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The life cycle of the tick *Amblyomma loculosum* in a sooty tern *Sterna fuscata* colony in the Seychelles

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(With 1 figure in the text)

An infestation of a sooty tern colony on Bird Island, Seychelles, with the ixodid tick *Amblyomma loculosum* was studied during visits to the colony in 1993 to 1995. During the infestation, adult ticks were numerous during the birds' incubation, larvae were abundant when young chicks were present, and there was some evidence that nymphs were found when older chicks were present. The life cycle of the tick appeared closely synchronized with that of its host. Following a breeding failure of the sooty terns, caused by adverse weather in August–September 1994, few adult ticks were found during the birds' breeding season of 1995, suggesting that the absence of chicks late in the 1994 breeding season led to starvation of the ticks and their failure to survive their diapause until the onset of the birds' next breeding season.

Introduction

Sooty terns *Sterna fuscata* L. (Aves: Laridae) breed in colonies, sometimes numbering hundreds of thousands of pairs, and nest at high densities of >6 nests per m^2 in suitable habitats (Feare *et al.*, In press). Nests are on the ground, usually among sparse, low vegetation, and consist of a scrape (shallow depression made by the birds) into which small amounts of dry vegetation and small stones may be incorporated. Each pair lays one egg.

On Bird Island, Seychelles, adult sooty terns begin to arrive at the island in January–February, but do not settle on the ground until May–June, and then initially for only short periods at night. They begin to spend most of the day on the ground just before laying, which is highly synchronous and usually occurs in early June. Incubation lasts 28 days and the young fledge about 60 days after hatching, so that most sooty terns leave the island in September–October (Feare, 1976*a*). The colony area is then deserted until the following May.

Sooty tern colonies in the Seychelles are often infested with ticks, large numbers of which may stimulate colony desertion (Feare, 1976*b*). People working in colonies of sooty terns, including researchers and egg collectors, are often bitten by ticks, and where tourists are able to visit tern colonies, as on Bird Island, they may also be bitten. On Seychelles islands, *Ornithodoros capensis* Neumann (Acari: Argasidae) and *Amblyomma loculosum* Neumann (Acari: Ixodidae) occur commonly and both have been found to be infected with Soldado virus (Hoogstraal & Feare, 1984), while the latter species may also be infected with Aride virus (Converse *et al.*, 1975). The effects of these viruses on avian and human hosts are unknown.

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The biology of sooty terns is being investigated on Bird Island as part of a study aimed at ensuring the sustainability of the commercial egg harvest in the Seychelles. In 1973 the island supported a colony of 395 000 pairs, covering 11.69 ha (Feare, 1976*a*); the colony may now be larger, although estimates are lacking. During visits in the breeding seasons of 1993–95, data were collected on the presence of the tick that is currently dominant, *A. loculosum*, both in the colony and on birds that were handled, mainly for ringing. These data have enabled us to describe the life cycle of the tick, which was formerly known only from laboratory studies (Hoogstraal *et al.*, 1976), in this sooty tern colony. In addition, annual differences in sooty tern productivity and in tick abundance during this study permitted identification of some of the factors that affect the interaction between the tick and its seabird host.

Materials and methods

Occurrence of ticks was recorded in August 1993, in August–September 1994 and 1995 during daytime while ringing 2–5-week-old sooty tern chicks, and also at night in August 1993 while filming the nocturnal activity of the chicks and their parents (Feare, Gill & Masanobu, 1995). Ticks were also recorded in June–July 1994 and 1995 during the handling of incubating adult sooty terns. Larvae of *A. loculosum* are very small (average length 0.62 mm, Hoogstraal *et al.*, 1976) and no attempt was made to count them. This would have entailed extending the ringing process, and excessive disturbance of young sooty tern chicks increases their mortality (Feare, 1976*a*). When numerous, larvae were readily apparent on the legs and feet of humans, especially at night, and the occurrence of larvae on humans was taken to indicate their presence/absence in the colony. Incubating adult sooty terns were caught using a hand net and the head, underwing and legs and feet were examined for ticks; these are the most common sites of attachment of *A. loculosum*. Adult *A. loculosum* ticks were counted and categorized according to sex and, for females, state of engorgement ('small'—body not swollen; 'medium'—body showing signs of swelling and thus of feeding; 'engorged'—body fully swollen). The few nymphs that were found were also recorded. Nests were not examined for ticks.

Ringing of adult sooty terns was undertaken in the early morning (06:30–08:30 h), mid-morning (10:30–12:30 h), and mid-afternoon (14:00–16:00 h), and the data for each of these periods were kept separate to identify any diurnal variation in infestation and state of engorgement that might indicate when birds were becoming parasitized. To complete the diurnal picture, samples of birds were collected in the late afternoon

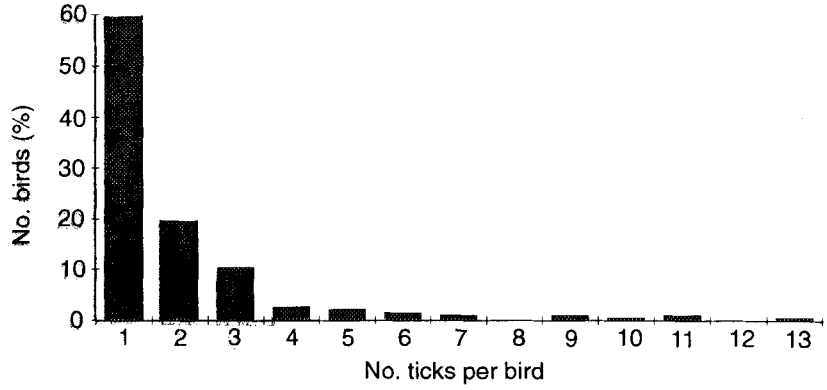


FIG. 1. The proportions of 195 incubating adult sooty terns that carried single and multiple infestations of *Amblyomma loculosum* on Bird Island, 22 June–13 July 1994.

TABLE I

Infestations of ***Amblyomma loculosum*** *on incubating adult sooty terns examined on Bird Island, 22 June–13 July 1994*

Date	No. of birds examined	No. of birds infested	% infested
22 June	398	32	8.0
23 June	400	33	8.2
24 June	349	25	7.2
25 June	100	8	8.0
26 June	50	3	6.0
27 June	550	76	13.8
1 July	200	11	5.5
4 July	200	3	1.5
5 July	300	0	0.0
13 July	200	2	1.0

(17:00–18:00 h), specifically to examine them for ticks. All of these samples were taken from central parts of the colony.

Results

Between 23 June and 13 July 1994, 2547 incubating adult sooty terns were caught and examined; 195 (7.6%) were infested with *A. loculosum*. These infestations involved 308 ticks, of which 193 were adult females, 112 adult males and three were nymphs. Most infested sooty terns carried only one tick but multiple infestations occurred (Fig. 1), the maximum being 13 ticks on one bird. All ticks were on the feet and nearly always on one foot only.

Infestation rates varied during the course of the observations, with a maximum of 13.8% of birds infested on 27 June; few *A. loculosum* were found after 1 July (Table I). Infestation rates showed little diurnal variation (Table II) but the proportion of females that were partially or fully engorged was greater from mid-morning onwards than in the early morning (Table II, $\chi^2 = 3.81$, $d.f. = 1$, $P = 0.05$).

In 1995, no ticks were observed on 300 adult sooty terns that were examined during incubation between 20 June and 4 July. No adult ticks, nymphs or larvae were recorded on birds or humans during the ringing of 1000 chicks in August–September (S. Stabinger, pers. comm.).

In mid-August 1993 and August–September 1994, large numbers of larval *A. loculosum* were present in the colony. Larvae were seen on chicks, and on humans while working in the colony during

TABLE II

Proportion of adult sooty terns on Bird Island that were infested with ***Amblyomma loculosum****, and proportion of female* ***A. loculosum*** *that were partially or fully engorged, according to time of day. Data refer to 23 June–1 July 1994*

Time (h)	06:30	10:30	14:00	17:00
% birds infested	9.1	8.9	11.4	8.7
No. examined	350	650	350	300
% females engorged	9.1	20.5	27.1	28.9
No. of females	33	73	48	38

the day, and in 1993 at night the legs of humans became covered with and were bitten by numerous larvae. No adult ticks or nymphs were seen during observations in 1993, but nymphs were recorded as present on older chicks in September 1994, however, neither the number of nymphs nor the proportion of birds infested were determined (G. and M. Norah, pers. comm.).

Discussion

The presence of large numbers of adult *A. loculosum* in the Bird Island colony from 23 June to 1 July 1994, followed by an almost total disappearance of these ticks from 4 to 13 July, suggests that the life cycle of *A. loculosum* is closely matched to the sooty tern breeding cycle. Further evidence for this comes from our failure to find adult *A. loculosum* in August 1993, when the colony carried a heavy infestation of larvae (Feare *et al.*, 1995). These observations suggest that adult ticks feed on the blood of adult sooty terns soon after the birds have laid eggs. The adult ticks disappeared in the later stages of the birds' incubation, with engorged females presumably falling off the hosts and laying eggs in the sand of the birds' nests. The heavy infestation of larvae in mid-August 1993 suggests that the tick eggs take about a month to hatch, corresponding well with the 36 days found by Hoogstraal *et al.* (1976) when reared in the laboratory. During this study, few nymphs were recorded; only three were found during the examination of incubating adult terns but more were noted, but not counted, during the ringing of older chicks in September, suggesting that nymphs feed on larger chicks in the later stages of the birds' breeding cycle. In their laboratory population, Hoogstraal *et al.* (1976) found that the life cycle was completed in 5 months, without diapause. On Bird Island, the sooty tern colony is deserted from late October to late May–early June, suggesting a diapause of 6–7 months. The occurrence of nymphs on larger chicks and adult ticks on incubating adult birds early in the breeding season suggests that the ticks survive the diapause as nymphs or adults. This ability of *A. loculosum* to adapt to prevailing conditions is seen also in other *Amblyomma* species; under ideal conditions *A. hebraeum* can complete its life cycle in 5 months, but when conditions are less favourable it can take three years (Howell, Walker & Nevill, 1978).

Species of *Amblyomma* can clearly complete their life cycle quickly, in contrast to other ixodid ticks that take three or more years. For example, *Ixodes uriae*, which parasitizes higher latitude seabird colonies, appears normally to have a 4-year life cycle. Eggs are laid in summer and larvae hatch in the first autumn or in the following spring. Larvae feed in the second summer and moult to nymphs; nymphs feed in the third summer and moult to adults which overwinter and reproduce in the fourth year (Mehl & Traavik, 1983). The life cycles of ticks at high latitudes may be constrained by the relative brevity of the birds' breeding season, potential hosts being present in the colonies for only 2–3 months (cf. 5–6 months in sooty terns) and by low temperatures which inhibit tick activity. This last factor can extend the life cycle of *I. uriae* to 5–7 years (Karpovich, 1973; Eveligh & Threlfall, 1974).

Previous observations on other islands of the Seychelles suggest that the close correspondence between the life cycle of the tick and the annual cycle of the sooty tern seen on Bird Island may occur elsewhere. In 1974, adult *A. loculosum* were abundant during the tern's incubation on North Island, African Banks (Hoogstraal & Feare, 1984), and in 1976 larvae were numerous on Goelette Island, Farquhar Atoll, when chicks were well-grown and fledging, and many had already left the colony (Feare & Feare, 1984). In this latter instance, nymphs and adult ticks were also found on the terns, indicating that these stages occur towards the end of the sooty terns' breeding season and suggesting, as on Bird Island, that diapause is survived as nymph or adult. Hoogstraal *et al.* (1976) reported that adult *A. loculosum* were found both on chicks and adult birds, while immature ticks were found almost exclusively on chicks. Furthermore, immature and adult ticks occurred on the same bird species, so

that this three-host tick (like other *Amblyomma* species (Petney, Horak & Rechav, 1987)) might be expected to have a life cycle closely timed to match that of its host, where the host is a seasonally breeding species. On some Seychelles islands, some species of seabirds breed all year (Feare, 1981). Under these circumstances, the ability of *A. loculosum* to complete its life cycle without diapause in captivity (Hoogstraal *et al.*, 1976) might enable all stages of *A. loculosum* to occur simultaneously and perhaps to parasitize different host species, but this situation has not been studied.

In August 1993, adult and juvenile sooty terns on Bird Island were observed repeatedly raising and shaking their feet during the night. Feare *et al.* (1995) suggested that this behaviour was a defence against larval tick infestation, either by minimizing the time of foot contact with the ground, and thus reducing the time available for ticks to climb on to the feet, or by shaking off unattached ticks. This conclusion was supported by night-time observations (by torch light) after 4 July 1994, when adult ticks had disappeared and before the appearance of larvae, which showed that adult sooty terns stood still in the colony, without foot-raising or shaking.

The 1993 observations of sooty tern behaviour at night, together with our experiences of being severely bitten by larvae at night but less so during the day, suggest that *A. loculosum* larvae are largely nocturnal. In 1994, we did not enter the colony at night during the period when ticks were abundant on the birds. However, the greater incidence of engorged adult female *A. loculosum* from mid-morning onwards (Table II) suggests that most adult ticks attach during the night or early morning.

Despite the heavy infestation of ticks on some individual sooty terns, which was usually concentrated on one foot, we did not witness any attempts by the birds to remove ticks. We observed no signs of morbidity in the birds, but some appeared lame, and many with engorged ticks and some with unfed ticks were reluctant to stand on the infested foot. Instead, these birds supported themselves with the carpal joint of the wing on the side of the infested leg. The mobility of these individuals was thereby restricted and we gained the impression that these birds tended to take flight at a greater distance from humans than unaffected birds. If this happened at the approach of predators, such as cattle egrets *Bubulcus ibis* (L.), this could render nests of infested birds more susceptible to egg loss through predation.

The absence of ticks in 1995 was in marked contrast to the abundances recorded in 1993 and 1994. August and September 1994 were exceptionally wet (G. and M. Norah, pers. comm.). Heavy rainfall can lead to weight loss and death in juvenile sooty terns (Feare, 1976*a*), and in the wet 1994 season the sooty tern colony on Bird Island suffered a breeding failure—most chicks had died by the end of September (G. and M. Norah, pers. comm.). As a result, larval and nymphal *A. loculosum* were presumably unable to feed and died, thereby leading to the absence of adult ticks during the birds' incubation in 1995. These observations suggest that the birds' breeding failure, attributed to adverse weather, led to a breaking of the ticks' annual cycle and therefore that environmental factors can be responsible for the elimination of heavy tick infestations. During the early 1970s, the argasid *Ornithodoros capensis* was the dominant tick in the Bird Island sooty tern colony, where a severe infestation led to desertion of part of the colony in 1973 (Feare, 1976*b*). This part of the colony was not colonized by birds in 1974 and 1975, and by the 1976 breeding season the area had become densely vegetated with *Suriana maritima*, which physically excluded sooty terns. These observations indicate that tick infestations can cycle within seabird colonies, and that both physical and biotic factors can curtail these cycles of abundance. Factors that promote severe infestations remain unknown.

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