

LABORATORY STUDIES ON THE OVIPOSITION, EGG-SIZES AND SHAPES AND EMBRYONIC DEVELOPMENT OF *DERMACENTOR VARIABILIS*, *RHIPICEPHALUS SANGUINEUS* AND *AMBLYOMMA MACULATUM*

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BIOLOGY OF
EGG AND
OVIPOSITION
AMBLYOMMA
MACULATUM
DERMACENTOR
VARIABILIS
RHIPICEPHALUS
SANGUINEUS

ABSTRACT : Ticks collected from dogs which were brought to the Veterinary Teaching Hospital of Tuskegee University were used for various experiments on the biology of the egg-phase. These included oviposition patterns, relationships between engorgement weight, number of eggs laid and rate of metabolism of oviposition tick, the sizes of eggs and their embryonic development, fluctuation of weight of egg-batches during embryonic development and the fluctuation of the weight of single freshly laid eggs within the sequence of oviposition.

The "Maximum Effective Engorgement Weight" (MEEW) was defined to characterize the weight — specific for each species — at which the number eggs laid is not influenced by the engorgement weight. Individual capability of engorged ticks to lay large or small numbers of eggs after attainment of MEEW was observed and this led to the recognition of two oviposition capabilities within a given tick species i.e. high and low. *Amblyomma maculatum* had the biggest eggs followed by *Dermacentor variabilis* and then *Rhipicephalus sanguineus*. Eggs of the species hatched as long as they were "egg-shaped" and not circular. In addition, eggs of *R. sanguineus* which were less than 0.30 mm failed to hatch irrespective of their shape. The viability of eggs laid by *R. sanguineus* and *D. variabilis* which engorged on dogs was higher than that of eggs laid by females which engorged on rabbits. The phases of embryonic development of eggs were described as well as the microscopic structure of the eggshells.

BIOLOGIE VON
EI-PHASE UND
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ZUSAMMENFASSUNG : Zecken der Hunden wurden für verschiedene Experimente über Biologie von Ei-phase gebraucht. Davon waren Schritteder Eilage, Verhältnis zwischen Blutsaugungsgewicht, Nummer der Eier gelegt und Rate des Metabolismus der Zecken, Grösse der Eier und embryonische Entwicklung.

"Maximum Effective Engorgement Weight" (MEEW) war definiert als das Gewicht wenn die Nummer der gelegten Eier nicht mehr von Blutsaugungsgewicht beeinflusst ist. Dieses Gewicht ist für jedes Zeckenspecies spezifisch. Ingendwann das Blutsaugungsgewicht eines Zecken über MEEW ist, hat es die Fähigkeit entweder viel oder kleine Nummer der Eier zu legen. Diese beobachtene Fähigkeit der individuellen Kapazität viel oder Kleine Nummer Eier zu legen wurde benutzt, um zwei Ovipositionskapazitäten der Zecken anzuerkennen d.h. hoch und niedrig. *Amblyomma maculatum* hatte die grossten Eier mit *Dermacentor variabilis* als nachste ; *Rhipicephalus sanguineus* hatte die kleinsten Eier. So lange die Eier der drei spezien "ei-formig"

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und nicht kreisförmig waren, entwickelten sie zu Larven. Aber Eier von *R. sanguineus*, die kleiner als 0.30 mm und kleiner waren, gaben keine Larven. Die Lebensfähigkeit der Eier, die von *R. sanguineus* und *D. variabilis* gelegt waren Blut von Hunden gesaugt, war höher als die Eier von den Zecken, die Blut von Kaninchen gesaugt haben. Die Phasen der embryonalen Entwicklung der Eier und die mikroskopische Struktur der Eizellen wurden beschrieben.

BIOLOGIE
DE L'ŒUF
ET DE LA PONTE
AMBLYOMMA
MACULATUM
DERMACENTOR
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SANGUINEUS

RÉSUMÉ : Des tiques récoltées sur des chiens qui avaient été apportés au Veterinary Teaching Hospital de l'Université de Tuskegee, ont servi pour différentes expériences sur la biologie de l'œuf. Celles-ci se rapportent aux modalités de l'oviposition, aux relations entre le poids de l'engorgement, le nombre des œufs déposés et le taux du métabolisme de la tique déposant ses œufs, aux tailles des œufs et à leur développement embryonnaire, à la variation de poids des grappes d'œufs au cours du développement embryonnaire et à la variation de poids de l'œuf pondu au cours de l'oviposition.

Le poids d'engorgement effectif maximum (MEEW) est défini comme la valeur du poids — spécifique de chaque espèce — pour laquelle le nombre des œufs déposés n'est plus influencé par le poids de l'engorgement. La capacité individuelle de la tique gorgée à déposer un grand nombre ou un petit nombre d'œufs une fois le MEEW atteint a été relevée et cela nous a conduit à reconnaître deux capacités d'oviposition au sein d'une espèce de tique donnée, une haute et une basse. *Amblyomma maculatum* présente les œufs les plus gros, suivi de *Dermacentor variabilis* et de *Rhipicephalus sanguineus*. Chez les trois espèces l'éclosion des œufs dure tout autant qu'ils sont oviformes et non pas circulaires. En outre, les œufs de *R. sanguineus* au dessous d'une taille de 0,30 mm n'arrivent pas à éclore quelle que soit leur forme. La viabilité des œufs de *R. sanguineus* et de *D. variabilis* pondus par des femelles gorgées sur des chiens est plus grande que lorsque les femelles se sont gorgées sur des lapins. Les phases du développement embryonnaire des œufs sont décrites, ainsi que la structure microscopique des parois des œufs.

The global importance of ticks is too well known to warrant detailed expatiation. Three species i.e. *Dermacentor variabilis*, *Rhipicephalus sanguineus* and *Amblyomma maculatum* are known to be serious pests of livestock, pet animals and man especially in the United States (HOOKER, BISHOPP and WOOD, 1912; BURGDORFER, 1977; RHODES and NORMENT, 1979; STRICKLAND, GERRISH, HOURIGAN and SCHUBERT, 1981; KOCH, 1982). This paper reports the results of laboratory investigations on some aspects of the biology of the three tick species.

MATERIALS AND METHODS

Ticks were collected from dogs brought to the Small Animal Clinic of the Veterinary Teaching Hospital of the School of Veterinary Medicine at Tuskegee University between January 1986 and December 1987. Any ticks found were carefully detached and taken to the laboratory for identifica-

tion. Nymphs were allowed to moult to adults while engorged females were weighed and divided into two groups. Observations were made directly on the eggs oviposited by one group (coded: "dog derived"). Larvae which hatched from the eggs produced by the other group and the resulting nymphs and adults were fed on rabbits (coded "rabbit derived") and observations were made on the eggs which they produced.

During studies on oviposition patterns, eggs laid by each engorged female were collected at 09:00 hours daily and counted under a dissecting microscope. Counting was facilitated by the addition of drops of xylene (DIPEOLU and OGUNJI, 1980). This continued until each tick ceased to oviposit for 7 consecutive days. In experiments designed to investigate the relationships between the number of eggs laid, corresponding weight losses and metabolic rates, the eggs oviposited daily were counted after each tick has been weighed. This continued for each tick until no eggs were produced for

7 consecutive days. The parameters adopted by DIPEOLU, AMOO and AKINBOADE (1989) for the measurement of the metabolic activity utilized by *Amblyomma variegatum* for the process of oviposition were adopted in this investigation. There were "oviposition efficiency, mass conversion efficiency" estimated for each engorged tick from the number of eggs laid on a day divided by the total number of eggs laid during oviposition, weight loss of tick per day divided by the total weight loss through oviposition and weight loss of tick per day divided by the number of eggs oviposited per day respectively.

The sizes of the eggs and the variations with sequence of oviposition were studied by measuring the length and breadth of each egg under a binocular microscope on which a stage eyepiece micrometer had been mounted. These measurements were made on the first 100 eggs picked at random from the pool of eggs laid by each experimental tick every three days. The microscopic structures of the egg-shells were studied immediately after size measurement and this was facilitated by the addition of 2 drops of xylene to each egg (DIPEOLU, 1982). Each layer of the egg-shells seen was measured. As a result of the wide range of sizes and shapes of eggs encountered, studies were conducted on the influence of sizes and shapes of oviposited eggs on the eclosion period. As many of the eggs laid by each experimental engorged tick were measured until 500 of each of the sizes were obtained. These were incubated and the length of time which the eggs of each size needed to hatch was recorded. This experiment took a long time to be undertaken because of the variety of egg sizes.

Studies on the embryonic development of eggs were also undertaken using the procedure described for *A. variegatum* (DIPEOLU, 1982). The fluctuations in the weights of eggs during embryonic development were also investigated. Eggs laid by each experimental tick during the oviposition period were pooled together into a batch every 3 days. Each batch was weighed every 3 days from laying until hatching started. Shortly after weighing, 10 eggs from each batch were examined under a binocular microscope to ascertain the phase of embryonic development. Finally, the fluctuation of weight of

single eggs with sequence of oviposition was investigated. Eggs laid by each experimental tick were collected at 18.00 hours daily and weighed with an electronic balance immediately afterwards. The eggs were subsequently counted and the estimation of the weight of a single egg made.

For each experiment 30 fully engorged ticks of each species were used; ticks and eggs were kept in an incubator maintained at 25-28° C over a saturated salt solution which produced a relative humidity of 90 % (WINSTON and BATES, 1960). For the taxonomy of ticks collected from dogs, the keys of COOLEY and KOHLS (1944), HOOGSTRAAL (1966) and COONEY and HAYS (1972) were used.

RESULTS

Fecundity of Engorged Ticks :

It was observed for the three tick species that the total number of eggs laid increased with the engorgement weight; for each tick species however,

TABLE 1. — Number of eggs laid by ticks * which possess high, or low oviposition capacities.

Tick Species and Host	Total Number of Eggs Laid	
	High Oviposition Capacity	Low Oviposition Capacity
<i>Dermacentor variabilis</i>		
Dog Derived	4,812 ± 164 (3,850 – 5,209) **	964 ± 117 (764 – 1,210)
Rabbit Derived	3,605 ± 152 (2,996 – 3,905)	702 ± 86 (536 – 826)
<i>Rhipicephalus sanguineus</i>		
Dog Derived	3,297 ± 101 (2,781 – 3,968)	1,225 ± 102 (905 – 1,512)
Rabbit Derived	2,718 ± 138 (2,305 – 3,188)	888 ± 81 (767 – 1,089)
<i>Amblyomma maculatum</i>		
Dog * Derived	14,363 ± 83 (12,861 – 15,011)	4,746 ± 178 (4,278 – 5,216)
Rabbit Derived	10,161 ± 152 (9,486 – 10,810)	3,716 ± 132 (3,318 – 4,026)

* All ticks have attained the "Maximum Effective Engorgement Weight".

** Data in bracket denote the range of number of eggs.

a weight was observed above which the total eggs laid was not influenced. This engorgement weight was 330 mg for *D. variabilis*, 220 mg for *R. sanguineus* and 1,100 mg for *A. maculatum* irrespective of whether the tick was dog or rabbit derived. This weight was hence referred to as « Maximum Effective Engorgement Weight » (MEEW). It was also observed that there were sharp differences in the total number of eggs laid by ticks which attained MEEW — majority laying high numbers, a few laying very low numbers. The former ticks were referred to as ticks with high oviposition capacity and the latter as ticks with low oviposition capacity. Table 1 shows the number of eggs laid by engorged *D. variabilis*, *R. sanguineus* and *A. maculatum* with high and low oviposition capacities. For each category, the number of oviposited eggs by dog-derived ticks was higher than that of the rabbit-derived ones.

Oviposition patterns :

Fig. 1 shows the oviposition patterns encountered in the three species. While *A. maculatum* and *R. sanguineus* exhibited Types 1 and 2 patterns, *D. variabilis* exhibited only Type 2. DIPEOLU *et al.* (1989) described Type 1 as the oviposition pattern characterized by an initial low oviposition and attainment of peak after a few days and a Type 2 as one characterized by an initial low oviposition and attainment of peak oviposition usually within the first set of eggs. Type I pattern was observed in approximately 78 % and 81 % of *A. maculatum* and *R. sanguineus* respectively irrespective of whether they were dog or rabbit derived or whether they had high or low oviposition capacities.

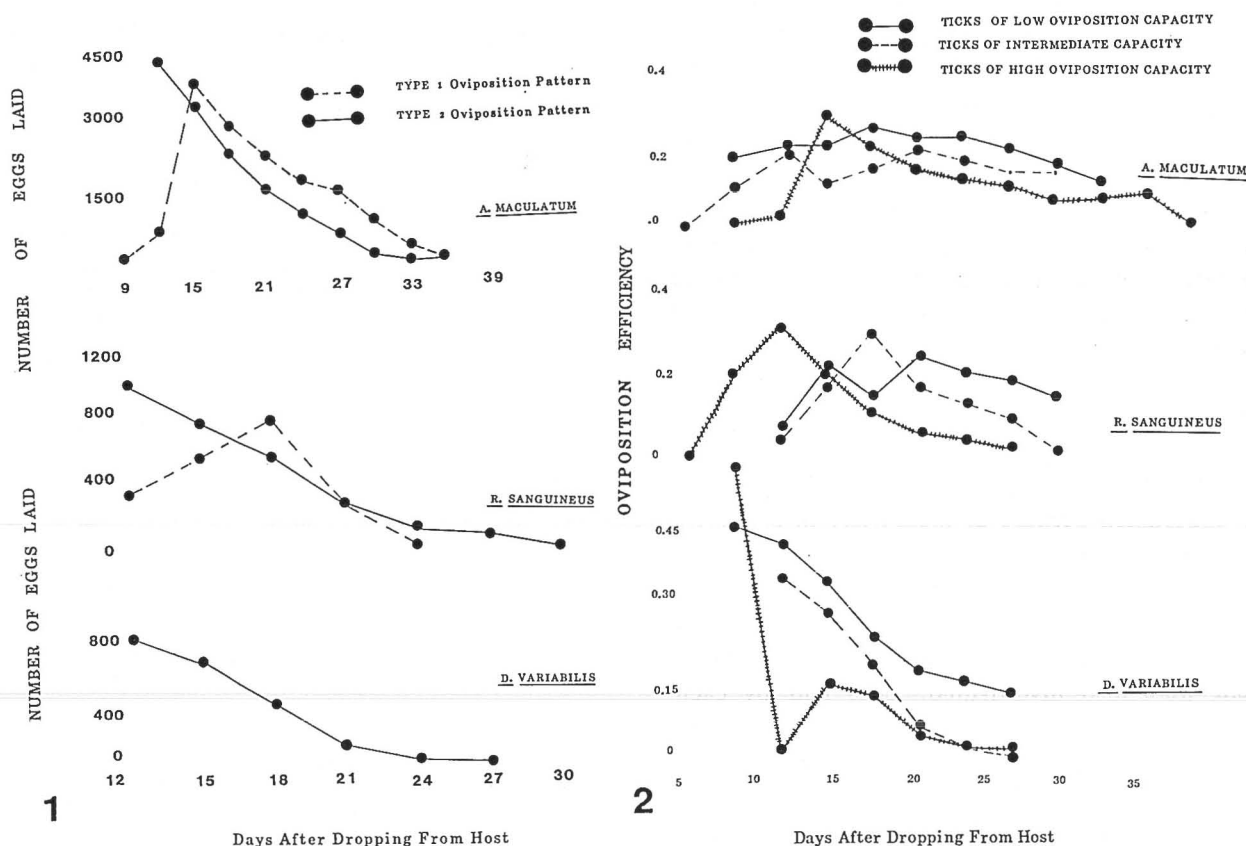


FIG. 1. — Oviposition patterns of *Rhipicephalus sanguineus*, *Dermacentor variabilis* and *Amblyomma maculatum*.

FIG. 2. — Daily fluctuations of oviposition efficiency during oviposition period.

Relationships between Oviposition and Metabolic Activity :

Table 2 shows the estimate of average oviposition efficiency, mass conversion rate, mass conversion efficiency and the preoviposition and oviposition periods and percent hatch of *D. variabilis*, *R. sanguineus* and *A. maculatum*. For all species, the average mass efficiency and oviposition efficiency were lowest and highest in ticks with high and low oviposition capacity respectively. The preoviposition and oviposition periods and percent egg-hatch were not influenced by the category of oviposition capacity. Fig. 2 shows the daily fluctuations of the oviposition efficiency of engorged ticks. In all the three species, the value higher in ticks with low oviposition capacity than in those with high oviposition capacity with the exception of day of

TABLE 2. — Comparison of biological data of ticks with high, or low oviposition capacities.

Biological Attribute	<i>D. variabilis</i>		<i>R. sanguineus</i>		<i>A. maculatum</i>	
	a	b	a	b	a	b
Average Oviposition Efficiency	0.143	0.20	0.063	0.083	0.032	0.051
Average Mass Conversion Rate	0.037	0.036	0.056	0.04	0.026	0.041
Average Mass Efficiency	0.014	0.044	0.046	0.065	0.000056	0.000073
Average Preoviposition Period (Days)	3	3	3	2.5	3.5	4
Average Oviposition Period (Days)	26	24	26	25	31	28
Average Percent Egg Hatch	97	97	95	97	96	96

a = Population with high Oviposition Capacity.
b = Population with low Oviposition Capacity.

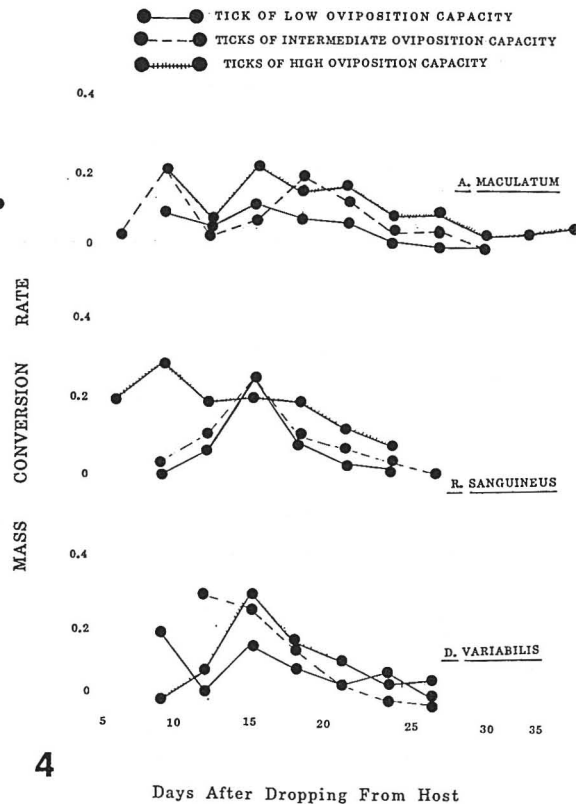
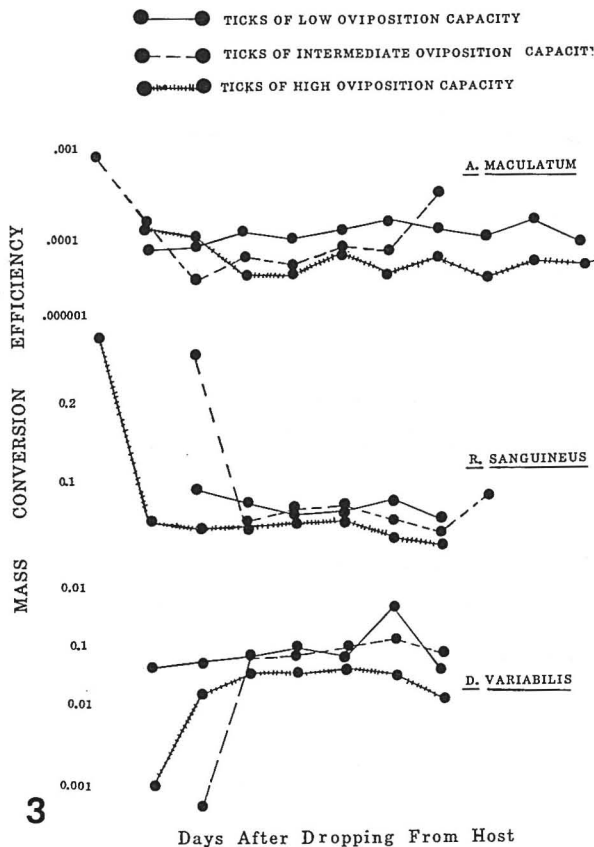


FIG. 3. — Daily fluctuations of mass conversion efficiency during oviposition period.

FIG. 4. — Daily fluctuations of mass conversion rate during oviposition period.

the peak value of the latter. The mass conversion efficiency shows a similar trend (Fig. 3). The mass conversion rate shows an opposite trend in which the values for ticks with oviposition capacity were mostly higher than those of the low oviposition capacity (Fig. 4).

Egg sizes and hatchability :

Of the ticks, *A. maculatum* has the biggest eggs, followed by *D. variabilis* and *R. sanguineus* (Table 3). The variation of size of eggs with sequence of

oviposition showed a similar trend in the three species in which the size of eggs increased gradually with sequence of oviposition, reached a peak and decreased towards the end of oviposition. Also, the values of lengths and breadths of eggs oviposited by rabbit-derived ticks were slightly less than those of the dog-derived in the three species. Table 4 shows the relationship between the sizes and shapes of eggs with hatchability and eclosion period. A large proportion of eggs of *A. maculatum* and *D. variabilis* were hatchable as long as they were oval (egg-shaped) ; in case of *R. sanguineus*, hatchability

TABLE 3. — Measurements of length and breadth of eggs of ticks laid on different days (dog-derived ticks).

Tick Species	Days of Oviposition									
	* 0	* 3	6	9	12	15	18	21	24	27
<i>R. sanguineus</i>										
Length (mm)	0.492 ± 0.586 ** (0.538 - 0.016)	0.499 ± 0.596 (0.547 - 0.012)	0.511 ± 0.578 (0.563 - 0.013)	0.508 ± 0.569 (0.559 - 0.014)	0.501 ± 0.551 (0.526 - 0.017)	0.432 ± 0.456 (0.444 - 0.009)	0.396 ± 0.414 (0.404 - 0.006)			
Breadth (mm)	0.382 ± 0.491 (0.424 - 0.013)	0.392 ± 0.500 (0.442 - 0.011)	0.399 ± 0.512 (0.455 - 0.010)	0.401 ± 0.516 (0.458 - 0.012)	0.391 ± 0.471 (0.438 - 0.012)	0.332 ± 0.368 (0.341 - 0.008)	0.305 ± 0.314 (0.323 - 0.008)			
<i>D. variabilis</i>										
Length (mm)	0.513 ± 0.596 (0.568 - 0.017)	0.521 ± 0.609 (0.573 - 0.116)	0.533 ± 0.619 (0.588 - 0.018)	0.518 ± 0.568 (0.538 - 0.010)	0.509 ± 0.564 (0.537 - 0.011)	0.442 ± 0.482 (0.459 - 0.008)	0.411 ± 0.429 (0.419 - 0.002)			
Breadth (mm)	0.402 ± 0.513 (0.464 - 0.013)	0.416 ± 0.520 (0.468 - 0.013)	0.433 ± 0.529 (0.483 - 0.016)	0.421 ± 0.520 (0.463 - 0.011)	0.406 ± 0.491 (0.451 - 0.011)	0.351 ± 0.383 (0.368 - 0.007)	0.331 ± 0.369 (0.343 - 0.006)			
<i>A. maculatum</i>										
Length (mm)	0.618 ± 0.689 (0.653 - 0.016)	0.631 ± 0.701 (0.683 - 0.17)	0.652 ± 0.718 (0.699 - 0.010)	0.683 ± 0.732 (0.703 - 0.012)	0.701 ± 0.754 (0.713 - 0.011)	0.725 ± 0.783 (0.721 - 0.012)	0.656 ± 0.703 (0.684 - 0.12)	0.632 ± 0.692 (0.651 - 0.014)	0.611 ± 0.656 (0.633 - 0.13)	0.593 ± 0.631 (0.619 - 0.011)
Breadth (mm)	0.413 ± 0.523 (0.472 - 0.014)	0.426 ± 0.531 (0.482 - 0.014)	0.443 ± 0.561 (0.494 - 0.18)	0.461 ± 0.535 (0.493 - 0.16)	0.479 ± 0.550 (0.501 - 0.15)	0.491 ± 0.586 (0.525 - 0.17)	0.416 ± 0.486 (0.438 - 0.11)	0.401 ± 0.456 (0.424 - 0.010)	0.378 ± 0.413 (0.393 - 0.011)	0.351 ± 0.399 (0.373 - 0.009)

* Day 0 represents the day oviposition started.

** Figures in brackets denote the average and standard deviation.

TABLE 4. — Relationship between sizes and shapes of eggs with eclosion period per-cent hatch (dog derived ticks).

Length (mm) and Shape of Eggs	Eclosion Period in Days and Percent Hatch		
	<i>R. sanguineus</i>	<i>D. variabilis</i>	<i>A. maculatum</i>
0.70-0.80	* —	—	32 ± 1.5 ** (96 - 98 %)
0.60-0.699	—	—	32 ± 2 (97 - 98 %)
0.50-0.599	31 ± 1.5 (95 - 97 %)	32 ± 2 (96 - 98 %)	33 ± 2.5 (95 - 98 %)
0.40-0.499	31 ± 2 (91 - 93 %)	31 ± 3 (94 - 97 %)	—
0.30-0.399	34 ± 3 (72 - 77 %)	—	—
Egg-like but below 0.30	No Hatching	—	—
Circular	No Hatching	No Hatching	No Hatching

* No egg of the size or shape found.

** Data in bracket denotes percent hatch.

was high in the big eggs also but decreased substantially in small eggs. As shown in Table 5 the source of the bloodmeal of *R. sanguineus* and *D. variabilis* influenced the proportion of sizes and shaped of eggs contained in egg batches. In both species, the proportion of the biggest eggs was significantly higher in the eggs laid by dog-derived ticks than in those laid by rabbit-derived ticks. In

A. maculatum, the proportion of all sizes and shapes of eggs were almost similar for dog and rabbit-derived ticks. The egg-shell structures of the three tick species were similar and identical to those of *A. variegatum*, *Boophilus* and *Hyalomma* species (DIPEOLU, 1982). However, the white and blue internal membranes were too thin to be measurable (Table 6).

TABLE 5. — Proportions of different sizes and shapes of eggs found in dog-derived and rabbit derived ticks.

Length (mm) and Shape of Eggs	<i>R. sanguineus</i>		<i>D. variabilis</i>		<i>A. maculatum</i>	
	Dog-Derived	Rabbit-Derived	Dog-Derived	Rabbit-Derived	Dog-Derived	Rabbit-Derived
0.70-0.80	—	—	—	—	51.8 %	47 %
0.60-0.699	—	—	—	—	37.4 %	35.9 %
0.50-0.599	56 %	38.4 %	56 %	44 %	9 %	15 %
0.40-0.499	29.2 %	27 %	30 %	36.9 %	—	—
0.30-0.399	9 %	22.5 %	10 %	13.2 %	—	—
Egg-like but below 0.30 (unhatchable)	3 %	5.6 %	—	—	—	—
Circular (unhatchable)	2.8 %	6.5 %	3.9 %	5.9 %	1.8 %	2.1 %

TABLE 6. — Comparison of sizes of eggshells of *Rhipicephalus sanguineus*, *Dermacentor variabilis* and *Amblyomma maculatum*.

Type of Membrane	Ticks Species (Measurement in Microns)								
	<i>R. sanguineus</i>			<i>D. variabilis</i>			<i>A. maculatum</i>		
	Lateral Sides	Anterior End	Posterior End	Lateral Sides	Anterior End	Posterior End	Lateral Sides	Anterior End	Posterior End
"Withe" external membrane	10/9	9	8	11/9	9	9	14/13	12	11
"Black" membrane	9/12	4	4	10/13	6	6	13/11	15	14

TABLE 7. — Phase descriptions of embryonic development of eggs of ticks and their periods of attainment.

Phase No	Description (DIPEOLU, 1982)	Number of days attained during embryonic development		
		<i>R. sanguineus</i>	* <i>D. variabilis</i>	* <i>A. maculatum</i>
1	Appearance of white differential zone	8-12	8-13	7-11
2	Appearance of unsegmented legs and guanin crystals	13-20	14-19	12-15
2 A	Assumption of crescent canoe shape	—	—	16-18
2 B	Resumption of elongate form through refolding	—	—	19-23
3	Concentration of guanin crystals into a sac-like structure	21-25	20-26	24-26
4	Segmentation of legs	26-30	27-31	27-30
5	Full formation of larvae	31-33	31-33	31-33

* In view of the fluctuation of eclosion period of *D. variabilis* and *A. maculatum* on the sequence of oviposition, the 2nd batch of eggs laid by the engorged females of these species were used for experiment.

Embryonic Development and Egg Weights :

The descriptions of phases of embryonic development and the period of their attainment are shown in Table 7. Of the three species, only the eggs of *A. maculatum* exhibited Phases 2 A and 2 B which involved the temporary assumption of crescent-shape and resumption of elongated form. Figs 5 and 6 show the fluctuations of weights of batches of eggs during embryogenesis. The eggs of *A. maculatum* and *D. variabilis* exhibited similar patterns; hence only the results of the latter is presented in Fig. 5. In the three species, the weights of hatched larvae were less than those of corresponding egg batches. Also, the weights of egg batches fluctuated, exhibited one or two peaks before decreasing gradually to the minimum shortly before hatching. Fig. 7 shows the fluctuations of weights of single eggs with the sequence of oviposition. Generally, the weight of the egg of *A.*

maculatum was the highest, followed by those of *D. variabilis* and *R. sanguineus*. The pattern of fluctuation was similar in *A. maculatum* and *D. variabilis* but different in *R. sanguineus*.

DISCUSSION

Several investigators have shown that fully engorged ticks lay greater number of eggs than partially engorged ones and that there was significant correlation between the numbers of eggs laid daily and the corresponding weight loss (NAGAR, 1968a, b; DRUMMOND and WHETSTONE 1970; DRUMMOND, WHETSTONE, ERNST and GLADNEY, 1971; BALASHOV, 1972; BASSAL and HEFNAWY, 1972; LONDT, 1977; KNIGHT, NORVAL and RECHAV, 1978; CAMPBELL and HARRIS, 1979; DIPEOLU and OGUNJI, 1980). DIEHL, AESCHLIMANN and OBENCHAIN (1982) stated that oviposition of engorged ticks is a result

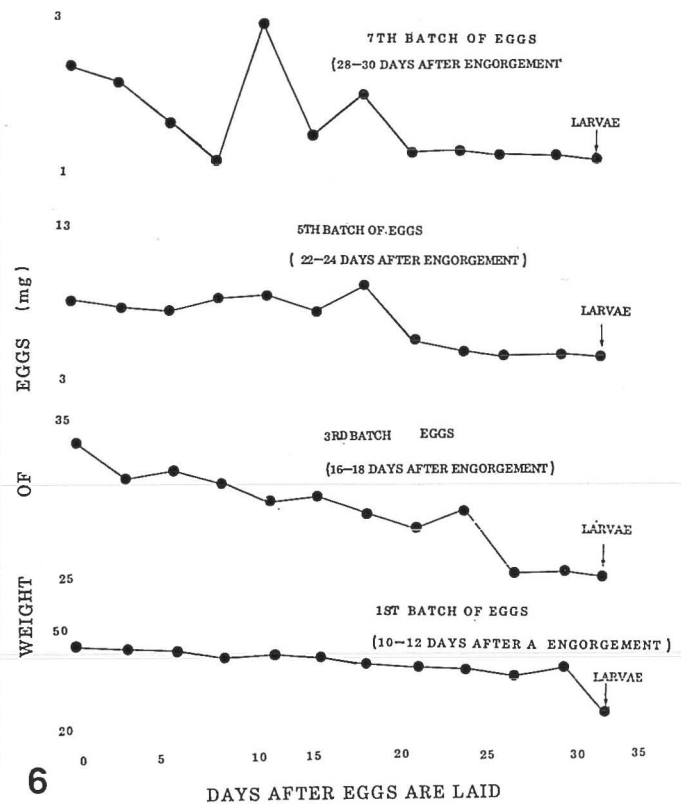
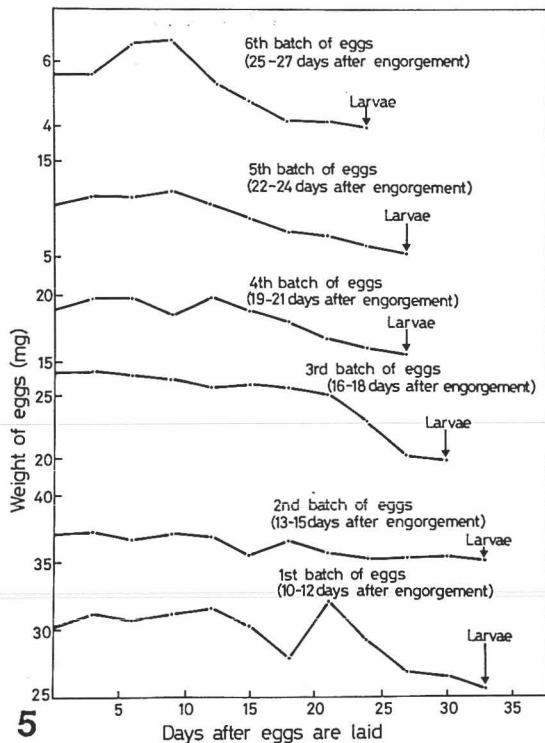


FIG. 5. — Daily fluctuations of the weight of egg-batch (*D. variabilis*) during embryogenesis.

FIG. 6. — Daily fluctuations of the weight of egg-batch (*R. sanguineus*) during embryogenesis.

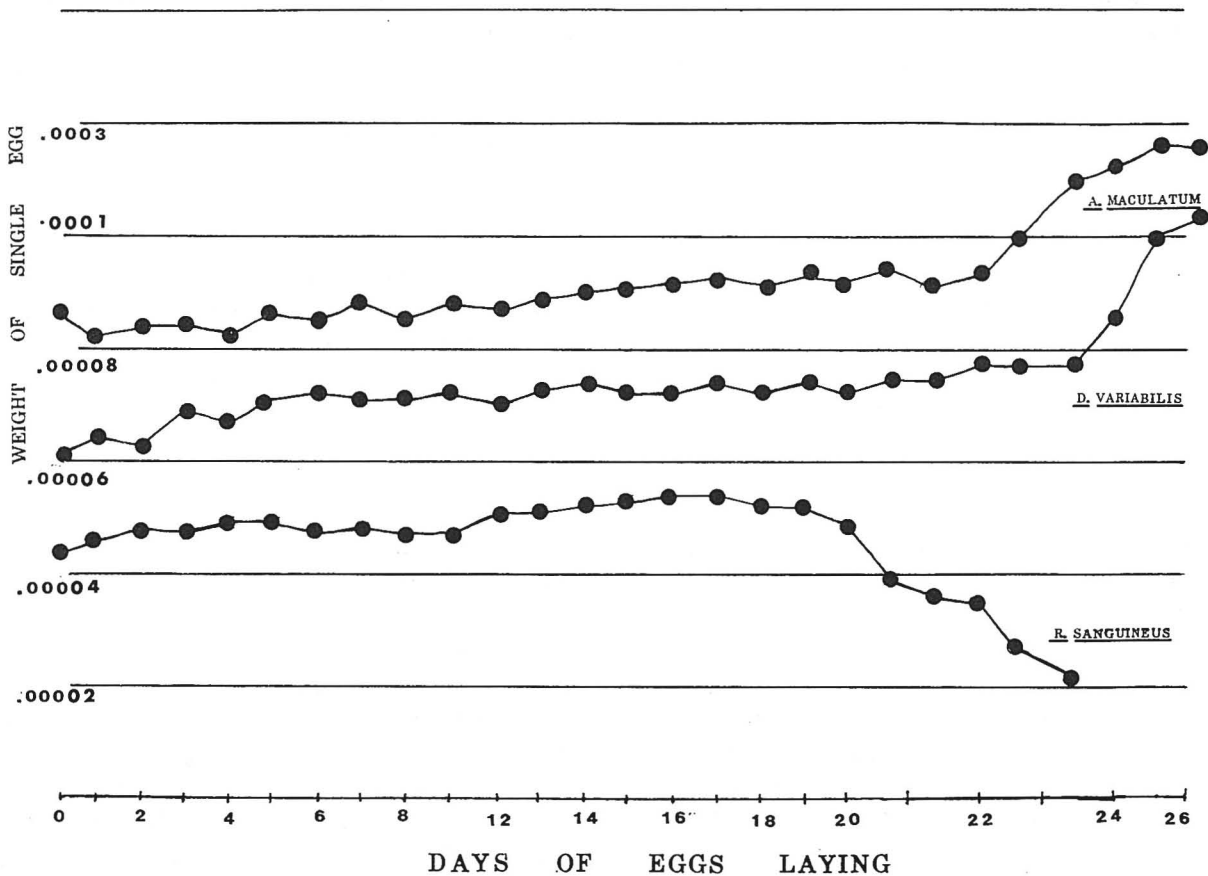


FIG. 7. — Fluctuations of the weight of a single egg with the sequence of oviposition.

of the utilization of engorged blood for somatic and reproductive growth. DIPEOLU *et al.* (1989) therefore related daily oviposition and weight loss to the estimates of oviposition efficiency and, mass conversion rate. They found that these estimates related more directly to the measure of metabolic activity devoted to oviposition and demonstrated the individual ability of ticks to produce large or small number of eggs. The results of the present investigation has provided a greater understanding of the individual ovipositional ability of ticks. The recognition of MEEW facilitated the recognition of individual capability of ticks to produce high or low number of eggs since this ability was being measured after the attainment of an engorgement weight at which maximum oviposition is expected. The MEEW is specific for each of the three experimental tick species and its adoption will

eliminate the recording of very wide ranges of engorgement weights and numbers of eggs laid which characterized the results of the previous workers on this field (NAGAR, 1968a, 1968b; DRUMMOND and WHETSTONE, 1970; DRUMMOND *et al.*, 1971; KOCH, 1982a). DIPEOLU, *et al.* (1989) pointed out the possibility of use of the differences in ovipositional capabilities of ticks for tick control. Further work in this laboratory has shown that populations of *R. sanguineus*, *D. variabilis* and *A. americanum* with high or low oviposition capacities can be bred in the laboratory. This work will form the basis of subsequent publications.

The two ovipositional patterns described for *A. maculatum* and *R. sanguineus* in this investigation were also found in *A. variegatum* (DIPEOLU *et al.*, 1989). Previous investigators however found only the Type 1 for these species (BISHOPP and SMITH,

1938; ACHEN, 1961; SWEATMAN, 1967; DRUMMOND and WHETSTONE, 1970; DRUMMOND *et al.*, 1971; CAMPBELL and HARRIS, 1979; KOCH, 1982b). As was the case with *A. variegatum*, the type 2 oviposition pattern was encountered in a small proportion of each tick species all of which were wild ticks collected from dogs. It is therefore suggested that Type 2 oviposition pattern is a characteristic of a small proportion of wild ticks which could be lost through laboratory breeding. The recording of Type 2 pattern for *D. variabilis* confirms the observations of SONENSHINE and TIGNER (1969) and CAMPBELL and HARRIS (1979).

The greater preponderance of large eggs and smaller proportions of unhatchable eggs among those oviposited by dog-derived *R. sanguineus* and *D. variabilis* show the influence of host's blood on the quality of eggs. The eggs of dog-derived females of these ticks showed greater vitality probably because dog is the principal host of these ticks (HOOKER *et al.*, 1912; NUTTALL, 1914; SAPRE, 1944; SMITH *et al.*, 1946; KEH, 1964; SRIVASTAVA and VARMA, 1964; THEIS, 1968; RHODES and NORMENT, 1979; KOCH, 1982a, b). The effect is poorly understood and CAMPBELL and HARRIS (1979) suggested that their effect on quantity and quality of viable eggs produced required further studies. DIPEOLU and AKINBOADE (1984) reported that the eggs laid by *A. variegatum* and *B. decoloratus* which engorged on red-flanked duiker (*Cephamophys rufulatus*) exhibited greater viability than those whose adults engorged on cattle; also DIPEOLU and ADEYEFA (1984) showed that the vitality of eggs laid by *A. variegatum*, *B. decoloratus* and *B. geigy* which engorged on cattle was higher than that of eggs laid by the females which have fed on sheep while the vitality of eggs from females which engorged on horses was very low. CAMPBELL and HARRIS (1979) also recorded differences in engorgement weights and numbers of eggs laid by female *D. variabilis* when they were fed on albino rat, wild-caught porcupines and raccoon. In this investigation, no effect of host difference on vitality of eggs was observed in *A. maculatum*. This is probably due to the fact that neither dog nor rabbit is a principal host of the tick and indicates that host effect on egg quality and quantity is more pronounced in situa-

tions where a principal host is being compared with a non-principal host.

The observation that the eggs of later ovipositions of *A. maculatum* and *D. variabilis* have shorter eclosion period than that of the earlier ovipositions confirmed the previous reports for *A. variegatum*, *Boophilus* and *Hyalomma* spp. (DIPEOLU, 1982, 1983, 1984). CAMPBELL and HARRIS (1979) and SONENSHINE and TIGNER (1969) however reported that the egg viability of *D. variabilis* was reduced towards the end of oviposition and they reasoned that this might be due to female ticks reaching a depleted level of nutrients and/or stored sperm to contribute to the last few eggs produced. AMOO, DIPEOLU and AKINBOADE (1984) showed however that the viability of the eggs of *B. decoloratus* and *B. geigy* laid during later oviposition was greater than that of those laid during earlier oviposition and the greater viability was also reflected in the hatched larvae. They stated that either intrauterine development of tick eggs takes place or that the metabolism of eggs of later oviposition runs faster than the quality of nutritive substances contained in them are superior than those of the earlier ovipositions. It is hoped that some biochemical studies being undertaken in this laboratory will provide some answers to these questions.

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