Some Characteristic Features of Feeding in Ticks

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The role of ticks in livestock economy merits special consideration, for not only are they annoying ectoparasites, but in temperate and tropical countries they surpass all other blood-sucking arthropods as vectors of various diseases of farm animals.

Due to complete dependence on blood of vertebrate animals as their food, the feeding apparatus and behavior pattern of ticks is basically adapted to utilization of blood. In the course of imbibing blood many of them secrete powerful anticoagulants or toxins that act adversely on the host. Others cause to be injected into the host's blood stream various parasitic microorganisms. In addition, loss of blood through simply mechanical withdrawal by ticks, which sometimes cause fatal anemia [6], is not negligible comparing with those of blood-sucking insect. Rather little attention has been directed to ticks' characteristic feeding phenomenon. The present short review treats of this problem.

Growth by feeding

Generally speaking, the feeding period of all stages of hard tick (Ixodidae) excepting subgenus *Alloceraea* [10] and larvae of soft tick (Argasidae) is measured in days, whereas in nymphs and adults of soft tick in minutes or hours.

The feeding of ticks as a growth phenomenon was noticed by Lees (1952), Kitaoka & Yajima (1958) and Balashov (1958), respectively. Fig. 1 [9] is showing growth curve of body length (A) and weight (B) in females of cattle tick, *Boophilus microplus* (=*B. caudatus*) during feeding. The feeding process of *B. microplus* was divided into three stages when based on the relative growth ratios of body length, body width and body thickness to body weight. During the first stage, increase in length and width ratios of the body are distinctive and exceed that of body thickness. The period of this stage lasted about 5 days and the body weight increased from about 3 mg to 10 mg. In the second stage, width and thickness ratios approach very nearly to one another and cuticle weight increased almost proprtional to surface area. The increase of body weight is moderate. In the third stage, the increase of thickness was noticeable and the maximum body weight reached about 200 to 400 mg in about 20 hours. Similar triphasic trends of feeding process have been observed in the engorgement of *Haemaphysalis neumanni* (formerly identified as *H. bispinosa*) by the author and of nine species in five genera of ticks by Balashov (1964). Kitaoka (1961a) [7] proved an existence of physiological stage in parallel with morphological changes mentioned above in the feeding process of *B. microplus* and *H. neumanni*. In the first stage, the bodily factors were almost constant and active excretion of waste products took place. In the third stage, rapid influx of blood by expansion of cuticle and intensive concentrating of blood were carried out. It was suggested that sterols in host blood is essential for the development of ticks [7]. Sutton & Arthur (1962) confirmed the three stages due to the difference in content of blood pigments in the body of *Ixodes ricinus* during feeding.

Amount of blood ingested and water regulation

Engorged ticks gain several hundred times of body weight to unfed ones. Earlier workers simply thought from analogy to blood-sucking insects, that the amount of blood ingested was the difference in weight between the unfed and the engorged bodies. Report by Jellison & Kohls (1938) was only a quantitative information available perior to the investigation by the author (1961b) on the withdrawal of blood from the host by ticks and *Dermacentor andersoni* ingested about two to six times as much blood from the host as it retained in its body.

Table 1 is the summarized result of the amount of blood removed by an engorged females of *B. microplus* and *H. neumanni* based on determination of total nitrogen, iron and sterols in tick body and excreta [8]. *H. neumanni* showed a higher degree of accumulation, concentration and excretion than *B. microplus*. Basic factors affecting the amount of blood removed were the amount of excreta discharged and the variation in engorged body weight. The feeding period of *H. neumanni* in these experiments was 6 days in the summer but about 10 days in the late autumn and the amount of excreta increased by prolonged feeding period under cold climate. Later Balashov (1964) reported similar value, which based on iron analysis, of all stages of

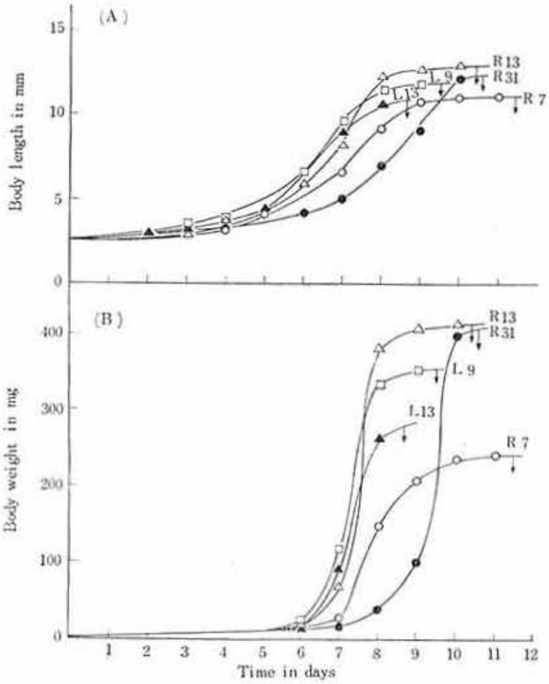

Fig. 1 Growth curves of body length (A) and weight (B) in adult female *Boophilus microplus* on feeding (Arrows indicate periods of dropping)

Table. 1. Determination of amount of blood removed by an engorged tick

Species	Month of feeding	Substance	Volume removed by a single tick (ml)	Ratio of ingested blood to final body weight
H. neumanni	July	N	0.88	3.3
		Fe	0.97	3.6
		Sterols	0.93	3.5
H. neumanni	Oct.	N	0.64	4.4
		Fe	0.70	4.8
		Sterols	0.74	5.0
H. neumanni	Nov.	N	0.77	5.0
		Fe	0.78	5.1
		Sterols	0.74	4.8
B. microplus	July	N	0.77	3.0
		Fe	0.71	2.8
		Sterols	0.81	3.1

Ixodes persulcatus, Haemaphysalis punctata, Dermacentor pictus, Rhipicephalus turanicus, and *Hyalomma asiaticum.* Larvae of these ticks removed an mount of blood 6.5 — 10, nymphs 4—6 and females 3—7.5 times greater than the engorged body weight.

Ticks of *Ixodes* and immature stages of various genera ingest frequently not only blood but also tissue fluids or non-blood components, and these individuals manifest various external color tints ranged whitish to blackish according to the ratios of such fluids ingested. Sutton & Arthur (1962) assumed the low content of blood pigments in *Ixodes ricinus* in the slow feeding stage would be caused by a change in feeding pattern into a predominance of non-blood. Females of *H. neumanni* and *B. microplus* never showed the change in body color to paler and also the iron content of engorged ticks was rather constant [7]. Accordance with the lowest iron content in the end of the slow feeding stage, the daily iron discharge of *H. neumanni* and *B. microplus* was the highest, as for instance 3.4 and 5.3 times amount of blood to the body weight three days after attachment, respectively. The low iron content in this stage implies surpassed excretion of waste blood against deposit or retention in the stomach and functionally enhanced feeding activity in contrast with superficially static appearence in growth.

As feeding ticks imbibe blood of several times greater than the engorged body weight, the excess water in the body might be discharged in the course of feeding process. Lees (1946), Sutton & Arthur (1965) considered that the excess water was lost mainly through the body surface or the cuticle by evaporation, as feeding ticks are in intimate contact with their host, having high body temperature. This hypothesis is not very acceptable, because the condensation rate of blood in the tick body of *H. neumanni* was never influenced when fed under saturated humidity condition (Kitaoka, 1967 unpublished). In another aspect of study, Gregson (1955) measured the amount of saliva of detached females of *D. andersoni.* Also Gregson (1967) observed the movement of tick-saliva and host-blood in the vicinity of the mouthparts of the feeding ticks and suggested the probable loss of water occurs through salivary serection into the host body. The recent observation on sodium and chloride economy during feeding by the author strongly supports his idea, though a part of water might be lost through the cuticle, respiration and as water content in excreta. It is reasonable to suppose that feeding process takes place along with various other functions, such as, utilization of nutritional materials in blood, water regulation and salivary secretion.

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Amounts of Trance Elements Contained in Grasses Produced in Okinawa

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Recent developments in studies of trace elements have revealed the physiological significance of trace elements, their role in the nutrition of life, and so on. Accordingly, trace elements have been recognized as an important factor in livestock breeding.

In Japan, too, the existence of several physiological disturbances of livestock attributable to excess or deficiency and imbalance of trace elements has been recognized,[4), 6), 7)] and attention has been given to the problem of amounts of trace elements in feedstuff.

Grasses are an important feedstuff for animals. But its value as a source of trace elements should be reexamined.

The authors analyzed trace elements in grasses produced in Japan and obtained some knowledge. The results have been published[5)]. They considered that future problem was trace elements in grasses produced in the tropical zone and other areas. Thus, they took an opportunity of conducting analysis of trace elements in grasses produced in Okinawa, and obtained a few very interesting results. They are summerized as follows.

Analyzing materials

Analyzing materials were collected from five districts of the Okinawa main island, i. e. Haneji and Nago Districts of the Northern Region, Ishikawa and Koza Districts of the Central Region, and Naha District of the Southern District, and sent to the authors with cooperation of the Economic Bureau of Okinawa Government, the Serum Producing Laboratory for Animal Diseases and other local agencies. They consisted of 122 samples of fodders and wild grasses. According to the names listed on the invoice they were classified into *Graminosae* (50 samples), *Leguminosae* (32 samples) and other species (15 species with 25 samples). 15 other samples could not be identified because of common or local names. The 25 samples of 15 species belonged to *Euphorbiaceae* and *Polygonaceae*, three each; to *Cyperaceae, Umbelliferae, Polypodiaceae, Moraceae. Compositae* and *Malvaceae*, two each; and to *Oxalidaceae, Musaceae, Cannaceae, Caprifoliaceae, Ranunculaceae, Urticaceae* and *rosaceae*, one each. For the sake of simplicity they were taken as one group. Table 1 shows the classification of the samples by harvested districts.

Method of Analysis

The analyzing materials were sent in air dried condition. They were immediately unpacked and further air dried in a well ventilated place for five or six days. Then