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EFFECT OF UNFED FEMALE WEIGHT ON THE BIOLOGY OF *HYALOMMA (HYALOMMA) IMPELTATUM* SCHULZE AND SCHLOTTKE (ACARI: IXODIDAE)

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ABSTRACT

Unfed female *Hyalomma (Hyalomma) impeltatum* Schulze and Schlottke in 4 different weight groups of 2.6-5.0, 6.2-10.0, 10.3-14.7 and 15.2-22.3 mg, respectively, were investigated for the effect of unfed female weight (UFW) on certain biological parameters. The results showed that the duration of the preoviposition period was not affected by UFW. The correlation coefficient values for each of the feeding and oviposition periods and of the engorged female weight and egg mass weight in relation to UFW varied greatly among the different weight groups but was positive for the pooled data. The conversion efficiency of unfed females weighing 5.0 mg or less was lower than that of larger females. However, the egg mass weight was strongly correlated with engorged female weight, and the conversion efficiency index was similar for all weight groups of unfed females weighing 6.2 mg or more as well as the pooled data. The oviposition pattern for the different weight groups (except for females weighing 5.0 mg or less) and pooled data appeared similar and lacked peak oviposition values. The results obviate the necessity of accurate random sampling or specifying the UFW when studying ixodid biology.

INTRODUCTION

Hyalomma (Hyalomma) impeltatum Schulze and Schlottke was reported to parasitize a wide variety of wild and domestic animals as well as human beings (Hoogstraal, 1956, Walker, 1974). Crimean-Congo hemorrhagic fever virus have been isolated from this species in Nigeria (Causey *et al.*, 1970), Senegal (Robin, 1973), Ethiopia (Wood *et al.*, 1978) and Mauritania (Saluzzo *et al.*, 1986), and Wanowrie virus from specimens collected from camels in Egypt (Williams *et al.*, 1973).

Khalil and Hagras (1988), while studying the biology of a Qatari strain of *H. impeltatum* observed that engorged female weight varied greatly and suggested that such variation might have been associated with the unfed female weight (UFW).

In the present study, we investigated the relationship between UFW of *H. impeltatum* falling within different weight ranges and (a) engorged female weight before and after oviposition, (b) egg mass weight, (c) oviposition pattern and (d) duration of the feeding, preoviposition and oviposition periods.

MATERIALS AND METHODS

A *H. impeltatum* colony originating from engorged females collected from camels in Miazar area in Qatar was maintained in the laboratory at 29 ± 1°C and 75% RH. Rabbits, *Oryctolagus cuniculus*, were used as hosts. Rearing methods were those of Berger et al. (1971).

Females were divided into 4 groups (n=10-11) according to the UFW, as determined by a Mettler H80 balance (Mettler Instrument AG., Zurich, Switzerland), on the day of placement on the host. These groups included the following weight categories: 5.0 mg or less, >5.0-10.0 mg, >10.0-15.0, and >15.0 mg; the actual weight ranges were 2.6-5.0 (group 1), 6.2-10.0 (group 2), 10.3-14.7 mg (group 3) and 15-2-22.3 mg (group4), respectively.

Each female was marked on one or more legs with fingernail paint to facilitate detection after engorgement, and random pools of 5 females from the 4 groups were placed to feed, 2 weeks postmolting with 5 males in each feeding capsule (2/rabbit). Females were checked daily for attachment which was delayed sometimes for 2 weeks. On engorgement day, each female was weighed (engorged weight) and placed in a rearing vial. The daily egg output weight was determined for each female as described by Khalil and Hagras (1988). Each female was then weighed 3 days after oviposition cessation (residual weight). The duration of the feeding, preoviposition and oviposition periods were determined for each female. The total egg mass weight was determined for each female in 4 similar groups (n=11-12) of undisturbed females.

The mean and standard error (SEM) values of each of the above parameters were calculated for each group and for the cumulative data of all females in the 4 groups (pooled data), and the data were compared using Student's t-test.

The following relationships for each female and their means and SEM for each group and for the pooled data were determined; these were (a) engorged female weight:UFW, (b) residual female eight:UFW, (c) egg mass weight:UFW and (d) egg mass weight: egnorged female weight. For each group, the linear regression equation (using the least-sum-of-squares method) and correlation coefficient were determined for the above relationships.

RESULTS

Feeding, preoviposition and oviposition periods

The mean feeding and preoviposition periods were similar for the 4 groups and pooled data (Table 1), and the oviposition period was similar for groups 2-4 and pooled data (i.e. females weighing >5.0 mg) and was longer for these groups than that of group 1 (i.e. the smallest females).

A great variation in the correlation of the feeding period with the UFW was observed, no correlation for females of group 1, a strong positive correlation for groups 2 and 4 and a strong negative correlation for group 3 (Table 1). When the data were pooled, a positive correlation was obtained. The preoviposition period was not correlated with the UFW for any of the 4 groups or for the pooled data (Table 1).

The oviposition period was positively correlated with UFW in group 1, and to a lower extent with UFW in group 3, but was not correlated with UFW in groups 2 and 4. However, a positive correlation existed when the data were pooled (Table 1).

Engorged, residual and egg mass weights

Females of group 1 exhibited the smallest means of engorged female and egg mass weights, those of group 4 exhibited the largest means, and females of groups 2 and 3 exhibited similar means of values intermediate between those of groups 1 and 4 (Table 2). On the other hand, the mean residual weight was similar for groups 2, 3 and 4 and pooled data, and the mean for groups 3 and 4 was larger than that for group 1 (Table 2).

A great variation occurred in the correlation between UFW and each of the engorged female weight and egg mass weight; no correlation for groups 2 and 4, a weak correlation for group 2 and a strong positive correlation for group 3 and pooled data (Table 2). On the other hand, a strong positive correlation occurred between UFW and the residual female weight for the 4 groups and pooled data (Table 2).

The ratio of egg mass weight:UFW was similar for groups 1, 2 and 3, and was smaller for group 4 than that of group 2 (Table 3).The ratio for the pooled data was not different from that of any of the 4 groups.

The positive correlation between egg mass weight and engorged female weight became stronger with increase of weight for groups 1, 2 and 3, respectively, but was weaker for females weighing 15.0 mg (group 4) (Table 4). However, the correlation was strongly positive when the data were pooled.

Table 1

Duration of feeding, preoviposition and oviposition periods of female *Hyalomma impeltatum* of different unfed weight categories

Female weight (mg)	Man period (days) ± SEM (range)	Regression equation⋆	Correlation coefficient
	Feeding Period		
2.6-5.0	11.0 ± 0.42a⋆⋆ (9-13)	Y = 10.5 + 0.13x	0.1300 (P>0.05)
6.2-10.0	11.1 ± 0.33a (10-12)	Y = 6.2 + 0.58x	0.9074 (P<0.001)
10.3-14.7	11.4 ± 0.57a (9-14)	Y = 25.7 - 1.20x	-0.8143 (P<0.01)
15.2-22.3	12.9 ± 0.85a (8-17)	Y = -4.8 = 0.96x	0.8374 (P<0.001)
2.6-22.3	11.6 ± 0.43a (8-17)	Y = 9.6 + 0.19x	0.4922 (P<.001)
	Preoviposition Period		
2.6-5.0	4.7 ± 0.21b (4-6)	Y = 4.7 + 0.001x	0.0019 (P<0.05
6.2-10.0	4.7 ± 0.23b (4-5)	Y = 4.2 + 0.06x	0.1843 (P<0.05)
10.3-14.7	5.0 ± 0.43b (3-7)	Y = 5.7 - 0.06x	-0.0759 (P<0.05)
15.2-22.3	5.1 ± 0.21b (4-6)	Y = 4.4 + 0.04x	0.1578 (P<0.05)
2.6-22.3	4.9 ± 0.13b (3-7)	Y = 4.6 + 0.03x	0.2183 (P<0.05)
	Oviposition Period		
2.6-5.0	16.7 ± 0.24c (16-17)	Y = 14.9 + 0.43x	0.7658 (P<0.01)
6.2-10.0	19.4 ± 0.22d (18-20)	Y = 19.1 + 0.40x	0.0094 (P>0.05)
10.3-14.7	19.1 ± 0.34d (18-20)	Y = 15.1 + 0.34x	⅞.5455 (P<0.05)
15.2-22.3	19.3 ± 0.30d (17-20)	Y = 16.1 + 0.17x	0.4739 (P>0.05)
2.6-22.3	18.6 ± 0.61d (16-20)	Y = 16.9 + 0.15x	0.6399 (P<0.001)

⋆Linear regression equation relating the feeding, preoviposition and oviposition periods (y) with unfed female weight (x) (mg).

⋆⋆Figures followed by similar letters are not significantly different (P>0.05); those followed by different letters are significantly different (P<0.01).

Table 2

Engorged and residual female weight and egg mass weight in *Hyalomma impeltatum* of different unfed weight categories

Female weight (mg)	Mean weight (mg) ± SEM (range)	Regression equation⋆	Correlation coefficient
Engorged Female Weight			
2.6-5.0	399.8 ± 65.30a⋆⋆ (231.9-883.7)	Y = -199.4 + 143.7x	0.5971 (P<0.05)
6.2-10.0	753.7 ± 64.90b (477.9-1202.4)	Y = 865.1 - 13.11x	-0.0867 (P>0.05)
10.3-14.7	867.1 ± 75.27b (493.1-1276.9)	Y = -757.4 + 136.5x	0.7921 (P<0.01)
15.2-22.3	1143.7 ± 79.18c (911.1-1308.7)	Y = 508.6 + 34.0x	0.3811 (P>0.05)
2.6-22.3	791.1 ± 154.00b,c (231.9-1308.7)	Y = 311.3 + 44.4x	0.7235 (P<0.001)
Residual Female Weight			
2.6-5.0	132.9 ± 31.70d (52.4-240.9)	Y = -143.2 + 72.5x	0.8167 (P<0.01)
6.2-10.0	211.1 ± 41.30d,e (107.4-340.3)	Y = - 17.8 + 32.9x	0.8714 (P<0.001)
10.3-14.7	223.7 ± 17.5e (138.5-315.9)	Y = 123.8 + 9.15x	0.8891 (P<0.001)
15.2-22.3	270.0 ± 18.51e (237.2-299.8)	Y = 138.3 + 6.7x	0.7076 (P<0.02)
2.6-22.3	209.4 ± 28.52D,E (52.4-340.3)	Y = 161.2 + 6.3x	0.5752 (P<0.001)
Egg Mass Weight			
2.6-5.0	187.3 ± 32.70f (77.4-432.4)	Y = -129.8 + 75.5x	0.6269 (P<0.05)
6.2-10.0	361.1 ± 25.05g (256.7-536.4)	Y = 446.9 – 10.1x	-0.1736 (P>0.05)
10.3-14.7	478.9 ± 46.05g,h (247.5-748.5)	Y = -569.5 + 88.1	0.8389 (P>0.001)
15.2-22.3	599.8 ± 44.9h (297.0-801.6)	Y = 444.6 + 8.3x	0.1644 (P>0.05)
2.6-22.3	406.8 ± 87.9h (77.4-801.6)	Y = 111.2 + 27.3x	0.7989 (p<001)

⋆Linear regression equation relating engorged or residual female weight or egg mass weight (Y) with unfed female weight (x), all weights in mg.

⋆⋆Figures followed by similar letters are not significantly different (P>0.05); those followed by different letters are statistically different (P<0.02-P<0.01).

The mean values of the ratio of egg mass weight:engorged female weight conversion efficiency index (Drummond and Whetstone, 1970) was similar for groups 2, 3 and 4 and was greater for these groups than that for group 1 (Table 3). However, when the data were pooled, the ratio was not significantly different from that of any of the 4 groups.

Table 3

Ratio of egg mass weight to unfed and engorged female weights of *Hyalomma impeltatum* of different unfed weight categories

Female weight (mg) category	Mean ratio of egg mass weight (mg) to female weight (mg) (range)	
category	Unfed	Engorged⋆
2.6-5.0	43.9 ± 5.85a,d⋆⋆ (22.1-86.5)	0.62 ± 0.01b (0.56-0.69)
6.2-10.0	43.8 ± 3.81a (26.5-59.6)	0.66 + 0.03b,c (0.51-0.87)
10.3-14.7	39.2 ± 2.75a,d (24.0-44.0)	0.73 ± 0.01c (0.66-0.87)
15.2-11.2	32.7 ± 2.35d (14.3-38.0)	0.72 ± 0.03c (0.50-0.86)
2.6-22.3	39.9 ± 2.60a,d (14.3-86.5)	0.69 ± 0.02b,c (0.50-0.87)

⋆Index of conversion efficiency (Drummond & Whetstone 1970).

⋆⋆Figures followed by similar letters are not significantly different ($P>0.05$); those followed by different letters are statistically different ($P<0.01$).

Oviposition pattern

The oviposition curves for groups 2, 3, and 4 and for the pooled data appeared nearly similar but were different from that representing oviposition by the smallest females (Fig. 1). Egg batches laid by females of the latter group were nearly similar ($P>0.05$) from day 1 until day 14. For each of groups 2, 3 and 4, the weights of egg batches laid on days 3-10, 2-10 and 3-8, respectively, were nearly similar ($P>0.05$) and were greater ($P<0.05$) than that of eggs laid before or after that period. When the data were pooled, the largest ($P<0.05$) egg batches were found to be laid on days 2-10.

Table 4

Egg mass weight in relation to engorged female weight in *Hyalomma impeltatum* of different unfed weight categories

Female weight (mg) category	Regression equation⋆	Correlation coefficient
2.6-5.0	Y = 35.4 + 0.38x	0.7548 (P<0.01)
6.2-10.0	Y = 127.5 + 0.31x	0.8157 (P<0.01)
10.3-14.7	Y = -32.7 + 0.59x	0.9721 (P<0.001)
15.2-22.3	Y = 188.1 + 0.36x	0.6372 (P<0.05)
2.6-22.3	Y = 4.9 + 0.50x	0.9135 (P<0.001)

⋆Linear regression equation relating egg mass weight (Y) with engorged female weight (x), both in mg.

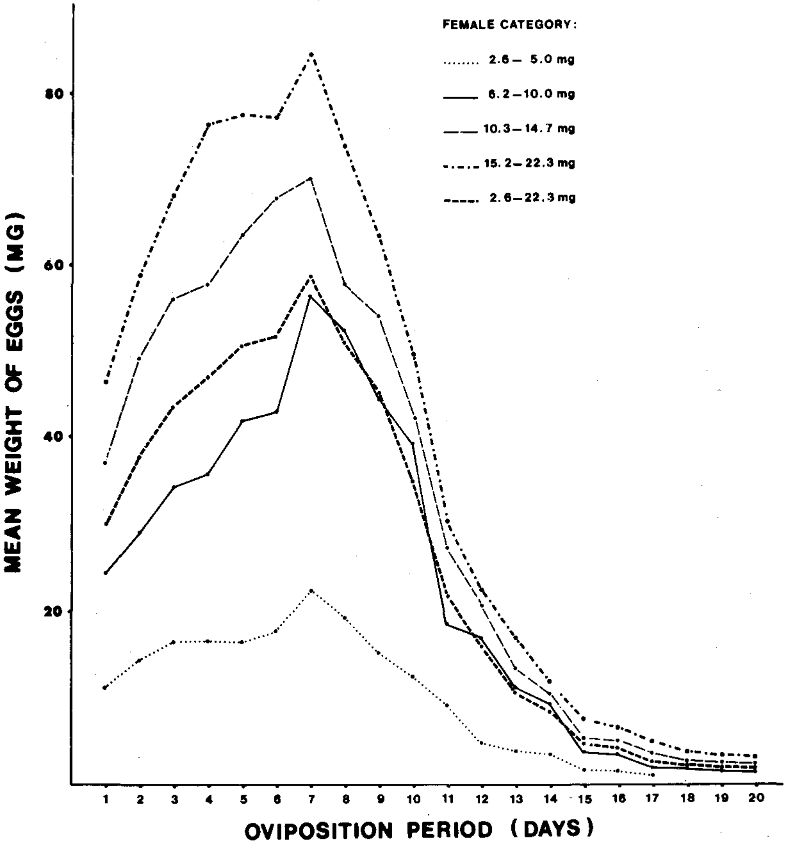

Fig. 1.. Oviposition pattern of female *Hyalomma impeltatum* of 4 different unfed weight categories and pooled data.

DISCUSSION

Data of the present study show that the duration of *H. impeltatum* preoviposition period is not affected by UFW. The great variation among the different weight groups in the correlation coefficient values for the feeding and oviposition periods suggest that these periods will vary according to the UFW of the specimens used. Experiments involving some of these parameters provided different results for the same species. Mourad and Ali (1982) and Nagar (1968) reported a positive correlation between the oviposition period and engorged female *Boophilus annulatus* (Canestrini) and *Dermacentor variabilis* (Say), respectively. Ouhelli et al. (1982) and Campbell and Harris (1979) reported that such correlation did not exist for these 2 species, respectively. Such variation in the results might have been associated with differences in the UFW of the female samples used in these studies. The findings of these authors and those of the present study obviate the necessity of accurate random sampling of unfed females when these parameters are involved in any investigation.

Results of the present study also show great variation among the different weight groups in the correlation between UFW and each of the engorged female weight and egg mass weight. Although a positive correlation is obtained when the data are pooled, a definite conclusion that these 2 parameters are positively correlated with UFW in this species cannot be made without reservation. In this respect, *H. impeltatum* appears to be different from *H. (H.) dromedarii* Koch (Bassal and Hefnawy, 1972, Khalil and Hagras, 1989) and *H. asiaticum kozlovi* Olenev (Wen-Bing et al., 1983) in which a definite positive correlation occurred between UFW and each of the engorged female weight and egg mass weight. However, variation in the prefeeding period of female *H. impeltatum,* which may remain unattached on the host for up to 2 weeks, may have contributed to the differences in the results, since the duration of the starvation period was reported to affect the amount of imbibed food in *D. variabilis* (Amin, 1969).

In the present study, the lower values of the conversion efficiency index for females of group 1 than of that of the other groups suggested that females weighing 5.0 mg or less are less capable of converting the blood meal to eggs than larger females. In this respect, *H. impeltatum* differs from *H. dromedarii* in which the smallest females appeared to be more capable of converting their meal to eggs (Khalil and Hagras, 1989). Investigation of the differences between these 2 species in the amount of eggs that may be retained in the female genital system after oviposition cessation and in the metabolic rate may provide clarification of the above differences.

Similar to other ixodid ticks (Khalil and Hagras, 1989), a strong positive correlation was observed between the egg output and the engorged female *H. impeltatum* weight. However, the imperical constants representing the Y-intercept and the slope in the regression equations expressing the relationship between these 2 parameters differ for the different weight groups. such difference would result in considerable variation of the theoretical threshold of the minimum engorged weight for ovipositing females which may be obtained by extrapolating the curves respresenting the above relationship.

In the present study, the oviposition patterns of the different weight groups lacked typical peak values similar to those observed in other ixodid species. However, in a previous investigation of *H. impeltatum* biology, typical peak values were also absent at a comparable incubation temperature (Khalil and Hagras, 1988).

Our results show that UFW may affect certain biological aspects of female *H. impeltatum,* and perhaps other ixodids as well. Therefore, random sampling or specifying the UFW must not be overlooked in investigations dealing with ixodid female biology.

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أثر وزن الأنثى الجائعة على بيولوجية هيالوما (هيالوما) إمبلتاتام شـــولتز وشلّوتك (أكـــاراي : أكســـوديدا)

أحمـــد الوزيـــر هجـــرس و جليلـــة مصـــطفى خليـــل

تم توزيع إناث **هيولوما إمبلتاتام** في أربع مجموعات حسب أوزانها في حالة الجوع وتشمل هذه المجموعات الوزنية الإناث التي تزن مـا بين ٢,٦ و ٥,٠ ملجم ، ٦,٢ و ١٠,٠ ملجم ، ١٠,٣ و ١٤,٧ ملجم ، ١٥,٢ و ٢٢,٣ ملجم . وتمت دراسة ومقارنة علاقة وزن الأنثى الجائعة ببعض القياسات البيولوجية للإناث في المجموعات الوزنية الأربع وكذلك لمجموع الإناث . وقد بينت الدراسة الآتي :

١ - أن وزن الأنثى الجائعة لايؤثر على طول فترة ما قبل وضع البيض .

٢ - أن معامل الإرتباط بين وزن الأنثى الجائعة وكل من (أ) طول فترة الإغتذاء و (ب) طول فترة وضع البيض و (جـ) وزن الأنثى بعد الإمتلاء و (د) وزن البيض يختلف اختلافاً كبيراً باختلاف المجموعات الوزنية . ولكن المعامل كان إيجابياً لمجموع الإناث .

٣ - إن قدرة الإناث الجائعة التي تزن ٥ مجم أو أقل على تحويل وزنها بعد الإمتلاء إلى بيض أقل من قدرة الإناث الجائعة ذات الوزن الأكبر .

٤ - أن معامل الارتباط كان إيجابياً وقوياً بين وزن الإناث بعد الامتلاء ووزن البيض ، وقد كان معامل القدرة على تحويل وزن الجسم إلى بيض متساوياً في جميع المجموعات الـوزنية التي تـزن الإناث فيهـا ٦,٢ ملجم أو أكثر وكـذلك لمجموع الإناث .

٥ - أن نمط وضع البيض كان متشابهاً لكل المجموعات الوزنية (عدا المجموعة التي تزن إناثها ٥,٠ ملجم أو أقل) ولمجموع الإناث ، ولم تُلاحظ في هذا النمط فترة ذروة لوضع البيض .

وقد بينت هذه النتائج أهمية أن يكون جمع العينات عشوائياً صادقاً أو أن يحدد الباحث أوزان القراد الجائع عند دراسة بيولوجية القراد الجامد .