggs disappeared without trace, presumably taken by aerial predators (6%). All others (82%) hatched successfully, suggesting that despite numerous predators, the tern's cryptic egg is effective in reducing predation. Monitoring in 1993 showed slightly higher levels of predation: 21 eggs hatched (64%), 7 (21%) disappeared in conjunction with jackal or unknown cat tracks at the nest, while 15% failed due to crow predation (crows were seen over nests and no mammal tracks were evident). Combining these totals (N = 66), 72% were successful, 17% fell to mammals and 11% were taken by crows. Intermediate levels of predation were found for terns breeding near Swakopmund (Clinning 1978): 76% of 51 eggs monitored hatched or were presumed to have hatched, 20% were lost to jackals and 8% disappeared without trace.

Predation differences between these areas were principally associated with greater aerial predation since mammalian predation (12%, 21% and 20%) was relatively constant. In Möwe Bay in 1993 Pied Crows bred simultaneously with terns in the Hoanib River and regularly over-flew the tern colonies, possibly adding to enhanced predation (15%).

Brown Hyaenas similarly take tern eggs. One was seen being mobbed by 36 adult terns as it moved through a colony south of Möwe Bay. This is contrary to the statement by Frost & Shaugnessy (1976) that Damara Terns are one of the few terns that does not mob communally. Hyaena tracks were seen leading to two newly destroyed eggs in the Ugab River area in 1992. Hyaena tracks constituted 7,3% of 1 665 mammal tracks encountered within 3 km of the coast in the Park in 1992/1993 (Simmons and Heber-Percy in prep.). Hence while mammal predation is dominated by jackals, hyaenas add to predation levels.

Clutch size, egg size and incubation

Breeding spanned eight months from November to June in the Skeleton Coast, with a peak in egg-laying in January (Fig. 1). A small second peak of chicks (26% of 84 chicks found) occurred in May and June. We suspect that these were from breeders which relaid after early failure. However, eggs produced as late as May–June are probably those of first-time breeders since this occurs in other small terns (Nisbet *et al.* 1984; Massey & Atwood 1981). Furthermore most adult Damara Terns leave after June (about 100 remain in Namibia during the winter: RS unpublished wetland bird counts), and terns farther south are known to abandon eggs laid in June (J. Friede pers. comm.). Hence these nests have little chance of success. While January was the peak egg-laying period for Skeleton Coast Damara Terns, peak egg laying occurs one month earlier in the West Coast Recreation area (Parr pers. comm.) and may vary uniformly with latitude (pers. obs.).

Of 159 clutches found in 1984/88, all but one were single eggs: the only two-egg clutch occurred north of Terrace Bay in 1987. All 104 clutches recorded in 1993 were similarly single eggs. Two egg clutches are generally rare and consitute less than 1% of all records (de Villiers & Simmons 1993).

were undertaken to find other nests. We do not claim, therefore, random sampling to locate and plot nest distances from the sea, and some bias may be present. Other methods employing stratified random sampling (Simmons 1993a) and searching a specified study area at Möwe Bay have since rectifed this possible bias. Most field work was undertaken by SB and staff at Möwe Bay (n = 243 nest records) and further samples were added by RS from 3 months work spanning November 1992 to February 1993. Areas sampled were Ogdon rocks (21 06 S; 13 34 E: n = 24 records), Huab River (20 55 S, 13 27 E: n = 40), Hoanib River (19 25 S; 12 45 E: n = 40) and Möwe Bay (n = 22). Hereafter the latter two areas are called Möwe Bay. Emphasis was put on assessing the limits to breeding and catching adults for morphological analysis.

Suitable habitats such as gravel plains and salt pans were searched for nests by walking or driving until terns were seen flying or sitting. Nests were found by watching birds with 10 × 40 binoculars, and by walking directly to their nests, once flushed. To obtain breeding density estimates in 1993, a study area 8 km long × 5,5 km inland was selected at Möwe Bay which encompassed the previously monitored area. It comprised yellow and pink gravel plains, broken rocky country interspersed with pink and grey gravel and a small salt pan. In 1993 we used a fat-wheeled motorbike to reach all corners of the area to eliminate any possible bias in the calculation of average distances of nests from the sea. Inter-nest distances were gauged by odometer accurate to 10 m. Sunrise and sunset were ideal periods for finding incubating birds, because their white plumage reflected the low level light, making them stand out on certain substrata. Birds also appeared more reticent to leave their nests at these times.

During the 1987/1988 breeding season, 33 nests with eggs were monitored on a daily basis at Möwe Bay, and 33 were also monitored in 1993. Egg and nestling masses were taken when possible and chicks were considered newly hatched if they were still in the nest scrape and had matted down. Eggs and chicks were weighed with 50 g or 100 g Pesola spring balances to the nearest 0,1 g and body measurements were taken with Vernier callipers and a butt-end wing rule to the nearest 0,1 mm. Adults were similarly measured, with wing chord being flattened and straightened for maximum length. Bill length was measured as the exposed culmen and bill depth was taken at the gonys. To determine egg volume we used the formula: length × $(\text{breadth})^2$ × 0,48 (Monaghan *et al.* 1989). Since eggs differ in size and we wished to calculate the loss in mass for all eggs, we used the decline in mass in conjunction with egg volume (mass/volume = density) to determine this parameter. This relationship between age and density could then be used to predict the laying date of any egg (Furness & Furness 1981).

Data on plunge diving success of Damara Terns were collected by RS using a dictaphone at the Cunene River mouth, where several birds were foraging in March 1991. Data were collected on dive/success rates and the habitat (opaque-fresh or clear-salt water) into which the birds dived.

RESULTS AND DISCUSSION

Breeding localities

Most previous authors suggest that Damara Tern colonies are probably not found farther north than Möwe Bay (Clinning 1978; Maclean 1985; Urban *et al.* 1986). However, breeding was observed and inferred from birds carrying fish inland along the entire Skeleton Coast Park coast at most suitable sites. Birds carrying fish were observed at the Cunene River mouth in December 1987 and 1988, flying into Angola and Namibia to feed young. An adult feeding young at the Cunene River mouth in March 1991 (below), and 94 records of eggs, chicks and juveniles north of Möwe Bay in Skeleton Coast Park in the national census in February 1992 (Simmons 1993a), confirm that Damara Terns breed along the entire northwest coast. Since the Namib Desert extends a further 150 km north into Angola and similar cold upwellings occur offshore there (Ashmole 1971; Shannon 1985; Simmons and Heber-Percy unpubl.), it is highly likely that breeding occurs in Angola (Brooke 1981).

Habitat and nest density

As in other areas farther south (Frost & Shaugnessy 1976; Clinning 1978; R. Braby & S. Braby in prep.), Damara Terns in the Skeleton Coast Park showed a preference for breeding on extensive, unvegetated flat gravel plains. However, pairs were also found nesting between barchan dunes on rocky ridges, sandy plains, stony areas, coastal marine terraces and hardened salt pans. In 1993, 72% of 60 nests occurred on hard and soft gravel plains, 18% occurred in broken rocky areas, and 10% were found among *Salsola* sp. hummocks. None occurred on the small salt pan. A preference for slightly elevated areas with good exposure was noted which we assume is associated with early predator detection. Most nests were also associated with some feature such as large dark or light coloured stones or rocks (33% of 56 nests), old tyre tracks (18%) small river washes (9%), drift wood or roots (4%) and once in an Ostrich *Struthio camelus* footprint. Only 36% of nests had no obvious feature within 5 m We believe that birds were marking their nests by laying their cryptic eggs near such obvious features. Three lines of evidence support this: (i) most pairs (64%) laid near obvious features; (ii) certain pairs nesting on featureless salt pans sometimes appeared unable to find their eggs; and (iii) use of features to locate nests is reported for two other Terns (Saino & Fasola 1993).

Nest dispersion and distance from ocean

Nests with eggs and newly hatched chicks were found from 90 m to 8 km from the sea, and averaged 1,75 km inland (n = 66). In 1993, none of the 62 nests at Möwe Bay occurred within 1 km of coast, 6 (10%) occurred within 2 km, 30 (48%) were within 3 km, 48 (77%) were within 4 km and 61 (98%) were within 5 km. The furthest nest was

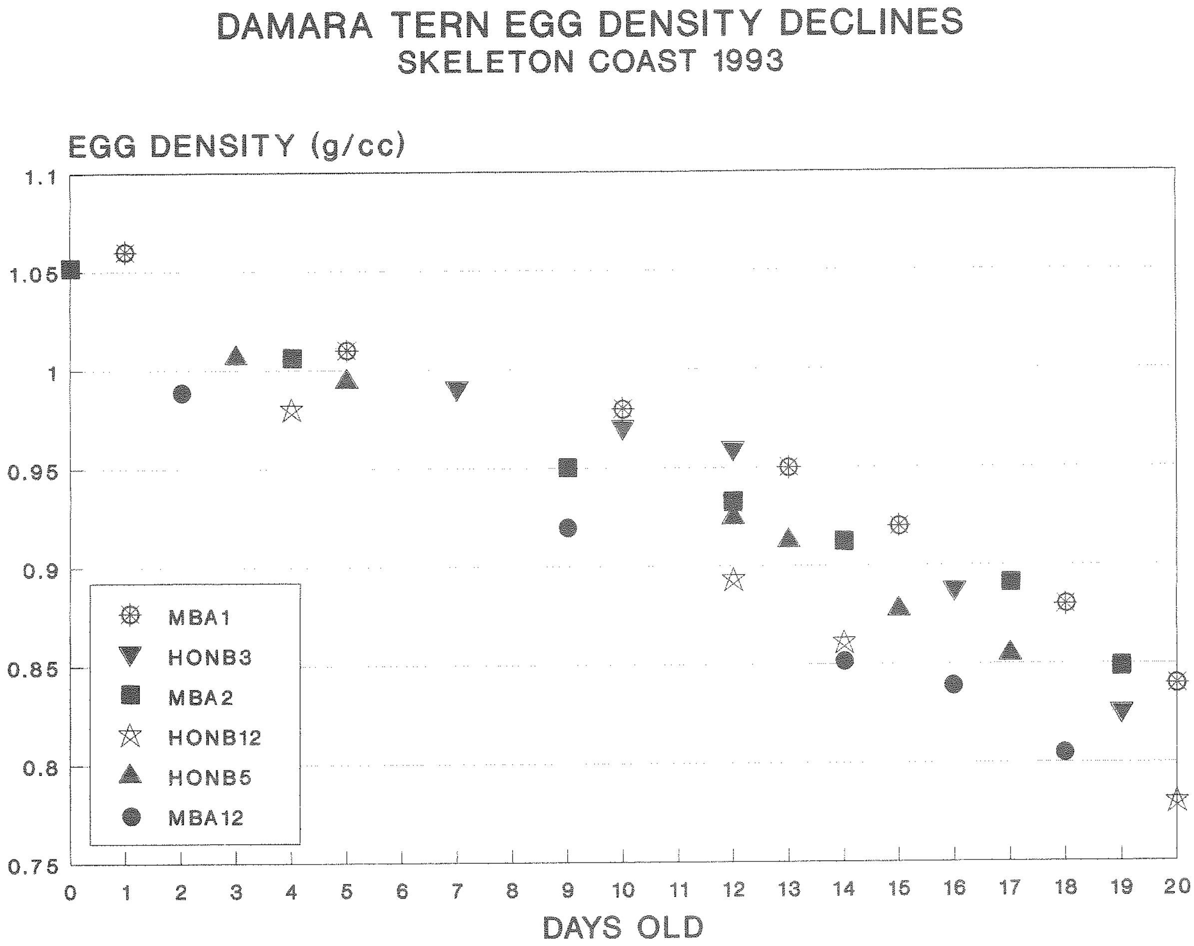

FIGURE 2

Loss in density of six Damara Tern eggs monitored throughout incubation in the Skeleton Coast Park in 1993. Density was determined from mass (g) divided by volume (cc), where volume = length × breadth^2 × 0,48. The graph can be used to estimate laying date of any Damara Tern egg within ±2 days.

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than small eggs (cf. MBA 1 in Figure 2, an egg of 9,22 cc, relative to MBA 12 an egg of 8,70 cc). This may arise from more (and thicker?) egg shell around larger eggs, but this remains unproven. Laying date could be calculated within ± 5 d using this method for any egg. However, greater accuracy is possible by ranking the egg as large, medium or small: large eggs start at 1,05 g/cc and decline uniformly to about 0,84 g/cc (Fig. 2), while small eggs start at just above 1,00 g/cc and decline to 0,78 g/cc Accuracy in ageing is then ± 2 days.

Egg size — chick relationships

The average mass of 18 newly hatched chicks taken in 1993 at Möwe Bay was 6,5 g (± 1,0 g S.D.). The heaviest chick recorded was 7,6 g and the lightest 4,8 g. To explore the relationship between egg size and hatching mass we included 10 recently hatched eggs found just south of the park on the Durissa Bay salt pans in 1992/93. In the total sample of 24 eggs for which we had both volume and the mass of the newly hatched chick we found no relationship between the two measures. However, inspection of the data revealed two outliers of apparently runt chicks of mass 4,9 g each, 25% lighter than the mean. On removal of these chicks, we found that there was a significant trend (R^2 = 19,5%, P = 0,04, n = 22) for the heaviest chicks to emerge from the largest eggs (Fig. 3). Because of the large movements of chicks (below) we were unable to ascertain whether chick size influenced survival as found in other species of sea bird (Parsons 1970; Nisbet 1978; Williams 1980).

Nestling movements

Young start to move from the nest scrape almost as soon as they are mobile at 2–3 days old. One newly hatched chick had moved 20 m from its nest scrape after 3 d and was a further 70 m away 2 d later. Movements get steadily larger thereafter: when tern chicks are about 14 d old and weigh *c.* 30 g they can move considerable distances generally west or south westerly into the prevailing wind (and sound of the ocean?). For example a chick of this age moved 200 m in 20 min shortly after being fed by an adult, and similar

Damara Terns laid a wide range of eggs both in size and colour: mean egg volume was 8,97 cc with the biggest eggs being 48% larger than the smallest eggs (Table 1). No differences in average volume were apparent between years and the details given in Table 1 are no different from those reported by Clinning (1978) farther south (33,3 × 23,9 mm). The smallest and largest eggs in the Skeleton Coast were well within the range reported elsewhere (Maclean 1985).

Most eggs had a greenish brown background with small black/brown spots and blotches. Some however, had spots highly concentrated around the blunt end, and none below. While we could not confirm that the ground colour of the egg varied with the pink, grey or white of the substrate on which it was laid (R. Loutit pers. comm.), we did find that eggs that died, quickly faded in the harsh desert environment and those left uncovered were quickly sand blasted paper thin.

Three incubation periods were accurately recorded following observations of birds obviously about to lay. One egg hatched 17,5 d and two hatched 20 d after laying ($\bar{x}$ = 19,2 d). One egg laid at approximately 11h00 on 26 February 1987, weighing 9,0 g was found starred and holed 17,5 d later at 18h00. It then weighed 4,8 g, a 47% mass loss. At 18h00 the following day the chick weighed 5,8 g, and 10 d later it weighed 22 g.

TABLE 1

MEAN EGG DIMENSIONS (± 1 S.D.) AND MAXIMUM AND MINIMUM VALUES OF EGGS MEASURED IN THE SKELETON COAST PARK IN 1984 TO 1988 AND 1992/93. ALSO GIVEN ARE VOLUMES BASED ON THE FORMULA: LENGTH × BREADTH^2 × 0,48.

Year	1984-1988	1992/93
Length (mm)	32,2 (n = 159)	33,00 (± 1,06) (n = 104)
Range	29,6–36,2	30,45–35,16
Breadth (mm)	24,1 (n = 159)	23,77 (± 0,58) (n = 104)
Range	22,6–24,9	22,14–25,30
Mean egg volume (cc)	8,98 (n = 159)	8,95 (n = 104)
Range (cc)	7,26–10,77	7,27–9,92

Using egg density to age eggs

Damara Tern eggs lose mass uniformly throughout incubation decreasing from an average 9,3 g for (7) freshly laid eggs to about 7,5 g just before hatch. Once the inner membrane is punctured, mass loss increases and hatching chicks may weigh as little as 4,8 g. In 1993 mass loss was quantified and eggs showed the steady loss in density (mass/volume: Fig 2) characteristic of other species (Furness & Furness 1981). There was a tendency for the largest eggs to start at a higher density

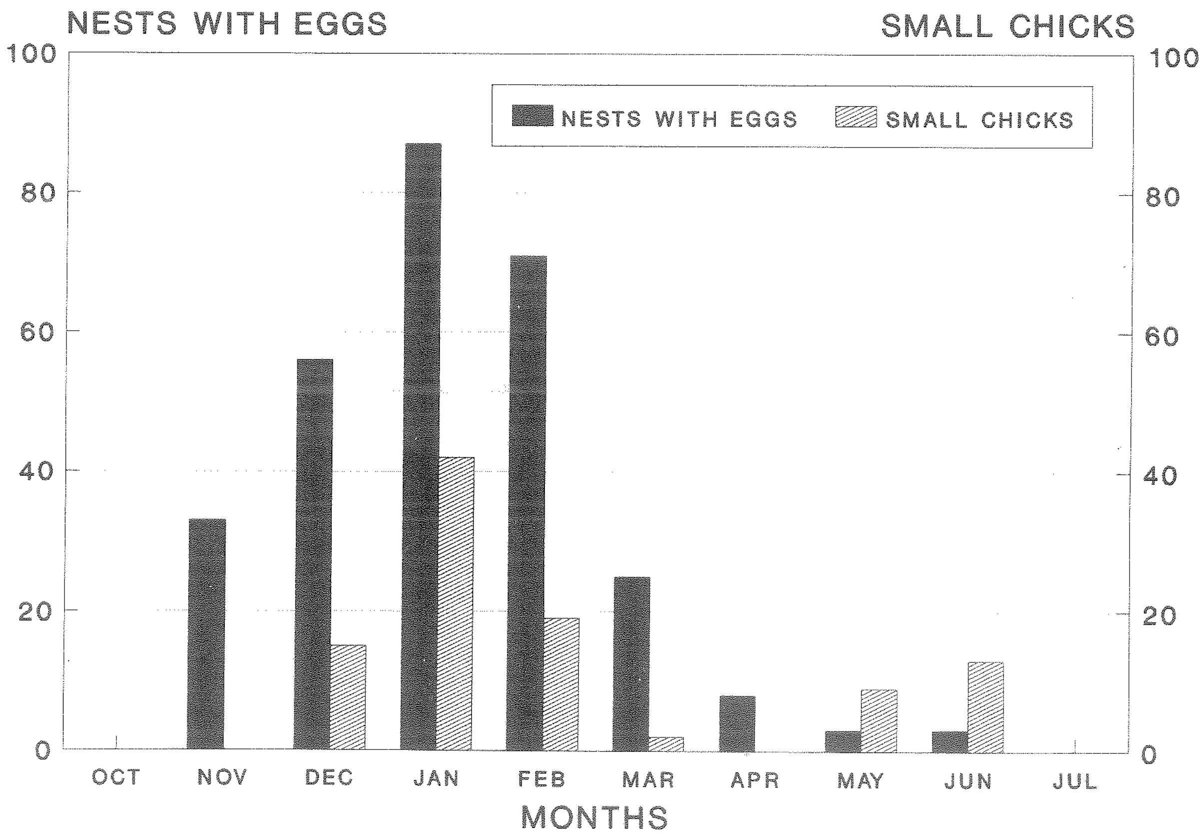

FIGURE 1

Seasonal peaks in the occurrence of Damara Tern eggs and flightless chicks throughout the Skeleton Coast Park, 1984–1988 and 1992. Based on records of 286 eggs and 84 chicks.