BREEDING SUCCESS OF THE CASPIAN TERN IN FINLAND

By Martti Soikkeli

The cosmopolitan Caspian Tern (*Hydroprogne caspia*) may suffer from human activity more than many other related species in the future. The largest tern in the world, it is killed by hunters and fish-pool keepers more frequently than other terns. The Caspian Tern may also experience significant losses owing to increasing water pollution, since many populations in Asia, Europe, and North America breed or winter in inland waters that might become polluted more quickly than oceans.

The breeding success of the Caspian Tern is poorly known. The only other paper, known to me, that discusses this topic is from North America (Ludwig 1965). The present paper includes clutch-size, hatching success, and chick mortality of the Caspian Tern over a three-year period in two colonies in the Finnish southwestern archipelago of the Baltic Sea.

STUDY AREA AND METHODS

The Baltic Sea is a fairly closed basin of mesohalinic water. The salinity is only 0.3 per cent in the north and 0.7-0.8 per cent in the south. The Caspian Tern population inhabiting the Baltic Sea, nesting mostly along the Finnish and Swedish coasts, has increased during this century and especially after World War II (Bergman, 1953; v. Haartman et al., 1963-66). According to a recent estimate, the entire population in the Baltic Sea area is approximately 2,000 pairs (Staav et al., 1972).

This field study was carried out from 1970 to 1972 in the parish of Brändö, situated in the northern archipelago of Åland between Finland and Sweden (60° 40′N, 21°00′E). Between 30-50 and 70-95 pairs, respectively, were breeding on the outermost, treeless, rocky small islands of Medarklubb and Gadden that are 4 km from each other. The colonies were visited eight times in each breeding season at intervals of 5 to 7 days, or if rough seas prevented landing, every 10 to 13 days. Nests were counted and marked by a number painted on a nearby rock, and the clutch- or brood-size was recorded at each visit. If necessary, the incubation stage of the egg was estimated by floating the egg in water. To prevent double counting, small chicks were marked by hen dye and banded later. In 1972, some dead chicks were collected for autopsy.

RESULTS

Breeding cycle. Eggs were laid from early May to late June or early July (Table 1). Every year the bulk of females laid on or before 20 May (Table 2). As judged from the number of clutches destroyed and replaced later, most of the clutches laid between 21-31 May were first attempts, but clutches that appeared in June (or exceptionally in July) were most certainly replacements.

TABLE 1. Laying seasons (calculated by the first egg in the clutch) in two colonies of the Caspian Tern in Finland in 1970-72.

Year	Laying started	Laying ceased	Length of season in days
1970	12 May	24-28 June	43-47
1971	5-6 May	4-5 July	60
1972	5-6 May	30 June-13 July	59-60

In different years the first chick hatched on the following dates: 1970, 5 June; 1971, 29-30 May; 1972, 1-2 June. The earliest flying young was seen on 5 July 1971 at an age of 36 days or less, approximately two months after the first eggs were laid in the colonies.

TABLE 2. Clutch-size of the Caspian Tern in different laying periods in Finland in 1970 to 1972 (n = 365).

Year		Periods											
		To 20 May			21-31 May			1-10 June			From 11 June		
		Eggs			Eggs			Eggs			Eggs		
		1	2	3	1	2	3	1	2	3	1	2	3
1970	n	2	10	46	10	29	10[a]	2	3	1	3	5	—
	Per cent	3	17	79	20	59	20	33	50	17	38	63	—
1971	n	4	18	43[b]	4	21	5	2	9	1	2	5	1
	Per cent	6	27	66	13	70	17	17	75	8	25	63	13
1972	n	—	24	68	—	11	3	6	9	1	5	2	—
	Per cent	—	26	74	—	79	21	38	56	6	71	29	—
Total	n	6	52	157	14	61	18	10	21	3	10	12	1
			215			93			34			23	
	Per cent	3	24	73	15	66	19	29	62	9	43	52	4
Average clutch-size		2.70			2.04			1.79			1.61		

[a]Including a nest with 5 eggs. [b]Including a nest with 4 eggs.

Fledging young began to follow their parent birds on distant fishing flights about one week after fledging. The first young were seen in the inner archipelago, 20 km from the breeding grounds, on 17 July 1970, on 14 July 1971, and on 12 July 1972 (R. Tenovuo, pers. comm.). In early August only a few Caspian Terns remained on the breeding islands.

Clutch-size. Egg-laying in a nest was considered to have ceased if three eggs or more were in the nest or the clutch-size was the same or smaller after five days, the shortest time between successive visits. In some cases the recorded clutch-size was probably not accurate due to egg predation before the nest was found.

In the beginning of the laying season, clutches of three comprised 73 per cent of the clutches, but at the end of the season after 10 June, they comprised only 4 per cent (Table 2). Only once, in 1971, was a clutch of three laid after 10 June. Three-egg clutches amounted to 49 per cent of all clutches for which the laying time was determined. Due to egg predation probably 50-55 per cent of all clutches were of three eggs. Clutches of one increased from 3 to 43 per cent as the breeding season progressed. Most or probably all clutches of one found before 21 May were reduced from larger clutches by predation, In 1972, when egg predation was low, no clutches of one were detected before June (Table 2). Clutches larger than three were found only twice. Four eggs were laid in a nest in 1970 and five eggs in another nest in 1971 in the Medarklubb colony.

Mean clutch-size decreased sharply in May, but less in June (Fig. 1). The average decline expressed in per cent between different

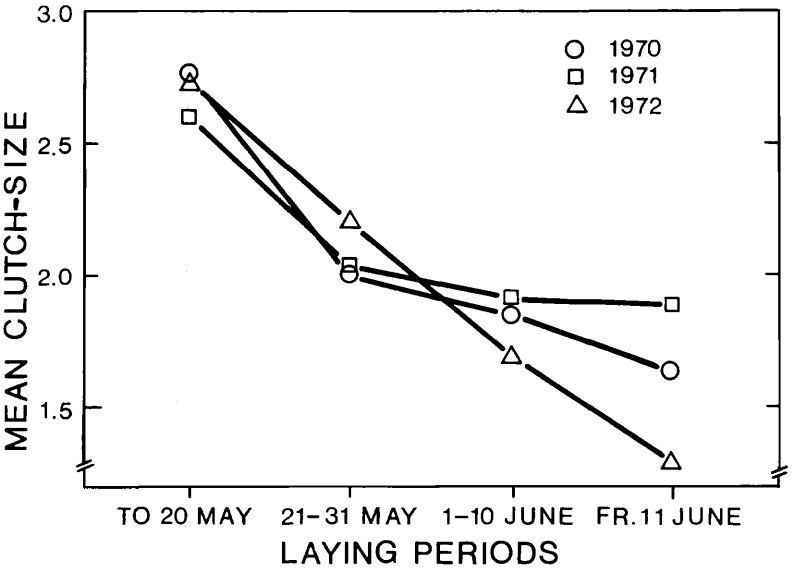

FIGURE 1. Seasonal variation in the mean clutch-size of the Caspian Tern in Finland, 1970 to 1972.

periods of laying (for periods see Fig. 1) was 23, 13, and 11. The decline through the entire laying season was even larger than shown in Figure 1, because the earliest clutches almost always contained three eggs and the last clutches more often contained one than two eggs. The variation in the mean clutch-size between years was lower in the beginning than at the end of the laying season (Fig. 1).

Hatching success. On the average, 1.78-1.86 chicks hatched per breeding pair (Table 3). Hatching success did not vary much annually. Of pairs attempting breeding, 80-87 per cent hatched chicks, but between 71 and 80 per cent of the nests produced chicks. Certainly all nests were not found before some of them were totally destroyed and hence this estimate of productive nests is probably high.

TABLE 3. Hatching success in two colonies of the Caspian tern in Finland in 1970-72.

Year	Pairs breeding	Nests found	Young hatched	Young per pair
1970	125	141	220–225	1.76–1.80
1971	120	133	199–214	1.66–1.78
1972	135	144	257–269	1.90–1.99
Total	380	418[a]	676–708	1.78–1.86

[a]n is greater than in Table 2, because the laying time of some clutches, included in this table, was not determined.

Losses of eggs were caused by predation by other Caspian Terns and perhaps gulls nesting close to the colony. Rotten eggs (infertile or with a dead embryo) amounted to 21, 8, and 13 in 1970, 1971, and 1972, respectively. Most likely some rotten eggs escaped notice due to their removal from the nest by a parent bird after hatching of the chicks. No deformed chicks were detected during the study.

Chick mortality. The number of fledged young depends on the number of chicks hatched per pair and on the mortality of chicks. In 1970 mortality was higher at Gadden, but in 1971 more chicks died at Medarklubb (Table 4). In 1972 chicks in both colonies suffered from a relatively high mortality. Chicks dying in 1970 were mostly large, almost fledglings, but in 1971 and 1972, chicks died most often when small.

Since the relatively high mortality in 1970 and 1971 occurred on only one of the islands each year, the cause(s) might have been a

TABLE 4. Number of young Caspian terns found dead before the fledging stage in two colonies in Finland, 1970-72.

Year	Colony		Total found dead	Total hatched	Per cent dying of total hatched
	Gadden	Medarklubb			
1970	17	3	20	220-225	9
1971	4	15	19	199–214	9–10
1972	40	13–14	53–54	257–269	20–21
Total	61	31-32	92-93	676–708	13–14

disease or other factor centered in the colony. In 1972 chicks died simultaneously on both islands, indicating a more common cause for death. There were no indications of predation by gulls or other animals on Caspian Tern chicks.

Nine chicks a few days to one week old that died in June 1972 were collected randomly and examined later at the State Veterinary Medical Institute. Eight of them were in a poor to very poor nutritional condition; only one was in a reasonably good nutritional state. Two chicks had small pieces of vegetation in their stomachs, and two others had each swallowed a large fish before dying. No specific infection by bacteria was found in the chicks. The primary cause of death was apparently starvation. Although growing chicks were not weighed, retarded growth was noticeable in the youngest chick of some of the 2- and 3-chick broods.

Of the chicks that died in 1972, 33 were from a 3-chick brood (n = 49) and 16 from a 2-chick brood (n = 44). In these samples, only those broods are included for which the number of hatched chicks was known. The difference in death frequency between 2- and 3-chick broods is not statistically significant ($\chi^2 = 2.28$, df = 1, $P > 0.1$); this suggests also that chicks of 2-chick broods died by starvation. No chick from a brood of one was found dead.

The behavior of parent birds was unusual during the starvation of chicks in June of 1972. Usually in the middle of the breeding season, first adults take off when a boat approaches but while it is still hundreds of meters from the colony. Most adults are on the

TABLE 5. Fledging success in two Caspian tern colonies in Finland in 1970-72.

Year	No. young hatched/pair	Per cent young dying	No. young fledged/pair
1970	1.76–1.80	9	1.60–1.64
1971	1.66–1.78	9–10	1.49–1.62
1972	1.90–1.99	20–21	1.50–1.59
Means	1.78–1.86	13–14	1.53–1.62

wing when a human appears at a distance of 100-200 m from the breeding grounds. When visiting the island of Gadden on 24 June 1972, I thought for a while that the whole colony might have been destroyed, because practically no Caspian Terns were flying, even though I was visible at a distance of 100-150 m from the nests. The less vigorous reaction of adults against human disturbance might have been in connection with a possible undernourishment of the parent brids, as well as the young.

Over 1.5 young fledged per breeding pair (Table 5). In reality, this figure is probably too high because some dead chicks might have escaped detection. Moreover, perhaps a few pairs, the clutch of which was destroyed before being found and which did not lay a replacement clutch, are not included in the number of breeding pairs. For these reasons, I deduce that on the average about 1.5 young per pair fledged instead of 1.53-1.62 as indicated in Table 5.

DISCUSSION

According to Bergman (1953), initial clutches were laid only during a period of two weeks from early May to 20 May in Finland. In the present study, 41 per cent of all clutches found were laid after 20 May, amounting to far more than the number of clutches destroyed before the same date. Thus, laying of many first clutches occurred in late May.

Clutch-size of many bird species is smaller in clutches laid later in the season (see review by Klomp, 1970). In terns the seasonal decrease in clutch-size has rarely been demonstrated, except for general remarks that later (replacement) clutches tend to be smaller than the first ones. Lemmetyinen (1973a) has recently shown that the clutch-size in Finnish Arctic Terns (*Sterna paradisaea*) decreases by 2-8 per cent a week as laying proceeds. In the Caspian Tern, the decline was more pronounced, 11-23 per cent between 10-day intervals (Fig. 1). Bergman (1953) found that nearly all early clutches in Finnish Caspian Terns contained three eggs, but most clutches laid in the second week of the laying period (about 14 to 20 May) contained two eggs. In the colonies in this study, clutches of two did not appear prevalent that early but after about the third week of laying (Tables 1 and 2).

Proximate factors affecting the seasonal changes in clutch-size are poorly known (Klomp, 1970). Bergman (1953), following Paludan (1952), suggested that in later-laying females, which can incubate even the first egg more steadily than earlier breeding females because of less disturbance within the colony, the follicle of the third egg degenerates under a stronger influence of the contact with the first egg in the nest (see also Weidmann, 1956). If this hypothesis is valid, undisturbed pairs, nesting solitarily should have only two eggs also in the beginning of the laying season. In Finland, they usually have three.

In addition to seasonal variations, annual variations in the clutch-size of birds within the same population also occur. In species showing a clear seasonal trend in the clutch-size, yearly overall means are not good indicators of annual variations, although frequently used (Klomp, 1970). As an example, heavy predation on early large clutches results in a decline of the mean clutch-size, because some early clutches are destroyed before being found and many smaller replacement clutches appear in the data. Thus, a comparison of clutch-size by each part ("periods" in Fig. 1) of the laying season between different years is more correct.

In the Caspian Tern, annual variations within each period were relatively small except in clutches laid after 10 June (Fig. 1). Small numbers do not permit a significance test, but in June of 1972, clutches of one were more numerous than in the other two years, and after 10 June, clutches of two were rarer (Table 2).

Food supply is one of the factors affecting variation in clutch-size in many bird species (Klomp, 1970). Starvation of Caspian Tern chicks clearly occurred only in 1972. Small clutches in June 1972 were laid during starvation of chicks and were possibly related to shortage of food for laying females. Availability of the roach (*Rutilus rutilus*) and the perch (*Perca fluviatilis*), the dominant food

species during the chick feeding period (Koli and Soikkeli, in prep.), might have been worse in June 1972 because of unusually warm weather repelling these fish to deeper waters.

Boecker (1967) found that clutch-size in populations of Common Terns (*Sterna hirundo*) and Arctic Terns was smaller in years when clupeid fish were lacking and the terns had eaten invertebrate animals. In the outermost archipelago in Finland, where Arctic Terns eat less fish food, they lay smaller clutches than in the nearby middle archipelago where more fish but less crustaceans are eaten (Lemmetyinen, 1973a). Consequently, food supply might have a direct influence on clutch-size of tern species between different years as well as between adjacent areas.

Because the Caspian Tern lays successive eggs at intervals of 2-3 days (Bergman, 1953) and starts incubating with the first egg, chicks hatch at different times. The age difference in a brood of three between the oldest and youngest chick averages 5-6 days (Bergman, 1953). An early start of incubation insures against egg predation but results in an asynchronous hatching in the Caspian Tern. In raptors, herons, and crows this mechanism has been considered to be an adaptation for maximal breeding success under varying conditions of food availability (Lack, 1954). In terns, Boecker (1967), Langham (1972), LeCroy and Collins (1972), and Lemmetyinen (1972) reported that the starvation of the youngest chick or chicks occurred in the years of insufficient food supply (often as a result of unusual weather). Asynchronous hatching as an adaptive mechanism producing potential survivors for good years and insuring the survival of one or two of the chicks during poor years, is as pronounced in this Caspian Tern population as in the groups Lack (1954) mentioned.

The number of fledged young per pair (1.5) in the present study is high, if compared with corresponding figures for Arctic and Common terns. In these species usually less than 1.0 or even less than 0.5 fledged young per pair was found (Pettingill, 1939; Hawskley, 1957; Boecker, 1967; Bengtson, 1971; Switzer and Lewin, 1971; LeCroy and Collins, 1972; Lemmetyinen, 1972, 1973b; Nisbet and Drury, 1972). Lemmetyinen (1973b) reported 1.4 fledglings per pair in the Common Tern in Finland. This is one of the highest fledging successes recorded in terns other than the Caspian.

In the Great Lakes region, Ludwig (1965) found the laying season of the Caspian Tern similar to that reported in this paper, viz. from early May to early July. Ludwig gives a mean clutch-size (2.81) only for initial clutches, but this figure approximates the mean clutch-size in the Finnish colonies in the beginning of the laying season (Fig. 1). In the Great Lakes region chick mortality during two breeding seasons averaged 19 per cent of the hatched young and was thus somewhat higher than in this study (Table 4). Ludwig estimated 1.61 fledglings per pair. However, he used only the clutch-size of initial clutches which apparently is higher than the mean clutch-size in all nests where chicks emerge (Fig. 1). Thus, the real fledging rate in the colonies studied by Ludwig was probably somewhat smaller than reported. A comparison of indices derived from these two studies carried out at different time periods and in

different continents shows a similarity which is surprising when examined in the context of highly variable results from studies of other tern species.

SUMMARY

In a three-year study of the Caspian Tern in Finland, laying started in early May and ceased in late June or early July. The mean clutch-size was 2.70 before 21 May, but decreased to 1.61 in clutches laid after 10 June. On the average, 1.78-1.86 chicks hatched per pair. The chick mortality averaged only 13 per cent. About 1.5 young fledged per breeding pair. Parameters of breeding success from this study and an earlier study in North America show a good similarity.

ACKNOWLEDGMENTS

I wish to thank my wife Anja, my daughter Marja, Dr. Karölis Bagdonas, and Mr. Juhani Virtanen for their assistance in the field work. Thanks are also due to Mrs. Litja Mäkinen of Kustavi, who allowed me, without knowing the exact contents of bags, to keep rotten carcasses of young Caspian Terns in her freezing box. Mr. Risto Lemmetyinen, M.Sc., critized the manuscript and made helpful references regarding other studies of tern species. Dr. James P. Ludwig of Bemidji, Minnesota, has reviewed the manuscript and made valuable suggestions and corrections. Dr. Karölis Bagdonas has kindly checked the English. The help of the State Veterinary Medical Institute in Helsinki is acknowledged.

LITERATURE CITED

BENGTSON, S.-A. 1971. Breeding success of the Arctic Tern, *Sterna paradisaea* (Pontoppidan), in the Kongsfjord Area, Spitsbergen in 1967. *Norwegian J. Zool.*, **19:** 77-82.

BERGMAN, G. 1953. Verhalten und Biologie der Raubseeschwalbe (*Hydroprogne caspia*). *Acta Zool. Fenn.*, **77:** 1-50.

BOECKER, M. 1967. Vergleichende Untersuchungen zur Nahrungs- und Nistökologie der Flusseeschwalbe (*Sterna hirundo* L.) und der Küstenseeschwalbe (*Sterna paradisaea* Pont.). *Bonner Zool. Beitr.*, **18:** 15-126.

HAARTMAN, L. VON, O. HILDÉN, P. LINKOLA, P. SUOMALAINEN, and R. TENOVUO. 1963-66. Pohjolan linnut värikuvin. I. Helsinki, Otava Press.

HAWSKLEY, O. 1957. Ecology of a breeding population of Arctic Terns. *Bird-Banding*, **28:** 57-92.

KLOMP, H. 1970. The determination of clutch-size in birds. A review. *Ardea*, **58:** 1-124.

LACK, D. 1954. The natural regulation of animal numbers. Oxford, Clarendon Press.

LANGHAM, N. P. E. 1972. Chick survival in terns (*Sterna* spp.) with particular reference to the Common Tern. *J. Anim. Ecol.*, **41:** 385-394.

LECROY, M., and C. T. COLLINS. 1972. Growth and survival of Roseate and Common Tern chicks. *Auk*, **89:** 595-611.

LEMMETYINEN, R. 1972. Growth and mortality in the chicks of Arctic Terns in the Kongsfjord area, Spitsbergen in 1970. *Ornis Fenn.*, **49:** 45-53.

—— 1973a. Clutch-size and timing of breeding in the Arctic Tern in the Finnish archipelago. *Ornis Fenn.*, **50:** 18-28.

—— 1973b. Growth and mortality in the chicks of the Arctic and Common Tern in southern Finland. *Ann. Zool. Fenn.*, **10** (in press).

LUDWIG, J. P. 1965. Biology and structure of the Caspian Tern (*Hydroprogne caspia*) population of the Great Lakes from 1896-1964. *Bird-Banding*, **36:** 217-233.

NISBET, I. C. T., and W. H. DRURY. 1972. Measuring breeding success in Common and Roseate Terns. *Bird-Banding*, **43:** 97-106.

PALUDAN, K. 1952. Contributions to the breeding biology of *Larus argentatus* and *Larus fuscus*. *Vidensk. Medd. Dansk Naturh. For.*, **114:** 1-128.

PETTINGILL, O. S., JR. 1939. History of one hundred nests of Arctic Tern. *Auk*, **56:** 420-428.

STAAV, R., B. ALMKVIST, and S. HEDGREN. 1972. The Caspian Tern *Hydroprogne caspia* in Sweden in 1971 (A summary). *Vår Fågelvärld*, **31:** 241-246.

SWITZER, B., and V. LEWIN. 1971. Shell thickness, DDE levels in eggs, and reproductive success in common terns (*Sterna hirundo*), in Alberta. *Can. J. Zool.*, **49:** 69-73.

WEIDMANN, U. 1956. Observations and experiments on egg-laying in the Black-headed Gull (*Larus ridibundus* L.). *Brit. J. Anim. Behav.*, **4:** 150-161.

Department of Zoology, University of Turku,
SF-20500 Turku 50, Finland.

Received 8 March 1973, accepted 4 May 1973.