IXODES POPULATIONS (*IXODES RICINUS* LINNÉ, 1758; *IXODES HEXAGONUS* LEACH, 1815) IN THE CITY OF LYON (FRANCE) AND ITS OUTSKIRTS: PRELIMINARY RESULTS

PICHOT J.*, GILOT B.**, ALMIRE N.*, POLETTE K.* & DEGEILH B.***

Summary :

For an eco-epidemiological purpose concerning environmental factors associated with Lyme borreliosis in France, *Ixodes* s.l. ticks were collected in the city of Lyon and its outskirts. The study area was divided in three ecological parts: urban core, suburban and periurban areas. Free stages of ticks were collected by using the flagging method; parasitic stages were picked up on domestic cat.

Two species were discovered: *Ixodes ricinus* (Linné, 1758), free and parasitic stages; *Ixodes hexagonus* (Leach, 1815), parasitic stages. Ixodes ricinus is more frequent as one goes from the very center of the city to the peripheral areas, where it colonizes natural as well as semi-natural and even some artificialized forests. *Ixodes hexagonus*, missing from town center, was collected in the suburban area but it was mainly found in the periurban area. Epidemiological incidence of these findings is emphasized.

KEY WORDS : *Ixodes*, Lyme borreliosis, eco-epidemiology, domestic cat, Lyon.

Résumé : LES POPULATIONS D'IXODES (*IXODES RICINUS*, LINNÉ, 1758; *IXODES HEXAGONUS*, LEACH, 1815) DANS LA VILLE DE LYON (FRANCE) ET SES ENVIRONS : PREMIERS RÉSULTATS

Des tiques Ixodes *s.l. ont été récoltées à Lyon et dans ses environs pour une étude éco-épidémiologique concernant les facteurs de l'environnement associés à la borréliose de Lyme en France. La zone d'étude a été divisée en trois parties : le noyau urbain, la zone sub-urbaine et la zone péri-urbaine. Les tiques libres ont été capturées par la méthode du drapeau, les tiques parasites ont été récoltées sur le chat domestique.*

Deux espèces ont été trouvées : Ixodes ricinus *(Linné, 1758) à l'état libre et parasite,* Ixodes hexagonus *(Leach, 1815) à l'état parasite.* I. ricinus *est plus fréquente lorsque l'on va du centre de la ville vers les zones périphériques où elle colonise des forêts naturelles, semi-naturelles et même des forêts artificialisées.*

I. hexagonus *absent du centre de la ville, a été récoltée dans la zone sub-urbaine mais surtout dans la zone péri-urbaine.*

L'incidence épidémiologique de ces résultats est discutée.

MOTS CLÉS : Ixodes, *borréliose de Lyme, éco-épidémiologie, chat domestique, Lyon.*

INTRODUCTION

During the last few years Lyme borreliosis seems to be increasingly diagnosed in France, even if no extensive and accurate statistic study can support this point of view. For instance, Doby & Couatarmanac'h (1985) mentioned a regular increase in Lyme Borreliosis cases diagnosed by physicians in the North-West of France, from 1972 to 1983. If clinical characteristics of this disease are nowadays well known, exact places and circumstances of contamination appear to be rarely studied.

Thus, in France, the effect of urbanization upon the epidemiology of the disease has never been considered. At first sight, this effect is of less importance because *Ixodes ricinus* (Linné, 1758), which is the main french vector of *Borrelia burgdorferi*, s.l., is almost exclusively found in forests, where this tick attaches to people and causes human infection.

However, the presence of this tick species in Lyon outskirts (Gilot & Pautou, 1982) and the occurrence of Lyme disease in natural areas surrounding the city and in the near country (Monts du Lyonnais, Dombes... Pichot *et al.*, 1994) led us to look for *Ixodes ricinus* inside the built-up area and to study the influence of urbanization over the disease distribution.

MATERIAL AND METHOD

This study was performed in the Urban Community of Lyon, covering 48.395 ha (see position of Lyon: Fig. 1).

* Département de Parasitologie et Mycologie Médicale, Faculté de Pharmacie, Université Claude-Bernard, 8, avenue Rockefeller, 69373 Lyon Cedex 08.

** INSERM-U 399, Département de Parasitologie, Faculté de Médecine, Aix-Marseille Unit, 13385 Marseille Cedex 05.

*** Laboratoire de Parasitologie et Zoologie Appliquée, Faculté de Médecine, avenue du Professeur Léon-Bernard, 35043 Rennes Cedex. Correspondence: Jean Pichot.
Tel: 04.72.41.32.20. Fax : 04.72.41.31.41.

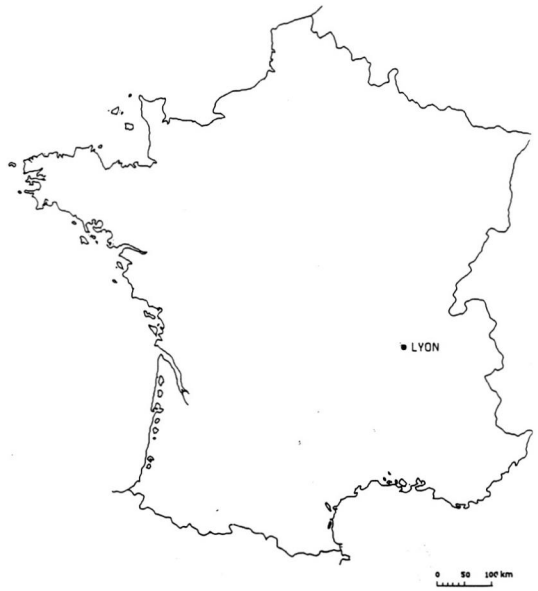

Fig. 1. — Position of Lyon in France.

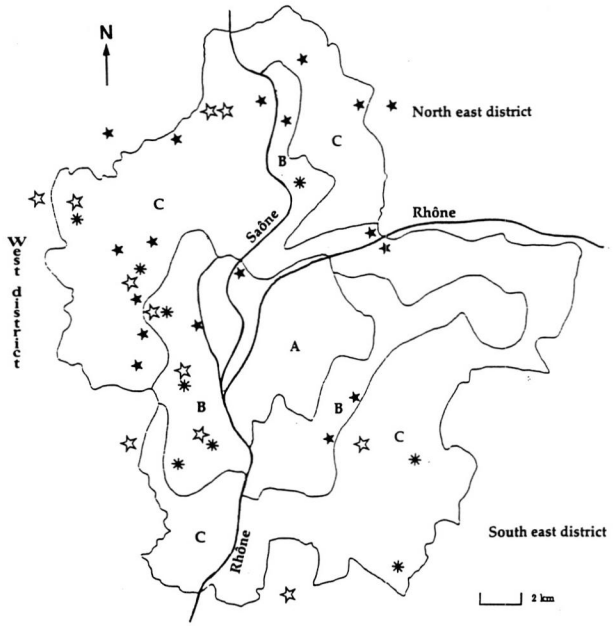

Fig. 2. — Distribution of the *Ixodes* ticks collected in Lyon and its outskirts.
A = Urban core; B = Sub-urban zone; C = Peri-urban zone.
★ Free stages of *Ixodes ricinus* (Flagging method).
☆ Parasitic stages of *Ixodes ricinus* (Cat).
✱ Parasitic stages of *Ixodes hexagonus* (Cat).

ZONING

We were satisfied with an extensive zoning, in order to have a general idea of the question.
For that purpose, the following characteristics were noticed: structure and density of buildings (individual houses or blocks of flats); nature and extent of the area between the buildings (private or public gardens, parks, forests, agricultural areas). These criteria led us to divide the study area in three ecological parts (Fig. 2):
– *Zone 1* (6,239 ha): urban core (town center), organized in two councils (Lyon and Villeurbanne), crowded with new and old blocks of flats. Interstitial area is narrow (543 ha of wooded area) and includes mostly road system.
– *Zone 2* (13,440 ha): suburban area, showing scattered buildings including mainly old and new blocks of flats, but also many individual houses. Interstitial area is quite important (1,628 ha of wooded area).
– *Zone 3* (28,716 ha): periurban area, with scattered individual houses and a preserved rural area (3,584 ha of wooded area).
Morever, suburban and periurban zones are each divided in three districts delimited by two rivers (Rhône and Saône): these natural borders could influence tick fauna, isolating autonomous urban islands, in a specific environment, where various hosts could be parasitized:
– North-eastern district (7,134 ha), extending to « Plateau de la Dombes ». Interstitial area shows mainly agricultural country (2,256 ha) and little wooded area (640 ha).
– South-eastern district (18,737 ha), extending to « Bas-Dauphiné ». Interstitial area shows more agricultural country (3,171 ha) than forests (1,193 ha).
– Western district (16,285 ha), constituted by « Monts d'Or » (highest point: 609 m) and the first slopes of « Monts du Lyonnais ». Interstitial area shows agricultural country (2,544 ha) and forests (3,922 ha).

TICK COLLECTING

Free stages of ticks were collected by using the flagging method. It was performed in spring of 1991 and 1993. The collecting period lasted 30 min for each of the 46 selected sites. In each site, one single place was investigated, at the exception of wide sites as « Parc de La-Croix-Laval », « Miribel-Jonage », « Parc de Bron-Parilly », where several collecting places were chosen.
Parasitic stages of ticks were picked up on only one host, domestic cat. This pet is moving in a restricted perimeter around its master's house. Ticks were taken of by ourselves or by 14 private veterinaries settled in our studied zone.

RESULTS

The 242 collected ticks belonged to 2 different species: *Ixodes ricinus* and *Ixodes hexagonus* (Leach, 1815). The first one was found free living as well as on domestic cats. The second one came from domestic cats only.

Tables I & II mention, for each species, the number of collected ticks regarding each zone previously defined.

DISCUSSION

Ixodes ricinus was found in the three « urban » zones. Free stages of this species were undoubtedly identified in town. For one year to the other, no *Ixodes ricinus* was detected in a same site. This fact shows that this tick population is an unsettled one (referring to the definition of settled tick populations elaborated by Cotty *et al.*, 1986). Almost all specimens collected were adults; no nymph was noticed. This fact means that *Ixodes ricinus* samples do not come from a local ecological cycle, linked to the presence of small mammals. On the contrary, *Ixodes persulcatus* (Schulze, 1930) collected in the City of Ufa (Russia, Ryl'Tseva, 1970, in Korenberg *et al.*, 1984), a town as spread as Lyon, is from local origin, parasitizing urban populations of *Clethrionomys glareolus*. In Lyon, *Ixodes ricinus* is probably carried by birds at engorged nymphal stage and the metamorphosis from the nymph to the adult is possible according to microclimatic conditions.

Referring to Daniel & Cerny's study (1990), in Prague, blackbird *(Turdus merula)* is the most predestined bird to convey the parasite from periurban area to town center. This bird is particularly apt to be an host for *Ixodes ricinus* at nymphal stage (Aeschlimann *et al.* 1974; Gilot, 1984) and is able to colonize any type of urban zone, including preserved natural, as well as artificial areas (parks, gardens) (C.O.R.A., 1977). Generally speaking, low occurrence and ephemeral life of a given tick species, in a specific environment, means that this environment is unpropitious to the tick. In rural area, bordering the South limit of *Ixodes ricinus* in France (supra-mediterranean series of *Quercus pubescens*), we noticed the same phenomenon. In urban area, Daniel & Cerny (1990), studying the repartition of *Ixodes ricinus* populations in Prague, had ascertained that urban core is unpropitious to *Ixodes ricinus* development, related to poor wooded area. Therefore, if the risk of contamination still exists in this zone, it appears to be very low.

Free or parasitic stages of *Ixodes ricinus* were often found in suburban areas and mostly in periurban areas. This fact had been already mentioned in several european cities (Cerny & Daniel, 1980; Daniel & Cerny, 1990).

At first sight, the tick distribution inside Lyon built-up area, is not equable (Fig. 2): North-eastern and Western districts seem to be more affected than South-eastern district. This is due to different ecological conditions. Propitious districts are associated with spread wooded areas and specific surroundings favoring ticks cycles. In North-eastern district, the periurban zone is adjoining the « Plateau de la Dombes », where *Ixodes ricinus* is widely spread (Gilot, 1985). In Western district, the periurban area is characterized by the importance of detached houses, widely spread wooded areas (24 % of the total area), and proximity of the « Monts du Lyonnais » where *Ixodes ricinus* finds many propitious biotopes (Roman *et al.*, 1973; Chorliet, 1987). *Ixodes ricinus* is less frequent in South-eastern district, related to poor wooded area (6.5 %); moreover, this district is the farthest from the massifs, the forests of which are favorable to ticks.

Prospections for *Ixodes ricinus* in Grenoble built-up area had been up to now unsuccessful (Gilot & Pautou, 1982). Some other inquiries, more limited, performed by the same authors in Lyon, had led to detect in 1981 a few specimens in a suburban area, in a damaged forest and its adjoining waste land (Gilot & Pautou, *op. cit.*). The present study, more systematic, discloses that this tick is more spready in Lyon than it was

	Prospected areas		
	Urban	Sub urban	Peri urban
Number of sites prospected	10	16	20
Number of positive sites (presence of *I. ricinus*)	1	5	10
Positive site occurrence (%)	10	31	50
Number of ticks collected	1M	6M, 15F, 19N	38M, 57F, 87N
Environment	Public gardens	Parks	Forests

M = Male; F = Female; N = Nymph.

Table I. — Free tick collecting results *(Ixodes ricinus)*.

	Prospected areas		
	Urban	Sub urban	Peri urban
Number of cats infected with *I. ricinus*	0	3	5
Collected stages	0	1N, 2L, 3F	5F, 1M
Number of cats infected with *I. hexagonus*	0	9	4
Collected stages	0	9F, 2M	4F, 4N

M = Male; F = Female; N = Nymph; L = Larva.

Table II. — Parasitic tick collecting results (*Ixodes ricinus* and *Ixodes hexagonus*).

expected. Several combined factors may explain the difference in colonization between Lyon and Grenoble, although theses two cities are relatively close to each other (about 100 km):

- As regards climatology: mean monthly temperature, Grenoble 11.1 °C, Lyon 12.2 °C.
- As regards topographic site: Grenoble is located in a narrow deforested basin; Lyon is situated in a wide plain where forest is still preserved.
- As regards plant communities: Grenoble is built-up in a context of two vegetation types (Alluvial series of the common oak, *Quercus pedunculata,* Northern series of *Quercus pubescens*), in most cases unpropitious to the species. Islets of natural vegetation are damaged or quite reduced, related to a high altudinal gradient due to the city site, that is a basin bordered by mountains. Lyon is located among plains, plateaus, and hills, where the natural vegetation (acidophilous series of oaks...) is propitious to the tick.

On the other hand, the presence of roe deer *(Capreolus capreolus)* on the vicinity of the city of Lyon must be taken in consideration. This animal is such a perfect rural host for *Ixodes ricinus*, that it has been used as a biological marker for the tick (Gilot *et al.*, 1994). Many authors (Gray *et al.*, 1992, in Ireland; Jaenson & Talleklint, 1992, in Sweden; Matuschka *et al.*, 1993, in Germany) established that roe deer might enhance *Ixodes ricinus* life cycle, but they all agree that this mammal does not act as a reservoir for the bacteria. In our studied territory, the last registration of roe deer population numbered 150 animals and this year it was expected to raise until 250 (Fédération des Chasseurs du Rhône). This increase of *Capreolus capreolus* population in Lyon follows the already one noticed in Rhône district, in May 1993, which gave a total of 5,500 to 6,000 roe-deers for 330,334 ha. Moreover, it is important to notice that the distribution of roe deer population in Lyon built up area is mainly located in the west district of the periurban zone, where our tick collection was the most important.

Regarding our study, domestic cat was selected for two reasons: firstly *Ixodes ricinus* shows strong affinity for this Carnivore; secondly, this pet spends its life around its master's house, contrary to dog which is often taken out for walks. Therefore, the parasites collected on domestic cats are more representative for local fauna. Thus, in the Southern France, Orsal (1977) detected on a single cat, wandering in various areas, three species of ticks. Among eight species found on cat in the french Alps and fore-country (Gilot, 1985), *Ixodes ricinus* was the most frequently noticed but mostly in rural countries. Therefore, its occurrence on cat is mainly related to tick microfocuses located around the farm. Our study exhibits that the same phenomenon may occur in a context of scattered periurban houses... Therefore, domestic cat may be propound as a good biological marker to verify the presence of the vector in a peridomestic environment. But, is cat epidemiological role enhanced by the fact that it may facilitate human contamination? Opinions are divided. In 1978, Steere *et al.* suggested that cat could be implied in human contamination. Later, Curran & Fish (1989) insisted that owning a cat increases the risk for Borreliosis, in carrying inside human dwellings, free stages of ticks. Other authors (Cimmino & Fumarola, 1989) thought that presence of cat in domestic environment does not increase the risk for borreliosis.

Our study reveals that, in urban area, cat may be parasitized by a second species of tick: *Ixodes hexagonus.* Referring to Garin & Bujadoux s' famous report (1922), we know that this tick had been, early, regarded as a *Borrelia burgdorferi* vector. Lately, several authors demonstrated that *Ixodes hexagonus* was naturally infected by the bacteria: Liebish *et al.* (1989), studying an amount of 303 ticks was able to detect the presence of the bacteria in 2.7 % of ticks; Doby *et al.* (1991), picked up ticks on fox and numbered 1.2 % of larvae and 5.5 % of adults infected. Gern *et al.* (1991), in a recent experimentation proved the vectorial role of *Ixodes hexagonus.* In a previous report Gilot & Aubert (1984) stressed the possible *Ixodes hexagonus* removing, by dogs, from a natural environment (carnivore earths), to a domestic rural environment (farms). This study shows that cat may also be involved in such ticks removing from natural biotopes toward urban detached houses.

CONCLUSION

One of us had previously insisted on the frequency of different tick species in urban environment. This report completes previous knowledge concerning urban ticks in France, in studying the urban distribution of two new species. As regards Lyme borreliosis, the colonization by *Ixodes ricinus* of some urban biotopes may have an epidemiological incidence. The present study shows that urban colonization seems to be verified in a context of centro-european vegetation as it has been observed in other biogeographic and floristic contexts, namely in cities located in the North-West of France (Gueglis *et al.*, 1996).

ACKNOWLEDGEMENT

This study was carried out thanks to the financial support of Institut National de la Santé et de la Recherche Médicale (Contrat n° 900.801). We thank the veterinaries who collected ticks on cats for this study.

REFERENCES

Aeschlimann A., Vaucher C. & Mermod C. The role of birds in the life cycle of *Ixodes ricinus* (L) in a low marsh forest of Switzerland. *Proceedings of 3rd International Congress of Parasitology* (Munich), 1974, *C9*, 949-950.

Cerny V. & Daniel M. Occurence of ticks and chigger mites in urban areas *Ceskolovenska Epidemiologie Mikcrobiologie Immunologie*, 1980, *29*, 178-183.

Chorliet C. Les tiques et les Babésioses équines dans les Monts du Lyonnais et les Monts d'Or. Thèse Doctorat en Pharmacie, 1987, Lyon I, 131 p.

Centre Ornithologique de la Région Rhône-Alpes (CORA) Les oiseaux nicheurs rhônalpins. Centre régional pédagogique de Lyon, 1977, 353 p.

Cimmino K. & Fumarola D. The risk of *Borrelia burgdorferi* infection is not increased in pet owners. *The Journal of The American Medical Association* (JAMA), 1989, *262*, 2997-2998.

Cotty A., Aeschlimann A. & Schneeberger S. Distribution and fluctuation in populations of *Ixodes ricinus*, *Haemaphysalis punctata* and *Dermacentor marginatus (Acarina, Ixodoidea)* in Switzerland. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*, 1986, *59*, 139-150.

Curran K. & Fish D. Increased risk of Lyme disease for cat owners. *The New England Journal of Medicine*, 1989, *320*, 183.

Daniel M. & Cerny V. Occurence of the tick *Ixodes ricinus* (L) under the conditions of anthropopressure. *Folia Parasitologica* (Praha), 1990, *37*, 183-186.

Doby J.M., Bigaignon G., Aubert M. & Imbert G. Ectoparasites du renard et borréliose de Lyme. Recherche de *Borrelia burgdorferi* chez les tiques *Ixodidae* et insectes *Siphonaptera*. *Bulletin de la Société Française de Parasitologie*, 1991, *9*, 279-288.

Doby J.M. & Couatarmac'h A. Données épidémiologiques sur l'érythème migrant de Lipschütz dans l'ouest de la France. I- répartition annuelle et saisonnière des cas. *Bulletin de la Société Française de Parasitologie*, 1985, *1*, 61-64.

Garin C. & Bujadoux A. Paralysie par les tiques. *Journal de Médecine de Lyon*, 1922, *71*, 765-767.

Gern L., Toutoungi L., Hu C. & Aeschlimann A. *Ixodes (Pholeoixodes) hexagonus*, an efficient vector of *Borrelia burgdorferi* in the laboratory. *Medical and Veterinary Entomology*, 1991, *5*, 431-435.

Gilot B. Premier inventaire des *Ixodidae* (*Acarina Ixodoidea*) parasites d'oiseaux dans les Alpes françaises et leur avant-pays, données écologiques sur quelques espèces peu connues. *Rivista di Parassitologia*, 1984, *1*, 303-318.

Gilot B. Bases biologiques, écologiques et cartographiques pour l'étude des maladies transmises par les tiques (*Ixodidae* et *Argasidae*) dans les Alpes françaises et leur avant-pays. Thèse Doctorat ès-Sciences, Grenoble, 1985, 535 p.

Gilot B. & Aubert M. Le parasitisme des carnivores domestiques par les tiques du genre *Pholeoixodes* (*Acarina, Ixodoidea*) dans les Alpes françaises et leur avant-pays : bases écologiques. *Acta Oecologica Ecologia Applicata*, 1984, *5*, 355-367.

Gilot B., Bonnefille M., Degeilh B., Beaucournu J.C., Pichot J. & Guiguen C. La colonisation des massifs forestiers par *Ixodes ricinus* (Linné, 1758) en France : utilisation du chevreuil *Capreolus capreolus* (Linné, 1758) comme marqueur biologique. *Parasite*, 1994, *1*, 81-86.

Gilot B. & Pautou G. L'évolution des populations de tiques (*Ixodidae* et *Argasidae*) en relation avec l'artificialisation des milieux dans les Alpes françaises : incidences épidémiologiques. *Acta Tropica*, 1982, *39*, 337-354.

Gray J.S., Kahl O., Janetzki C. & Stein J. Studies on the ecology of Lyme disease in a deer forest in county Galway, Ireland. *Journal of Medical Entomology*, 1992, *29*, 915-920.

Gueglis B., Guibert Ph., Lepelletier O., Figureau Cl., Ferard Ph. & Marjolet M. Phytosociologic analysis of urban parks and risk of Lyme borreliosis, example of the Nantes area. VIIth International Congress on Lyme Borreliosis, 16-21 June 1996, San Francisco.

Jaenson T. & Talleklint L. Incompetence of roe deer as reservoirs of the Lyme Borreliosis spirochete. *Journal of Medical Entomology*, 1992, *29*, 813-817

Korenberg E., Cerny V. & Daniel M. Occurence of Ixodid ticks, the main vectors of tick-borne encephalitis virus in urbanized territory. *Folia Parasitologica* (Praha), 1984, *31*, 365-370.

Liebish A., Olbrich S., Brand A., Liebish G. & Mourettou-Kunitz M. Natürliche Infektionen der Zeckenart *Ixodes hexagonus* mit Borrelien (*Borrelia burgdorferi*). *Tierärztliche Umschau*, 1989, *44*, 809-810.

Mac Leod J. The bionomics of *Ixodes ricinus* L. « the sheep tick » of Scotland. *Parasitology*, 1932, *24*, 382-400.

Matuschka F., Olbrich S., Brand A., Liebisch G. & Mourettou-Kunitz M. Diversionary role of hoofed game in the transmission of Lyme disease spirochetes. *American Journal of Tropical Medicine and Hygiene*, 1993, *48*, 693-699.

Orsal J.C. La fièvre boutonneuse dans la vallée du Rhône. Étude épidémiologique. Thèse de Doctorat en Médecine, 1977, Montpellier.

Pichot J., Gilot B., Soulier V., Rey-Coquais A., Degeilh B. & Doche B. Éco-épidémiologie de la Borréliose de Lyme dans la région Rhône-Alpes : répartition, contexte écologique, relations avec la distribution d'I*xodes ricinus*. (Linné, 1758). *Parasite*, 1994, *1*, 335-342.

Roman E., Lu Huynh-Thanh & Pichot J. Étude biogéographique et écologique sur les tiques (Acariens : Ixodoidea) de la région lyonnaise. *Bulletin Mensuel de la Société Linnéenne de Lyon*, 1973, n° spécial, 65-73.

Ryl'tseva E. [A contribution to the ixodid tick fauna in Ufa and its environs.] Akaralogicheskoe Soveshchanie Tezisy Dokladov Kiev, 1970, 114-115 (in russian).

Steere A., Broderick T. & Malawist S. *Erythema chronicum migrans* and Lyme arthritis: epidemiologic evidence for a tick vector. *American Journal of Epidemiology*, 1978, *108*, 312-321.

Reçu le 10 décembre 1996
Accepté le 11 janvier 1997