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EFFECT OF TEMPERATURE ON *HYALOMMA (HYALOMMA) IMPELTATUM* SCHULZE AND SCHLOTTKE (IXODOIDEA: IXODIDAE)

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ABSTRACT

The effect of 21, 25, 29 and 34°C on developmental period duration, weight of different stages in the life cycle and conversion efficiency in *Hyalomma (H.) impeltatum* Schulze and Schlottke was investigated at 75% relative humidity. Generally, egg incubation, larval and nymphal premolting and female preoviposition and oviposition periods were prolonged with the decrease in temperature. However, the egg incubation and preoviposition periods were the most greatly affected. Larval, nymphal and female feeding periods were not affected by temperature. Also, the percentage loss in weight by larvae before feeding and during molting and by nymphs and females before feeding was not affected by temperature but nymphal loss in weight during molting was greater at 34°C than at 21-29°C. Fifty percent of the egg masses were deposited within 7.9, 6.8, 4.6 and 4.2 days, and 90% within 20.0, 18.0, 11.6 and 9.3 days at the tested temperatures, respectively. The conversion efficiency of female weight to egg mass weight was not affected by temperature. The results were discussed in relation to those obtained for other ixodid ticks.

INTRODUCTION

Temperature is an important ecological factor affecting ixodid tick development. The duration of egg incubation (Ryabova, 1971a, Londt, 1977, Heath, 1979, Wen-Bing and Kuo-Ting, 1981a, Shiraishi *et al.*, 1982), larval and nymphal premolting (Ryabova, 1971b, Hamel and Gothe, 1974, Heath 1981, Wen-Bing and Kuo-Ting, 1981a, Shiraishi *et al.*, 1982, Ouhelli and Pandey, 1984, Koch and Tuck 1986), female preoviposition (Ryabova, 1971a, Hamel and Gothe, 1974, Fujisaki *et al.*, 1975, Ogunji, 1979, Hafez and Bassal, 1980, Mourad *et al.*, 1982, Ouhelli et al., 1982, Ouhelli and Pandey, 1984, Wen-Bing, 1985) and oviposition (Snow and Arthur, 1966, Sweatman, 1967, Sonenshine and Tigner, 1969, Drummond *et al.*, 1971, Ryabova, 1971a, Branagan, 1973, Bennett, 1974, Hamel and Gothe, 1974, Fujisaki *et al.*, 1975, Londt, 1977, Norval, 1977, Campbell and Glines, 1979, Campbell and Harris, 1979, Hafez and Bassal, 1980, Ali, 1982, Mourad *et al.*, 1982, Ouhelli *et al.*, 1982, Wen-Bing, 1985) periods are greatly affected by temperature. Also, female fecundity may be affected by the ambient temperature (Arthur, 1951, Hitchcock, 1955, Sweatman, 1967, 1968, Ryabova, 1971a, Bennett, 1974, Hamel and Gothe, 1974, Fujisaki *et al.*, 1975, Campbell and Glines, 1979, Campbell and Harris, 1979, Ogunji, 1979, Mourad *et al.*, 1982, Ouhelli and Pandey, 1984, Wen-Bing, 1985). In this work, we investigate the effect of 4 different temperatures on the ixodid tick *Hyalomma (H.) impeltatum* Schulze and Schlottke.

MATERIALS AND METHODS

A *H. impeltatum* colony originating from engorged females collected from camels in Miazar area in the State of Qatar was maintained in the laboratory at 28 ±1°C and 75% relative humidity (RH). Rabbits, *Oryctolagus cuniculus*, were used as hosts. Methods of rearing were those of Berger *et al.* (1971).

Experimental conditions:

Four groups of eggs pooled from 15 females were held in incubators at 21 ±, 25 ± 1, 29 ± 1, and 34 ± 1°C and 75% RH. Larvae, nymphs and adults resulting from these eggs were maintained before, during and after feeding on rabbits at the same temperatures at which the egg masses were held.

Duration of developmental periods in the life cycle:

At each of the above temperatures, the mean and standard error of the egg incubation period (n = 200-300) larval and nymphal premolting and feeding periods (n = 40-50) and female feeding, preoviposition and oviposition periods (n = 16-20) were calculated.

Weights of different stages in the life cycle:

One hundred-200 larvae and 30-40 nymphs and adult females reared at each of the above temperatures were collected at random and weighed on a Mettler H80 balance (Mettler Instrument AG., Zurich, Switzerland) on the days of eclosion or molting, placement to feed and engorgement. The egg masses were weighed 2 days following oviposition completion. The mean and standard error of the weights were calculated for each of these stages at each of the tested temperatures.

The daily egg output by 5-6 females held at each of the 4 tested temperatures were weighed using the Mettler balance until oviposition ceased. The mean weight of daily egg output, the standard error and cumulative percentage of the egg mass weight were calculated at each of the 4 temperatures.

Conversion efficiency:

The ability of females to convert body weight to egg weight was calculated on the basis of percentage of mg egg/mg female (i.e. index of conversion efficiency % (Drummond and Whetstone, 1970). The data were compared using Student's t-test and test of proportions (Steel and Torrie, 1960).

RESULTS

Duration of developmental periods (Table 1):

Stages off the host: The preattachment period required for each stage was not investigated. However, 14-day-old larvae and 7-day-old nymphs held at any of the 4 different temperatures attached readily to the host. On the other hand, adults (males and females) placed on the host 1-6 weeks postmolting remained unattached for at least one week and most of them attached after 2 weeks (when the rabbit hair had grown to nearly full length).

Table 1

Duration of developmental periods in *Hyalomma impeltatum* life cycle at four different temperatures and 75% relative humidity

Developmental		Mean period in days ± SE (range)			
Stage	Period	21°C	25°C	29°C	34°C
Egg	Incubation	51.6 ± 1.84a* (46-57)	36.3 ± 2.79b (21-49)	21.2 ± 0.55c (18-23)	17.7 ± 0.34d (17-19)
Larva	Feeding	6.0 ± 0.43e (4-8)	6.4 ± 0.57e (4-9)	7.3 ± 0.82e (4-12)	8.0 ± 1.12e (4-13)
	Premolting	12.9 ± 1.13f (7-22)	11.1 ± 1.18f (5-16)	7.9 ± 1.39g (3-19)	5.2 ± 0.78g (3-11)
Nymph	Feeding	7.9 ± 0.51h (6-18)	8.9 ± 0.71h (7-13)	10.2 ± 0.94h,i (6-15)	11.0 ± 0.96i (8-17)
	Premolting	47.4 ± 0.58j (45-49)	37.6 ± 0.69k (35-39)	19.4 ± 1.05n (17-23)	15.4 ± 0.41m (14-16)
Female	Feeding	11.8 ± 1.45v (11-22)	16.0 ± 0.06v (15-17)	13.5 ± 0.58v (13-14)	14.7 ± 1.69v (8-15)
	Preoviposition	41.4 ± 7.09p (18-67)	7.5 ± 0.48q (4-11)	4.2 ± 0.34r (3-7)	3.4 ± 0.22r (3-5)
	Oviposition	26.1 ± 1.0s (23-30)	16.4 ± 1.32t (11-20)	15.6 ± 1.33t (12-21)	12.0 ± 0.75u (9-14)

* Figures in the same row with similar letters are not significantly different ($p>0.05$); those with different letters are significantly different ($P<0.02$-$P<0.001$).

The egg incubation and nymphal premolting periods were prolonged with the decrease in temperature. However, larval premolting periods at 21 and 25°C were similar and were longer than those at 29 and 34°C; the larval premolting periods at 29 and 34°C were not significantly different.

The female preoviposition period was much longer at 21°C than those at 25-34°C. At 25°C, it was still longer than those at 29°C and 34°C; at the latter 2 temperatures the preoviposition periods were nearly similar. Also, the oviposition period was longer at 21°C than those at 25-34°C. At 25 and 29°C, the oviposition periods were nearly similar but were longer than that at 34°C.

Stages on the host: The feeding period of each of larvae, nymphs and adult females on rabbits held at the 4 different temperatures did not differ significantly.

At the tested temperatures, the life cycle duration in days was 179-285 at 21°C, 133-196 at 25°C, 106-155 at 29°C and 99-138 at 34°C.

Weights of different stages:

When the weights of larvae were compared on the days of hatching, placement on the host (14 days posthatching), or engorgement, no significant difference was observed among larvae held at the 4 different temperatures (Table 2). Larvae lost 26.8-33.9% of their weight during the preattachment period when held at 21, 25 and 29°C (Table 3); the percentages of loss at these 3 temperatures were not significantly different. Larvae lost a higher percentage of their weight (40.2%) when held at 34°C during the prefeeding period.

Table 2

Weight of developing *Hyalomma impeltatum* larvae held at four different temperatures and 75% relative humdity

	Mean weight in ug ± SE (range) on day of		
Temperature C	Hatching	Feeding*	Engorgement
21	53.0 ± 1.9a** (48.6-56.5)	38.8 ± 6.5b (17.0-46.0)	498.0 ± 43.9c (310.0-690.0)
25	68.3 ± 4.6a (47.6-71.3)	48.9 ± 4.9b (27.0-80.0)	458.3 ± 53.1c (300.0-810.0)
29	52.8 ± 1.8a (46.0-57.3)	34.9 ± 3.3b (21.0-49.0)	453.8 ± 22.7c (370.0-630.0)
34	62.0 ± 0.4a (61.0-63.0)	37.1 ± 4.6b (22.0-55.0)	444.2 ± 31.3c (280.0-660.0)

* Larval weight 14 days posthatching.

** Figures with similar letters in the same column are not significantly different ($p>0.05$).

Table 3

Percentage loss in body weight during larval, nymphal and female *Hyalomma impeltatum* development off the host at four different temperatures and 75% relative humidity

Developmental		Loss in weight % at temperature			
Stage	Period	21°C	25°C	29°C	34°C
Larva	Prefeeding	26.8a*	28.4a	33.9a	40.2b
Molting		29.7c	30.2c	31.6c	32.5c
Nymph	Prefeeding	35.7d	28.7d	30.0d	39.3d
	Molting	30.5c	24.7e	24.7e	48.9f
Female	Prefeeding	27.7g	32.8g	32.3g	29.2g

* Figures in the same row with similar letters are not significantly different ($P>0.05$); those with different letters are statistically different ($P<0.01$-$P<0.001$).

Similarly, when the weights of nymphs were compared on the days of molting, placement on the host (7 days postmolting) or engorgement, no significant difference was observed among nymphs held at the 4 different temperatures (Table 4). Nymphs weighed 29.7-32.5% less than the engorged larvae from which they emerged (Table 3). Loss in weight during the molting period and process was nearly the same at the 4 different temperatures.

Table 4

Weight of developing *Hyalomma impeltatum* nymphs held at four different temperatures and 75% relative humidity

Mean weight in mg ± SE (range) on days of			
Temperature °C	Molting	Feeding*	Engorgement
21	0.350 ± 0.030a** (0.260-0.680)	0.225 ± 0.024b (0.113-0.270)	33.350 ± 1.325c (23.700-39.000)
25	0.320 ± 0.020a (0.240-0.380)	0.228 ± 0.021b (0.190-0.290)	33.510 ± 1.191c (27.700-39.080)
29	0.310 ± 0.024a (0.220-0.390)	0.217 ± 0.014b (0.210-0.245)	33.480 ± 2.351c (20.500-40.900)
34	0.300 ± 0.040a (0.160-0.480)	0.182 ± 0.023b (0.139-0.247)	24.835 ± 1.986c (14.380-37.570)

* Nymphal weight 7 days postmolting.

** Figures with similar letters are not significantly different ($p>0.05$).

At 21, 25 and 29°C, females weighed 24.7-30.5% less than the nymphs from which they emerged and were heavier than those held at 34°C; the latter females weighed 48.9% less than the nymphs (Table 3). During the preattachment period (14 days),

Table 5

Weight of undisturbed female *Hyalomma impeltatum* and the egg masses laid at four different temperatures and 75% relative humidity

Mean female weight in mg ± SE (range) on days of					
Temperature °C	Molting	Feeding*	Engorgement	Mean egg mass weight in mg ± SE (range)	Conversion efficiency
21	23.16 ± 1.16a** (19.80-27.50)	16.74 ± 0.62c (17.10-21.00)	1,085.8 ± 33.88e (970.60-1,203.30)	730.72 ± 63.24f (550.00-895.80)	76.1 ± 1.60g (70.6-78.2)
25	25.24 ± 0.71a (21.60-28.90)	16.96 ± 0.76c (12.40-19.40)	1,127.98 ± 66.69e (754.40 ± 1,404.10)	647.77 ± 74.34f (430.10-846.80)	73.5 ± 5.14g (60.0-87.7)
29	25.20 ± 1.74a (23.40-31.10)	17.06 ± 0.93c (15.70-22.40)	784.90 ± 58.34e (612.70-949.40)	825.24 ± 79.90f (554.60-1,050.90)	72.3 ± 2.44g (66.3-79.4)
34	12.69 ± 1.65b (11.42-16.76)	8.99 ± 1.42d (7.10-15.70)	875.04 ± 122.48e (478.00-1,129.40)	680.28 ± 113.10f (238.50-1,025.50)	66.6 ± 5.00g (41.7-76.6)

* Female weight 14 days postmolting.

** Figures in the same column with similar letters are not significantly different ($P>0.05$); those with different letters are statistically different ($P<0.01$-$P<0.001$).

females lost 27.7-32.8% of their weight (Table 3); the percentages of loss at the 4 different temperatures were not significantly different. Thus, on the feeding day females held at 21, 25 and 29°C were heavier than those held at 34°C.
On the engorgement day, a great variation in female weight was observed at each of the tested temperatures (some females were about 1.2-2.4 × the weight of others) (Table 5). However, the means of weight of females engorging on hosts held at the 4 tested temperatures were not significantly different.

Table 6

The mean weight of daily egg output during the oviposition period of female *Hyalomma impeltatum* held at 4 different temperatures and 75% relative humidity

	Mean egg mass weight (mg) ± SE at temperatures			
Ovip. day	21°C	25°C	29°C	34°C
1	102.18 ± 25.01a*	50.65 ± 19.93a,b	98.50 ± 10.17a	45.20 ± 6.79b
2	36.38 ± 3.35b	40.12 ± 11.39b	93.60 ± 12.96a	72.95 ± 10.65a,b
3	41.20 ± 4.71b	49.07 ± 4.78b	102.81 ± 21.44a	98.45 ± 35.35a
4	49.55 ± 6.72b	69.93 ± 15.49a,b	90.52 ± 13.36a	99.85 ± 19.85a
5	50.00 ± 9.73b	55.50 ± 19.89a,b	52.61 ± 4.76a,b	100.85 ± 24.84a
6	43.73 ± 6.15b	31.88 ± 4.12b,c	109.73 ± 25.15a	69.22 ± 17.94a,b
7	42.88 ± 12.36b	38.95 ± 12.81b,c	48.10 ± 7.91b	45.98 ± 10.94b
8	26.98 ± 6.01c	41.25 ± 4.53b	50.82 ± 9.47b	31.88 ± 7.79b.c
9	32.15 ± 4.05b,c	26.25 ± 6.12c	40.42 ± 6.91b	56.40 ± 16.12a,b
10	40.65 ± 11.37b,c	30.58 ± 6.92b,c	21.93 ± 7.47c	27.48 ± 7.32c
11	36.34 ± 6.65b,c	23.73 ± 7.84c	28.04 ± 4.73c	20.86 ± 10.48c,d
12	32.18 ± 7.31b,c	30.37 ± 11.87b,c	22.90 ± 4.01c,d	16.88 ± 5.12d,e
13	25.78 ± 3.42c,d	41.23 ± 22.17b,c	16.21 ± 1.71d,e	14.23 ± 2.55d,e
14	35.35 ± 5.34b,c	25.90 ± 9.69c	11.30 ± 1.09d,e	11.00 ± 2.93d,e
15	15.60 ± 3.21d	40.40 ± 21.86b,c	12.31 ± 5.29d,e	7.15 ± 2.32e
16	10.33 ± 1.69d	13.83 ± 2.46d	16.69 ± 5.98d,e	4.90 ± 1.91e
17	13.80 ± 1.57d	8.43 ± 1.96d,e	9.88 ± 7.73d,e	9.55 ± 0.50d,e
18	30.20 ± 7.09b,c	26.07 ± 10.17c	8.12 ± 3.05d,e	3.30 ± 0.76e
19	21.88 ± 8.33c,d	6.30 ± 0.57e	3.04 ± 1.17e	2.50 ± 0.00e
20	7.13 ± 1.37d,e	3.85 ± 0.39e	3.20 ± 0.71e	—
21	8.93 ± 1.16d,e	5.25 ± 1.32e	10.72 ± 5.43d,e	—
22	13.70 ± 7.31d,e	77.30 ± 0.00a,b	6.10 ± 0.00e	—
23	11.25 ± 2.95d,e	1.60 ± 0.00e	4.21 ± 0.00e	—
24	15.25 ± 6.82d,e	89.60 ± 0.00a,b	5.70 ± 0.00e	—
25	16.67 ± 6.63d,e	29.90 ± 0.00c	—	—
26	5.25 ± 2.25e	—	—	—
27	11.70 ± 4.71d	—	—	—
28	6.00 ± 0.00e	—	—	—
29	37.80 ± 0.00b	—	—	—
30	4.10 ± 0.00e	—	—	—

* Figures with similar letters are not significantly different (P>0.05); those with different letters are statistically different (P<0.02-P<0.001).

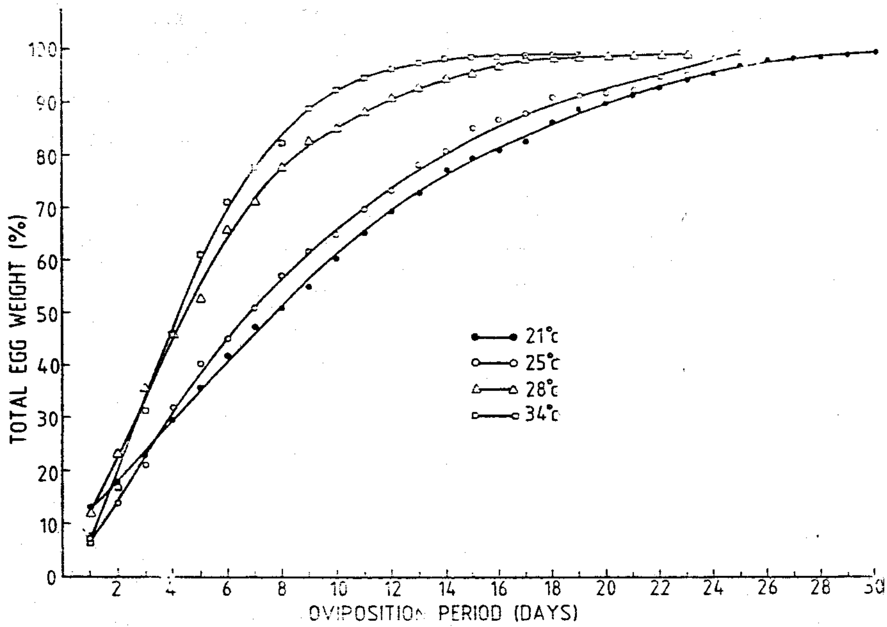

Fig. 1: Cumulative percentage of weight of *Hyalomma impeltatum* eggs laid by females held at 21, 25, 29 and 34°C and 75% relative humidity.

A great variation was also observed in the weight of egg masses laid by undisturbed females held at the same temperature; some egg masses were about 1.6-4.3 × the weight of others (Table 5). However, the means of weight of egg masses laid by females held at the 4 tested temperatures were not significantly different. The mean weight of the daily egg output (Table 6) and the cumulative percentage of egg mass weight (Figure 1) showed that the oviposition pattern was nearly similar at 21 and 25°C. Fifty % of the eggs were laid within 7.9 and 6.8 days, respectively, and 90% within 20 and 18 days, respectively. Also, the oviposition patterns at 29 and 34°C were nearly similar but were different from those at 21 and 25°C. At 29 and 34°C, 50% of the eggs were laid within 4.6 and 4.2 days, respectively, and 90% within 11.6 and 9.3 days, respectively. No peak oviposition values were observed at 25°C. Females held at 21°C laid the heaviest egg batch on the first oviposition day and those held at 29°C laid heavier egg batches on days 1-4 and 6. On the other hand, females held at 34°C showed a peak in egg mass weight on days 3-5.

Conversion efficiency:

A mean of 66.6-76.1% of the engorged female weight was converted to egg masses at the 4 tested temperatures (Table 5); the conversion efficiency was nearly similar at the 4 temperatures.

DISCUSSION

Duration of developmental periods:

The duration of *H. impeltatum* stages off the host were generally prolonged with the decrease in temperature. However, the egg incubation and preoviposition periods were more greatly prolonged than other periods. The incubation period at 21 and 25°C was 3× and 2×, that at 34°C, respectively. This period was also reported to be much longer at 15°C in *Haemaphysalis japonica douglasi* Nuttall and Warburton (Ryabova, 1971b) and at 20°C in *Boophilus decoloratus* (Koch) (Londt, 1977) than that at higher temperatures.

During the present study, the preoviposition period of *H. impeltatum* at 21°C was about 5.5×, 10× and 12× that at 25, 29 and 34°C, respectively. This period was also much longer at 25°C in *H. lusitanicum* (Koch) (Ouhelli and Pandey, 1984), at temperatures below 20°C in *Haem. longicornis* Neumann (Fujisaki *et al.*, 1975) and at 18°C in *Amblyomma variegatum* (Fabricius) (Ogunji, 1979) than that at higher temperatures.

In the present study, the *H. impeltatum* feeding period did not vary for larvae, nymphs or adult females with change in the temperature at which the rabbit host was held. This homiothermic host has probably provided similar microclimatic conditions for the attaching ticks despite the change in the ambient temperature. The feeding periods were also reported to be similar when *H. aegyptium* (L.) were reared on homiothermic animals at 32-40°C (Sweatman, 1970) and when larval *Ixodes ricinus* (L.) were fed on white mice at 15-30°C (Balashov, 1972). However, when the latter two species were fed on poikelothermic animals (reptiles) at 20-30°C, the feeding period was longer at the lower temperatures than at the higher ones and larval and nymphal *H. aegyptium* died without engorgement when the host was held at temperatures below 20°C. The natural hosts of larval and nymphal *H. impeltatum* in Qatar may be reptiles and/or rodents; larval and nymphal feeding periods on these hosts require investigation.

In the present study, the duration of most of the developmental periods were different from those reported for a Sudanese strain of *H. impeltatum* reared at comparable temperatures (Osman, 1979). Also, in the present study, *H. impeltatum* behaved as a 3-host tick while the Sudanese Strain was mainly a 2-host one. A similar variation in behaviour was reported for other *Hyalomma* species such as *H. aegyptium* (Sweatman, 1970), *H. a. anatolicum* (Koch) (Serdyukova, 1946; Feldman-Muhsam, 1948; Chaudhuri *et al.*, 1969; Koshy *et al.*, 1979), *H. dromedarii* Koch (Delpy, 1946; Honźaková, 1971; Bouchalova *et al.*, 1977) *H. impressum* Koch (Mojolobesiginwa Ogedegbe, 1979), and *H. marginatum rufipes* Koch (Hoogstraal, 1956; Knight *et al.*, 1978). In the present study, the larval premolting period was as short as 3 days at temperature conditions comparable to those maintained by Osman (1979). Selection for ticks with short premolting periods in the laboratory may result in a strain behaving mainly as a 2-host tick. However, such assumption requires verification.

In the present study, adult *H. impeltatum* did not attach readily, regardless of their age, and attached only after the rabbit hair had grown to nearly full length. The adults might be more host-specific than the immature stages, and the rabbit might not be as attractive for adult ticks as the camel. A similar behaviour was reported for the elephant tick, *A. tholloni* Neumann when placed to feed on sheep (Norval *et al.*, 1980). On the other hand, the adult ticks might have found the clipped areas of the rabbit skin unattractive for attachment because of lack of a tactile stimulus. O'Kelly and Spiers (1983) suggested that *B. microplus* (Canestrini) larvae favoured unclipped areas of the host skin either to escape the heavier solar load on the clipped skin or for certain microclimatic requirements such as humidity or tactile stimulus.

Loss in weight of unfed stages:

During the prefeeding period of *H. impeltatum,* the loss in larval, nymphal and female body weight was more or less the same at the 4 different temperatures except for larvae held at 34°C. The majority of the lost weight was probably due to defication and excretion. The temperatures tested, 21-34°C, were probably within an optimum range of temperatures at which unfed nymphs and females normally survive. *H. impeltatum* have probably adapted to live in the Qatar climate in which the diurnal temperature is around 40°C for about 5 months per year. Also, the 75% RH maintained during the present study was probably above the critical equilibrium humidity of *H. impeltatum.* At 75% RH, unfed nymphs and adults held at all of the tested temperatures and larvae held at 21-29°C were probably able to take up moisture at a similar rate and, therefore, compensated for most of the water lost in functional activities (Wharton and Devine, 1969, Rudolph and Knulle, 1974, 1978, Knulle and Rudolph, 1982, Wharton, 1983). On the other hand, the delicate unfed larvae in nature probably live in burrows at a relatively low temperature and a high RH. Engorged female *Margaropus annulatus* Say {= *Boophilus annulatus* (Say)} (Hunter and Hooker, 1907) and *I. ricinus* (Milne, 1950) were reported to burrow a few centimeters below the surface and female *A. americanum* (L.) (Patrick and Hair, 1979) to select favorable microhabitats for egg deposition which protected the eggs and emerging larvae from low humidities and high temperatures. Also, *I. ricinus, I. hexagonus* Leach and *Dermacentor marginatus* Schultze were reported to survive and develop in microclimatic conditions at 5 cm below the ground surface which provided an adequate RH for these stages (Honzáková, 1973). The effect of different temperatures on the survival of *H. impeltatum* held in various RH conditions is under investigation.

Loss in weight of fed stages:

During the premolting period and molting process, *H. impeltatum* lost weight mainly by shedding the exuviae and excretion, and to a lower extent owing to functional activities and evaporation of some of the molting fluid. With the exception of the exuvial weight, loss in weight owing to the other processes should have been affected by temperature. However, loss in weight by engorged larvae was more or less uniform at the 4 tested temperatures. On the other hand, loss in weight by engorged nymphs was uniform at 21-29°C and was of a higher magnitude at 34°C only. These results suggested that engorged nymphs were more sensitive to this relatively high temperature than engorged larvae. Since this species may behave as a 2-host tick, engorged larvae are probably able to adjust to the relatively high body temperature of rodent hosts in nature. However, this assumption requires verification.

Oviposition pattern:

In the present study, the oviposition pattern of *H. impeltatum* was studied in terms of egg mass weight rather than egg number. At 21 and 25°C, this pattern lacked typical peak values. At 29°C, peak values were observed during the first 4 oviposition days while peak values on the 2-4 oviposition days, similar to those usually observed in most ixodid ticks, occurred only at 34°C. However, at all of the tested temperatures, female *H. impeltatum* laid 50% of their egg masses within about the first third of the oviposition period. Results more or less similar to the latter observation, were reported at comparable temperatures for *A. americanum* (L.) (Sonenshine and Tigner, 1969), *A. hebraeum* (Koch) (Norval, 1974), *A. tholloni* (Norval *et al.*, 1980), *B. annulatus* (Say) (Ali, 1982, Mourad and Ali, 1982, Mourad *et al.*, 1982, Ouhelli *et al.*, 1982), *B. decoloratus* (Londt, 1977), *B. microplus* (Bennett, 1974), *D. variabilis* (Say) (Sonenshine and Tigner, 1969, Drummond *et al.*, 1971, Campbell and Harris, 1979), *D. silvarum Olenev* (Wen-Bing and Kuo-Ting, 1981b), *Haem. leporispalustris* (Packard) (Campbell and Glines, 1979), *H. aegyptium* (Sweatman, 1968), *H. a. anatolicum* (Snow and Arthur, 1966), *H. asiaticum kozlovi* Olenev (Wen-Bing *et al.*, 1983, Wen-Bing, 1985), *H. lusitanicum* Koch (Ouhelli and Pandey, 1984, Hueli *et al.*, 1984) *H. m. marginatum* Koch (Hueli, 1979), *H. m. rufipes* Koch (Knight *et al.*, 1978), *R. lunulatus* Neumann (Colborne, 1985), and *R. sanguineus* (Latreille) (Sweatman, 1967, Hafez and Bassal, 1980).

Conversion efficiency:

In the present study, female *H. impeltatum* conversion efficiency was nearly the same at the 4 tested temperatures. These results suggested that the tested temperatures were within the normal range at which females have adapted to oviposit in nature; **such** ability might be an important factor affecting *H.*

impeltatum survival and distribution. At a comparable range of temperatures, similar results for the conversion efficiency or fecundity were reported for *B. annulatus* (Ouhelli *et al.*, 1982) *H. lusitanicum* (Ouhelli and Pandey, 1984) and *R. evertsi evertsi* Neumann (Hamel and Gothe, 1974). However, the conversion efficiency of *Haem. leporispalustris* varied within a similar range of temperatures (Campbell and Glines, 1979).

The minimum and maximum temperatures at which oviposition may occur in the local *H. impeltatum* strain requires investigation to correlate this phenomenon with the tick fecundity in nature and to compare it with that in other tick species. Some tick species were reported to be unable to oviposit at temperatures which are not usually considered to be very low such as *H. a. anatolicum* (Snow and Arthur, 1966) and *H. asiaticum koslovi* (Wen-Bing, 1985) for which the minimum temperature for oviposition was 20°C. On the other hand, other tick species were able to oviposit at relatively very low temperatures; the minimum oviposition temperature for *B. microplus* was 8.1°C (Fujisaki *et al.*, 1975), *I. hexagonus* 10°C (Arthur, 1951), *Haem. japonica douglasi* 12°C (Ryabova, 1971), *Haem. longicornis* 12.3°C (Fujisaki *et al.*, 1975) and *B. annulatus* (Mourad *et al.*, 1982) and *D. variabilis* 15°C (Campbell and Harris, 1979).

The great variation in engorged female *H. impeltatum* weight and, consequently, egg mass weight observed in the present study might have been associated with the initial body weight of the unfed female. The females used were collected at random and, therefore, females varying greatly in weight were included in the present study. The effect of unfed female weight on the engorged weight and fecundity is currently under investigation.

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تأثير الحرارة على هيالوما (هيالوما) امبلتاتم شولتز وشلوتك (اكسودويديا : اكسوديدا)

جليلة مصطفى خليل و احمد الوزير هجـــرس

تمت دراسة تأثير درجات الحرارة ٢١ ، ٢٥ ، ٢٩ ، ٣٤ ، مئوية عند درجة رطوبة ٧٥٪ على طول فترة النمو والتحول وأوزان الأطوار المختلفة في دورة الحياة وقدرة أنثى **هيالوما (هـ) امبلتاتم** على تحويل جزء من وزنها إلى بيض وبصفة عامة لوحظ أنه كلما انخفضت درجة الحرارة طالت فترة حضانة البيض وفترة ما قبل الإنسلاخ في كل من اليرقات والحوريات وفترة ما قبل وضع البيض في الأنثى وتلك اللازمة لوضعه . وكانت أكثر الفترات تأثراً فترة حضانة البيض والفترة السابقة على وضعه . ولم تختلف فترات إغتذاء اليرقات والحوريات في الإناث باختلاف درجات الحرارة . كذلك فإن النسبة المئوية لما يفقده جسم اليرقة قبل الإغتداء وأثناء فترة الانسلاخ وما يفقده جسم الحورية أو الأنثى قبل الإغتداء لم تختلف باختلاف درجات الحرارة ، ولكن الحوريات فقدت من وزنها عند درجة ٣٤م نسبة مؤوية أعلى من تلك التي فقدتها عند الدرجات الأقل . وقد وضعت الاناث ٥٠٪ من البيض (وزناً) خلال ٩ ، ٧ ، ٨ ، ٦ ، ٤ ، ٤,٢ يومياً - على التوالي - و ٩٠٪ منه خلال ٢٠,٠ ، ١٨,٠ ، ١١,٦ ، ٩,٣ يوما - على التوالي - عند درجات الحرارة المستعملة . ولم تختلف قدرة الإناث على تحويل جزء من وزنها إلى بيض بإختلاف درجات الحرارة . وقد نوقشت النتائج وعلاقتها بتلك المعروفة من الأنواع الأخرى من القراد الجامد .