POSSIBILITIES OF PERSISTENCE IN NEW BIOTOPES OF TICKS IMPORTED BY BIRDS

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Abstract. Survival and development of 6 tick species (*Hyalomma anatolicum, Rhipicephalus sanguineus, Haemaphysalis punctata, Dermacentor marginatus, D. reticulatus* and *Ixodes ricinus*) were studied in 3 groups differing in the range of distribution with respect to the place of importation, as a model for the knowledge of their possible inclusion in the new local biocenosis during transportation by natural hosts.

In spring and autumn millions of birds migrate annually between continents. The routes of European bird species lead mainly to Africa. About 600,000,000 birds are estimated to migrate annually from Europe westward from the longitude of 34° E (Moreau 1961-after Nuorteva and Hoogstraal 1963). Naturally, in both directions the birds carry their permanent ectoparasites, e.g. biting lice (Mallophaga) and feather mites. Regular studies showed (Hoogstraal and Kaiser 1961, Hoogstraal et al. 1961, 1963, 1964) that during migrations in both seasons many bird species are also infested with ticks, mostly with larvae and nymphs. This fact may be illustrated by the results from Egypt, where the infestation in 13 positive bird species studied in spring varied between 4.8—60.0 %, with 1.0—5.6 ticks per positive bird (Hoogstraal et al. 1961). The above mentioned figures signify the enormous numbers of ticks which are regularly imported in spring from Africa to Europe where they subsequently leave their hosts. Similar connections naturally also exist between other continents. Due to the fact that ticks are known to be vectors of many pathogenous agents of paramount importance, there is a real possibility of importation of some of these agents from other continent (Hoogstraal 1961, L'vov and Lebedev 1974). Further dissemination of pathoergont in the place of importation might be anticipated during its transstadial and transovarial transmission, or possibly when the imported tick is devoured by some susceptible vertebrate. In fact, however, all ticks imported by birds to more northern regions perish or at most produce new adults which are to be found sporadically in places outside regions of their occurrence. Such are e.g. the findings of *Amblyomma variegatum* from tropical Africa in France (Lamontellerie 1954) or in Bulgaria (Levi 1969), of *Amblyomma hebraeum* from south Africa in Bulgaria (Pavlov and Popov 1951) or of *Amblyomma gemma* from east Africa in the USSR in Crimea (Klyushina 1972). Also in the USSR the east African species *Amblyomma lepidum* was found on *Burhinus oedicnemus* (Pospelova-Shtrom and Abusalimov 1957) and the south-east-Asiatic species *Haemaphysalis ornithophila* on *Turdus dauma* (Pospelova-Shtrom and Naumov 1965). With the spring migrants from Africa to Europe *Hyalomma marginatum rufipes* is found most frequently (Hoogstraal et. al. 1961, 1964). A small number of the ticks *Hyalomma marginatum* sspp. (including *Hyalomma marginatum marginatum*) happen to be regularly transported as far as Finland (Nuorteva and Hoogstraal 1963, Saikku et al. 1971) and Sweden (Brinck et al. 1965). This species, parasitizing migrant birds (*Anthus trivialis, Luscinia suecica, Erithacus rubecula*), has been also reported from

Czechoslovakia (Černý and Balát 1957). A single female was collected in this country from cattle in southern Slovakia (Černý 1972). In regions situated between wintering grounds and nesting sites the fauna of ticks transported by birds is obviously much more heterogenous, as evidenced by *Amblyomma lepidum*, *Amblyomma nuttalli*, *Amblyomma variegatum* and *Argas streptopelia* found on spring migrants in Cyprus (Kaiser et al. 1974).

With regard to all above mentioned facts we set up the goal in our studies to elucidate under conditions in this country, the developmental possibilities of the ticks

a) whose range of distribution is considerably distant from the site of planting, the supposed place of importation,
b) whose range of distribution is situated near the place of importation,
c) whose place of importation is within their range of distribution.

For these studies we selected the representatives of the family Ixodidae, because they belong, together with mosquitoes, to the best known vectors of transmissive diseases and because their importations outside the range of their normal distribution occur regularly in nature every year and the methods of their colonization under natural conditions have been well elaborated.

MATERIAL AND METHODS

Origin of experimental material. Ticks used in the studies described below were obtained in two ways. The first group consisting of unfed adults was collected by flagging method in the field, the second group came from laboratory colonies. Exact names of localities are stated with each species. The ticks of both groups were allowed to feed on rabbits directly at the site of experiment. Engorged adults were used for a long-term experiment. Total numbers of ticks used are stated in the Results.

Methods used in the field experiment. For the studies proper two biotopes differing in temperature were selected, henceforward denoted as "forest" and "meadow", situated in the vicinity of the field station Belvedere at Valtice. The first biotope is a deciduous forest with abundant litter and humus, the second is an open sunny terrain overgrown with grass. Detailed methods employed in the experiment are described in the paper by Daniel et al. (1976).

RESULTS

1. TICKS PLANTED OUTSIDE THE RANGE OF THEIR DISTRIBUTION

Hyalomma anatolicum excavatum Koch. At the beginning of May 4 engorged females from laboratory colonies of this species were planted in the meadow. All females oviposited during June, but in no batch of eggs larvae hatched. All females and batches of eggs were attacked by fungus.

Rhipicephalus sanguineus (Latr.). Towards the end of August a total of 9 engorged females from laboratory colonies were planted in the meadow and the forest. No one of the planted females laid eggs. During control carried out at the beginning before overwintering 7 females were found to be dead, 2 females planted in the meadow were alive. After termination of overwintering these two females were already dead.

2. TICKS PLANTED AT THE OUTER MARGIN OF THEIR RANGE OF DISTRIBUTION

Haemaphysalis punctata Can. et Fanz. At the beginning of May 9 engorged females collected in southern Slovakia (Dolné Tisovce) were planted in the meadow. At the end of May all females oviposited. In four cases no larvae hatched from the eggs, in five cases the hatching took place. Larvae from two batches of eggs were left for survival. During July unfed larvae of this species survived maximally 4 weeks. Larvae from three batches of eggs were allowed to feed. They attached themselves very reluctantly and of the whole number only 8 larvae engorged at the end of July. After three weeks (in mid-August) 4 nymphs moulted but refused to feed.

Dermacentor marginatus (Sulz.). The specimens of this species were of similar origin as those of the preceding species. In the forest 34, in the meadow 35 engorged females were planted at the beginning of May.

In the forest 32 females (94.1 %) oviposited at the end of May, and larvae hatched in 28 batches of eggs at the beginning of July (82.3 % of the number planted). Larvae from 23 batches of eggs were left for survival, but they lasted maximally 4—5 weeks. Larvae from 5 batches of eggs were allowed to feed in the second half of July and their subsequent development was observed. From these 5 batches a total of 3,169 larvae engorged and 2,602 nymphs (82.1 %) moulted from them. The development from engorged larva to unfed nymph was very short, the first nymphs appearing as early as 14 days after engorgement of larva. When they were allowed to feed soon after moulting, a total of 742 nymphs engorged. Before hibernation the nymphs did not moult, in the spring some of them were dead, but the remaining engorged nymphs survived until June of the next year. Not a single adult moulted from the total number.

In the meadow in the same period as in the forest, 33 engorged females (94.3 %) oviposited, and in 22 batches of eggs larvae hatched at the end of June (62.9 % of the number planted). Larvae from 17 batches of eggs were left for survival. The length of survival was as long as that in the forest, larvae surviving until the end of July. Larvae from 5 batches of eggs were allowed to feed at the beginning of July and their subsequent development was studied. A total of 7,868 larvae engorged, out of which 5,614 nymphs moulted (71.4 %). The development from engorged larva to unfed nymph lasted as long as that in the forest. Within 14 days after moulting the nymphs were allowed to feed, of these 1,322 engorged and similarly as in the forest survived a relatively long time (the last specimen did so until June next year), but no adult moulted from them. Some of the unfed nymphs (410) were left for survival; the nymphs that had moulted at the end of July survived until the beginning of October.

3. TICKS PLANTED WITHIN THE RANGE OF THEIR DISTRIBUTION

Dermacentor reticulatus (Fabr.). This species does not occur directly in the given biotope, but it has been found in a limited area of a locality about 30 km away from the place of experiment. Two groups of ticks were used in the studies. One group was collected in nature on the border between Moravia and Slovakia (Moravský Ján), the second group came from laboratory colonies.

In the first group (ticks collected in free nature) 25 engorged females were planted in the forest at the beginning of May, average weight of female being 0.42 g. 24 females oviposited at the end of May and larvae hatched in 22 batches of eggs. 16 batches of eggs were left for survival and during the summer months larvae survived maximally 5 weeks. Larvae from 6 batches of eggs were allowed to feed in mid-July, and a total of 958 larvae engorged; after a very short period (at the end of July) 722 nymphs (75.3%) moulted from them. The nymphs from 3 batches were left for survival; 6 weeks proved to be the maximum period (until the beginning of September). The nymphs originating from another 3 batches were allowed to feed in mid-August; a total of 33 nymphs engorged, but they moulted into adults neither before hibernation nor before the beginning of subsequent vegetation season.

25 engorged females of this group were planted in the meadow, each weighing 0.35 g on the average. 24 females oviposited and in 16 batches of eggs larvae hatched. Larvae from 7 batches of eggs were studied for the length of survival. In contrast to the similar group studied in the forest, the larvae in the meadow survived a shorter period (2 weeks), no longer than until the beginning of July. Larvae from 9 batches of eggs were allowed to feed at the beginning of July, and a total of 1,489 larvae engorged. Out of this number 1,156 nymphs (77.6 %) moulted by the end of July. A group of nymphs survived until the second third of August. During feeding of another group of nymphs at the beginning of August 91 engorged, and produced a total of 19 adults (20.9 %). 10 adults moulted as early as in the autumn (at the beginning of November), the remaining ones (9) after overwintering in the spring of subsequent year. Single moulted adults survived as long as 5 months, but most of them died soon after moulting.

In the second group (ticks coming from laboratory colonies) 5 engorged females, each weighing 0.33 g on the average, were planted in the forest. All females oviposited, and from the eggs laid by 3 females larvae hatched at the beginning of July. Larvae from one batch of eggs were left for survival and lasted until the beginning of August. Of the larvae from two batches of eggs 98 engorged in mid-July, and 66 nymphs (67.3 %) moulted from them at the beginning of August. After one month the nymphs were allowed to feed, but only 3 engorged. All nymphs overwintered, 1 nymph succumbed after overwintering in April of subsequent year, 2 survived until May. In this group no adult was produced. Of the 6 females planted in the meadow and weighing each 0.33 g on the average, only 4 oviposited. In no batch of eggs, however, any larvae hatched.

Ixodes ricinus (L.) The ticks of this species used in the experiment originated from three groups: those flagged directly in the biotope where experiments were carried out; those collected from other region of Slovakia (Zlaté Moravce locality) and those from laboratory colonies. However, the adults used as initial material in this studies were allowed to feed directly in the site of experiment on the same hosts.

From the group collected in the biotope proper 13 engorged females weighing each 0.26 g on the average, were planted in the meadow at the beginning of May. Only 7 females oviposited, the mean number of eggs being 2,000. In no batch of eggs any larvae hatched.

In the same period 14 engorged females, each weighing 0.32 g on the average, were planted in the forest. 11 females oviposited, the mean number of eggs being 3,300. Larvae hatched in 10 batches of eggs. 4 batches of eggs produced larvae which were left for survival, the remaining larvae (in 6 batches of eggs) were allowed to feed. Since hatching unfed larvae survived in 3 batches between July and November, in one batch they survived the winter and large numbers were still alive until April of subsequent year. From 6 batches a total of 3,720 larvae engorged producing 49 nymphs (1.3 %) of which 20 engorged. Only 5 adults moulted from these 20 engorged nymphs.

The final production of adults in the two biotopes was far lower than in the preceding years in experiments on the developmental cycle of *Ixodes ricinus*. This fact may be explained by the high mortality during the development of engorged larvae due to their affliction with pathogenous fungi. Also microclimatic conditions of the vegetation zone might have played a role here.

Of the ticks collected in Slovakia 31 engorged females of average weight of 0.28 g were planted in the meadow. The mean number of eggs in batches was 2,400. 27 females oviposited and in 16 cases larvae hatched from the eggs. A total of 2,205 larvae engorged, of these 7 nymphs (0.3 %) moulted; 4 nymphs engorged, but no adult moulted from them.

31 engorged females of 0.28 g average weight were planted in the forest. The mean number of eggs in a batch was 2,400. 28 females oviposited and larvae hatched from all eggs. A total of 4,850 larvae engorged, from which 300 nymphs (6.2 %) moulted. 91 nymphs engorged and produced 45 ♀♀ and 25 ♂♂.

The females from laboratory colonies, in contrast to preceding groups, revealed a very low weight after engorgement (Tab. 1, 2), the average weight being 0.13 g. 6 females were planted in the meadow, only 2 females oviposited, but no larvae hatched in any of the two batches.

At the beginning of May 5 engorged females of 0.16 g average weight were planted in the forest. All females oviposited at the beginning of June and in 4 batches of eggs larvae hatched at the end of July. In September 315 larvae engorged. The majority of engorged larvae (231) died by the outset of overwintering, the remaining larvae overwintered and in August of subsequent year 2 nymphs moulted (0.6 %).

DISCUSSION

The results obtained in the studies with ticks planted outside the range of their distribution showed that the ticks (in experiments with engorged females) merely survived and at most were capable of oviposition as proved to be the case of *Hyalomma anatolicum excavatum*. However, no batch of eggs laid by *H. anatolicum excavatum* produced any larvae, although in the control colony of the same tick strain under standard laboratory conditions (22° C/90 % RH) larvae hatched within 37—52 days (Honzáková 1971). When engorged females of *Rhipicephalus sanguineus* were planted, no oviposition took place. Eventual objection that these females were planted too late, i.e. at the height of summer, was ruled out by parallel laboratory studies, in which the pre-oviposition period with this tick species lasted only 12—39 days (observed in autumn with the same strain of laboratory *R. sanguineus*). Consequently, the physiological state of ticks was not a hindrance to the oviposition taking place before the autumnal abrupt change of weather.

The experiments showed that the two tick representatives planted outside the range of their distribution are able merely to survive the vegetation period even in the warmest south-Moravian localities, but never to continue their developmental cycle, let alone to set up a local population. This fact rules out their contact with local fauna of vertebrates or introduction of the infectious agent into biocenosis.

Reactions of planted specimens of the second tick group, i.e. the species planted on the margin of their range of distribution in places where they do not occur, were different, but the results showed that neither in this instance any permanent foothold of the ticks and setting up of local population may be considered. Though 100 % of *Haemaphysalis punctata* oviposited, only one half of laid eggs produced larvae which attached themselves to the host very reluctantly and sporadically; the tick development practically halted at this stage. If we contemplate this fact under conditions of free nature, we may say that neither in this instance practically any contact of larvae with hosts could take place and consequently any eventual transmission of pathogenous agent would be conceivable.

In the second tick group *Dermacentor marginatus* showed best results: the first part of its developmental cycle progressed quickly and without any great losses. The successful development was halted by the ouset of winter; the engorged nymphs did not moult before the end of vegetation period and during the first spring checking the majority of them was dead. From the remaining small number of nymphs which had survived the winter, no adults developed. The dissection of dead nymphs showed that in all cases fully developed imagoes were inside, but they never became released from the nymphal exuvia. Thus, neither in this species the possible setting up of local population may be confirmed; in case that a pathogenous agent were imported along with the females transported by birds, only the contact with small murine mammals would be conceivable.

The third group of ticks planted within the range of their distribution was composed of *Dermacentor reticulatus* and *Ixodes ricinus*. *D. reticulatus* represented a transition between the group 2 and 3, because it does not occur at present in the close environment of the experimental site (in a beeline, its closest sporadic occurrence was about 30 km distant) but in the past its distribution in the south-Moravian region had been most probably greater. This fact agrees with the favourable outcome of its developmental cycle in the grassy biotope and the ability of the planted females to give rise to a local population and to join the biocenosis completely. In the experimental forest site such an outcome failed to be recorded. The development of *I. ricinus* showed good results, whether the planted specimens came from the population infesting the pastures in Slovakia, or from the forest biotopes (wild places of infestation) in the immediate surroundings of the experimental site. Fluctuations in the favourable outcome of the developmental process at its separate stages became practically balanced during a total assessment.

A significant difference in ticks of the third test group was revealed when the ticks collected in free nature and those coming from laboratory colonies were compared. Great differences were observed while comparing the size of batches of eggs. For this purpose we used the knowledge derived from other experimental material (Honzáková et al. 1975) that the size of batch depends solely on the amount of blood engorged by a female. We therefore weighed the tick females tested (Table 1) and found out that the egg production of the females from laboratory colonies was lower. This fact agreed with their decreased viability. The developmental cycle in *Dermacentor reticulatus* as well as in *Ixodes ricinus* coming from laboratory colonies did not take place even in the grassy site. We consider this observation to be very important because it shows clearly that conclusions drawn from experiments carried out with laboratory material, even under natural conditions, should be judged with caution.

The following conclusions may be drawn from the above investigations on developmental cycles of ticks of different provenance:

1. Ticks whose range of distribution is considerably distant from the place of importation, are unable to produce a new generation. A regular transstadial or transovarial transmission of pathogenous agent cannot be anticipated.
2. Ticks whose range of distribution is close to the place of importation, are halted in their further development depending on the species and conditions of environment which may considerably differ in different localities in particular years. The possibility of transstadial transmission of pathogenous agent and its inclusion in the local components of biocenosis may be reckoned with.
3. Ticks, whose place of importation is situated within their range of distribution are completely included in the other components of biocenosis and likewise is included the pathogenous agent harboured by the ticks.
4. Ticks from long-term laboratory colonies reveal in some life manifestations a decreased viability and in new environment are unable to complete their developmental cycle. The conclusions drawn from field experiments with colonized ticks should be therefore judged with great caution.

Table 1. Weight of engorged females of ticks from field experiments (planted in the forest)

Tick species and its origin	Weight of engorged ♀♀ in g			
	min.	max.	average	n
Ixodes ricinus — local natural population (thermophilic oak-forest)	0.210	0.440	0.32	14
Ixodes ricinus — natural population (pastures in Slovakia)	0.199	0.390	0.28	31
Ixodes ricinus — laboratory colonies	0.120	0.203	0.16	5
Dermacentor marginatus — natural population	0.179	1.123	0.64	34
Dermacentor reticulatus — natural population	0.209	0.998	0.42	25
Dermacentor reticulatus — laboratory colonies	0.132	0.576	0.33	5

Table 2. Weight of engorged females of ticks from field experiments (planted in the meadow)

Tick species and its origin	Weight of engorged ♀♀ in g			
	min.	max.	average	n
Ixodes ricinus — local natural population (thermophilic oak-forest)	0.100	0.444	0.26	13
Ixodes ricinus — natural population (pastures in Slovakia)	0.150	0.399	0.28	31
Ixodes ricinus — laboratory colonies	0.091	0.346	0.190	6
Dermacentor marginatus — natural population	0.326	0.904	0.64	35
Dermacentor reticulatus — natural population	0.208	0.526	0.35	25
Dermacentor reticulatus — laboratory colonies	0.064	0.397	0.33	6
Haemaphysalis punctata — natural population	0.153	0.488	0.26	9
Hyalomma anatolicum excavatum — laboratory colonies	0.311	1.087	0.80	4

ВОЗМОЖНОСТИ СОХРАНЕНИЯ ИКСОДОВЫХ КЛЕЩЕЙ В НОВЫХ БИОТОПАХ ПРИ ИХ ЗАНОСЕ ПТИЦАМИ

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Резюме. Изучено выживание и развитие 6 видов иксодовых клещей (*Hyalomma anatolicum*, *Rhipicephalus sanguineus*, *Haemaphysalis punctata*, *Dermacentor marginatus*, *D. reticulatus* и *Ixodes ricinus*) в 3 группах, различающихся по ареалу распространения, принимая во внимание место их заноса, в качестве модели для познания их возможного включения в местный биоценоз во время заноса естественными хозяевами.

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