



ECTOPARASITES *CTENOCEPHALIDES* (SIPHONAPTERA, PULICIDAE) IN THE COMPOSITION OF MIXED INFESTATIONS IN DOMESTIC DOGS FROM POLTAVA, UKRAINE

Yevstafieva, V.¹, Horb, K.¹, Melnychuk, V.¹
Bakhur, T.², Feshchenko, D.³

¹Department of Parasitology and Veterinary-Sanitary Examination, Institute of Veterinary Medicine
Poltava State Agrarian Academy, Skovorody Str., 1/3, 36003, Poltava

²Department of Parasitology and Pharmacology, Bila Tserkva National Agrarian University
Soborna Sq., 8/1, 09100, Bila Tserkva, Kyiv region

³Department of Parasitology, Veterinary-Sanitary Expertise and Zoohygiene, Polissia National University
Staryy Blvd., 7, 10008, Zhytomyr,
Ukraine

evstva@ukr.net; fly_13@ukr.net

ABSTRACT

One of the most common ectoparasites on domestic carnivores are fleas from the genus *Ctenocephalides*. This group of blood sucking insects are one of the most important in medical and veterinary terms, as they can serve as carriers of dangerous infectious and may cause other invasive diseases. Research studies have established a variety of fleas and other contagions parasitizing domestic dogs in Poltava, Ukraine. Certain peculiarities of these ectoparasitic studies, as a part of mixed infestations of dogs, have recently been determined. The results of the studies have shown that the species composition of the fleas was represented by two main species. The dominant species was *Ct. felis*, and their prevalence was 36.05 %. Another species (*Ct. canis*) was diagnosed less often and had a prevalence of 27.94 %. It was found that in 31.18 % of the dogs, the blood-sucking insects

were mostly parasitizing in the form of an associations with: nematoda (*Toxocara canis*, *Trichuris vulpis*, *Uncinaria stenocephala*), *Cestoda* (*Dipylidium caninum*), protozoa (*Cystoisospora canis*), and another ectoparasite (*Trichodectes canis*). Overall, 33 types of mixed infestations were detected. Moreover, the number of different parasitic species in each dog ranged from one to seven. Fleas of the genus *Ctenocephalides* (in the composition of two species of parasites) were registered the most often (14.60 %). The infestation of dogs with other forms of mixed infestations was 0.69—8.01 %. The most frequent co-members for *Ct. felis* were *Cestoda* [*D. caninum* (13.47 %)], for *Ct. canis*—*Cestoda* [*D. caninum* (11.23 %)] and *Nematoda* [*T. vulpis* (8.29 %)].

Key words: cohabitants; domestic dog; fleas; mixed infestation; prevalence

INTRODUCTION

Dog breeding is gaining importance in various sectors of the economy today. The need for the development of service, decorative, sports and special dog breeding is growing, as these animals are indispensable helpers of humans. Therefore, their health is of constant concern to humanity. One of the most common groups of diseases among the population of domestic dogs are entomosis infestations caused by fleas. Their ability to use humans as an alternative host determines the importance of these parasites in the field of human health care [6, 12, 22, 29].

Most species of fleas parasitize animals of a certain species or group of species, but can easily change their hosts. Rarely, other specific non-flea parasites are registered among the fleas, tied only to the one or several close species of animals, which even after prolonged starvation can't drink the blood of their unusual host [10, 21]. Therefore, the establishment of the identity of these non-flea cohabitants of fleas that parasitize domestic dogs in different climatic regions will increase the effectiveness of measures to control and prevent them, as well as prevent the diseases they transmit.

Thus, most scientists claim that domestic dogs are parasitized by fleas of the *Ctenocephalides* genus (Stiles, Collins, 1930). Two species of fleas are particularly important—*Ctenocephalides felis* (Bouché, 1835) and *Ctenocephalides canis* (Curtis, 1826), which are dominant in dogs. These species are non-specific to carnivores; they can attack and feed on a variety of hosts, including humans. This feature of parasitic insects contributes to their significant stability in the environment [9, 15, 25]. At the same time, there are reports of parasitism of fleas by other species, i. e., *Echidnophagia gallinacea*, *Pulex irritans*, *Xenopsylla cheopis* and *Cediopsylla simplex* on dogs [14, 27]. The degree of infestation of domestic dogs with *Ct. felis* and *Ct. canis* varies and depends: on the climatic conditions of the region, the method of animal keeping, as well as preventive insecticide treatments [1, 2, 19, 20].

Thus, the study of the species composition of fleas parasitizing on domestic dogs in certain geographical regions of Ukraine, establishing the peculiarities of their course together with other pathogens of parasitic diseases are important in conducting comprehensive treatment measures, and control of the epizootic situations. This must take into account the sensitivity of certain species of fleas to insecti-

cides; because it is known that the species *Ct. felis* is resistant to the most common insecticides [8, 13].

MATERIALS AND METHODS

Animals and study design

The research was conducted during 2017—2020 in the Laboratory of Parasitology of Poltava State, Agrarian Academy and Veterinary Service “Vetexpert” located in Poltava (49°34' N, 34°34' W). It is located in the north-eastern part of Ukraine. In general, the city's climate is moderately continental with cool winters and warm (sometimes hot) summers. The average annual temperature is 7.6 °C, the lowest in January (–6.6 °C), and the highest in July (20.1 °C). The relative humidity averages 74 %; it is the lowest in May (61 %), and the highest in December (88 %).

A total of 3,171 domestic dogs of different breeds and crossbreeds were investigated. They were aged from 1 month to 11 years when they were brought to the Veterinary Service area for study.

Parasitological study

The isolation of fleas and chewing lice from the body of animals was performed by combing them with a plastic small-toothed special comb for 10 minutes. The collected insects were fixed in 70 % ethyl alcohol. The identification of the isolated parasitic insect species was established by microscopy according to the morphological taxonomic features [7, 17, 28].

The faeces were collected from dogs from which the fleas were isolated; coproscopic examinations were performed according to the Kotelnikov–Khrenov's method [16]. The identification of the species affiliation of helminthic eggs and oocysts of coccidian parasites were performed using recognized identifiers [11, 23].

Microphotography was performed using a digital camera and MBS-10 binocular microscope at a magnification of 8—16 times.

Statistical analysis

Standard indices of infestation of dogs with parasitic disease pathogens were calculated:

- Prevalence (P, %)—the ratio of the number of dogs infected with invasive disease pathogens to the number of animals studied;

- Intensity (I, specimens per animal)—the number of fleas of a certain species per infected host.

The datasets were expressed as mean $\pm$ standard error of the mean (SE). Statistical processing of the experimental results was carried out using Microsoft Excel software.

RESULTS

Our studies have shown that the average P of ectoparasites *Ctenocephalides* spp. on domestic dogs at the territory of Poltava, Ukraine was 49.48 % with an average I 19.30 ± 0.31 specimens per animal. It was found that the fleas of the genus *Ctenocephalides* was represented by two species—*Ctenocephalides felis* (Bouché, 1835) (Fig. 1) and *Ctenocephalides canis* (Curtis, 1826) (Fig. 2). The dominant species was *Ct. felis*, where the P reached 36.05 % with the I 15.87 ± 0.34 specimens per animal. The *Ct. canis*

species was registered less often and the P was 23.98 % with the I 13.63 ± 0.35 specimens per animal.

It was found that in 31.18 % of the dogs, the blood-sucking insects mostly parasitize in the form of an associations with the causative agents of nematodes, cestodes, protozoans and entomotic infestations. Less commonly diagnosed was the mono-infestation (14.79 %), where the infestation of dogs by *Ct. felis* only was 9.71 %, and *Ct. canis*—5.07 %. The infestation of dogs simultaneously by two species of fleas was 3.50 % (Table 1).

A total of 33 types of mixed infestations were identified, where the cohabitants of the flea *Ctenocephalides* genus were: cestodes of the species *Dipylidium caninum* (Linnaeus, 1758); nematodes of the species *Toxocara canis* (Werner, 1782), *Trichuris vulpis* (Frölich, 1789), and *Uncinaria stenocephala* (Railliet, 1884); coccidia of the species *Cystoisospora canis* (Nemeséri, 1959); and chewing lice of the species *Trichodectes canis*



Fig. 1. *Ctenocephalides felis* fleas of *Ctenocephalides* genus: a—♀; b—♂
1— sloping forehead; 2—long teeth of oral ctenidium



Fig. 2. *Ctenocephalides canis* fleas of *Ctenocephalides* genus: a—♀; b—♂
3—steep forehead; 4—short teeth of oral ctenidium.

Table 1. Indicators of domestic dog flea infestation of *Ctenocephalides* genus as a part of mono- and mixed infestations

Infestations' types	Number of infected animals	Prevalence % (n = 3,171)	% of infected animals (n = 1,569)
<i>Ct. felis</i>	308	9.71	19.63
<i>Ct. canis</i>	161	5.07	10.26
<i>Ct. felis</i> + <i>Ct. canis</i>	111	3.50	7.07
Other (mixed) infestations	989	31.18	63.03

(de Geer, 1778). Moreover, the number of parasitic species in each animal ranged from one to seven.

The parasitizing of *Ctenocephalides* spp. in domestic dogs more often was registered in a combination with two species of agents (P = 4.60 %). Simultaneous parasitism of three (8.01 %), four (6.09 %), five (1.07 %), six (0.69 %) and seven (0.3 %) agent species were found less often.

Nine mixed infestations with two agents were identified, of which the associations of fleas *Ct. felis* with cestodes *D. caninum* (P = 5.27 %) and with nematodes *T. vulpis* (P = 3.12 %) were most often diagnosed. Less common were the associations of fleas *Ct. felis* with nematodes *T. canis* (P = 1.86 %) and fleas *Ct. canis* with nematodes *T. vulpis* (P = 1.10 %). The infestation of dogs by association of fleas *Ct. canis* with nematodes *T. canis*, *U. stenocephala*, cestodes *D. caninum*, coccidia *C. canis* and chewing lice *Tr. canis* did not exceed 0.95 % (Table 2).

Among the associations of the fleas with two other agents, 10 types of combinations were established: *Ct. felis* with cestoda (*D. caninum*), nematoda (*T. canis*, *T. vulpis*), protozoa (*C. canis*), ectoparasites and (*Tr. canis*); and *Ct. canis* with cestoda (*D. caninum*), nematoda (*U. stenocephala*, *T. canis*), protozoa (*C. canis*), and ectoparasites (*Tr. canis*). The P ranged from 0.35 to 2.21 %. The mixed infestations of fleas with 3 other agents were represented by 7 types of parasitic associations. Thus, the fleas *Ct. felis* were together with cestoda (*D. caninum*), nematoda (*T. canis*, *T. vulpis*, *U. stenocephala*), and protozoa (*C. canis*), where the P ranged from 0.22 to 2.05 %. The fleas *Ct. canis* were together with cestoda (*D. caninum*), nematoda (*T. canis*, *T. vulpis*), and protozoa (*C. canis*); P ranged from 0.35 to 2.05 %. The mixed infestations with five co-members were

Table 2. The most common two-members mixed infestations in domestic dogs included *Ctenocephalides* spp.

Species of mixed infestations' co-members	Number of infected animals	Prevalence [%] (n = 3,171)	% of mixed infestations (n = 989)
<i>Ctenocephalides canis</i>			
Nematoda (<i>T. vulpis</i>)	35	1.10	3.54
Cestoda (<i>D. caninum</i>)	30	0.95	3.03
Ectoparasites (<i>Tr. canis</i>)	22	0.69	2.22
Protozoa (<i>C. canis</i>)	18	0.57	1.82
Nematoda (<i>T. canis</i>)	17	0.54	1.72
Nematoda (<i>U. stenocephala</i>)	16	0.50	1.62
<i>Ctenocephalides felis</i>			
Cestoda (<i>D. caninum</i>)	167	5.27	16.89
Nematoda (<i>T. vulpis</i>)	99	3.12	10.01
Nematoda (<i>T. canis</i>)	59	1.86	5.97

represented by three types of associations, namely: *Ct. canis*, *Ct. felis*, nematoda (*T. canis*, *T. vulpis*) and cestoda (*D. caninum*)—0.47 %; *Ct. canis*, *Ct. felis*, cestoda (*D. caninum*), nematoda (*T. vulpis*) and ectoparasites (*Tr. canis*)—0.28 %; *Ct. canis*, *Ct. felis*, protozoa (*C. canis*), cestoda (*D. caninum*) and nematoda (*U. stenocephala*)—0.32 %.

The mixed infestations that included six and seven co-members were represented by two types of parasitic associations. Thus, cases of cohabitation of six parasites were represented by *Ct. canis*, *Ct. felis*, nematoda (*T. canis*, *T. vulpis*), cestoda (*D. caninum*), and protozoa (*C. canis*)—0.57 %, as well as *Ct. canis*, *Ct. felis*, cestoda (*D. caninum*), nematoda (*T. vulpis*, *U. stenocephala*), and ectoparasites (*Tr. canis*)—0.13 %. The mixed infestations with seven-members were characterized by associated parasitizing of *Ct. canis*, *Ct. felis*, nematoda (*T. canis*, *T. vulpis*), cestoda (*D. caninum*), protozoa (*C. canis*), and ectoparasites (*Tr. canis*)—0.32 % and *Ct. canis*, cestoda (*D. caninum*), nematoda (*T. vulpis*, *U. stenocephala*, *T. canis*), ectoparasites (*Tr. canis*), and protozoa (*C. canis*)—0.41 %.

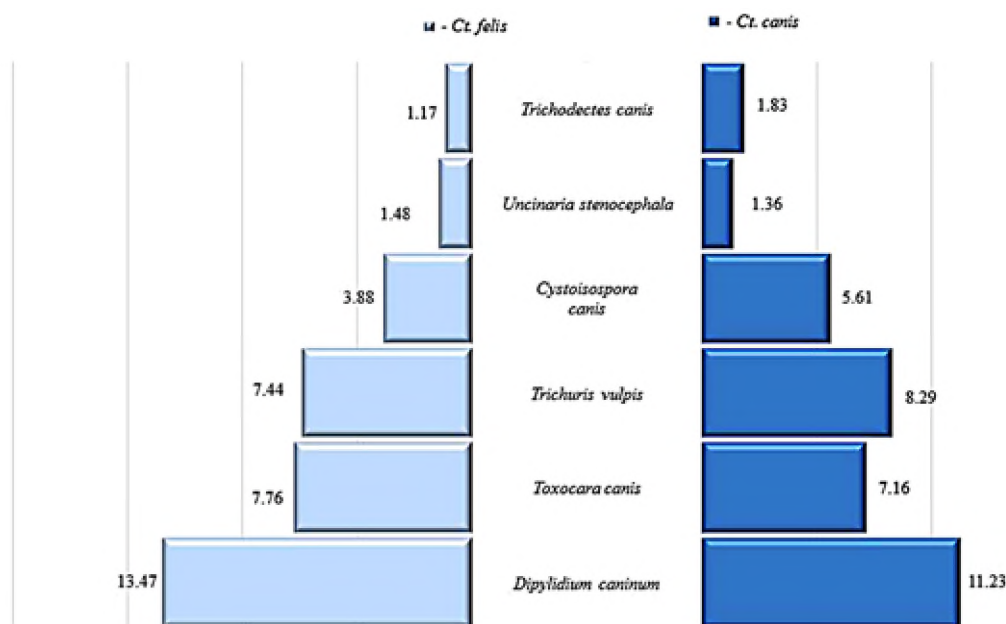


Fig. 3. Species composition of the fleas *Ctenocephalides* genus co-members in mixed infestations of domestic dogs

Cestodes *D. caninum* were the main co-member of the *Ct. felis* fleas in mixed infestations. A lower percentage was the characteristic of other associations (Fig. 3).

Thus, haematophagous ectoparasites of the *Ctenocephalides* genus were common pathogens of invasive diseases among the population of domestic dogs in Ukraine, where the fleas were represented by two species, i. e., *Ct. canis* and *Ct. felis*; the dominant species was *Ct. felis*. However, fleas of the identified species were more likely to parasitize in dogs simultaneously with the causative agents of nematode, cestode, coccidian and entomotic infestations. The most common co-members of fleas' *Ct. canis*, as well as *Ct. felis*, were the cestodes *D. caninum*.

DISCUSSION

It is known that fleas are a group of blood-sucking parasitic insects that plays an important role in the transmission of focal disease pathogens of both humans and domestic animals around them including dogs on most continents of the world [22, 29]. According to the literature, *ctenocephalidosis* of domestic dogs is a very common infestation worldwide, caused by ectoparasites of *Ctenocephalides* genus. Thus, scientists have found that in France, 89 % of the domestic dogs were infested with *Ct. felis* fleas. Dog infestations with *Ct. canis* were detected in only 10 % of

the cases [3]. Other authors reported that the prevalence of *Ct. felis* in dogs was 90 % in the USA and 57 % in Germany [18]. In Korean climatic conditions, parasitism of the one species (*Ct. canis*) was found in 28.4 % of the dogs [1]. In Erzurum region of Turkey the prevalence of *Ct. canis* was 31.25 % on dogs, and 4.17 % with *Ct. felis* [2]. At the same time, in Mexico, *Ct. felis* is the most common species of fleas that parasitize dogs in 17 states, where the prevalences ranged from 3.75 to 100 %. However, *Ct. canis* was found in only 9 states of Mexico, mainly in areas with high or low temperatures; the prevalence ranged from 1.40 to 100 % [19, 20]. According to scientists in the metropolis of Moscow, the prevalence of *Ct. felis* in dogs was 26.64 %. And the stray dogs were the most infested where the prevalence reached 100 % [24]. In the Ukraine, questions about the epizootiological features of the spread of fleas have been studied in fragments and were described in only a few works [26].

Therefore, a study was conducted to determine the prevalence of fleas among the population of domestic dogs in Ukraine, Poltava city; their species composition and features of flea parasitism as part of mixed infestations was also investigated. The studies have shown that *Ctenocephalides* spp. fleas are common and adapted to the climatic conditions of the north-eastern part of Ukraine (Poltava) among the population of domestic dogs. This is evidenced by the high prevalence rates, reaching 49.48 %, with an in-

tensity of up to 72 specimens per animal. It was found that the flea environment was represented by two main species, where *Ctenocephalides felis* was dominant, the prevalence was 36.05 %, and the intensity was 15.87 ± 0.34 specimens per animal. The second species (*Ct. canis*) was diagnosed slightly less; the prevalence was 23.98 %, and the intensity was 13.63 ± 0.35 specimens per animal. This dominance of *Ct. felis* over other species of fleas has been established by other authors, who noted that this was due to their greater adaptability to environmental conditions, as well as their high resistance to insecticides [8, 15, 25]. At the same time, other scientists pointed out that in Korean climates, most *Ct. canis* fleas have been found on dogs. According to them, keeping dogs in rooms with underfloor heating affects the development cycle of parasitic insects [1].

Also, we determined that *Ctenocephalides* spp. were parasitizing domestic dogs as mixed infestations more often ($P = 31.18$ %) together with cestodes (*Dipylidium caninum*), nematodes (*Toxocara canis*, *Trichuris vulpis*, *Uncinaria stenocephala*), coccidia (*Cystoisospora canis*) and ectoparasites (*Trichodectes canis*). Overall, 33 types of mixed infestations were detected, where the fleas of the *Ctenocephalides* order were parasitizing in associations with 2—7 other agents. The most often we determined 2-member mixed infestations, and cestodes *D. caninum* were dominant co-member of the fleas in dogs ($P = 13.47$ %). This relationship has been explained by the development cycle of the cestode of this species, where fleas are intermediate hosts. Reports from scientists suggest that the level of infestation of *Ctenocephalides* spp. fleas by cysticercoides of dipilidia can reached 100 % [4]. Also, there are reports of the specificity of different flea species in terms of the infestation by *D. caninum*, which may indicate the existence of two clear genotypes from infected *Ct. felis* and *Ct. canis* [5].

Our data on the associative parasitism of fleas in domestic dogs can increase the effectiveness of therapeutic and preventive measures; to conduct comprehensive treatment of animals, as well as to take into account the species composition of mixed infestations when prescribing drugs.

CONCLUSIONS

Two species of fleas, *Ctenocephalides felis* and *Ctenocephalides canis*, were determined on domestic dogs in the territory of Poltava city, Ukraine. The prevalence rates were

36.05 and 23.98 %, respectively, with an average prevalence of *Ctenocephalides* spp. 49.48 %. Features of parasitising of isolated fleas in dogs were characterized by the formation of mixed infestations, where helminths *T. canis*, *T. vulpis*, *U. stenocephala*, *D. caninum*, coccidia *C. canis* and chewing lice *Tr. canis* were their co-members. Moreover, the most often was determined the parasitizing of *Ct. felis* together with *D. caninum*, prevalence reached 13.47 %. *Ct. canis* fleas were detected mostly together with *D. caninum* (11.23 %) and *T. vulpis*, and the prevalence was 11.23 and 8.29 % respectively.

REFERENCES

1. Ahn, K. S., Huh, S. E., Seol, S. W., Kim, H. J., Suh, K. H., Shin, S., 2018: *Ctenocephalides canis* is the dominant flea species of dogs in the Republic of Korea. *Parasit. Vectors.*, 11, 1, 196. DOI: 10.1186/s13071-018-2769-9.
2. Aldemir, O. S., 2007: Epidemiological study of ectoparasites in dogs from Erzurum region in Turkey. *Rev. Med. Vet.*, 158, 148—151.
3. Beugnet, F., Porphyre, T., Sabatier, P., Chalvet-Monfray, K., 2004: Use of a mathematical model to study the dynamics of *Ctenocephalides felis* populations in the home environment and the impact of various control measures. *Parasite*, 11, 4, 387—399. DOI: 10.1051/parasite/2004114387.
4. Beugnet, F., Labuschagne, M., Fourie, J., Jacques, G., Farakas, R., Cozma, V., et al., 2014: Occurrence of *Dipylidium caninum* in fleas from client-owned cats and dogs in Europe using a new PCR detection assay. *Vet. Parasitol.*, 205, 1—2, 300—306. DOI: 10.1016/j.vetpar.2014.06.008.
5. Beugnet, F., Labuschagne, M., Vos, C., Crafford, D., Fourie, J., 2018: Analysis of *Dipylidium caninum* tapeworms from dogs and cats, or their respective fleas. Part 2. Distinct canine and feline host association with two different *Dipylidium caninum* genotypes. *Parasite*, 25, 31. DOI: 10.1051/parasite/2018029.
6. Bitam, I., Dittmar, K., Parola, P., Whiting, M. F., Raoult, D., 2010: Fleas and flea-borne diseases. *Int. J. Infect. Dis.*, 14, 8, 667—676. DOI: 10.1016/j.ijid.2009.11.011.
7. Blagoveshenskij, D. I., 1940: The identifier of the chewing lice (*Mallophaga*) of domestic animals. *Fauna of the USSR* (In Russian). USSR Academy of Sciences, Moscow, Leningrad, 76—86.
8. Bossard, R. L., Hinkle, N. C., Rust, M. K., 1998: Review of insecticide resistance in cat fleas (*Siphonaptera: Pulicidae*).

- dae). *J. Med. Entomol.*, 35, 4, 415—422. DOI: 10.1093/jmedent/35.4.415.
9. Chesney, C. J., 1995: Species of flea found on cats and dogs in South West England: further evidence of their polyxenous state and implications for flea control. *Vet. Rec.*, 136, 14, 356—358. DOI: 10.1136/vr.136.14.356.
 10. Clark, N. J., Seddon, J. M., Šlapeta, J., Wells, K., 2018: Parasite spread at the domestic animal—wildlife interface: anthropogenic habitat use, phylogeny and body mass drive risk of cat and dog flea (*Ctenocephalides* spp.) infestation in wild mammals. *Parasit. Vectors*, 11, 1, 8. DOI: 10.1186/s13071-017-2564-z.
 11. Dahno, I. S., Dahno, J. I., 2010: *Ecological Helminthology* (In Ukrainian). Cossack shaft, Sumy, 2010, 220 pp.
 12. Dobler, G., Pfeffer, M., 2011: Fleas as parasites of the family Canidae. *Parasit. Vectors*, 4, 139. DOI: 10.1186/1756-3305-4-139.
 13. el-Gazzar, L. M., Milio, J., Koehler, P. G., Patterson, R. S., 1986: Insecticide resistance in the cat flea (*Siphonaptera: Pulicidae*). *J. Econ. Entomol.*, 79, 1, 132—134. DOI: 10.1093/jee/79.1.132.
 14. Harman, D. W., Halliwell, R. E., Greiner, E. C., 1987: Flea species from dogs and cats in north-central Florida. *Vet. Parasitol.*, 23, 1—2, 135—140. DOI: 10.1016/0304-4017(87)90031-8.
 15. Hernández-Valdivia, E., Cruz-Vázquez, C., Ortiz-Martínez, R., Valdivia-Flores, A., Quintero-Martínez, M. T., 2011: Presence of *Ctenocephalides canis* (Curtis) and *Ctenocephalides felis* (Bouché) infesting dogs in the city of Aguascalientes, México. *J. Parasitol.*, 97, 6, 1017—1019. DOI: 10.1645/GE-2701.1.
 16. Kotelnikov, G. A., 1974: *Diagnostics of Animal Helminthiasis* (In Russian). Koloss, Moscow, 240—241.
 17. Lelej, A. S., 2006: *Identifier of Insects of Russian Far East. Diptera and Fleas* (In Russian). Dalnauka, Vladivostok, VI, 4, 893—914.
 18. Liebisch, A., Reimann, U., 2000: The efficacy of imidacloprid against flea infestation on dogs compared with three other topical preparations. *Canine Practice*, 25, 2, 8—11.
 19. Linardi, P. M., Nagem, R. L., 1973: Pulicídeos e outros ectoparasitos de cães de Belo Horizonte e municípios vizinhos. *Rev. Bras. Biol.*, 33, 4, 529—537.
 20. Linardi, P. M., Santos, J. L., 2012: *Ctenocephalides felis* vs. *Ctenocephalides canis* (*Siphonaptera: Pulicidae*): some issues in correctly identify these species. *Rev. Bras. Parasitol. Vet.*, 21, 4, 345—354. DOI: 10.1590/s1984-29612012000400002.
 21. Maleki-Ravasan, N., Solhjoui-Fard, S., Beauclournu, J. C., Laudisoit, A., Mostafavi, E., 2017: The fleas (*Siphonaptera*) in Iran: Diversity, host range, and medical importance. *PLoS Negl. Trop. Dis.*, 11, 1, e0005260. DOI: 10.1371/journal.pntd.0005260.
 22. Ng-Nguyen, D., Hii, S., Hoang, M. T., Nguyen, V. A., Rees, R., Stenos, J., Traub, R. J., 2020: Domestic dogs are mammalian reservoirs for the emerging zoonosis flea-borne spotted fever, caused by *Rickettsia felis*. *Sci. Rep.*, 10, 4151. DOI: 10.1038/s41598-020-61122-y.
 23. Ponomar, S. I., Goncharenko, V. P., Soloviova, L. M., 2010: *Handbook of Invasive Animal Diseases' Pathogens Differentiation* (In Ukrainian). Agricultural Education, Kyiv, 327 pp.
 24. Prokopenkova, I. A., 2004: Distribution of ctenocephalidosis in dogs and cats in the Moscow metropolis (In Russian). *Biomedical Problems*, 13, 39—40.
 25. Rinaldi, L., Spera, G., Musella, V., Carbone, S., Veneziano, V., Iori, A., Cringoli, G., 2007: A survey of fleas on dogs in southern Italy. *Vet. Parasitol.*, 148, 3—4, 375—378. DOI: 10.1016/j.vetpar.2007.06.036.
 26. Semenko, O. V., Kurinets, D. M., 2011: *Distribution of Ectoparasites Among the Population of Stray Dogs in Kyiv* (In Ukrainian). Scientific Reports of the National University of Life and Environmental Sciences of Ukraine, 7, 29, 1—5.
 27. Tavassoli, M., Ahmadi, A., Imani, A., Ahmadiara, E., Javadi, S., Hadian, M., 2010: Survey of flea infestation in dogs in different geographical regions of Iran. *Korean J. Parasitol.*, 48, 2, 145—149. DOI: 10.3347/kjp.2010.48.2.145.
 28. Wall, R., Shearer, D., 2001: *Veterinary Ectoparasites: Biology, Pathology and Control*. 2nd edn., Blackwell Science Ltd., Oxford, 304 pp.
 29. Zouari, S., Khrouf, F., M'ghirbi, Y., Bouattour, A., 2017: First molecular detection and characterization of zoonotic *Bartonella* species in fleas infesting domestic animals in Tunisia. *Parasit. Vectors*, 10, 436. DOI: 10.1186/s13071-017-2372-5.

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