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Breeding ecology of the avocet (*Recurvirostra avosetta* L.) in the Evros delta (Greece)

by

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Introduction

Although the avocet is an important wader of European wetlands, it has been studied mainly in western Europe.

The avocet is a well known breeding bird in Greece (Bauer et al. 1969, Bauer & Müller 1969).

The present study was carried out during the breeding seasons of 1979—1983, to contribute to the knowledge of the ecology of this bird, providing data from an interesting Mediterranean region.

Study area

For avocets, only the seaward lower part of the delta was of importance (Fig. 1). The greatest activity was observed at the fishpond areas Drana and Palukuia and on the surrounding mudflats. In the interior of Drana there are islets covered by halophytic vegetation.

The brackish waters of the mudflats evaporate in summer months. Some of the mudflats (3 and 4 in Fig. 1), were flooded every year, whereas in others water was present only on some occasions (in 1980), depending on the management regime (5 and 6 in Fig. 1).

All of these areas in the delta, except islet 1 in Drana and the coastal islets, are heavily grazed by cows and sheep.

Materials and methods

The population changes were evaluted by bird counts made weekly, or even more frequently, by use of a 20—60 x 80 telescope and 10 x 50 binoculars. Visits to colonies were made at intervals of 1—4 days. Each nest was individually marked by a small numbered indicator. At each visit the numbers of eggs and/or chicks were recorded, also the losses and, where possible, the reasons. The chicks were ringed with plastic coloured rings.

After preliminary observations, which indicated destructive predation of the eggs by the corvids *Corvus corone cornix* (L.) and *Pica pica* (L.), a programme of experimental extermination of their eggs and young ones was applied, partly for 1980 and intensively for 1981: the eggs and nestlings of these birds, found in the study area, were destroyed until the adults left.

Observations were made on feeding birds at the feeding grounds in combination with sampling at the same sites for the study of available food.

This combination usually gives a good description of the wader diets (Goss-Custard 1973). Quantitative food sampling was carried out monthly from April to July 1980, at an important feeding area (7 in Fig. 1). For this purpose, an appropriate landing net was used. The frame base inserted in the substrate was 27 cm long (similar to the width of the avocet bill scooping at feeding, Hamilton 1975). Five samples were taken, scraping the bottom to a depth of 2 cm, along five non-intersecting runs, each of 10 m in length, in area 30 x 30 m and in water of depth 10—20 cm. The material was sieved and the organisms preserved in 10 % formalin for identification.

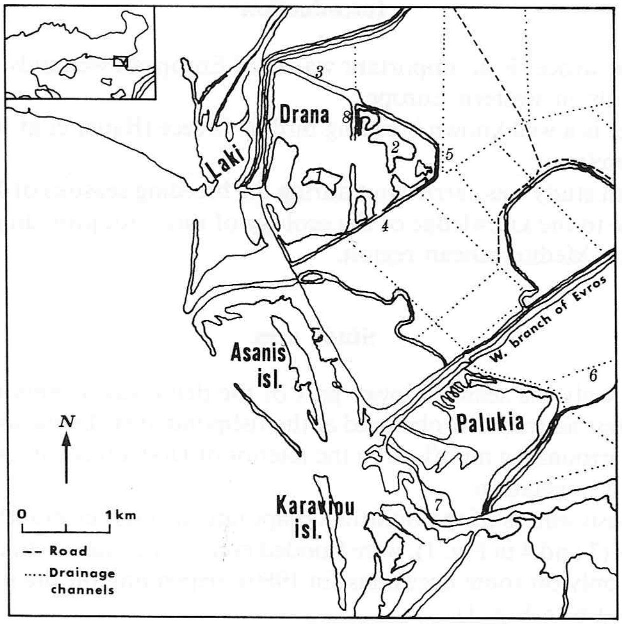

Figure 1. Map of the seaward part of the Evros delta. The numbers are references to the text.

Results

1. Population and movements

The avocet population changes, for the breeding seasons of 1980 and 1981, are shown in Fig. 2. This population arrived from elsewhere earlier in the season and was not constituted of birds remaining to winter after breeding.

Some birds departed after mid-March; most of the remainder gathered on islets 1 and 2 in Drana (Fig. 1). Although breeding activity started in about mid-

April, population changes due to arrival and/or departure were continuous, especially during 1981. In May, a large part of the breeding population left because of nest destruction due to herd trampling and flooding. Arrival of birds occurred after the beginning of June in 1980, whereas in 1981 — except for relatively slight changes — the population decreased. The picture appearing after mid-June during 1981 was representative for all years except 1980: the avocets left gradually, together with their young ones, so that no birds were encountered after the end of July. The exception which appeared in 1980 was related to the management of the delta and especially to the presence of water in some areas (5 and 6 in Fig. 1). These areas constituted breeding sites and also gathering sites of a population of avocets coming from elsewhere for moulting. This arrival happened within the limits of an "invasion" of waders at the same sites (Goutner 1983).

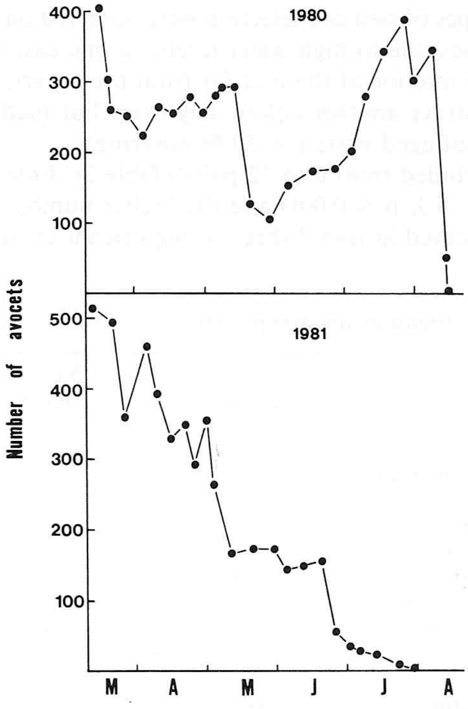

Figure 2. Avocet population changes in the breeding season.

2. Nest site selection

2.1. Nesting sites

The breeding sites consisted of level areas on the most isolated islets in Drana (1 and 2 in Fig. 1) and of dykes around Drana and Palukia (5 and 6 in Fig.

1) isolated by water 0.5—1 m in depth. The dykes were occasionally used only in 1980 (under the special management conditions mentioned), as was the case also for a very small islet in Drana (8 in Fig. 1).

2.2. Nest construction and colonies

By comparing the availability of plant material at the breeding grounds (Babalonas 1979, 1980), with the materials found in the avocet nests (Table 1), it was clear that the birds used material readily available in their environment. Out of a total of 530 nests found, 91.1 % were made among plants belonging to the broad class Puccinellio-Salicornietea. The rest (8.9 %) were made mainly on the dykes. Note that *Ruppia maritima* (L.), *Ulva lactuca* (L.) and the shells of bivalve *Cerastoderma glaucum* (L.), were brought to the nesting sites by wave action.

Two different types of nest site selection were observed on the islets of Drana after extensive losses due to high water levels: in one case the birds extended their colony to the interior of the islet far from the waterside. In another, the pairs did not construct another colony anywhere but bred at scattered sites, making well-camouflaged nests (> 50 % covering).

The colonies included from 6 to 72 pairs (Table 2). From 1979 to 1981, the larger colonies ($t = 8.3$, $p < 0.001$) and the higher number of pairs ($t = 5{,}19$, $p < 0.01$) were observed at islet 2 (Fig. 1). Significant change with preference

Table 1: Materials found at the avocet nests.

Materials	Islet1	Islet 2	Areas Site 5	Site 6	Site 8
Plant					
Halocnemum strobilaceum	+	+	+	—	—
Salicornia europaea	+	—	+	+	—
Limonium gmelinii	—	+	—	—	—
Artemisia monogyna	—	+	—	—	—
Aeluropus litoralis	—	+	—	+	—
Puccinellia festuciformis	—	+	+	—	—
Halimione portulacoides	+	—	—	—	—
Bromus spp.	—	+	—	—	—
Salsola kali	—	—	+	—	—
Pholiurus incurvatus	—	—	—	+	—
Bolboschoenus maritimus	—	—	—	+	—
Tamarix smyrnensis	—	—	+	—	—
Ruppia maritima	+	—	—	—	+
Ulva lactuca	+	+	—	—	—
Animal					
Cerastoderma glaucum	+	—	+	—	—

\+ Included in the nest spreading
— Not included in the nest spreading

to islet 1 was observed after 1981. This change was possibly the result of the increasing interference (grazing) at the islet 2.

2.3. Interspecific competition

Significant changes were observed in the extent of the avocet colonies at islet 1 through the years (Fig. 3). This was due to gulls and terns which bred on this islet (Table 3). The largest part of the 1981 colony area of the avocets was, in the next two years, occupied by gull and tern colonies (C and D in Fig. 3). This condition appeared to be intensified, not only by the desertion of islet 2 by the avocets, but also by the alteration of the breeding biotope of some Laridae on the coastal islands (Goutner in press), forcing them to search for new breeding sites. The reduction of the available breeding space for the avocets is supported by the differences in the mean nearest neighbour distances measured at the colonies (Table 4). These distances did not differ significantly before 1982 ($t = 0.73$, $p > 0.1$) but they did between 1981 and 1982 ($t = 2.37$, $p < 0.02$). The lack of breeding space pushed the avocets to construct loose colonies on islet 1, separate from the main one (b and c in Fig. 3C, b in Fig. 3D). The area "a" appeared to be more favourable than "b" and "c" (Fig. 3), because during

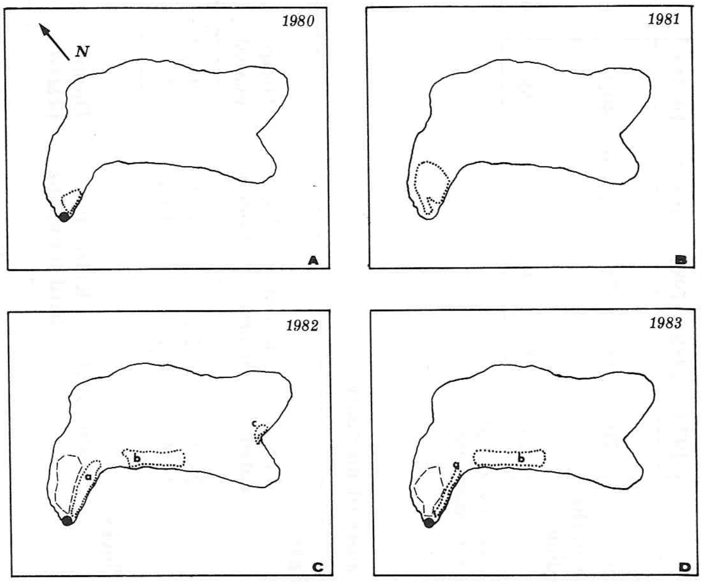

Figure 3. Position of the avocet colonies in relation to those of other Charadriiformes at islet 1 in Drana. Stippled line: limits of avocet colonies. Black dots: *Sterna hirundo* and *S. albifrons* colonies. Broken line: other Lari colonies. a: main avocet colonies. b and c: other avocet colonies.

Table 2: Colony and pair distribution of avocets.

	Islet 1					Islet 2					Dykes Site 5	Dykes Site 6	Dykes Site 8
	1979	1980	1981	1982*	1983**	1979	1980	1981	1982	1983	1980	1980	1980
No of pairs at the colonies	20	18	28	72,10,6	40,18	62	56	69	—	—	17	19	9
No of pairs in the whole breeding season	21	18	28	88	58	93	64	105	8	—	17	21	9

* Three colonies were constructed
** Two colonies were constructed

Table 7: Causes of mortality.

Stage 1: Eggs	Pre-dated	Laid out of nests	Nest flooded	Disap-peared	Unfer-tilized	Trampled by herds	Nest deserted	% Total	Eggs total
1980	28.2	2.7	11.5	7.6	0.9	26.0	4.4	81.3	366
1981	18.9	1.2	30.3	7.1	1.1	17.1	4.5	80.2	517

Stage 2: Chicks	Predated	Killed by herd trampling	Disap-peared	Found dead	Defor-mities	% Total	Chicks total
1980	3.6	26.2	26.2	1.2	1.2	58.4	49
1981	13.4	8.7	31.5	3.1	—	56.7	72

Figures are percentages expressed as proportion of individuals alive at the beginning of each stage incubation the birds were better protected there, from the prevailing NE winds (Babalonas 1979), thanks to tall plant associations of *Halimione portulacoides* (Aellen) and *Artemisia monogyna* (Wald & Kit), covering the N and NE sites of this islet.

On the dykes, although the mean nest distances did not differ significantly between the areas ($t = 1.00$, $p > 0.3$), the spectrum of the values appeared significantly broader at site 6 ($F = 5.16$, $p < 0.001$) (table 4), due rather to differences in the nest placement arising from different constructions of the dykes.

3. Egg laying and incubation

The earliest eggs were laid on 13 April 1980 and the latest ones on 8 July of the same year. In all the other years egg laying took place from mid-April to mid-June. The breeding peak appeared at the beginning of May (Fig. 4). The egg laying patterns differed significantly between 1980 and 1981. This was due to differences in the timing of losses (due to herds and flooding) and to the continuation of laying after mid-June in 1980 at the incidental breeding sites.

The mean clutch size (Table 5) increased non-significantly from year to year ($p > 0.1$ in all cases), However, there was a negative correlation between clutch size and number of breeding pairs ($r = -0.919$, $p < 0.05$, line equation: $y = -0.106x + 0.779$).

The avocets usually incubated for 23—24 days (observations on 67 nests). On islet 1 a few pairs incubated for longer or shorter times (Table 6).

Table 3: Number of Lari pairs present on islet 1, at start of avocet breeding.

	1980	1981	1982	1983
Larus melanocephalus	—	—	150*	250
Gelochelidon nilotica	—	—	60*	30
Sterna sadvicensis	—	—	—	2
Sterna hirundo	15	—	25	26
Sterna albifrons	5	—	20	5

* Present later in the season (see Goutner in press).

Table 4: Mean nearest neighbour distances (m) of the avocet nests in the colonies.

Areas	Mean	S.D.	Measurements
Islet 2 (1980)	6.05	3.58	50
Islet 1 (1981)	5.35	2.50	17
Islet 1 (1982)	4.08	1.66	54
Site 5 (1980)	10.05	5.00	16
Site 6 (1980)	13.28	11.33	15

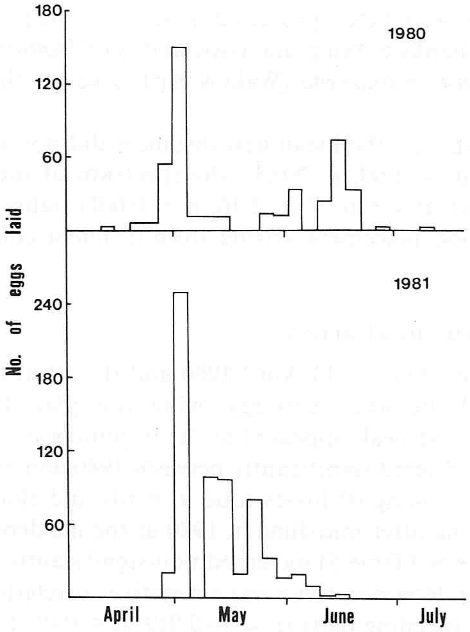

Figure 4. Timing of egg laying in the avocet.

Table 5: Mean clutch sizes.

Year	Mean clutch size ± S.D.	no of completed clutches
1980	3.64 ± 0.68	97
1981	3.76 ± 0.64	95
1982	3.85 ± 0.43	72
1983	3.94 ± 0.30	52

Table 6: Incubation period (days) of avocet eggs in 17 nests on islet 1 (1981).

No of nests	1	6	3	2	2	2
Incubation period	22	23	24	25	26	27

4. Hatching and fledging

The hatching patterns for 1980 and 1981 are shown in Fig. 5. The causes of the egg and chick mortality are indicated in Table 7. The main egg predators were the corvids already mentioned. The gulls of the region took eggs mostly from unattended nests. The main chick predators were foxes (*Vulpes vulpes* L.) and, in some cases, marsh-harriers (*Circus aeruginosus* L.). The proportions of egg and chick mortality were similar in each year (Table 7). However, the causes of loss at the egg stage differed. There was also marked difference in the egg predation and this was mainly due to the extensive application of the corvid extermination programme in 1981.

After hatching, the chicks were usually guided by the parents to the feeding grounds which were mainly mudflats around the breeding areas. The avocet chicks fledged 26—28 days after hatching (Table 8).

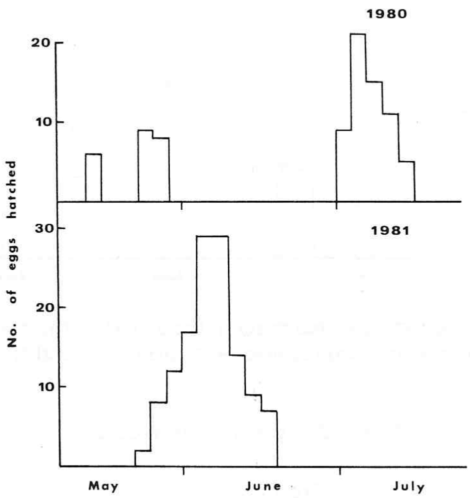

Figure 5. Timing of hatching in the avocet.

Table 8: Fledging period of avocets (days).

	26	27	28	Unknown*
1980	17 (48.6)	2 (5.7)	4 (11.4)	12 (34.3)
1981	20 (34.6	6 (10.9)	8 (14.5)	21 (38.2)

* The chicks in this category were not ringed
Parenthesized figures are percentages on fledged chicks

5. Factors affecting breeding success

5.1 Food

The most important food organisms of avocets are indicated in Table 9. The biomass of the most important food (*Gammarus aequicauda* Martynov) increased steadily from April to July at the mudflats, favouring the chicks which hatched during this period (Fig. 6).

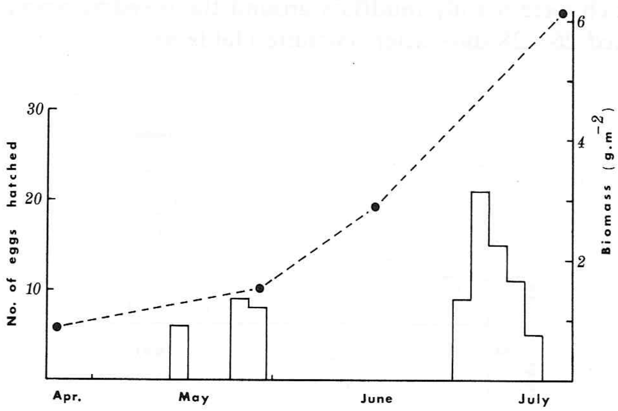

Figure 6. Relation of the timing of hatching in the avocet to the changes of the biomass of the amphipods *Gammarus aequicauda* (wet formalin weight) (1980).

Table 9: Food organisms of avocets.

Annelida
Nereis diversicolor
Crustacea
Gammarus orientale
Gammarus aequicauda
Other amphipods
Insecta
Coleoptera (Hydrophylidae)
Diptera (Tabanidae, Ephydridae)
Heteroptera (Gerridae, Corixidae)

5.2. Nest site attendance

To obtain a more objective picture of the nest site attendance, we measured the time spent by the parents on the eggs during incubation, because for that part of the time the eggs were under full protection. Observations were made throughout the day on 7 nests at two of the nesting areas (6 and 8 in Fig. 1) in 1980, after the completion of egg laying (Table 10). The significant difference in the attendance between these sites ($chi^2 = 60.13$, $p < 0.001$) was possibly due to a higher density of enemies at area 8, making the avocets uneasy and causing them to leave the eggs more frequently in pursuit.

An important peculiarity was observed in the way of nest site attendance at islet 1 (this was confirmed up to 1981 but not for the subsequent years): many avocets left to fed on the mudflats, leaving their nests unattended for hours. This may have led to the longer incubation period at some of the nests (Table 6). The behaviour of the birds was possibly due to the fact that the eggs were well camouflaged by the vegetation which is not grazed on this island.

The breeding success was similar for 1980 and 1981 and seems to be very low (Table 11).

Table 10: Nest site attendance of avocets, expressed as minutes of incubation.

	Area	
Bird minutes	Site 6	Site 8
On the eggs	1 664 (93.2)	1 780 (85.3)
Off the eggs	122 (6.8)	306 (14.7)
Total	1 786	2 086

Parenthesized figures are percentages.

Table 11: Breeding success of avocets.

	1980	1981
Eggs laid	450	644
Eggs hatched	84	127
Chicks fledged	35	55
Hatching success	0.18	0.20
Chicks fledged per egg laid	0.08	0.08
Chicks fledged per egg hatched	0.42	0.43

Discussion

The change of the nesting pattern observed after nest flooding possibly indicates that the avocets "learn" after disasters how to avoid new ones of a similar kind. In our case, this was expressed in the exhibition of a behaviournal change, according to which the impulse for new, safer breeding was stronger than that for colony construction. Learning by the avocets is also supported by the change in the preference for nesting sites (islets) through years. This possibly indicates that at least a part of the population arriving is the same each year. Returning of avocets to breeding sites for many successive years is known from ringing studies (Cadbury & Olney 1978).

In the avocet breeding areas (islet 1), there also nested about 100 pairs of *Glareola pratincola* (L.), most of which started laying after most of the avocet hatchings were completed, that is in the first fortnight of June. These birds laid significantly earlier at the coastal islets of the delta (Goutner 1983). This behaviour possibly indicates a way of surpassing competition for breeding space between species with similar ecological preferences.

There are cases of human interference on bird predator populations for the protection of breeding avocets and other birds (Olney 1967, Duncan 1978). Similar interfence to the corvids in our area resulted, as explained, in reduction of egg predation but not in a simultaneous increase of breeding success, as many other reasons of failure existed.

The fledging period in our area was much shorter than those observed elsewhere (Derscheid 1939, Brown 1949, Walters 1972, Witherby et al. in Walters 1972). According to Walters (1972), there may be significant differences in the fledging period of a species under natural conditions. In our area the weather conditions were excellent (at least until 1981) during chick development. Also, the food was available in great amounts at this stage and it is probable that these two factors resulted in very early fledging.

Despite the protection of their eggs during incubation, the avocets suffered high egg losses by corvid predation. Our observations revealed that many of these losses happened because of the techniques applied by these predators for stealing the eggs, rather than through the lack of nest site protection by the avocets.

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Summary

The avocet population arriving in the delta exhibited characteristic changes through the breeding season due to migration movements and to departure following nest destruction. The presence of a population after mid-June was highly dependent on the presence of water at the breeding grounds.

The avocets bred in colonies constructed on isolated islets and dykes. The nests were usually made among low halophytic vegetation. Nest construction away from the waterside was observed after destructions by floods. Changes to preference for the islets for nesting was observed through years. Also, interspecific competition for breeding space was observed between the avocets and other Charadriiformes at one of the islets.

Egg laying mainly took place between mid-April and the end of June, the breeding peak appearing at the beginnig of May. There was a negative correlation between clutch

size and number of breeding pairs across years. Most pairs incubated for 23—24 days but some did so for 25—27 days.

The main causes of egg mortality were corvid predation, herd trampling and nest flooding; of chick mortality were herd trampling and predation. Hatching took place from mid-May to mid-July and the chicks fledged in 26—28 days after hatching.

The avocets fed on annelid worms, insects and especially on crustaceans, whose steady biomass increase in the season favoured chick development.

The amount of time spent by the parents on nest site attendance was higher than 85 % of the total observation time.

The breeding success was very low (0.08 chicks fledged per egg laid).

Zusammenfassung

Die im Delta eintreffende Säbelschnäbler-Population unterlag während der Brutzeit charakteristischen Veränderungen als Folge von Migrationsbewegungen und Abwanderungen nach Nestverlust. Die Anwesenheit einer Population nach Mitte Juni hing stark davon ab, ob Wasser im Brutgebiet vorhanden war.

Die Säbelschnäbler brüteten in Kolonien, die auf isolierten Inseln oder Deichen lagen. Die Nester wurden gewöhnlich in niedriger Halophyten-Vegetation angelegt. Nestbau in größerer Entfernung vom Wasser wurde beobachtet, nachdem die Nester durch Fluten zerstört worden waren. Veränderungen in der Bevorzugung von Inseln als Nestplatz wurden über mehrere Jahre beobachtet. Auf einer Insel wurde interspezifische Konkurrenz um den Brutplatz zwischen Säbelschnäblern und anderen Charadriiformes registriert.

Die Eiablage erfolgte in der Regel von Mitte April bis Ende Juni, der Brutgipfel lag Anfang Mai. Es bestand eine negative Korellation zwischen Gelegegröße und der Anzahl Brutpaare. Die meisten Paare brüteten 23—24, einige auch 25—27 Tage.

Hauptursachen für Eierverluste waren Krähenfraß, Zertrampelung durch Vieh und Überflutung der Nester; für Kükensterblichkeit waren es Zertrampelung durch Vieh und Krähenfraß. Küken schlüpften zwischen Mitte Mai und Mitte Juli und waren 26—28 Tage nach dem Schlupf flügge.

Die Säbelschnäbler ernährten sich von Anneliden, Insekten und besonders von Krebsen, deren mit der Jahreszeit zunehmende Biomasse die Kükenentwicklung begünstigte.

Die Eltern waren mehr als 85 % der gesamten Beobachtungszeit am Nestplatz anwesend.

Der Bruterfolg war sehr niedrig (0.08 flügge Küken auf ein gelegtes Ei).

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