STUDIES ON THE DYNAMICS OF ACTIVE POPULATIONS OF THE SHEEP TICK, *IXODES RICINUS* L. IN CO. WICKLOW, IRELAND

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IXODES RICINUS IN IRELAND STASES AND THEIR ACTIVITIES DURING THE YEAR

ABSTRACT : This study on *I. ricinus* has shown that two peaks of nymphal and adult activity, and one main peak of larval activity occurred each year over a five year period. At the start of the study period the autumn-feeding population was very prominent but by the fifth year the situation had changed and the spring-feeding population had become dominant. This was probably brought about by two unusually warm successive summers acting on summer-feeding larvae that were derived from autumn-feeding adults. It was concluded that weather has little effect on active ticks once temperature thresholds for activity have been reached but that weather is of great importance in determining the availability of active ticks by affecting development rates. Explanations for the maintenance of patterns of tick activity are discussed.

IXODES RICINUS EN IRLANDE SES STASES ET LEURS ACTIVITÉS AU COURS DE L'ANNÉE

RÉSUMÉ : Cette étude, effectuée pendant une période de cinq ans, démontre l'existence de deux pics d'activité annuels chez les nymphes et adultes d'*I. ricinus*, alors qu'il n'y en a qu'un seul chez les larves. Au début du travail, la population se nourrissant en automne était très importante. Au cours de la cinquième année, la population se nourrissant au printemps était dominante. Ce fait était probablement dû à la température extrêmement élevée, enregistrée pendant 2 années de suite, la chaleur agissant sur les larves nées d'adultes s'étant gorgés en automne ou au milieu de l'été précédent. L'effet des conditions météorologiques sur l'activité des tiques est peu important une fois que le niveau de température critique a été atteint. On constate cependant que la météorologie influe sur les divers stades évolutifs, plus particulièrement sur le nombre de tiques actives disponibles.

Les raisons du maintien des modes d'activité des tiques sont discutées.

INTRODUCTION

The sheep tick *I. ricinus* has been the subject of many studies during the last 50 years and a considerable amount of data on its life cycle and seasonal activity have been obtained (reviewed by ARTHUR, 1962 ; BABENKO, 1971 ; BAUCH, 1971, 1972 ; CHMELA, 1969 ; ČERNÝ, DANIEL & ROSICKÝ, 1974 ; WALTER & LIEBISCH, 1980). Little comparable work has been carried out in Ireland where *I. ricinus* occurs mainly on open hill land and rough permanent pasture in contrast to its woodland and forest habitat in Continental Europe.

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The studies described in this paper were designed to obtain data for work on tick-transmitted diseases in Ireland and also in an attempt to elucidate factors that may influence seasonal and annual fluctuations in tick numbers. The studies consisted of weekly sampling for active ticks using tracer sheep and blanket sampling, and the investigation of the effects of varying stocking rates and of weather on numbers of ticks sampled with these methods. A preliminary report on the first two years of this study has already been published (GRAY, TURLEY & STRICKLAND, 1978) and this paper deals with the results obtained over the full five year period of the study.

MATERIALS AND METHODS

■ *Sites*

Two contrasting sites were selected. Site A was situated in a sheltered valley bottom and consisted of 3 hectares of fenced permanent pasture (Fig. 1A). The vegetation was mostly a short sward of coarse grasses and moss with scattered thistles. Rushes were present along one side of the site which was bordered by a small stream.

Site B was situated about 10 km from site A and consisted of 2.5 hectares of very rough ground on an exposed hillside (Fig. 1B). The vegetation was mainly bracken fern and coarse grasses and the site was fenced.

A third site, Site C, was also used and this was situated about 2 km from site B and consisted of an unfenced area of about 1 hectare of heather and coarse grasses (Fig. 1C).

■ *Stocking patterns*

Site A. This site was utilised for 4 years, 1975-1978. The normal practice of the farmer was to put his sheep from the lambing ground onto this site in late April and to move them again in late June. The site was used periodically as a holding area for the rest of the grazing season. Dipping took place in late June — early July against blowfly and late October — early November against scab mite. Dipping lambs as a tick control measure was discontinued 3 years before the study commenced.

In the first year, 12 ewes and their lambs were retained on the site after the rest of the flock of about 25 ewes had been moved. The sheep were dipped against both blowfly and scab mite.

In the second year, 30 hoggets were maintained on the site from January to late April when 20 of them were replaced by 10 ewes and 10 lambs. These animals were not dipped against blowfly and were kept on the site until late October.

In the third year, the farmer's normal stocking pattern was resumed. From 5-30 animals were present on the site throughout the grazing season apart from a 6 week period from mid-June to the end of July and a 4 week period from mid-September to mid-October. This pattern of stocking was continued in year 4.

Site B.. This site was utilised for 3 years, 1976-1978. The area was fenced off and 12 wethers or hoggets were put onto it in January or February of each year. Hay and supplement was given to the animals throughout in order to augment the inadequate grazing on the site. The sheep were taken off the site each year in early December and replaced with another group of animals.

Site C. This was surrounded by a mixture of bog, heather, bracken and coarse grasses. It was used exclusively for blanket dragging and no attempt was made to control stocking. Sheep and cattle had had access at low densities to this area from May to November of each year for at least the previous 10 years. Sampling was carried out in 1978 and 1979.

■ *Sampling Methods*

The active tick populations at sites A and B were sampled at weekly intervals using tracer sheep and blanket dragging. At site A tick counts on sheep and on blankets were made in 1975 and 1976. Blanket counts only were carried

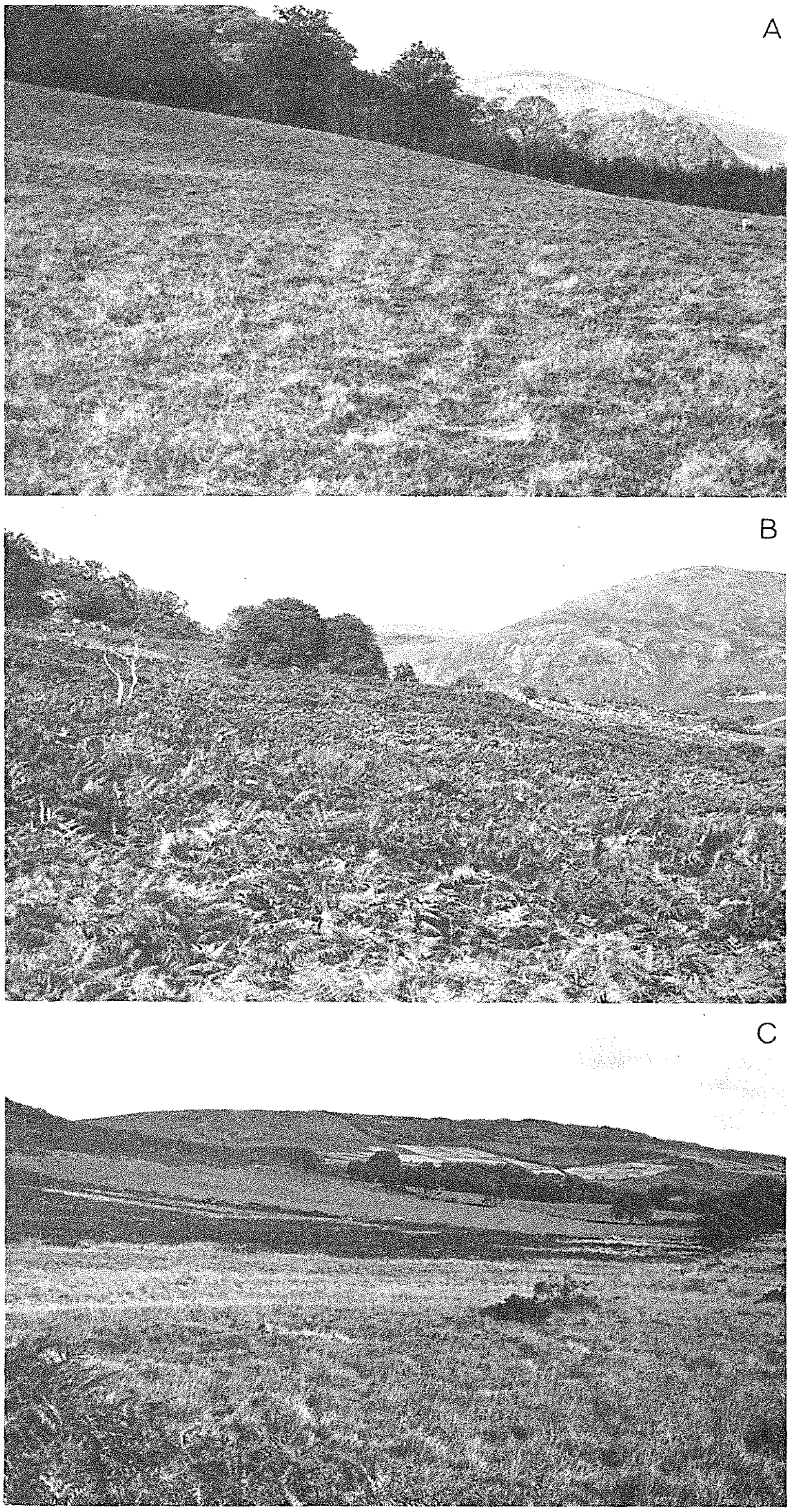

FIG. 1 : Sites in Co. Wicklow, Ireland, used for sampling *I. ricinus* 1975-1979.
A) Site A, B) Site B, C) Site C.

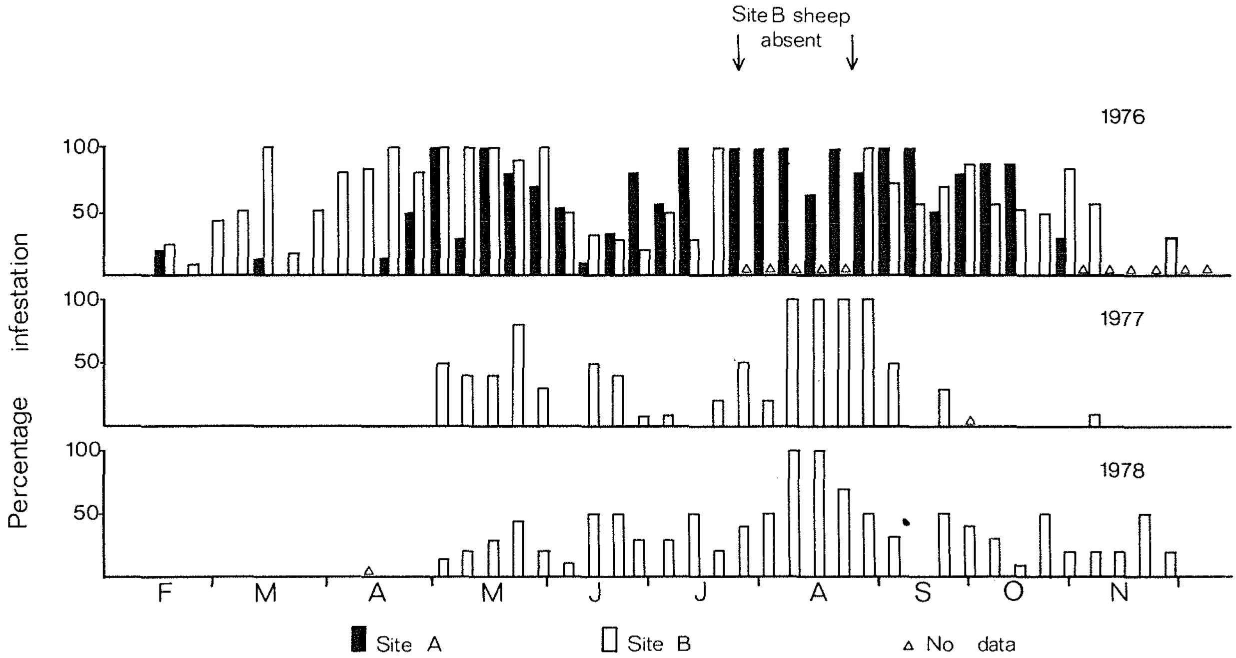

FIG. 2 : Percentage of sheep infested with *I. ricinus* larvae at Sites A and B.

out in 1977 and 1978. At site B all tick counts were made on sheep throughout the study period, 1976-1978. At site C which was sampled in 1978 and 1979 only blanket sampling was carried out.

Tick counts on sheep : Adult female and nymphal ticks were counted on the groin, axillae and head. It proved too difficult to count tick larvae but the proportion of animals with detectable larvae was recorded.

Tick counts on blankets : Blankets were used to capture active ticks on the vegetation and the procedure adopted was based on that described by MILNE (1943). The blankets, which measured 1.75 m × 1.15 m were supported by a length of wood on the leading edge and were dragged at a slow walking pace for 25 m, turned over, dragged for a further 25 m and then placed in plastic bags for subsequent examination in the laboratory. Five to six blanket drags were carried out at each sampling. Areas for dragging were selected at random but those dragged in the preceding 4 weeks were avoided.

■ *Meteorology*

A Stevenson screen containing a thermohygrograph was placed at each site and these instruments gave a continuous record of temperature and relative humidity at the three sites. Use was also made of weather data obtained from a meteorological station situated 10 km from site A and 4 km from sites B and C.

RESULTS

Site A

Spring and autumn activity of adults and nymphs were observed throughout the study period. Adult and nymphal activity occurred concurrently in spring, but peak autumn nymphal activity occurred 4-6 weeks after peak autumn adult activity. Almost all larval activity took place in mid-summer (June-August), although a few larvae were active in the spring. These features can be seen for both the tick counts on sheep (Figs 2, 3, 4) and the tick counts on blan-

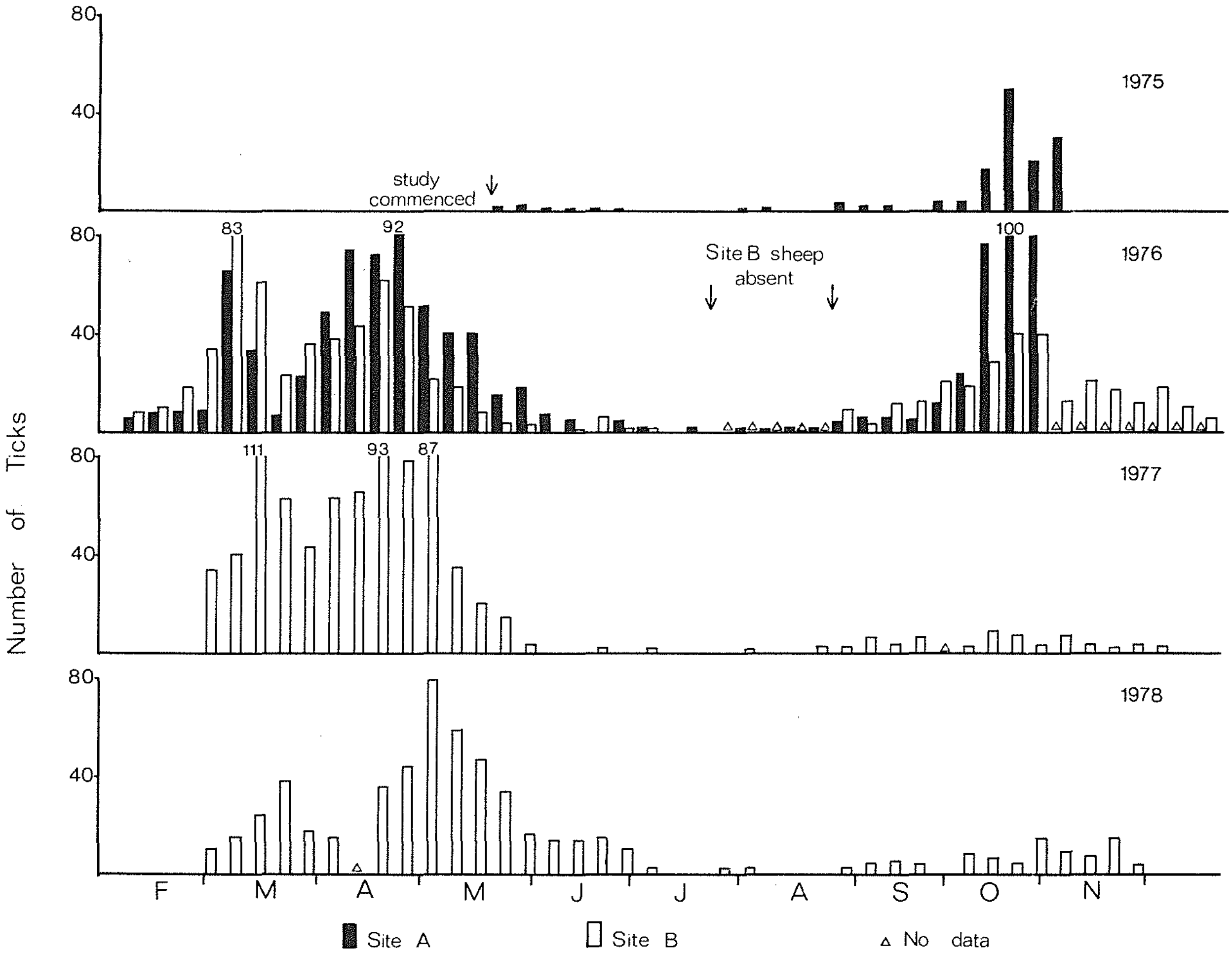

FIG. 3 : Mean numbers of *I. ricinus* nymphs on sheep at sites A and B.

kets (Figs 5, 6, 7). Although counts on sheep were only carried out for the first 2 years on this site it was found that they compared surprisingly well with counts on blankets and a statistically significant correlation was obtained for nymphs during 1976 (GRAY et *al.*, 1978).

A notable feature of the blanket counts is that autumn adult activity was initially greater than in spring but by the last year of the study on this site (1978) spring activity had become dominant and autumn activity was much reduced in relation to spring activity (Fig. 7). The same increasing prominence of spring activity relative to autumn activity can be observed for the nymphs, although nymphs were always more numerous in spring than in autumn (Fig. 6).

A marked increase in tick numbers particularly larvae, occurred on this site up to 1977. This was partly due to the continuous stocking in 1975 and 1976 and after normal stocking was resumed in 1977 fewer larvae and nymphs were present in 1978. For the adults the situation is complicated somewhat by the shift from autumn to spring activity.

Site B

Although this habitat showed considerable differences in vegetation and stocking pattern from

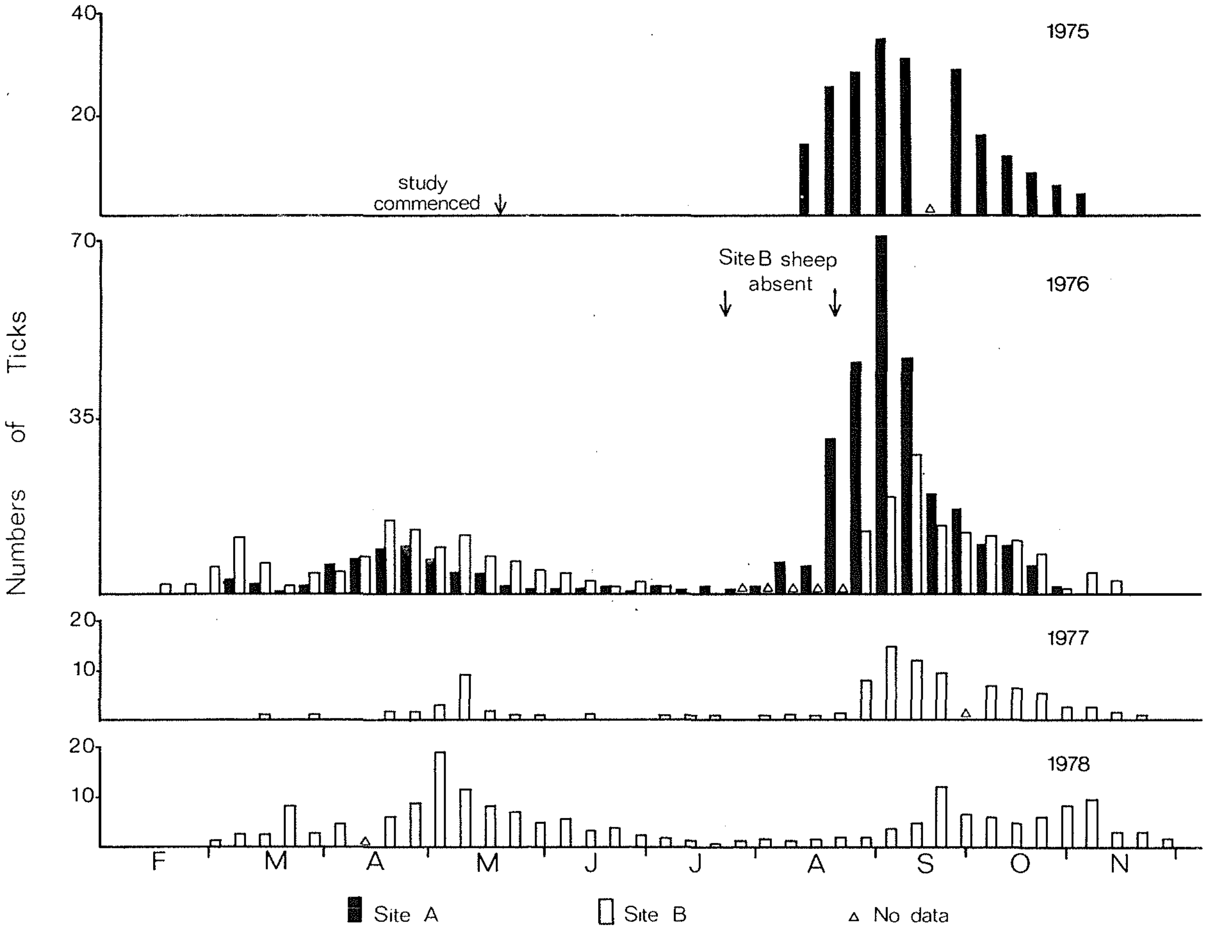

FIG. 4 : Mean numbers of *I. ricinus* females on sheep at sites A and B.

Site A, patterns of tick activity were similar (Figs 2, 3, 4). However, spring activity of all stages was initially more prominent than at Site A and also the increase in numbers of nymphs in 1977 was much less than occurred at Site A. (Fig. 3).

Despite the high stocking density throughout the study on this site numbers of ticks did not seem to increase, which contrasts with the situation on Site A.

Site C

Studies on this site were commenced in order to determine the continuation of trends observed at Site B, where work had to be discontinued.

The results confirmed the developing domination of spring-active adults and nymphs over the autumn population and in both years (1978, 1979) spring nymphs and adults were much more numerous than in autumn. Although many adults were present in spring 1978, larval activity still seemed to be largely confined to midsummer in the following year.

The effect of temperature on tick activity

It was established that the temperature threshold for activity was 7°C (weekly average maximum daily air temperature) for ticks on sheep and 10°C (current air temperature) for ticks on blankets. For analysis weather data were selected to exclude sub-threshold temperatures and periods when tick

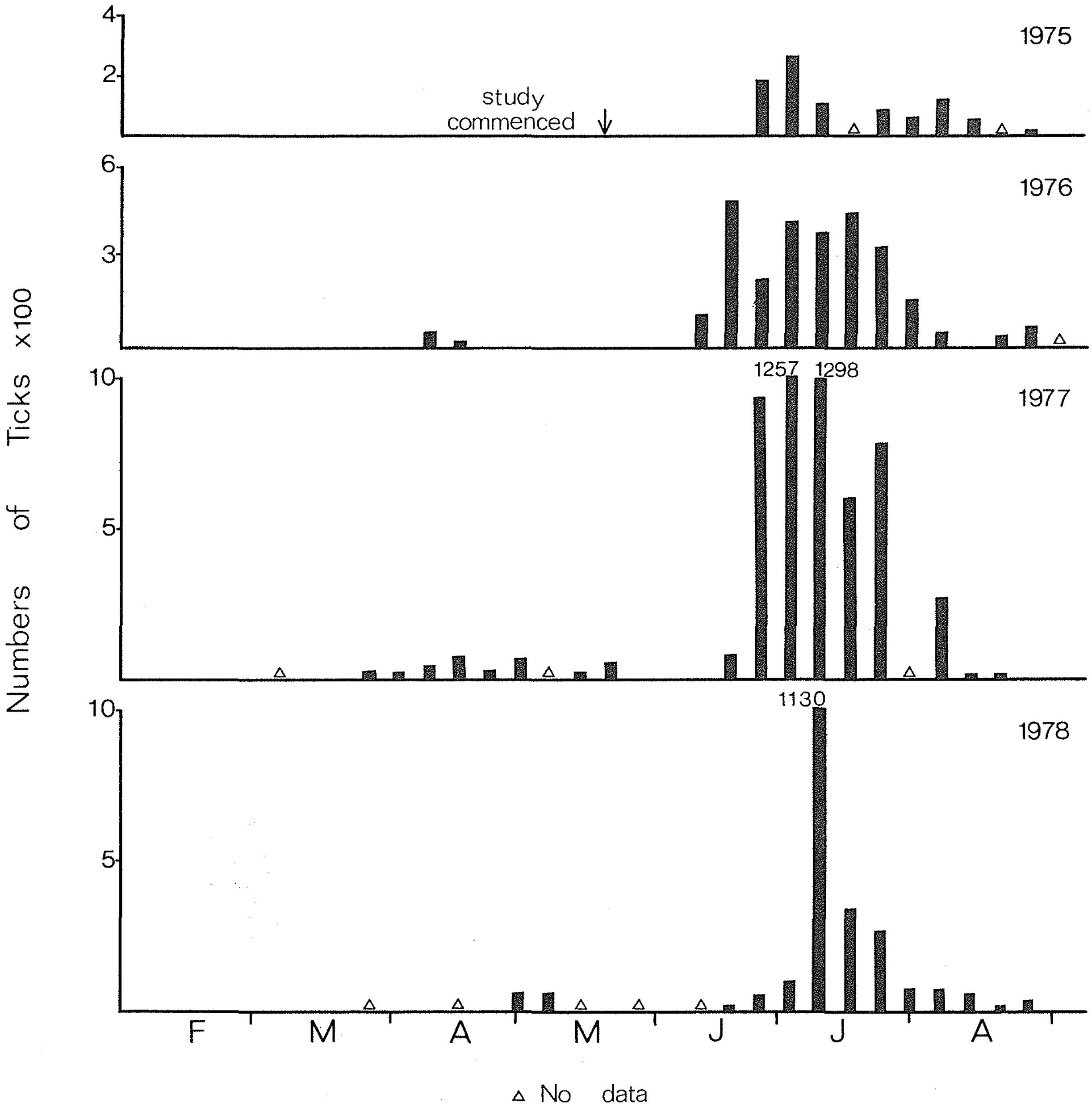

FIG 5 : Numbers of *I. ricinus* larvae per six blanket-drags at Site B.

activity was declining as a result of exhaustion of the population. The results show that these measures resulted in significant positive correlation between air temperature and numbers of spring nymphs, spring adults and autumn adults on sheep, but in negative correlation between air temperature and autumn nymphs (Table 1). No significant correlations were obtained between air temperature and larvae or autumn nymphs captured by blanket dragging. A weak correlation was obtained for spring nymphs.

■ *Activation threshold temperature*

An attempt was also made to determine at what temperature ticks became activated in the spring.

TABLE I. Correlation coefficient for weekly activity of ticks and air temperatures during the rising phase of tick activity (Spring = Feb-June, Autumn = July-Oct.).

Tick counts on sheep (threshold 7°C average max. daily temp).

	n	r	P
Spring (Feb-June)			
Nymphs	32	0.5363	< 0.01
Adults	34	0.3532	< 0.05
Autumn			
Nymphs	62	— 0.3889	< 0.01
Adults	62	0.6102	< 0.001

Tick counts on blankets (threshold 10°C air temperature at sampling)

	n	r	P
Larvae	37	— 0.0993	> 0.1
Spring nymphs	17	0.4834	< 0.05
Autumn nymphs	38	— 0.2426	> 0.1

This was done by comparing temperatures taken at 50 mm soil depth with tick activity data obtained by counts on sheep and on blankets. It was found that appreciable numbers of nymphs and adults occurred on sheep when soil temperatures in the previous week averaged 4.3°C and 4.75°C respectively. For ticks caught with blankets the activation temperature for nymphs was 6.8°C and for the adults 7.1°C.

DISCUSSION

Bimodal activity of nymphal and adult *I. ricinus* has been described previously for both Western Britain (MACLEOD, 1939 ; MILNE, 1945 ; EVANS, 1951) and for Ireland (WALTON & O'DONNELL, 1967) and was, therefore, expected in this study. Nymphal and adult activity occurred concurrently in the spring which is in agreement with these earlier studies, but peak nymphal activity in the autumn occurred much later than adult activity, a feature that does not seem to have been described before. Studies on confined ticks in the field have shown that this late peak of autumn nymphs is derived from larvae that fed before August in the same year (GRAY, 1982). Nymphs derived from larvae that overwintered in developmental diapause become active in early September (GRAY, 1982) and were not very prominent in the present study.

Larval activity in this study was almost monomodal and most activity took place in July and August. Such midsummer larval activity has been described several times in Continental Europe (ČERNÝ *et al.*, 1974 ; CHMELA, 1969 ; MERMOD, AESCHLIMANN & GRAF, 1973 ; SIMON, RANCIEN & EUZEBY, 1974, WALTER & LIEBISCH, 1980), but only once in Britain (BARNETT, 1965). It has been established that adult ticks that feed in the autumn give rise to larvae that become active in late July and August in most years whereas larvae from spring adults become active in late May (GRAY, 1982). It is probable, therefore, that most midsummer larvae are derived from autum-fed adults. However, even though adults became more numerous in spring than in autumn in the latter part of the study, most larval activity still occurred in midsummer rather than in spring. This aspect is being studied further.

The midsummer larval activity seems to have been crucial in determining the dynamics of tick populations in the different seasons during this study. It is probable that the warm summers of 1975 and 1976 (Fig. 8), resulted in many larvae, derived from autumn adults, becoming nymphs in spring by feeding before the diapause threshold period of early August (GRAY, 1982). This nymphal population was probably also contributed to by larvae which came out of developmental diapause as a result of high temperatures ; diapause being broken by air temperatures of 21°C or more in the laboratory (CAMPBELL, 1948). Furthermore it is likely that the very dry conditions in August 1976 killed many larvae that fed at this time. Only 5.9 mm rain fell during this particular month compared with an August average of 29.4 mm for 1974-1979.

These processes explain the decrease in numbers of autumn nymphs and the increase in spring nymphs in the following year (1977) so that by 1978 most adult activity took place in the spring rather than the autumn — a reversal of the situation observed in 1976. It appears that a similar large scale transfer of autumn ticks to the spring population probably occurred in 1966 in Czechoslovakia (CHMELA, 1969).

An attempt to investigate the effect of altering stocking patterns on the dynamics of tick populations met with limited success mainly because of the complications produced by the hot summers of 1975 and 1976. It is probable, however, that the increased stocking density at Site A in the autumn of 1975 and 1976 resulted in increased numbers of larvae in 1976 and 1977. After resumption of the normal stocking pattern in 1977 there was a decrease in numbers in 1978.

It was anticipated that a similar increase in midsummer larvae would occur at Site B, but instead there was an overall decrease. The sheep on this site lost condition and their enforced withdrawal during the midsummer larval season of 1976 was partly responsible for this decrease. It is also probable that the high stocking densities on this site, combined with the very dry conditions in the autumn of 1976, resulted in some destruction of tick habitat with consequent poor survival of engorged stages. The withdrawal of sheep during the 1976 larval season also explains the relatively small increase in spring nymphs in 1977 compared with Site A.

The initial dominance of the autumn population at Site A owes something to stocking patterns. However, this factor does not explain the initially

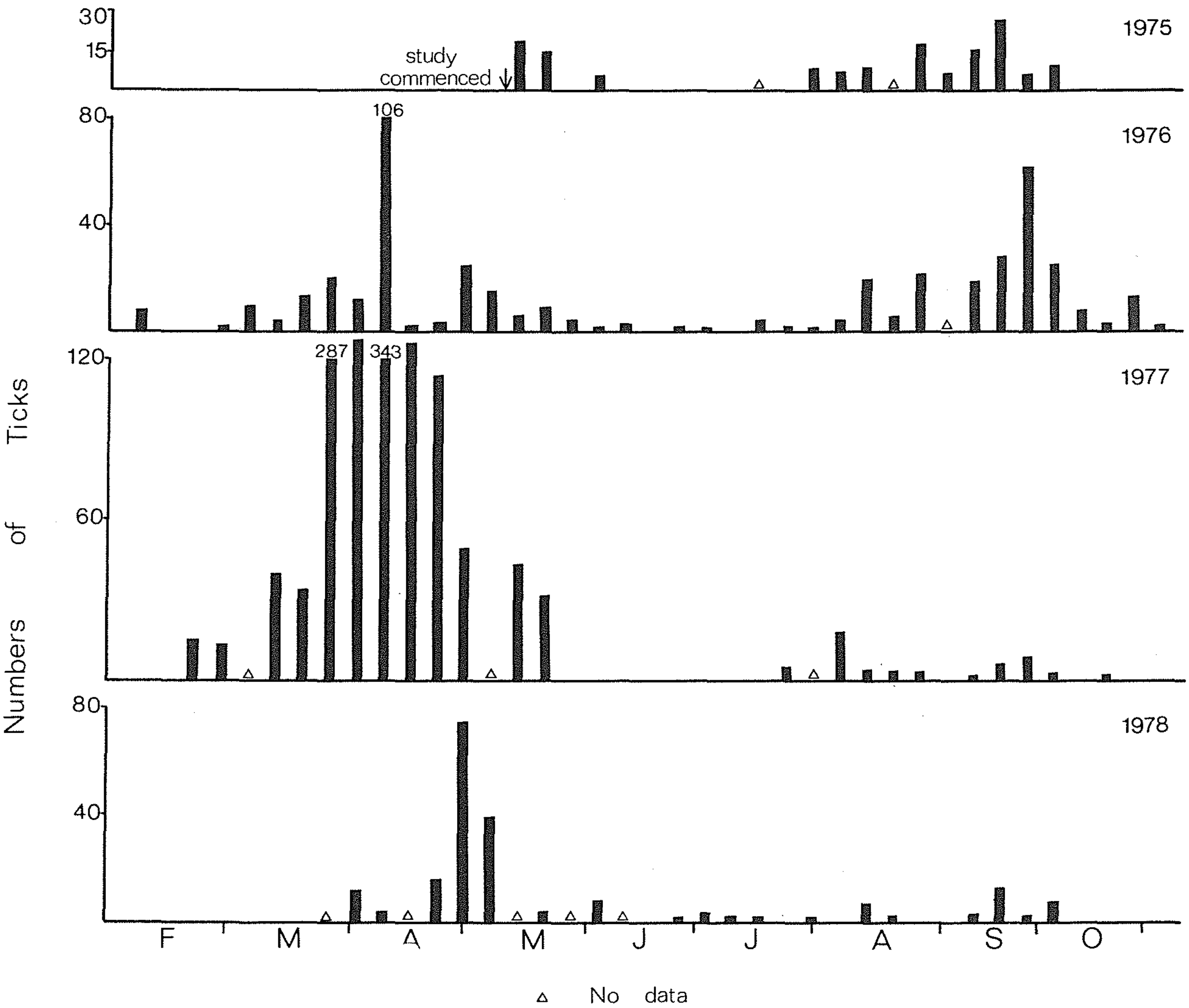

FIG. 6 : Numbers of *I. ricinus* nymphs per six blanket-drags at Site B.

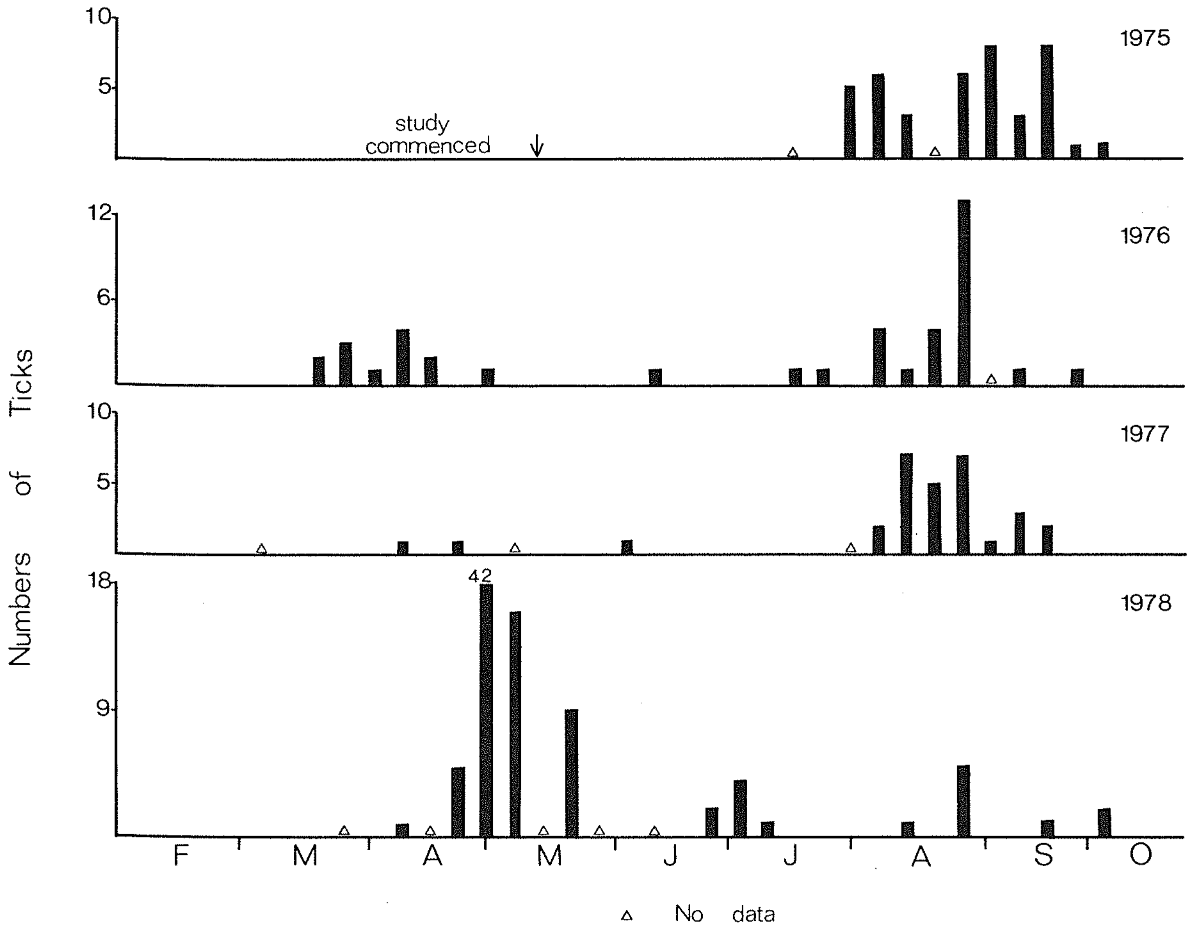

FIG. 7 : Numbers of *I. ricinus* adults per six blanket-drags at Site B.

prominent autumn population at site B, which probably arose by the slow recruitment of spring-fed larvae and nymphs to the autumn population in the preceding few years. This would have occurred when the summer weather was warm and moist enough to allow individuals to moult and become active again in the same year, but not hot enough to enable large numbers of larvae, derived from autumn adults, to become spring nymphs.

There was some inconsistency in the relationships between air temperature and tick activity above threshold temperatures and this does not entirely support the findings of NOSEK (1978), who demonstrated that, in the laboratory, tick activity increases with increasing temperature. However, the data presented here are also supported by another study in Co. Meath (GRAY, 1980) and it would seem that any effect that temperature might have on tick activity above the threshold is obscured by the overall pattern of availability and exhaustion of a population of active ticks.

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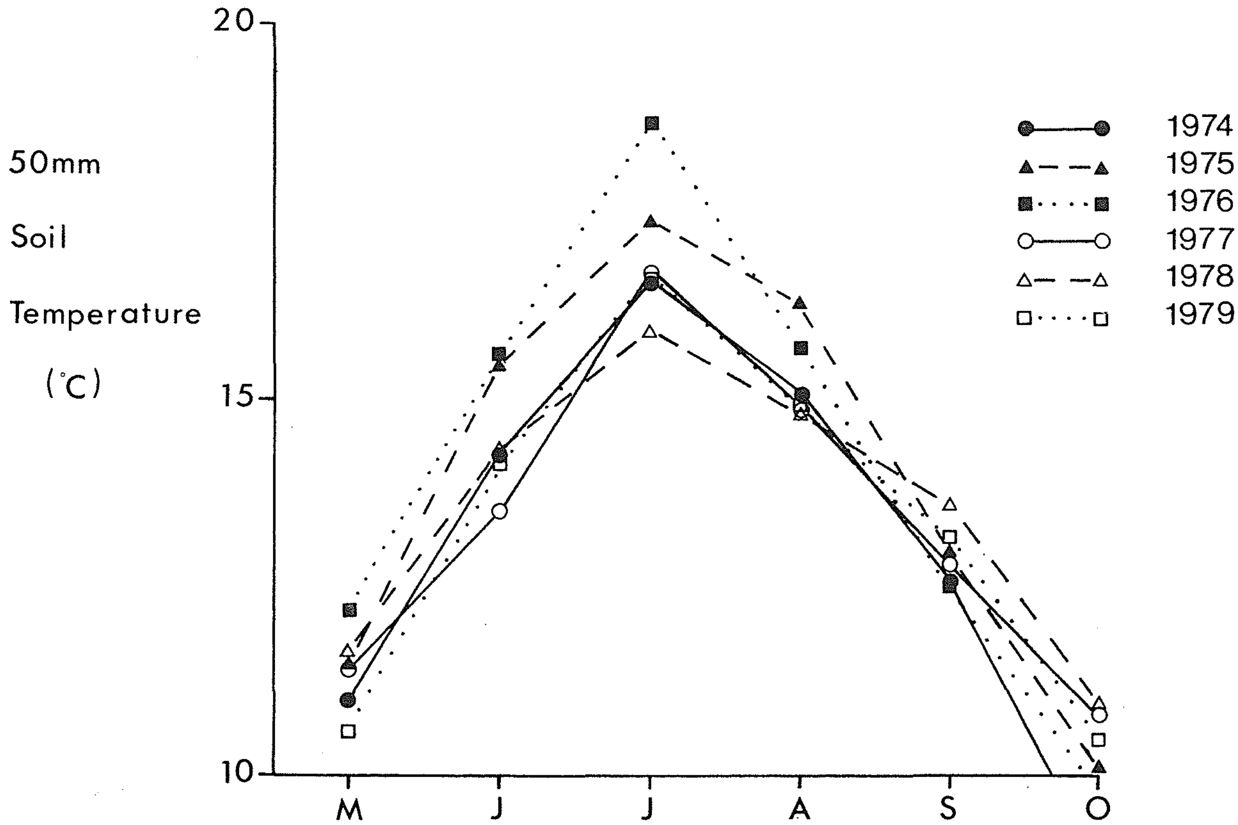

FIG. 8 : Average monthly soil temperatures at 50 mm, Rathdrum, Co. Wicklow 1974-1979.

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