ON THE DEVELOPMENT OF THE TICK IXODES HEXAGONUS LEACH, 1815 IN THE NORTH-MORAVIAN NATURAL FOCUS OF TICK-BORNE ENCEPHALITIS

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Abstract. The paper comprises the results obtained in studies on the development of individual stages of the tick *Ixodes hexagonus* Leach, 1815, conducted in a forest clearing in the foothills of Nízký Jesenik (altitude 325 m), where a 2 to 6-year cycle of development was ascertained. The 3-year developmental cycle was predominant.

The tick *Ixodes hexagonus* is the abundant parasite of the hedgehog (*Erinaceus roumanicus* Barr. Ham., *E. europaeus* L.), fox (*Vulpes vulpes* L.), dog (*Canis familiaris* L.) and polecat (*Putorius putorius* L., *P. evermannii* Lesson) in Czechoslovakia. As early as 1952 Rosický and Weiser (1952) directed attention to the species *Ixodes hexagonus* as possible vector of pathogenous agents within the range of several host species (hedgehog, fox) and in this connection also to its finding on man. The importance of this species as vector in the transmission of tick-borne encephalitis (TBE) virus was experimentally proved by Streissle (1960). The great importance of the specific host of this species, the hedgehog, in the circulation of the TBE virus was demonstrated by Kožuch et al. (1967). In the natural foci of TBE this tick was frequently found on hedgehogs, different developmental stages occurred together with the ticks *Ixodes ricinus*. While assessing the degree of importance of the tick *I. hexagonus* in the natural foci of TBE in Czechoslovakia and its epidemiological or epizootological importance at large, the bionomy of this species should be studied. Its seasonal occurrence in England and the developmental changes of individual stages at various temperatures in laboratory are relatively well known (Arthur 1963). The development of this species by method of exposing the ticks to direct effects of natural environment between feeding on host has not been studied up till now. For this reason we studied its developmental cycle in the TBE natural focus directly.

MATERIAL AND METHODS

Our methods were similar to those used by Černý (1958). Four females collected from hedgehogs in April and 6 females collected in June 1965 were used in our studies. Other ticks were the progeny of these females and were reared in the field. The ticks were allowed to feed on white laboratory mice (Nosek 1956) and after they fell off they were placed in glass tubes. One glass tube contained 1—2 females, 1—8 (usually 5) nymphs and 4—34 (usually about 10) larvae. A total of 24 females, 62 nymphs and 435 larvae were studied. The ticks were brought to the laboratory immediately before
feeding and the tubes containing engorged ticks were placed back in the field. They were covered with a layer of litter about 5 cm high and inspected at 14-day intervals. The beginning and course of oviposition, moulting and hatching of larvae and nymphs were traced in 1965—1969.

The capability of ticks to attack a host soon after moulting was tried out on white mice whose legs and tails were fastened to a wooden board with a sticking plaster to restrict their activities except feeding. The board with a mouse taped to it was placed in a glass container measuring 20 × 10 × 10 cm and covered with a silon fabric and a plastic lid with small openings for air supply. To keep the air humid inside the container a moist cotton wool was added and the ticks placed on it. After 24 hours the number of attached and unattached specimens was counted. In this way 137 larvae, 46 nymphs and 4 females were observed at various time intervals.

CHARACTERISTICS OF REGION AND LOCALITY STUDIED

The region and locality were described in the studies on the developmental cycle of the common tick (Chmelka, 1969), carried out in the same locality in 1965—1967. The data differ only in mean annual temperature: while studying the development of I. hexagonus the mean temperature in January was —3.3 °C, in July 18.1 °C.

RESULTS

The females had been feeding on white mice for 7—21 days, falling off and ovipositing from March to September (in groups of the same date of feeding there was always simultaneous oviposition) 25—67 days after engorgement (Fig. 1). The females which left their host in the middle of August and in September continued to lay eggs from March to May of the next spring. The females which left their host in October started to oviposit in spring, first in April, then in May 202 and 208 days after engorgement. (The oviposition which started in May to August lasted maximally about one month, while the oviposition throughout winter lasted about 7.5 months and the oviposition which started in April lasted about 1.5 months.)

![Graph](image)

**Fig. 1.** The beginning of oviposition by females after engorgement in the first year and the course of hatching of larvae from the deposited eggs.
From the eggs deposited until the first half of July larvae hatched from August to November the same year. The interval between the beginning of oviposition and the moment larvae started to hatch was 91—132 days. From the eggs deposited since the first half of July and later larvae hatched between March and October the next year. The interval between the beginning of oviposition and hatching was 239—348 days (Fig. 1).

Larvae had been feeding on white mice for 6—14, mostly 7—12 days. Those which had been feeding in the period from spring till August moulted from June to November of the same year 36—123 days after engorgement (Fig. 2). Larvae which finished feeding in September overwintered in the engorged state and had been moultling since the end of March until June 188—290 days after engorgement.

Nymphs had been feeding 7—21 days, usually 7—14 days. Those which finished feeding between March and the beginning of August moulted between June and November the same year 46—115 days after engorgement. The nymphs which finished feeding at the end of August and in September underwent diapause and moulted in June and July next year 293—330 days after engorgement (Fig. 3).

We observed that larvae were capable to feed (by attachment to white mice under a plastic cover) from March to September after 24—26 days since hatching, nymphs between April and August after 24—30 days since moultling and females in July after 28 days. Only a small percentage of larvae and females attached themselves to the host after two months since hatching and moultling. (The ticks which failed to attach themselves perished.)

Larvae and nymphs were capable to attack the host (in the glass container) and attach themselves to it after one month since hatching and moultling (33 days), while females were ready for feeding on the host after two months (64 days). During the autumn the ticks ceased to be active, larvae accumulated into clusters and all stages moved slowly only when stirred up by warmth.

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*Fig. 2. The course of moulting of larvae after engorgement in the first year.*
In the terrain all stages overwintered both in engorged and unengorged state. Also eggs overwintered. All stages of ticks which overwintered in unengorged state continued to live until the autumn, but most of them perished during the summer.

**Fig. 3.** The course of moulting of nymphs after engorgement in the first year.

**EVALUATION OF RESULTS**

Our results are similar to those obtained in laboratory culturing by Arthur (1963) who used a natural host - the hedgehog. Probably because we used an unspecific host (white mouse) in our laboratory studies, the ticks had been feeding somewhat longer. After Arthur (1963) the seasonal occurrence of ticks *I. hexagonus* has two maxima (similar to those of *I. ricinus*), one in spring and second in autumn. Dyk (1957) reported from Brno the occurrence of females, nymphs and larvae in May and of females and nymphs in July.

The developmental changes of individual stages of ticks, their capability to attack and feed on host soon after metamorphosis as well as the survival of unengorged ticks and occurrence of ticks throughout the year indicate a 2 to 6-year developmental cycle. Fig. 4 shows some examples of possible developmental cycles. The 2-year cycle shown refers to a smaller number of progeny from females feeding in spring and autumn. In this case with all stages shortly after moulting only a small number of those ticks were feeding which were the first to finish metamorphosis. The main cycle proved to be 3-year cycle with maximum occurrence of feeding ticks in spring and autumn. The ticks readily attached themselves only after hibernation. As they have a close biological relationship to the range of hosts and attack a host as soon as they are physiologically mature, we assume that the 3-year developmental cycle is predominant. This fact is indicated by considerable deaths of ticks during summer when they did not find a host in spring and failed to engorge. Due to the seasonal occurrence which in general lines corresponds with the occurrence of the ticks *I. ricinus* we assume that 3 to 6-year developmental cycles are mainly to be anticipated as with the species *I. ricinus* (Černý 1958, Chmela 1969). The period between the engorgement of females and the hatching
of larvae is somewhat longer, otherwise the developmental periods are shorter than with *I. ricinus*. On an average, the development of ticks *I. hexagonus* appears to be shorter than the development of the species *I. ricinus*.

![Diagram](image)

Fig. 4. Some examples of developmental cycles of the tick *Ixodes hexagonus* Leach, 1815.

The metamorphosis (hatching and molting) lasts for a longer period than with *I. ricinus*, except the molting of nymphs, practically throughout the warm season. This fact conditions the existence of an endless number of further combination possibilities in which the developmental cycle lasting 2–6 years surely occurs, although to a smaller extent.

**REFERENCES**

ALFEJEV N. I., (Long-time cycle of development of ticks *Ixodes ricinus* L. in natural conditions of Leningrad district.) Veterinarija 7: 11–12, 1947. (In Russian.)


Received 15 January 1970. J. Ch., OHS, Wolkerova 6, Olomouc, ČSSR
This publication, as stated by the author in the Introduction, has been assigned to the widest public. It is informative, readable and will be useful to both specialists and laymen. It covers 204 pages including the index and is accompanied by 81 drawings.

The Introduction deals with the nature of parasitism, helminthology and worms. This is followed by well-illustrated chapters on the transition from free to parasitic life and a survey of the most important infections of animal and man. In the section Nematoda the author describes and figures the life cycles of several nematode species parasitizing man, such as *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Enterobius vermicularis* and *Wuchereria bancrofti*; the next chapter deals with lung and intestinal nematodes of domestic animals parasitizing sheep, cattle, horse and swine (*Dictyocaulus*, *Ascaris*, *Ascarops*, *Physocelis, Trichinella*) and the most important nematodes of fishes and passeriform birds (*Contracaecum, Porrocaecum, Camallanus, Syngamus* etc.). The chapter on Acanthocephala contains a detailed description of their anatomy and data on the life cycles of several species of Acanthocephala accompanied by original drawings.

The section Trematoda is the largest covering 80 pp. It contains illustrations of the life cycles of the most important parasites of wild and domestic animals such as *Fasciola, Paraphistomum, Dicrocoelium, Prosthogonimus*. Special attention has been given to the life cycles of bird trematodes — the genera *Cotylurus*, *Strigea* — and to trematodes of the families *Diplostomidae*. This section is concluded by notes on schistosomiasis of man.

The section Cestoda contains descriptions of various cestode genera (e.g. *Hymenolepis, Diphylidium, Mesocestoidea*), discussions on diphyllobothriasis, echinococcosis and drawings of various types of cysts recorded from animal and man.

In the chapter Monogenoidea, the routes of infection and the development of parasites of this group are described.

In conclusion, a short chapter has been devoted to leeches and tongue worms.

The book offers a clear-cut picture of the origin of helminthic infections and the various routes of infecting the hosts; it elucidates, at the same time, the economic importance of these infections. It can be highly recommended to all who are interested in parasitology as a very serious and valuable work.

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