Studies on Seasonal Fluctuations of Populations and Overwintering in the Cattle Tick, Haemaphysalis longicornis

Shiraishi, Satoshi
Zoological Laboratory, Faculty of Agriculture, Kyushu University

Yoshino, Kenichi
Zoological Laboratory, Faculty of Agriculture, Kyushu University

Uchida, Teruaki
Zoological Laboratory, Faculty of Agriculture, Kyushu University

https://doi.org/10.5109/23887

出版情報：九州大学大学院農学研究院紀要. 34 (1/2), pp.43-52, 1989-11. Kyushu University
バージョン：
権利関係：

J. Fac. Agr., Kyushu Univ., 34 (1・2), 43-52 (1989)

Studies on Seasonal Fluctuations of Populations and Overwintering in the Cattle Tick, *Haemaphysalis longicornis*

Satoshi Shiraishi, Kenichi Yoshino* and Teru Aki Uchida

Zoological Laboratory, Faculty of Agriculture,
Kyushu University 46-06, Fukuoka 812, Japan

(Received May 9, 1989)

The present study elucidated the difference in seasonal fluctuation of the cattle tick (*Haemaphysalis* ***Longicomis)*** populations between Sasaguri pasture and a pasture at Kujū highland with different climates, and the effetc of ambient temperatures on the tick activity was discussed. In Sasaguri pasture, the peak number of the ticks collected by dragging occurred according to the instar in order of nymphs (April)→adults and larvae (July)→nymphs (September). At Kujū highland, on the other hand, the peak number appeared in sequence of nymphs (June)→adults (July)→larvae and nymphs (September) : in this case more ticks were captured under shade trees than on grassland. Such disparities seemed due to the difference of temperature between the two districts. The ticks in the field were able to overwinter underground in the unfed larval and nymphal states : the majority of the ticks were obtained at the depth of 5-15 cm from the ground surface under the shade trees, Overwintering experiments revealed that the ticks became less active or inactive when the ambient temperature at noon went down to 11-15°C, and that the survival ratio was 38.5% for larvae, 28.0% for nymphs and 68.0% for adults (females, 64.0% ; males, 72.0%).

INTRODUCTION

In Japan, the cattle tick *Haemaphysalis* ***longicornis*** is the most dominant species in pastures and one of the most harmful ectoparasites for grazing cattle. The tick has been known as the vector for theileriosis caused by *Theileria sergenti* and as a cause of such symptoms as physiological disorder, motor nerves paralysis and malnutrition with anemia (Namba, 1958 ; Yoshida, 1975 ; Chikaki, 1976). The tick has greatly reduced profits from the livestock industry. The Kujū highland in Ōita Prefecture has been especially notorious as one of areas infested by theileriosis. Fundamental studies on the ecology of the cattle tick are desirable for its logical control. Nevertheless, there have been such a few reports (Hirotsu et ***al.,*** 1981 ; Shiraishi et al., 1982 ; Yano et ***al.,*** 1985). The aim of this paper is to elucidate the difference in seasonal fluctuation of the tick populations between two localities with different climates, and to discuss the effect of atmospheric temperatures on the tick activity.

---

*Present address : Department of Oralneuroscience, Kyushu Dental College, Kitakyushu 803, Japan.

MATERIALS AND METHODS

Ticks on grasslands

A meadow in the Kasuya University Forest of Kyushu University (Sasaguri pasture, Fukuoka Prefecture) and a pasture at Kujū highland (Ōita Prefecture) were selected as study areas. The former is located at 50-60 m above the sea level and the latter at an elevation of ca. 1,000 m. In Sasaguri pasture, ticks were collected 18 times (l-3 times a month) on the grassland from 29 April to 17 November in 1986. This area was used as a pasture in 1985, but harvested as a meadow early in August in 1986. At Kujū highland, the ticks were collected 6 times (once a month from 19 June to 30 November in 1986) both on a grassland and under shade trees. During the survey period cattle were grazed in this pasture. The numbers of ticks on the vegetation were determined by a dragging method in which a piece of white cotton flannel of 1 m^2 was dragged about 10 m in distance. After collecting all ticks clinging to the cloth, they were counted according to the instar. This operation was repeated 12 times in each survey in Sasaguri pasture and 10 times in the pasture at Kujii highland. The ambient temperatures at 50 cm above the ground surface in both pastures were measured with a digital thermo-hygrometer (Model HN-K, CHINO WORKS, LTD.)

Ticks from soil samples

On 30 November 1986 with an ambient temperature of ~13.0°C at 11:00~12:00, when the ticks were no longer collected by the dragging method, soil samples were cut out as three blocks with a thickness of 5 cm each from the ground (10 x 10 cm) to the depth of 15 cm both on the grassland (2 points) and under the shade trees (4 points) in the pature at Kujū highland. These samples were directly packed into plastic bags and carried back to our laboratory. The Tullgren apparatus with a lighted electric bulb (60 w) was used to expel the ticks from the soil blocks. A saucer filled with water of this apparatus was changed every day for a week, and the number of ticks fallen into it was counted according to each instar.

Overwintering experiments of the ticks

Three sets of containers made of two kinds of acrylic pipes (outside diameter 15 cm, height 50 cm ; outside diam. 14 cm, h. 10 cm) were prepared to examine the overwintering ability of the ticks (Fig. 1). A kind of soil (Kanuma-tsuchi) was packed in the short pipe and two orchard grasses (*Dactylis glomerata*) were planted there. The experimental ticks per each container, consisting of 800 larvae hatched in an incubator (30°C) in late September 1986, 100 nymphs and 100 adults (50 males and 50 females) all of which were collected in June and July 1986, were released onto the grasses on 14 October 1986. The number of active ticks on the surface of the container, soil and grasses was counted at noon every 5-7 days from 23 October 1986 to 2 February 1987 when live ticks became invisible. The temperatures in the containers during the experimental period were measured at noon with two thermocouples set at 10 cm and 30 cm above the surface of soil, and taken the average. The soil and grasses were transferred into the Tullgren apparatus to detect live ticks, and the survival ratio of the ticks was calculated according to the instar.

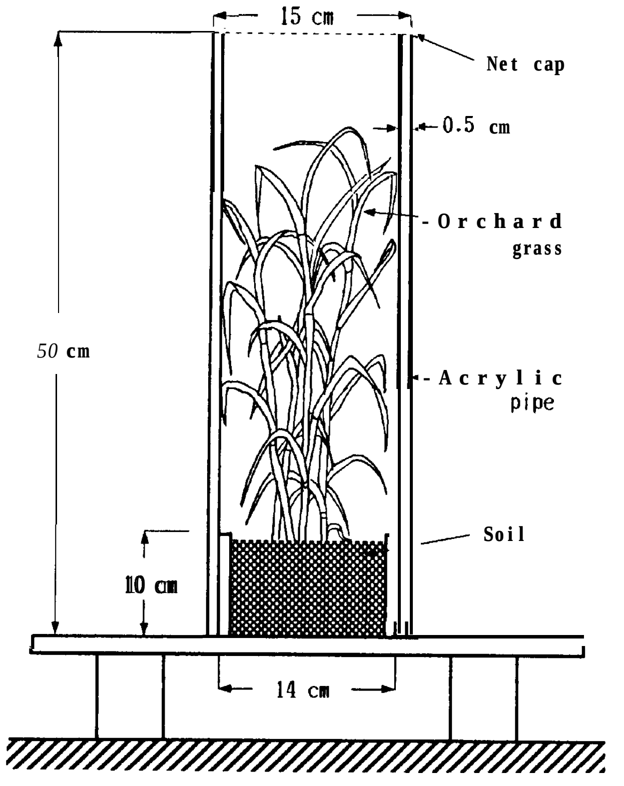

Fig. 1. Acrylic pipe-container used for overwintering experiments of cattle ticks.

RESULTS

Seasonal fluctuations of the ticks on grasslands at the active stage

In Sasaguri pasture (Fig. 2), a total of 2,229 larvae were collected during the survey period from 29 April to 17 November, except on 9, 21 and 31 May and 17 November, and the number reached to a peak (700 larvae) on 31 July. The nymphs summed up to 691 individuals from 29 April to 26 October except on 31 · July : peaks appeared twice, i. e. on 29 April (98 nymphs) and 15 September (174 nymphs). As for the adults (71 in total) collected during the period from 21 May to 15 September, the maximum number (19) was seen on 31 July. The peaks in number of collected ticks according to the instar occurred in the following order : nymphs (April)→adults and larvae (July)→nymphs (September). In addition to the cattle tick, a few *H. flava* and *Ixodes nipponensis* were collected.

At Kujū highland, 2,275 larvae and 84 nymphs were collected from 19 June to 30 October, and 69 adults from 19 June to 29 August on the grassland (Fig. 3A). On the other hand, 32,308 larvae, 129 nymphs and 26 adults were obtained from 19 June to 30 October, to 27 September and to 29 August, respectively, under the shade trees (Fig. 3B), where a few engorged cattle ticks were scraped off grazing cattle by rubbing their body against shade trees (Fig. 4). As a whole, the peaks in number of collected nymphs

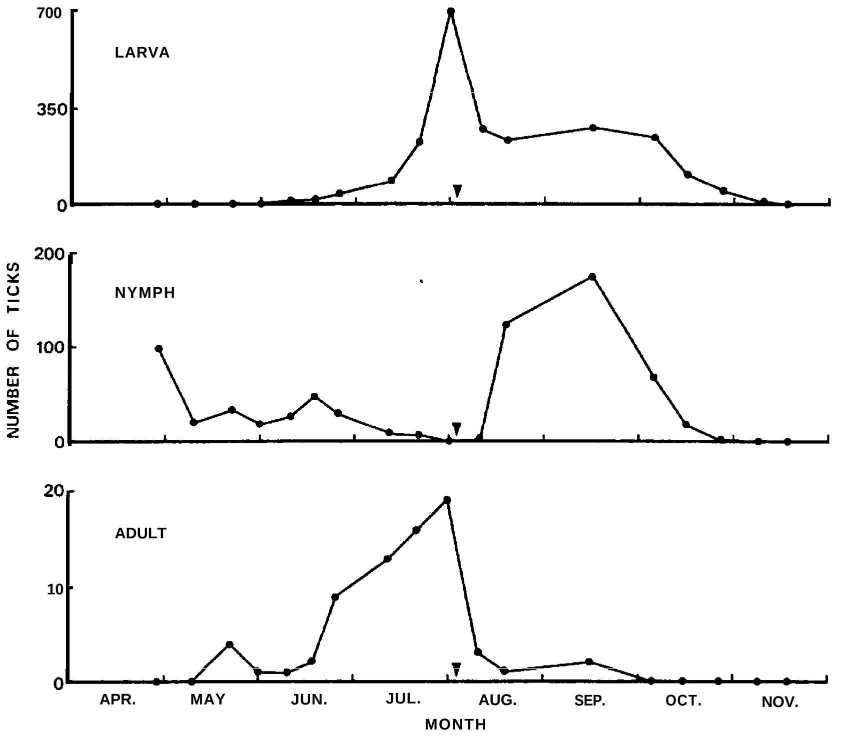

Fig. 2. Seasonal fluctuations of cattle ticks collected by dragging in Sasaguri pasture in 1986. ▼, harvest time.

appeared conspicuously on 19 June (47 on the grassland and 90 under the shade trees) and slightly on 27 September (12 and 10), and those of adults and larvae were obtained on 23 July (45 and 17) and 27 September (1,423 and 20,360), respectively. The peaks in number of collected ticks in each instar occurred in the order of nymphs (June)→adults (July)→larvae and nymphs (September).

During this survey, the ambient temperature at noon in Sasaguri pasture was higher by 8-10°C than in the pasture at Kujū highland. The highest temperature was 35.0°C (31 July) in the former and 25.0°C (19 July) in the latter, while lowest 18.0°C (26 October) and 8.0°C (30 October), respectively.

Habitat of the ticks during the overwintering stage

The average number of cattle ticks found from the soil samples which were obtained at Kujū highland on 30 November when the ticks disappeared from the surface of the grassland was shown in Table 1. On the grassland, only nymphs were detected with 0.5 individual per soil sample from a depth of 5-10 cm. Under the shade trees, the numbers of larvae were 1.5 per sample (O-5 cm in depth), 8.0 (5-10 cm) and 4.3 (10-15 cm), and nymphs were 1.5 (O-5 cm in depth), 8.8 (5-10 cm) and 3.8 (10-15 cm), respectively, but no adult was detected.

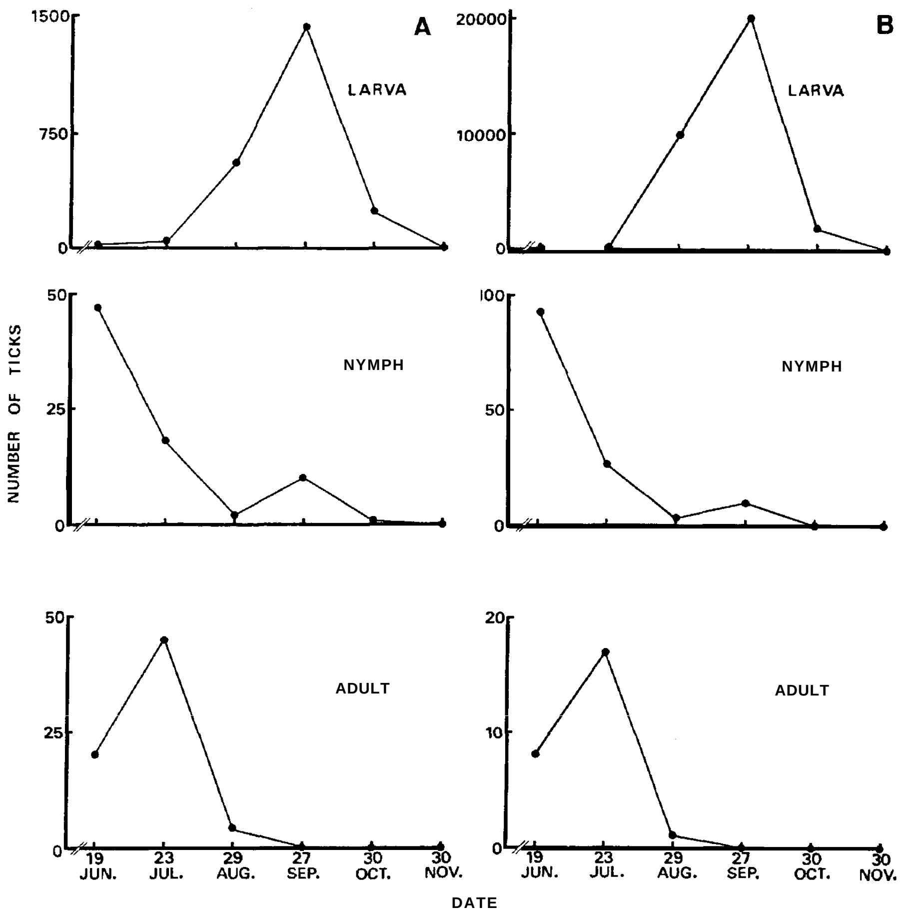

Fig. 3. Seasonal fluctuations of cattle ticks collected by dragging on the grassland (A) and under the shade trees (B) at Kujū highland in 1986.

Overwintering ability of the ticks

The results obtained from the overwintering experiments of cattle ticks in the containers were shown in Fig. 5. The activity ratio (the number of active ticks/the total number of released ticks) of larvae increased from 50.8% on 23 October to 88.8% on 9 November in 1986, and then decreased prominently from 80.6% on 20 November to 31.3% on 10 December, and no active larvae were seen on 2 February 1987. The activity ratio of nymphs gradually decreased from 34.0% on 23 October to 25.0% on 20 November and remarkably reduced to 3.0% on 10 December : no active nymph was found after 31 December. The activity ratio of adults had much the same tendency as that of nymphs, increased slowly from 35.0% on 23 October to 37.0% on 3 December, and remarkably decreased to 3.0% on 24 December, and no active adult was detected after 14 January 1987.

On 2 February 1987 when no active ticks were found, both the soil and the orchard

Fig. 4. Engorged cattle ticks scraped off grazing cattle by rubbing their body against a shade tree (photographed on 19 June, 1986).

Table 1. The average number of cattle ticks detected from the soil samples at Kujū highland on 30 November 1986.

Depth from the ground surface (cm)	Grassland*			Shade trees'		
	Larva	Nymph	Adult	Larva	Nymph	Adult
o- 5	0.0	0.0	0.0	1.5	1.5	0.0
5-10	0.0	0.5	0.0	8.0	8.8	0.0
10-15	0.0	0.0	0.0	4.3	3.8	0.0

* Two samples were examined for each depth class.
† Four samples were examined for each depth class.

grasses in each container were moved into the Tullgren apparatus to check the overwintering ticks. The survival ratio of the larvae, nymphs and adults each was 38.5%, 28.0% and 68.0% (females, 64.0% ; males, 72%) (Table 2).

DISCUSSION

In Sasaguri pasture harvested in early August, the peaks in number of each instar of the collected tick were shifted as follows ; nymphs (April)→adults and larvae (July) →nymphs (September). In this case, the peak in adults synchronized with that in larvae. According to Bremner (1959) and Yano *et al.* (1985) who studied on the developmental duration of the cattle tick under laboratory conditions, it takes ca. 50 days from feeding attachment of adult females to egg hatching, and the duration required for larvae to moult to nymphs is ca. 17 days. If the harvest would not had taken place in early August, taking also the above durations and the peaks in adult and

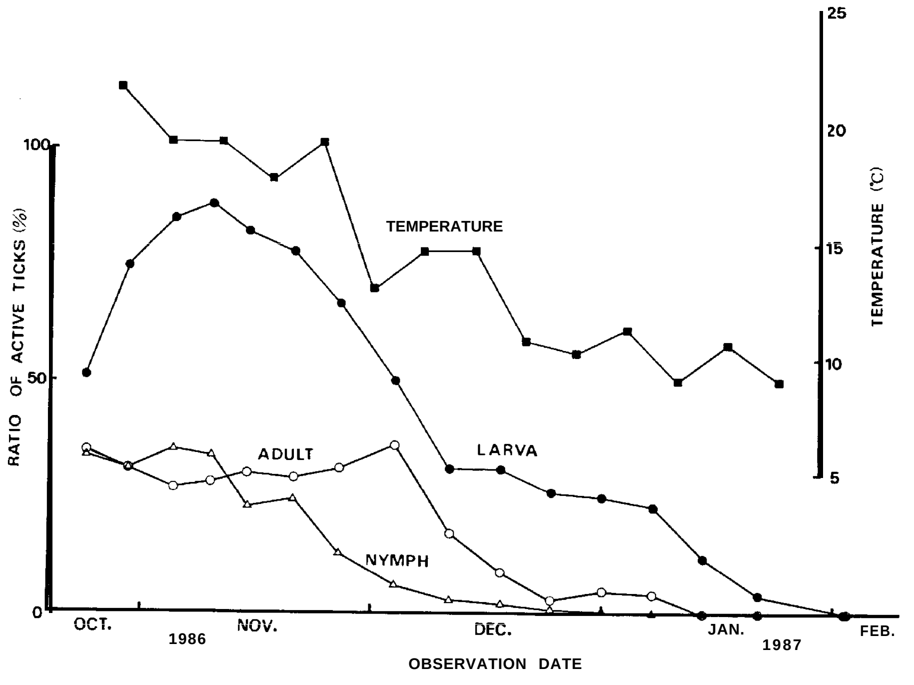

Fig. 5. Relationships between the weekly mean temperature at noon and the ratio of active cattle ticks to total ones in the acrylic pipe-container.

Table 2. Survival ratio (%) of cattle ticks in acrylic pipe-containers 102 days after the beginning of the experiment.

Larva (N = 800)	Nymph (N = 50)	Adult		
		Female (N = 50)	Male (N = 50)	Mean (N = 100)
38.5	28.0	64.0	72.0	68.0

nymphal populations into account, it is suggested that the peak in the larval population might have appeared from the last decade of August to the first third of September. Thus, the peaks in number of the tick population would occur in the following order ; nymphs→adults→larvae→nymphs.

Distinct differences in the peak time of larvae (on 31 July in Sasaguri pasture and 27 September at Kujū highland) and nymphs (on 15 September and 27 September, respectively) seemed to be resulted from shortening of the developmental duration in the tick life cycle, because higher ambient temperatures in Sasaguri pasture than at Kujū highland play a role in such phenomenon.

Such bimodal fluctuations of nymphs on grasslands as seen in our study areas have been known also in Hokkaido (Namba, 1958), but not in other districts (Chikaki, 1976 ; Ito *et al.*, 1983 ; Ōtake et *al.*, 1985). As mentioned above, the seasonal fluctuations of the tick differ with different districts in Japan. The reason for this, however, can not be sufficiently explained by the effect of temperature alone on the developmental duration of each instar. There is the possibility that such differences were caused also by the density and behaviour of hosts (Ito et *al.,* 1983) and the rainfall (Ōtake et *al.,* 1985), etc. Further studies are necessary to clarify the relationship among the seasonal fluctuation of the tick populations and these factors.

It has been reported that the overwinter commencement of the tick is about the time when the decadal mean temperatures fall to 10–15°C (Namba, 1958) or ca. 13°C (Chikaki, 1976). Also in our experiments on overwintering, the number of active ticks

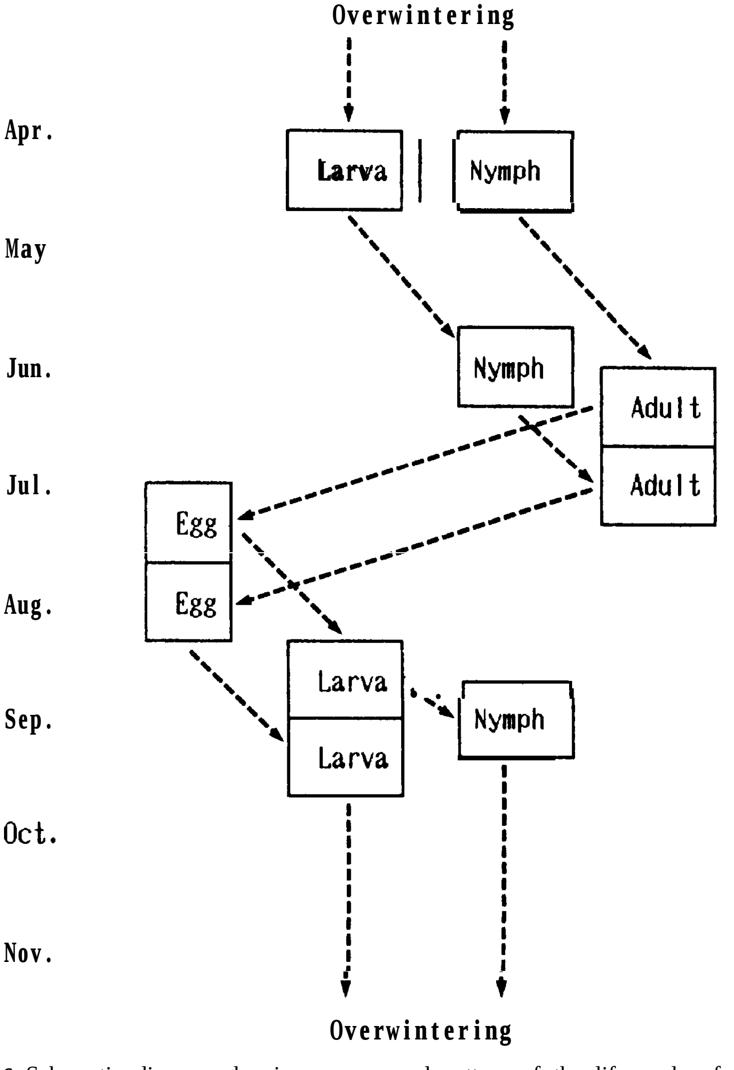

Fig. 6. Schematic diagram showing a presumed pattern of the life cycle of cattle ticks at Kujū highland.

rapidly decreased at temperatures of 11-15°C from 20 November to 24 December. These results suggest that the tick seems to begin to overwinter at the temperature of about 13°C.

In *H. longicornis*, overwintering occurs in the states of unfed and engorged larvae, unfed nymphs and adults, and probably in the egg stage (Namba, 1958). On the other hand, according to Chikaki (1976) and Yoshida (1975, 1980), it has been said that the eggs and larvae cannot overwinter alive. The present study (Table 1), together with Hirotsu et *al*. (1981) who collected the larvae and nymphs in spring at Kujū highland, revealed that unfed larvae and nymphs are able to pass alive the winter in this area. Taking these facts into consideration, the presumed pattern of the life cycle in the cattle tick at Kujū highland is shown in Fig. 6.

Our overwintering experiments also adduced evidence of the larval wintering (Table 2). In spite of the high survival ratio of adults in our experiments, no overwintering adults could be collected at Kujii highland. This difference would be explained on the assumption that nymphs in the field were forced to move underground without feeding owing to low temperature in late autumn. According to Yoshida (1980) and Ito et al. (1983), overwintering ticks could not be collected in the central part in grassy pastures, but captured only around the resting or drinking places of cattle. Also at Kujū highland, it seems likely that the overwintering of the cattle tick is carried out mostly under shade trees (Table 1) as described by the above authors.

At Kujū highland, the ticks seem to overwinter in the soil at the depth of 5-15 cm during winter (Table 1). In Shimane Prefecture the overwintering ticks are found in the soil depth of l-5 cm, but neither on the ground surface nor in the soil deeper than 5 cm in depth (Chikaki, 1976) : in Yamanashi Prefecture, however, the ticks overwinter at 10 cm in depth (Yoshida, 1980). Such disparities in soil depth of tick overwintering might be due to differences of microclimate on the ground surface, vegetation and nature of the soil, etc. In this study, since the soil deeper than 15 cm was not examined, further investigations are needed to clarify the overwintering of the ticks.

ACKNOWLEDGEMENTS

The authors wish to thank the late Professor Y. Motoda, Laboratory of Agricultural Meteorology, Faculty of Agriculture, Kyushu University, for his help in the course of our experiments, Dr. T. Mōri and graduate students of our laboratory, and the staffs of Kujū Agricultural Research Center of Kyushu University and Kyushu University Farm for their facilities ; and Professor E. W. Jameson, Jr., University of California for comments on the manuscript. This work was supported in part by a Grant-in-Aid from the Ministry of Education, Science and Culture, Japan.

REFERENCES

Bremner, K. C. 1959 Observation on the biology of ***Haemaphysalis bispinosa*** Neumann (Acarina: Ixodidae) with particular reference to its mode of reproduction by parthenogenesis. *Aust. J. Zool.*, **7** : 7-12

Chikaki, H. 1976 Biological studies on ***Haemaphysalis longicomis.*** Special Reports of Insect Management Laboratory, Fac. Agr., Shimane Univ., (1) : 1-76 (In Japanese)

Hirotsu, J., T. Goto, K. Ishiguro, F. Fujinaga, M. Hikita and R. Umezu 1981 Effects of ixodid ticks-control procedures for three years in two pastures at Kujū highland. ***Douyaku Kenkyu (25)*** :

21-28 (In Japanese)

Ito, Y., N. Watanabe and T. Matsumura 1983 Overwintering *Haemaphysalis Zongicornis* (Acari: Ixodidae) at a pasture, Nasu plateau, Japan. *Bull. Natl Grassl. Res. Inst.*, (24) : 110-118 (In Japanese with English summary)

Namba, N. 1958 Ecological studies on *Haemaphysalis bispinosa*, a harmful tick in the pasture of northern Japan. *Rep. Hokkaido Natl Agr. Exp. Stn, (50)* : l-99 (In Japanese with English r&sum&)

Ōtake, H., I. Ito and K. Hayashi 1985 Relationships between population density of the tick, *H. longicomis,* and environmental factors in the armanent pasture. *J. Japan. Grad. Sci., 30 : 452-457* (In Japanese with English summary)

Shiraishi, S., T. Mōri, K. Funakoshi, S. Arai, N. Kawaji, M. Nishimura and T. A. Uchida 1982 Fundamental studies on the control of the cattle tick, *Haemaphysalis Zongicornis,* at Kujū highland. I. Preliminary report on the ecolcgy of the tick. Sci. *Bull. Fac. Agr., Kyushu Univ., 36* :101-114 (In Japanese with English summary)

Yano, Y., S. Shiraishi and T. A. Uchida 1985 Fundamental studies on the control of the cattle tick, *Haemaphysalis longicomis.,* at Kujū highland. II. Development and growth of the tick under laboratory conditions. *Sci. Bull. Fac. Agr., Kyushu Univ., 39* : 159-164 (In Japanese with English summary)

Yoshida, T. 1975 Ecological studies for the control of the ticks in the pasture. *J. Fac. Lib. Arts, Shinshu Univ., 9* : 27-111 (In Japanese with English summary)

Yoshida, T. 1980 Ecology of the tick, *Haemaphysalis Zongicornis,* in the pasture of Japan. *Seibutsu Kagaku (Bio. Sci.), 32:* l-10 (In Japanese)