CLIMATIC REGULATION OF THE TWO-COHORT POPULATION OF *IXODES DAMMINI* IN COASTAL MASSACHUSETTS

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IXODES
DAMMINI
ANNUAL
POPULATIONS
MASSACHUSETTS

ABSTRACT : Over a 29 year period on Cape Cod Massachusetts there were 5 fall outbreaks of adult *Ixodes dammini* and a crash following an outbreak year. These outbreaks were proceeded by 2 years with normal November December temperature and winters with limited frozen bare ground. The crash was proceeded by a winter with an extended period of frozen bare ground. The range of this tick is limited to the coastal area with a normal average November December mean at or above 2.8° C, a period critical for the development of the spring adult cohort for this tick with a summer adult diapause. The below normal November December means from 1959 to 1973 on upper Cape Cod was a period of very low infestation of fall adult *I. dammini*.

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RÉSUMÉ : Pendant une période de 29 ans à Cape Cod, dans le Massachusetts, il y a eu 5 éruptions d'automne des *Ixodes dammini* adultes et un fracas suivant une année d'éruption. Ces éruptions avaient été précédées de deux années où la température était plus haute que la normale pendant les mois de novembre et de décembre, et les hivers éperonnaient une limite de terre gelée nue. La distribution de cette tique est bornée aux aires côtières et à une température normale de $\geq$ 2.8° C pour les mois de novembre et de décembre, période critique pour le développement de la cohorte adulte de printemps de cette tique avec une diapause adulte d'été.

During a meeting on the American dog tick at Waltham in 1970, O. JOHNSON, the head of the Cape Cod Extension Service, brought up the question of the fall " deer tick " infestation on Cape Cod, Massachusetts. This tick was unknown and not recognized as a problem at the meeting. However, according to O. JOHNSON, there had " always " been an occasional fall tick infestation. He particularly recalled a " spectacular " outbreak during the 1958 fall hunting season but since that time this fall tick had been either rare or absent as little note was since taken of it. From 1971 to 1987 adult ticks were collected from dog owners, animal shelters and veterinary dog grooming services on upper Cape Cod. From 1979 to 1987 tick burdens were followed on bird dogs during the fall hunting season at Hatchville in a state game preserve (McENROE, 1984, personal observation). During the period from 1971 to 1974 an adult tick identified as *Ixodes scapularis*, subsequently separated as *I. dammini* (Spielman *et al.*, 1979), was occasionally found on dogs on the upper Cape. On

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Marthas Vineyard Island, just off the Cape, adult *I. dammini* were usually common on dogs, both in the fall and early spring, during the sixties and early seventies (P. JOSEPHS, H. B. HOUGH, personal communication).

In the fall of 1975 there was an outbreak of this tick fitting the description of the " deer tick " but the infestation crashed in 1976 (SPIELMAN, 1976 ; MCENROE, 1977, 1978 a). This tick remained rare through 1978. As measured by fall tick burdens on hunting dogs the infestation remained depressed through 1983. Fall outbreaks occured in 1984, 1985 and 1986 at Hatchville. At 10° ± 2° C the average tick burdens on dogs, after three hours in the field increased from 1 tick/dog to 11 ticks/dog. During this period many hunters believed that this was a " new " tick as they had not noted it in previous years either on themselves or their dogs. The restriction of this tick to the immediate coastal area indicated that this limitation was associated with the decline in fall and winter temperature which occurs from the coast into the interior (MCENROE, 1977, 1978 a).

In this coastal area, *I. dammini* has a 2 cohort cycle with alternate breeding seasons by the fall and spring adult cohorts. That is a 2 generation 3 year cycle (MCENROE, 1984). The spring adults are the parental generation of the fall adults. Spring adults are usually rare on the upper Cape as a result of the low reproductive success of fall breeding because of the following temperature regime.

At high levels of breeding activity the size of the following adult cohort is insensitive to the amount of breeding but when the breeding level is depressed, sensitive to a small increase (MCENROE, 1987). An increase over the usual level of extremely depressed spring breeding activity would have a large effect on the F_1 fall generation. The spring adult cohort develops from a late fall nymphal molt.

Survival under modest water stress records the history of previous adult activity (MCENROE and SPECHT, 1987), and their accumulated age effect (LEES, 1964). This process was shown in 1987-1988. The short survival of October adults (Fig. 1, line 1) shows the effect of their fall activity. The bimodal survival response of late fall adults (Fig. 1, line 2) shows the entrance of new adults at this time. The response of spring adults (Fig. 1, line 3) shows only the presence of the new spring cohort.

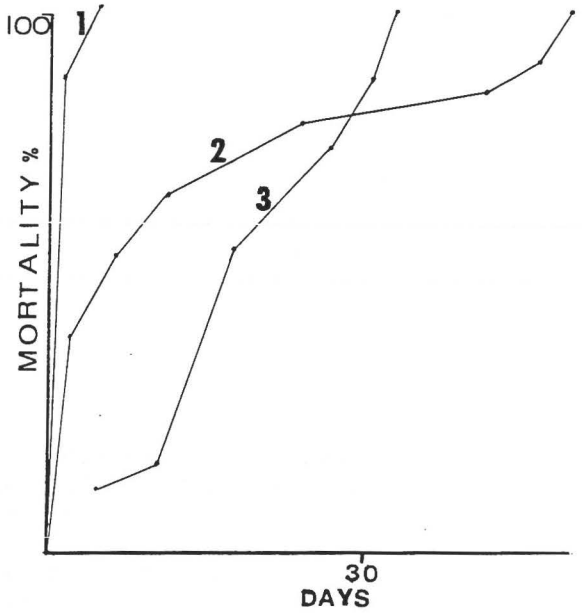

FIG. 1 : Adult *I. dammini* survival at 20° C and 80 % RH. Line 1. Late October adults, N = 20. Line 2, Late November, mid-December adults, N = 20. Line 3, Early spring adults, N = 20. Field collected adults from Cape Cod and Marthas Vineyard Island, 1987-1988.

The optimum November December mean temperature for the two cohort cycle appears to be around 5° C present on the islands which are traditionally the areas of highest infestation (PIESMAN *et al.*, 1979 ; GOOD, 1973). Inland from the coast, where the mean falls below 2.8° C, this tick is absent (MCENROE, 1984, 1988). With an increase of the temperature regime, adult activity continues through the fall and winter for a one generation, one year cycle with the absence of a spring adult cohort (ROGERS, 1953 ; MCENROE, in press). On the upper Cape, where the normal average November December mean is 3° C, above average means will increase the potential size of the spring adult cohort. A winter with limited frozen bare ground with its desert-like surface (GEIGER, 1965) is a requirement for adult survival (MCENROE, 1984). This regime will result in increased spring breeding and a potential for an outbreak of F_1 fall adults. Immature development can continue

through the spring and summer and a warm fall will insure the completion of the larval molt for the spring nymphs. Limited frozen bare ground is again required for survival of these nymphs which molt to the summer diapause adults. This series of events result in the fall adult outbreaks on the upper Cape.

The running two year average November December means for the upper Cape are shown in fig. 2. These means, previous to the fall outbreaks were above normal at *ca* 4° C. The records for the winters of 1956-57 and 1957-58 indicate snowcover during cold periods. The following outbreak years were also preceded by two winters with limited frozen bare ground. The below normal means from 1959-1969 (fig. 2) and the below winter means of 1968-73 with extended periods of frozen bare ground and a depressed *D. variabilis* infestation (McEnroe, 1979) coincided with the extended period when this tick was rare. The population crash in 1976 followed an open winter with continuous frozen bare ground when the *D. variabilis* population also crashed.

On the islands, where the normal November December means run 2° C above that on the Cape (fig. 2) and the winter mean around 0.5° C limits frozen bare ground conditions remain favorable for the nymphal molt to the spring adult cohort followed by temperature inactivation and survival of these adults until early spring for the two cohort cycle.

Because of the usual high level of *Dermacentor variabilis* breeding activity on the upper Cape, this tick shows an immediate increase following a single winter with limited frozen bare ground. In contrast *I. dammini* requires a generation cycle for recovery.

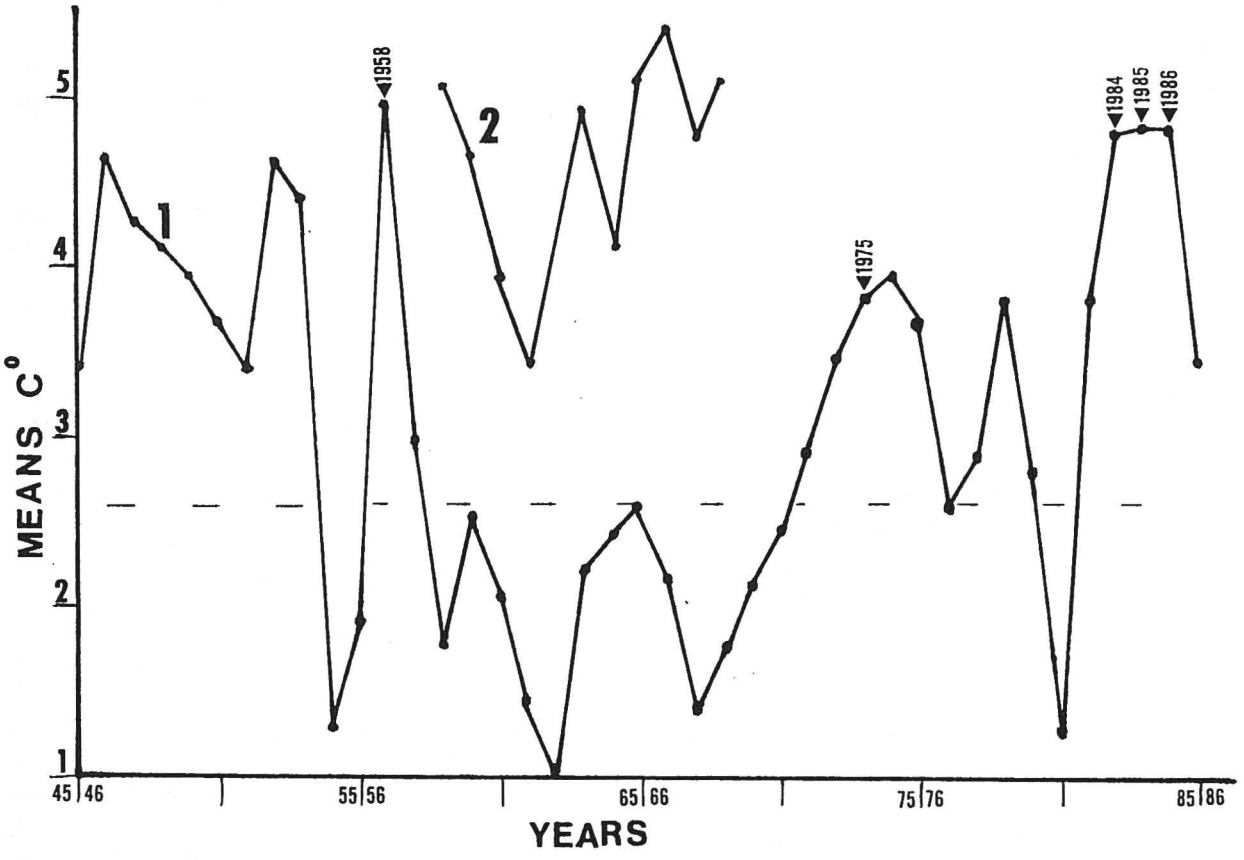

FIG. 2 : Running two year average November December means ; Line 1, upper Cape Cod, East Wareham ; Line 2, Nantucket Island. Two year mean relevant to following fall tick season *ie* 1975 fall season, 1973-74 means. Fall outbreaks on Cape Cod indicated at previous means. Dashed Line, normal average mean temperature limit of the coastal population of *Ixodes dammini*.

The two year fall and winter regulation of *I. dammini* results in the eratic appearance of fall outbreaks on the upper Cape. The adaptation of *I. dammini* to the marginal conditions on the Cape is limited by its lack of winter diapause (McEnroe, 1985). Long term secular variation of the temperature regime can account for the apparent absence or appearance of this tick over a marginal region adjacent to an area of continuous infestation.

The interaction of diapause period(s) and temperature dependent rates will, over a transect of temperature regime, result in a life cycle flitted to local conditions with a central optimum within a marginal area (McEnroe, 1978 b, 1978 c, 1982).

In the early spring of 1990 on upper Cape Cod, when a low level of spring adult tick infestation about 1/4 of that in the fall is usually present, the local dogs appeared to be tick free. Animal clinic personal also reported that only an occasional *I. dammini* was found. During October of 1990 at Hatchville, during the usually peak of fall adult tick activity, the tick burdens on hunting dogs were extremely depressed as noted on the dogs as they returned from the field. This observation was confirmed by the hunters who, in contrast to previous years, found many of their dogs had remained tick free.

This crash could not be ascribed to winter mortality because the two previous winters had very limited periods of frozen bare ground which was followed by heavy spring adutlt *D. variabilis* infestations. This crash was correlated with the 2° C below normal average mean temperature for mid-November-December of 1989, the critical temperature period for the completion of late season interstage development of the following spring and fall adult cohorts. Below normal temperature at this period had an oppositive negative effect on the tick population from that of the positive effect of above normal temperature.

The 5° C decline from 3.4° C in late fall temperature which occurs immediately at the base of Long Point Ontario, a narrow sand spit which extends several kilometers into Lake Erie, isolates an *I. dammini* infestation on the point from the adjacent lake shore. This disjunct population, restricted to less than 5 km^2, shows the absolute regulatory control of late fall temperature over the two cohort cycle of *I. dammini*.

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