DETRIMENTAL EFFECTS OF TICKS *ORNITHODOROS MARITIMUS* ON THE GROWTH OF YELLOW-LEGGED GULL *LARUS MICHAHELLIS** CHICKS

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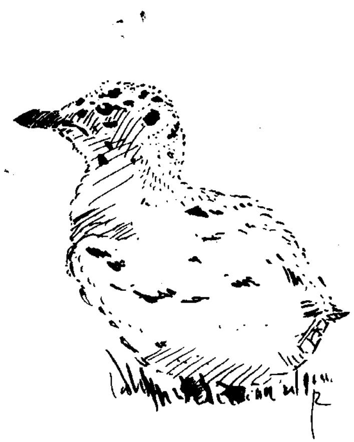

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The effect of tick *Ornithodoros (Alectorobius) maritimus* larvae on the growth of Yellow-legged Gull *Larus michahellis** chicks was studied at the Medes Islands colony (NE Spain). Within broods, chicks infested by more larvae weighed less had a poorer body condition and a shorter wing length than their less infested siblings measured at a similar age. There were no differences in body measurements before tick infestation. Because mass and size of gull chicks are significant predictors of probability of fledging, the detrimental effect of *O. maritimus* larvae on these parameters may affect the breeding success of Yellow-legged Gulls, and consequently their life-history and population dynamics.

Key words: *Larus michahellis* - *Ornithodoros (Alectorobius) maritimus* - chick growth B tick infestion

*Formerly known as *Larus argentatus cachinnans* (Voous 1973) or *L. argentatus michahellis* (Cramp 1983) or *L. cachinnans michahellis* (Del Hoyo *et al.* 1996)

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INTRODUCTION

Colonial birds can benefit from living in groups, e.g. by improving their defence against predators or their foraging efficiency (Wittenberger & Hunt 1985; Brown *et al.* 1990; Danchin & Wagner 1997), but this can also incur several costs. A frequently reported cost is the greater risk of acquiring ectoparasites, since close proximity of individuals facilitates host infestation (Wittenberger & Hunt 1985; Brown & Brown 1986; Poulin 1991). The effects of ectoparasites on their hosts are diverse and include reduced host survival, fecundity, quality of offspring, and breeding or mating success (see reviews in Møller *et al.* 1990; Lehmann 1993). However, for some ectoparasite species no discernible effect has been detected (e.g. Rogers *et al.* 1991; Tella *et al.* 1995; Dawson & Bortolotti 1997).

Ornithodoros (Alectorobius) maritimus (Acari, Argasidae) is a soft tick that parasitises many species of seabirds breeding in colonies from W. Europe and NW Africa (Hoogstraal *et al.* 1976). Like any tick, it is an obligate blood feeder parasite (Olivier 1989). It may therefore affect host fitness directly by taking blood and also indirectly by transmitting pathogens such as viruses (Chastel 1988; Chastel *et al.* 1993). Very few studies deal with the effects of this tick on the fitness of its hosts, so information is needed to assess any detrimental effect, and consequently to evaluate their possible impact on host population dynamics. In this paper we report the effects of *O. maritimus* larvae on chick growth of the Yellow-legged Gull *Larus michahellis*, a gull that breeds in large, dense colonies most of which are located in the Mediterranean basin (Beaubrun 1993).

METHODS

The study was performed on the Medes Islands (42°00'N, 3°13'E; NE Spain). These islands are a small calcareous archipelago of 20 ha, with one of the largest breeding colonies of Yellow-legged Gulls in the Mediterranean basin: ca. 13 500 pairs in 1993 (Bosch *et al.* 1994). This colony provided the first Spanish record of *O. maritimus*, and a preliminary survey showed that around 90% of gull chicks were infested by larvae of this tick (Estrada-Peña *et al.* 1996). From 1992 to 1996 the colony was periodically culled by the regional nature conservancy agency (DARP) because of the possible harmful effect of gulls (but see Bosch 1996). Culls were conducted on only some parts of the colony, so it was possible to distinguish between unculled and culled areas (Bosch & Sol 1998).

During the breeding season of 1994, chicks from 42 nests in an unculled part of the colony were periodically measured and searched for *O. maritimus* larvae from hatching to fledging or dying. Chicks were marked just after hatching with indelible ink and with metal rings from 15 days of age. Every two or three days, body mass and lengths of wing, bill and tarsus were recorded, and the number of *O. maritimus* larvae on each chick was counted visually and by palpation of skin when body parts where covered with feathers (Danchin 1992; Boulinier & Danchin 1996). All the parts of the chicks were systematically and exhaustively examined for ticks.

The effects of tick infestation on chick growth were analysed by comparing measurements of siblings with different infestation levels. For each brood we identified the most infected chick and the least infected chick measured at a similar age (in all cases, 2 or less days of difference). The ranking of chicks according to infestation proved reliable when compared with the ranking of the same brood at least five days before (Kappa index = 0.85, Z = 2.03, df = 11, P = 0.04, Fleiss 1981). Normal approximation to the Wilcoxon Paired-Sample test (Z distribution) (Zar 1996) was used to compare the measurements obtained for each pair of siblings in the last control obtained for both individuals, since data were not normally distributed. Only 12 of the 42 broods studied could be included in the analyses because in the remaining broods only one of the chicks hatched or survived more than one week after hatching, or because the whole brood was uninfected. Since all the chicks in each brood were captured, measured and checked for parasites with a same periodicity, any possible effect of investigator disturbance on chick development was assumed to affect equally both groups of siblings (most and least infected).

To test for possible differences in chick growth unrelated to parasite infestation, body measurements were also compared by using data from the same pairs of individuals on the last control before reporting the presence of parasites on any of the siblings. Two pairs were not available for these analyses because at least one of the chicks was infested by ticks from the first control after hatching.

By comparing data obtained from siblings with different levels of parasites we solved the non-independence of data obtained from the same broods, so controlling for any parental effect on chick measurements (Merino & Potti 1995; Alves 1997). A possible association between intensity of parasites and hatching order within a brood was investigated using the Fisher Exact test, to establish whether most infected siblings systematically hatched before or after least infected siblings.

Finally, to simultaneously control for the effect of parasites and hatching order, we calculated growth rates for chicks measured at least twice during the lineal phase of growth (between 15 and 30 days in this population; M. Bosch & D. Oro unpubl. data). Measurements were standardised to account for inter-brood differences by expressing chick growth with respect to mean brood growth. Two-way ANOVA were calculated on these scores to test the effects of hatching order and parasite load on growth rate. In this case data was not available for one brood last measured at 7 days of age, so sample size was reduced to 22 individuals of 11 different broods. Body condition was not included in these analyses because it was a character derived from other two morphological parameters, and it is not warranted to assume a period of lineal increase in this variable.

RESULTS

Most and least infested groups differed by a factor of three in the intensity of their infestations (4.3 ± 4.9 vs 13.9 ± 10.3 ticks per chick; Wilcoxon paired-sample test, Z = 3.10, n = 12, P = 0.002). Chicks with more ticks grew smaller wings (Z = 2.223, n = 12, P = 0.03), weighted less (Z = 2.51, n = 12, P = 0.01) and were in a poorer body condition (Z = 2.98, n = 12, P = 0.003) than least infested individuals at the time of measurement (Table 1). However, no differences were found in either bill (Z = 1.42, n = 11, n.s) or tarsus length (Z = 0.55, n = 12, n.s). The differences in size were not explained by differences in the age of siblings, since the age when chicks were measured did not differ significantly between siblings (Z = 0.35, n = 12, n.s). Furthermore, no significant relationship was detected between the hatching order of chicks and tick abundance (Fisher exact test, n.s.).

Before infestation by *O. maritimus* no differences were detected for any of the characters between the most infected and least infected siblings (bill: Z = 0.46, n = 10, n.s.; body condition: Z = 0.97, n = 10, n.s.; tarsus: Z = 0.25, n = 10, n.s.; mass: Z = 0.53, n = 10, n.s.; wing: Z = 0.34, n = 10, n.s.). Once again no differences in the age of measurement occurred between either group of siblings (Z = 0.00, n = 10, n.s.).

Table 1. Measurements of the most and least infested sibling chicks on the date of last control and on the last control before detection of ticks on any of the siblings. Mean ± SD and number of broods analysed are reported for each variable.

	Last control			Last uninfected control		
	Least	Most	Broods	Least	Most	Broods
Bill	41.3 ± 8.5	40.4 ± 8.3	11	24.0 ± 7.3	24.2 ± 8.5	10
Body condition	12.2 ± 2.9	11.1 ± 2.9	12	4.4 ± 2.7	4.7 ± 3.3	10
Tarsus	63.5 ± 9.6	62.4 ± 11.9	12	35.3 ± 11.6	35.5 ± 12.1	10
Mass	798 ± 253	722 ± 256	12	181 ± 184	203 ± 236	10
Wing	248 ± 103	235 ± 107	12	42 ± 37	53 ± 73	10
Age	34 ± 14	34 ± 13	12	6 ± 6	6 ± 6	10

Table 2. Chick growth rate (expressed in mm day^{-1} and g day^{-1}) according to hatching order and parasite rank during the lineal phase of chick growth (between 15 and 30 days). Values for each chick have been standardized by taking away the mean brood growth rate. Mean ± SD and number of chicks analysed are reported for each variable.

Hatching order	Parasite rank	Mass	Bill	Tarsus	Wing	*n*
first	least	3.71 ± 4.08	0.05 ± 0.07	0.00 ± 0.19	0.67 ± 1.40	8
first	most	-5.86 ± 6.61	-0.01 ± 0.19	-0.25 ± 0.31	-1.50 ± 1.83	3
later	least	5.86 ± 6.61	0.01 ± 0.19	0.25 ± 0.31	1.50 ± 1.83	3
later	most	-3.71 ± 4.08	-0.05 ± 0.07	-0.00 ± 0.19	-0.67 ± 1.40	8

Although we did not detect differences in hatching order between more and less infested chicks, given our small sample size and consequently small power to detect such kind of differences, we controlled for the possible effects of tick load and hatching order on growth rate in a two-way ANOVA. A significant effect of parasite load on tarsus growth rate was detected ($F_{1,18}$ = 5.59, P = 0.03), in addition to the previously reported effects on body mass ($F_{1,18}$ = 17.63, P = 0.0005) and wing length ($F_{1,18}$ = 9.03, P = 0.008; Table 2). Again, no effects of parasite load on bill growth rate were detected ($F_{1,18}$ = 0.93, n.s.). Although studying the effects of hatching order was not among the objectives of this study, we found a significant effect on tarsus growth ($F_{1,18}$ = 5.52, P = 0.03) but no effect for the other variables (body mass, $F_{1,18}$ = 0.89, n.s.; bill, $F_{1,18}$ = 0.62, n.s.; wing, $F_{1,18}$ = 1.32, n.s.).

DISCUSSION

Several studies have shown that nestlings are very susceptible to ectoparasites, resulting in a decrease of their body size and condition (Arendt 1985; Brown & Brown 1986; Eeva *et al.* 1994; Møller *et al.* 1994; Merino & Potti 1995; 1996; Christe *et al.* 1996; Dufva & Allander 1996; Alves 1997; Allander 1998, Hurtrez-Boussès *et al.* 1998) or a lower fledging success (Brown & Brown 1986; Eeva *et al.* 1994; Møller 1990; 1994; Merino & Potti 1995; 1996). In the present study, Yellow-legged Gull chicks with high levels of *O. maritimus* larvae were lighter mass, had a poorer body condition and a smaller wing length than those least infested. Such differences in body measurements did not occur before any parasitism was detected, so were probably due to the infestation by ticks. Since comparisons were performed between siblings within broods, no parental effect on the size and condition of chicks from different broods (Bolton 1991) could bias these results. Because laying order and sequence of hatching within a clutch can affect growth and body condition of gull chicks (Parsons 1970; Barrett & Runde 1980), the smaller size and leaner body condition of the most infected siblings could have been also due to having hatched later than those least infected. However this hypothesis is rejected because tick intensity was not related with the hatching order of siblings, and the differences remained significant even when controlling for this variable.

The detrimental effect of *O. maritimus* could arise as a direct or indirect consequence of its haematophagous habits. A direct effect would be because consumption of blood from hosts can impose energetic costs on hosts (Møller *et al.* 1994). In this way, Chastel *et al.* (1987) noted that hyperinfestation by *O. maritimus* might lead to enough subacute or acute anaemia to produce chick death. Indirect effects would be through pathogen transmission, such as viruses or haematozoa which, in turn, could also cause a deteriorate body condition of gulls (Bosch *et al.* 1997). More than nine viruses have been isolated from *O. maritimus*, some of which are pathogenic for birds (Hoogstraal *et al.* 1976; Chastel 1988; Chastel *et al.* 1993). The transmission of haematozoa by this tick species is still unknown, but seems probable since it has been found for another species of the same genus (Bennett *et al.* 1992). In addition, it has been reported that *O. maritimus* bites cause severe cutaneous irritation and sometimes febrile reactions (see references in Chastel 1988) that also could affect the body condition of chicks.

It has been suggested that ticks may affect the breeding success and, consequently, the life-history and population dynamics of colonial seabirds (Duffy 1983; Boulinier & Danchin 1996). The detrimental effect of *O. maritimus* on growth of gull chicks might affect the fledging success of infested chicks, since mass and size of gull chicks are significant predictors of their probability of fledging (Parsons 1970; Bolton 1991). In such case, given the high percentage of chicks infected by this tick in the Medes Islands colony (more than 90% in a preliminary survey; Estrada-Peña *et al.* 1996) a potential effect of *O. maritimus* on the breeding success and dynamics of this colony should not be underestimated.

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SAMENVATTING

Het leven in kolonies heeft een flink aantal voordelen, zoals de mogelijkheid tot collectieve verdediging tegen predatoren en een verhoging van de efficiëntie bij het foerageren. Er zijn echter ook kosten. Zo lopen dicht opeen nestelende vogels een groter risico om met ectoparasieten besmet te raken. Parasieten zoals veerluizen en teken hebben allerlei nadelige effecten voor de gastheer, uiteenlopend van een verhoogde sterfte van de gastheer, via een verminderde vruchtbaarheid, tot bijvoorbeeld een geringere vitaliteit van de kuikens. Over het algemeen wordt aangenomen: hoe meer parasieten hoe groter het nadelige effect, en voor jonge vogels zullen de gevolgen al snel groter zijn dan voor oudere dieren. De effecten van ectoparasieten zijn echter nog niet vaak in detail bekeken. *Ornithodoros (Alectorobius) maritimus* is een teek die in veel zeevogelkolonies in West-Europa en Noordwest-Afrika wordt aangetroffen. Zoals vrijwel alle teken leeft deze parasiet van het bloed van de gastheer. Behalve een direct nadeel (het aftappen van bloed) levert deze parasiet ook risico's op door de overdracht van bijvoorbeeld virusziekten. In dit artikel wordt het effect van een tekenbesmetting op de groei van kuikens onderzocht bij Geelpootzilvermeeuwen *Larus michahellis* in een kolonie op de Medes Eilanden (NO Spanje). Voorafgaande aan de besmetting met teken bestonden er geen meetbare ver-

schillen tussen de verschillende groepen onderzochte meeuwenkuikens. Kuikens die met teken besmet raakten, bleven achter in de groei (lager gewicht, langzamere groei van de vleugels) dan een kuikens waarbij geen teken werden gevonden. Deze onderlinge verschillen waren zelfs zichtbaar bij kuikens van hetzelfde nest. De negatieve effecten op de groei hingen af van de mate van besmetting met teken.

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