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# FERTILIZATION CAPACITY OF *BOOPHILUS DECOLORATUS* (KOCH, 1844) (ACARINA: IXODIDAE)

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ABSTRACT

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Thirty individual *Boophilus decoloratus* (Koch, 1844) males were studied daily, some during the whole observation period of 37 days. Newly moulted males spent a mean of 3,8 days (range 3–6) on the host before mating. Males mated with between 1–8 females (mean 4,6), spending 2,6 days (range 1–10) with each and 0,5 days (range 0–4) in between females. The time spent by adult males on the host was from 9–37 days. The ability for males to produce viable offspring remained fairly constant with each successive female fertilized. Development took place in eggs produced by unfertilized female ticks but only a very small percentage (mean 0,008%) of these eggs hatched.

*Résumé*

*L'APTITUDE À LA FERTILISATION DE* BOOPHILUS DÉCOLORATUS *(KOCH, 1844) (ACARINA: IXODIDAE)*

*L'auteur a étudié quotidiennement trente mâles* Boophilus décoloratus *(Koch, 1844) au cours d'une période d'observation de 37 jours. Les mâles nouveau-mus ont un séjour moyen de 3,8 jours (limite de 3–6 jours) sur l'hôte avant l'accouplement. Un mâle s'accouple avec 1–8 femelles (moyen 4,6), restant 2,6 jours (limite 1–10 jours) avec chaque femelle, et 0,5 jours (limite 0–4 jours) en route entre eux. Les mâles adultes restent 9–37 jours sur l'hôte. La capacité des males à produire de la progéniture viable s'est maintenu à un niveau constant au cours de la fertilisation de femelles successives. Les oeufs produits par des femelles qui n'ont pas étées fertilisées, ont développés mais avec un pourcentage d'éclosion très bas (moyen de 0,008 p. 100).*

## INTRODUCTION

Because of the economic importance of ticks as vectors of various disease organisms and of their ability to develop acaricide-resistant strains, it has become increasingly important that studies on all aspects of their biology be undertaken.

Balashov (1972) and Oliver (1974) reviewed the more important literature on tick reproduction, mostly on gametogenesis and on copulation and its effects on egg production by the female, but very little has been written about the fertilizing ability of male ticks. It has been shown that adult male Ixodidae can successfully fertilize a number of females: e.g. *Hyalomma marginatum* Koch [=*plumbeum* (Panzer)] males can fertilize 25 females (Pervomaisky, 1954, cited by Oliver, 1974); *Amblyomma americanum* (L.) inseminated 27–37 females (Gladney & Drummond, 1970) and *Dermacentor variabilis* (Say) males mated with an average of 14,3 females (maximum 22) (unpublished work of Watt & Oliver, cited by Oliver, 1974). Feldman-Muhsam & Havivi (1967) and Oliver (1974) found that the first spermatophores produced by male ticks are sometimes without spermiophores, so presumably females receiving these spermatophores produce infertile eggs. Rechav & Oppenheim (1969) demonstrated, however, that *Hyalomma excavatum* (Koch) males, mating for the first time, were as successful in fertilizing females as males with previous mating experience.

Although it has been shown that males of a number of species are able to mate with many females, there is little information about the success of these sequential matings. Gladney & Drummond (1970) did state, however, that, in the case of *A. americanum*, "the reproductive potential of females held at a 1:1 ratio (i.e. of males to females) is apparently greater than that of females held at a 1:10 ratio". These authors go on to say, however, that no statistically significant conclusions could be derived from their data.

This paper deals with the fertilization capacity of the Blue Tick, *Boophilus decoloratus* (Koch, 1844), an economically important one-host species, with particular emphasis on the time male ticks spend with each female and the degree of fertility of each successive impregnation.

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## MATERIALS AND METHODS

Laboratory-moulted adult ticks were placed in small plastic containers stuck to the backs and necks of Friesland calves with a contact adhesive. In the main series of experiments, 1 male and 3–4 females were placed in each container initially and, when males had commenced mating, additional females were supplied from time to time so that each male was always accompanied by unmated females. In the case of 6 males (see Table 1), a shortage of freshly emerged females terminated the observations. Daily records were kept of the positions of the males, and any females that had fed and detached were collected and placed in tubes in an incubator (26°C; 95% R.H.) to oviposit. The number of larvae produced were counted 2 months later.

In another, smaller, series of experiments, females were allowed to feed in the absence of males in order to establish whether they were able to reproduce parthenogenetically.

## RESULTS AND DISCUSSION

### *Multiple mating by male ticks*

Data on the movements of 30 adult male ticks throughout their reproductive phase are shown in Table 1. The mean pre-mating period (i.e. the time from male attachment after moulting until the first female was encountered) of 3,8 days (range 2–6 days) is in keeping with the findings of Arthur & Londt (1973) and Londt & Spickett (1976). The mean number of females impregnated in these experiments was 4,6 (range 1–8), a somewhat lower result than has been reported for other ixodids (Oliver, 1974), but as the total time spent on the host only ranged from 9–37 days (when the experiment was terminated) this was to be expected. *A. americanum* on the other hand inseminated 27–37 females within a period of 68–127 days on the host (Gladney & Drummond, 1970). *B. decoloratus* males spent from 1–10 days with each female (mean 2,6 days) and, although this is statistically insignificant, there appears to be a tendency for males to spend longer with each successive female encountered (Table 1), at least up to and including the 6th female. Similarly, the period between successive females tended to increase (mean 0,5 days : range 0–4 days) (Table 1).

TABLE 1 Movements of adult *Boophilus decoloratus* males during their reproductive phase. (1)=♂ gone (dead): unmated females still present. (2)=♂ still present at final reading: unmated females no longer available (*=experiment terminated)

| Male No. | Pre-mating period (days) | Time with 1st ♀ (days) | Move to 2nd ♀ (days) | Time with 2nd ♀ (days) | Move to 3rd ♀ (days) | Time with 3rd ♀ (days) | Move to 4th ♀ (days) | Time with 4th ♀ (days) | Move to 5th ♀ (days) | Time with 5th ♀ (days) | Move to 6th ♀ (days) | Time with 6th ♀ (days) | Move to 7th ♀ (days) | Time with 7th ♀ (days) | Move to 8th ♀ (days) | Time with 8th ♀ (days) | (See legend) | No. ♀♀ mated | Total time ♂ on host (days) | Average time ♂ spent with each ♀ (days) | Total time ♂ spent without a ♀ (days) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 5 | 0 | 2 | 0 | 1 | 4 | 5 | 0 | 4 | | | | | | | (1) | 5 | 25 | 3,4 | 4 |
| 2 | 4 | 5 | 0 | 3 | 4 | 7 | 0 | 3 | 4 | 1 | | | | | | | (1) | 5 | 31 | 3,8 | 8 |
| 3 | 4 | 1 | 0 | 1 | 0 | 3 | 0 | 2 | | | | | | | | | (1) | 4 | 11 | 1,8 | 0 |
| 4 | 6 | 3 | 0 | 3 | 0 | 1 | 0 | 2 | 1 | 10 | 1 | 3 | 0 | 3 | 4 | | (2) | 7 | 37* | 3,6 | 2 |
| 5 | 5 | 2 | 1 | 2 | 0 | 1 | 3 | 5 | | | | | | | | | (1) | 4 | 21 | 2,5 | 6 |
| 6 | 4 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | | | | | | | | | (1) | 4 | 11 | 1,8 | 0 |
| 7 | 4 | 2 | 0 | 1 | 0 | 2 | 4 | 3 | 0 | 6 | 1 | 7 | 7 | | | | (2) | 6 | 37* | 3,5 | 5 |
| 8 | 5 | 1 | 1 | 3 | 0 | 2 | 1 | 3 | 0 | 4 | 3 | 9 | 0 | 5 | | | (2) | 7 | 37* | 3,9 | 5 |
| 9 | 4 | 8 | 3 | 6 | 4 | | | | | | | | | | | | (1) | 2 | 25 | 7,0 | 7 |
| 10 | 4 | 4 | 0 | 3 | 0 | 1 | 3 | 5 | 2 | | | | | | | | (1) | 4 | 22 | 2,6 | 5 |
| 11 | 5 | 1 | 0 | 3 | 0 | 6 | 0 | 3 | | | | | | | | | (2) | 4 | 18* | 3,3 | 0 |
| 12 | 3 | 1 | 0 | 1 | 0 | 2 | 0 | 4 | 0 | 1 | 0 | 4 | 0 | 1 | | | (1) | 7 | 17 | 2,0 | 0 |
| 13 | 4 | 5 | 0 | 2 | 0 | 1 | 0 | 4 | 0 | 1 | | | | | | | (1) | 5 | 17 | 2,6 | 0 |
| 14 | 4 | 1 | 4 | | | | | | | | | | | | | | (1) | 1 | 9 | 1,0 | 0 |
| 15 | 3 | 2 | 0 | 1 | 0 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | (1) | 8 | 15 | 1,5 | 0 |
| 16 | 3 | 1 | 0 | 2 | 0 | 3 | 0 | 4 | 0 | 3 | | | | | | | (1) | 5 | 16 | 2,6 | 0 |
| 17 | 3 | 6 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 4 | | | | | | | (1) | 3 | 18 | 3,0 | 0 |
| 18 | 4 | 1 | 0 | 1 | 0 | 3 | 0 | 2 | 0 | 5 | 0 | 2 | | | | | (2) | 6 | 18* | 2,3 | 0 |
| 19 | 4 | 1 | 0 | 3 | 1 | 4 | 0 | 2 | 0 | 3 | | | | | | | (2) | 5 | 18* | 2,6 | 1 |
| 20 | 6 | 3 | 0 | 2 | 0 | 1 | 0 | 6 | | | | | | | | | (1) | 4 | 18 | 3,0 | 0 |
| 21 | 4 | 1 | 0 | 3 | 1 | 4 | 0 | 1 | 1 | 2 | 1 | | | | | | (1) | 5 | 18 | 2,2 | 3 |
| 22 | 2 | 4 | 1 | 2 | 2 | | | | | | | | | | | | (1) | 2 | 11 | 3,0 | 3 |
| 23 | 3 | 2 | 0 | 3 | 0 | 2 | 0 | 3 | 1 | | | | | | | | (1) | 4 | 14 | 2,5 | 1 |
| 24 | 3 | 1 | 0 | 2 | 0 | 1 | 4 | 1 | 1 | | | | | | | | (1) | 4 | 13 | 1,3 | 5 |
| 25 | 3 | 2 | 0 | 2 | 1 | 4 | 0 | 1 | 1 | | | | | | | | (1) | 4 | 14 | 2,3 | 2 |
| 26 | 4 | 1 | 1 | 2 | 0 | 1 | 0 | 4 | 0 | 6 | 2 | | | | | | (1) | 5 | 21 | 2,8 | 3 |
| 27 | 3 | 3 | 0 | 2 | 0 | 5 | 0 | 1 | 4 | 2 | 0 | 1 | 1 | | | | (1) | 6 | 22 | 2,3 | 5 |
| 28 | 3 | 1 | 0 | 4 | 0 | 3 | 2 | | | | | | | | | | (1) | 3 | 13 | 2,7 | 2 |
| 29 | 3 | 3 | 0 | 2 | 1 | 4 | 3 | | | | | | | | | | (1) | 3 | 16 | 3,0 | 4 |
| 30 | 4 | 3 | 0 | 2 | 3 | 2 | 0 | 1 | 1 | | | | | | | | (1) | 4 | 16 | 2,0 | 4 |
| Means | 3,8 | 2,5 | 0,4 | 2,4 | 0,6 | 2,5 | 0,9 | 2,8 | 0,8 | 3,5 | 0,9 | 3,9 | 0,2 | 2,5 | 0,0 | 2,0 | | 4,6 | | 2,6 | 2,7 |

TABLE 2 The fertilization capacity of 10 *Boophilus decoloratus* males. — = lost ♀; * = ♀ and egg mass attacked by fungal growth (not used in calculation of means)

| Male No. | Percentage hatch of egg batches produced by successive females mated by a single male (Figures in brackets represent total eggs laid) | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | ♀ 1 | ♀ 2 | ♀ 3 | ♀ 4 | ♀ 5 | ♀ 6 | ♀ 7 | ♀ 8 | |
| 1 | 3,6 (3 223) | 1,4 (1 961) | 79,0 (2 379) | 99,1 (3 818) | 96,8 (2 591) | | | | 56,0 (2 794) |
| 2 | 99,0 (2 808) | 99,1 (1 501) | 99,4 (2 743) | 98,6 (2 871) | — | | | | 99,0 (2 481) |
| 3 | 95,7 (3 341) | 91,3 (3 005) | 94,3 (2 475) | 97,3 (2 839) | | | | | 94,7 (2 915) |
| 4 | 89,0 (3 421) | 99,5 (2 980) | — | 77,4 (868) | 12,8* (172) | 94,2 (2 511) | 98,3 (2 572) | | 91,7 (2 470) |
| 5 | 98,1 (3 710) | 14,4 (709) | 99,4 (1 350) | 99,6 (3 233) | | | | | 77,9 (2 251) |
| 6 | 99,2 (3 516) | 96,7 (3 089) | 99,2 (2 716) | 95,8 (3 792) | | | | | 97,7 (3 278) |
| 8 | 98,2 (2 167) | 96,3 (2 817) | 86,8 (3 313) | 98,8 (2 284) | 65,5 (3 310) | 95,9 (3 427) | 75,4 (1 734) | | 88,1 (2 722) |
| 12 | 98,7 (2 271) | 96,2 (3 085) | 97,8 (2 251) | 98,5 (2 298) | 95,8 (3 118) | 95,7 (1 425) | 96,2 (1 461) | | 97,0 (2 273) |
| 13 | 99,3 (3 572) | 89,2 (3 164) | 82,3 (2 105) | 86,9 (2 450) | | | | | 89,4 (2 813) |
| 15 | 81,8 (1 894) | 93,0 (2 643) | 94,3 (2 063) | 87,4 (1 467) | 90,7 (1 577) | 94,5 (2 470) | 97,4 (2 868) | — | 91,3 (2 140) |
| Mean | 86,3 (2 992) | 77,7 (2 495) | 92,5 (2 377) | 93,9 (2 592) | 87,2 (2 649) | 95,1 (2 458) | 91,8 (2 159) | | 88,7 (2 574) |

*Success of sequential matings*

Except in the case of 1 male (Male No. 1), the number of fertile eggs resulting from a male's first mating was not significantly lower than that for subsequent matings nor did their fertilizing ability decrease with subsequent matings (Table 2). Some males were outstandingly successful at fertilizing females. For example, Male No. 8 (Tables 1 & 2) fertilized 7 females which together produced a total of 15 430 eggs, 14 941 (i.e. 97%) of which hatched. After making counts of a maximum number of 9 spermiophore capsules in the seminal receptacles of female *B. decoloratus* ticks, Londt & Spickett (1976) deduced that females could be impregnated at least 5 times, and possibly as many as 9 times. Under the conditions provided by Londt & Spickett (1976), it was likely that multiple impregnation of females took place as a result of the experimental design. Although the females were not dissected in the present study, it is probable that each was impregnated only once as virgin females were always available to the males and the mean period of 2,6 days spent with each successive female was comparatively short.

TABLE 3 Percentage hatch of egg masses produced by unfertilized *Boophilus decoloratus* females

| Female No. | No. eggs laid | No. eggs hatched | % hatch |
|---|---|---|---|
| 1..... | 1 352 | 2 | 0,002 |
| 2..... | 164 | 0 | 0,000 |
| 3..... | 1 203 | 3 | 0,003 |
| 4..... | 1 321 | 2 | 0,002 |
| 5..... | 2 925 | 70 | 0,024 |
| 6..... | 1 079 | 1 | 0,001 |
| 7..... | 853 | 9 | 0,011 |
| 8..... | 575 | 12 | 0,021 |
| 9..... | 1 057 | 13 | 0,012 |
| Means..... | 1 170 | 12,4 | 0,008 |

*Parthenogenicity*

Female ticks isolated from males produced significantly fewer eggs (mean 1 170—Table 3) when compared to fertilized females (mean 2 574—Table 2), and of these eggs a mean of only 0,008% (range 0,000–0,024%) hatched. Although this is a very low percentage hatch, most of the eggs contained fully developed larvae. The larvae that emerged were usually sluggish, however, and died within a few days. Parthenogenesis has also been reported in the closely related species *Boophilus microplus* (Canestrini, 1888) by Stone (1963). Although it appears that *B. decoloratus* is capable of this type of reproduction it probably has very limited survival value.

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