REVIEW





Which arthropods could have survived the COVID-19 lockdown? A narrative review and an algorithm for indoor epizoonoses at the reopening of the military training centers

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Abstract - Epizoonoses are dermatitis provoked by the temporary or permanent presence of ectoparasites on human skin; they can occur indoor, especially in buildings uninhabited for a long time. In Italy, during the COVID-19 pandemic, the military training has been temporarily unprioritized and some training centers and their dormitories have been emptied and closed. In their quarters, while humans were absent, some tiny animals thrived undisturbed: among them, some arthropods are now devious causative agents for indoor epizoonoses in the trainees. A systematic search was conducted on MEDLINE (PubMed) from inception to July 2022 using as keywords "military" and the arthropods most frequently responsible for indoor ectoparasitoses. Published articles with an English version available were included. The search strategy with "military" and "Cimex lectularius"/"Bed bug" as keywords retrieved only 3 pertinent articles. We developed an algorithm to quickly identify the most probable agent causing an indoor epizoonosis in the military considering service members' anamnestic and clinical data. A rapid identification of the pathogen agent is crucial in the war against these dermatological problems.

Key Words: - epizoonosis, diagnostic tool, COVID-19, military training, survival, arthropods.

Key Messages:

- After the reopening of the quarters in the Italian military training centers, epizoonoses have become common among trainees: a rapid identification of the pathogen agent permits a fast fumigation and a quick recover of the operational efficiency.
- Further articles should implement the scientific knowledge about indoor ectoparasitoses in service members.

Introduction

During COVID-19 (COronaVIrus Disease 19) pandemic, military training in Italy has been temporarily unprioritized and quarters in some training centers have been emptied and closed for months. The complete absence of food and people determined a natural selection among arthropods and other tiny animals with parasitic behavior possibly present in these buildings: some died and some thrived undisturbed.

The uncertain Ukrainian political situation and the slow decrement of SARS-CoV-2 (Severe Acute Respiratory Syndrome-CoronaVirus-2) cases are pushing commanders to activate military training centers and their quarters again. In these environments uninhabited for a variable time (from weeks to months) spiders, scorpions, flies, wasps, and ticks could have survived without feeding; nevertheless, they are visible and quite

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easy to find and to eliminate throughout an extensive – and sometimes dangerous - cleaning. Instead, some arthropods are now devious causative agents for indoor epizoonoses in the trainees.

Epizoonoses are dermatitis provoked by the temporary or permanent presence of ectoparasites on the human skin (1). These dermatological issues, also known as ectoparasitoses, are frequent outdoor but are possible even indoor in buildings uninhabited for some months, like quarters of the military training centers during the SARS-CoV-2 pandemic.

Cimex lectularius (bed bug), Pyemotes ventricosus, Sclerodermus domesticus, Cephalonomia gallicola, Dermanyssus gallinae (poultry red mite) and fleas are considered the most probable responsible for indoor epizoonosis in Europe, able to survive for some months without food or people (1–7).

Aim of the study

This study intends to investigate the scientific literature about indoor epizoonoses in the military. The secondary goal was to provide a specific and smart algorithm to quickly individuate the most probable causative agents in Europe considering only service people's anamnestic and clinical data.

Methods

A systematic search was conducted on MEDLINE (PubMed) from inception to July 2022.

The keywords used were "military" and "bed bug"/"Cimex lectularius" or "Pyemotes ventricosus" or "Sclerodermus domesticus" or "Cephalonomia gallicola" or "Dermanyssus gallinae"/"poultry red mite" or "Pulex irritans". Articles with an English version available were included.

Results

The results are shown in Table 1 (*Tab. 1*). Using the keywords "military" and "Cimex lectularius"/"Bed bug", the search strategy retrieved 11 references: 2 were not in English, 1 did not show any text, 5 were not pertinent, so only 3 articles were included.

Using the keywords "military" and "Pyemotes ventricosus" no appropriate articles were found. No results were displayed using "Sclerodermus domesticus" or "Cephalonomia gallicola" or "Dermanyssus gallinae"/"poultry red mite" or "Pulex irritans" and "military". Considering the arthropods' characteristics, we developed an algorithm to quickly identify the most probable agent causing an indoor epizoonosis after the reopening of the Italian military training centers (*Tab. 2*).

Discussion

A systematic review was not possible to perform due to the shortage of specific scientific articles about epizoonoses in the military. In the literature, the impact of these cutaneous issues in service members is probably underestimated, but daily experience shows that they are quite prone to develop ectoparasitoses, especially when employed in training activities or deployed abroad (8,9). Further studies are needed to compare the real incidence of epizoonoses in military and civilian people.

A research highlighted the importance of an integrated pest management support against Cimex lectularius for the service members deployed abroad to limit infestation and the dispersal back to the their

Tab. 1 - Results The Table shows the articles retrieved in MEDLINE (PubMed) using the specific keywords.

Keywords used with "military"	Articles displayed	Articles not in English	Full-text not available	Articles not pertinent	Articles included
Cimex lectularius/bed bug	11	2	1	5	3
Pyemotes ventricosus	1	0	0	1	0
Sclerodermus domesticus	0	0	0	0	0
Cephalonomia gallicola	0	0	0	0	0
Dermanyssus gallinae/poultry red mite	0	0	0	0	0
Pulex irritans	0	0	0	0	0



Tab. 2 - An algorithm to detect epizoonoses causative agents and to decide resulting actions: Considering service members' anamnestic and clinical data, the Table indicates the most probable responsible arthropod for indoor epizoonoses in quarters recently reopened and it suggests the next steps.

Period without military personnel	Specific cutaneous lesions	Uncovered skin involved	Arthropod dimensions/ visible by naked eye	Causative agent	Parts of the building needing to be checked	Possibility of contextual infectious diseases transmission
Up to 8 months	No	Yes	1 mm/ Yes	Dermanyssus gallinae	Drainpipes, windowsills, and terraces	Yes
Up to 12 months	Breakfast, lunch, and dinner sign	No	5 mm/ Yes	Cimex lectularius	Dark crevices and mattress seams	Still debated
Up to 12 months	Breakfast, lunch, and dinner sign	No	2-3,5/ Yes	Pulex irritans	Dark crevices and carpets (or humans/animals)	Yes
Contextual presence of A. Punctatum	Comet sign	Yes	0,2 mm/ No	Pyemotes ventricosus	Worm-eaten furniture	No
Contextual presence of A. Punctatum	No	No	2-4 mm/ Yes	Sclerodermus domesticus	Worm-eaten furniture	No

homes (8). Other Authors performed a study about bed bugs strains collected from several United States military installations in Korea (from 2009-2019) using a quantitative sequencing. They found an high percentage of mutational status conferring resistance to pyrethroids: they proposed to restrict the use of these insecticides (9).

Future research should disclose the best approach and the most appropriate chemical products for bed bugs fumigation in every country: ectoparasites eradication from a military base means to evacuate all the personnel and to steal precious time from training activities.

A Chinese review investigated bed bug resurgence around the world and considered military dormitories as highly risky environments for this infestation, since they are crowded and transient areas (10). Actually, we consider quarters as potentially inhabited by Cimex lectularius environments even if the military personnel have not slept there for several weeks (*Tab. 2*).

Interestingly, all the retrieved articles focus on bed bugs, even if they are rarely found by direct indoor dust examination in Europe (1): probably these ectoparasites are the most characterized and famous and very easy to detect naked eye (1,2).

From the clinical point of view, an itching dermatitis presenting a vesicle or a hemorrhagic punctum on the top of an erythematous-edematous papule – either the arthropods try to take the human blood or not – is the best-known stigmata of epizoonosis (1). Although the diagnosis is not difficult, the correct identification of the causative agent(s) can be extremely challenging; therefore, focu-

sing on the minimal anamnestic and clinical differences between the specific arthropods' infestation is advisable. In Table 2 we propose an easy-to-follow algorithm to recognize the most probable responsible ectoparasite and to plan the right fumigation without hesitation.

In detail, only minuscule arthropods can bite passing through clothes and only insects without wings feed determining three lesions in a linear pattern, corresponding to the three main blood meals (breakfast, lunch and dinner sign) (2). Instead, a hemorrhagic punctum from which a lymphangitis starts (comet sign) is a singular feature strongly linked to Pyemotes ventricosus epizoonoses (11) (*Fig.* 1); this mite could be microscopically found for few days under the hemorrhagic punctum (3).

Moreover, the possibility of a contextual infectious disease transmitted during





Fig. **1** - A 30-year-old woman complained about an itching sensation on her trunk. The Figure shows her right flank where a hemorrhagic punctum with a lymphangitis (comet sign) was evident. In the room where the young lady had slept there were worm-eaten chairs.

ectoparasitoses must be considered, but the infectious agent must have survived the quarters closure too.

For instance, avian mites or fleas are blood-sucking arthropods able to transmit infectious diseases; instead, bed bug abilities in this field are still debated (2).

Cimex lectularius is an obligate bloodsucking insect that presents the breakfast, lunch and dinner sign when it bites its hosts. It can live up to one year without blood meals, although some authors suggest a shorter survival (128 days) (12). It resembles an apple seed due to its wingless, flat, oval, darker brown appearance of about 5 mm in length. It hides in dark crevices and in mattress seams and it feeds at night, attracted by carbonic dioxide produced by humans sleeping. Because skin lesions could represent a delayed hypersensitivity reaction, a skin response may be seen even a few days later (2).

Flea bites are associated to breakfast, lunch and dinner sign too. These arthropods usually live on their victims or hidden in warm and comfortable environment, like carpets or crevices and, when they sense the exhaled carbon dioxide or the vibrations of the movement of a potential new prey, they use their strong hind-legs to jump on. They generally provoke an itching dermatitis on human exposed skin, especially on the legs, if the person is parasitized when walking (6).

The most important species for human pathology is Pulex irritans, although Ctenocephalides felis (common in cats), Ctenocephalides canis (in dogs) and Xenopsylla cheopis (in rats) can parasitize humans too, since the preference is not strict. Pulex irritans larvae, that measure about 0.6 mm and normally feed on organic debris, could resist dormant up to one year without hosts and could become an active and hungry bloodsucking adult. It is a wingless insect approximately 2-3.5 mm long. Pulex irritans adults can survive without feeding only for few days (6).

Obviously, the former presence in the building of an animal or a person carrying fleas should be investigated, since these parasites rarely move for long distances without their hosts.

If the quarters have old furniture, Anobium punctatum, a woodworm, can proliferate. Different arthropods such as Sclerodermus domesticus, a cuckoo wasp, also known as "antiquarian's friend", and Pyemotes ventricosus, a mite, can feed on Anobium punctatum larvae. When they are in a great number and close to people, they can sting the human skin accidentally without sucking blood (3,4). Since their survival depends on Anobium puctatum presence, they can live until there are worm-eaten furniture; they die in few days without feeding.

The most important differences between Sclerodermus domesticus and Pyemotes ventricosus are dimension and clinical symptoms since Sclerodermus domesticus female measures 2-4 mm and provokes a rapid onset erythematousedematous lesion with pain and itching sensation (4) and Pyemotes ventricosus measures 0.2 mm and may not cause pain but only itching (13), sometimes associated with the comet sign (11).

Other arthropods taxonomically similar to Sclerodermus domesticus, such as Cephalonomia gallicola, can share their parasitic behavior and their clinical presentation when they attacks human (7).





Fig. 2 - A 41-year-old service man noticed on his trunk and limbs some itching erythematous-edematous papules with a hemorrhagic punctum. The Figure shows his left forearm. He had slept naked with all the windows opened wide in a room closed for some months: a deepened cleaning revealed an uninhabited bird nest on the balcony.

Avian mites, Dermanyssus gallinae (poultry red mite), Ornithonyssus sylviarum (northern fowl mite), Ornithonyssus bursa and Ornithonyssus bacoti (tropical rat-mite) are non-burrowing, bloodsucking ectoparasites of similar shape and size (about 1 mm in length). Excepting for Ornithonyssus sylviarum, which usually lives permanently on its host, they are temporary and nocturnal visitors of their victims, hiding nearby during daytime (5). The most common species, Dermanyssus gallinae, affects egg layers in several country and can survive up to 8 months without feeding (14).

When the availability of its preys diminishes, such as when birds move to other climates as seasonal behavior, Dermanyssus gallinae can bite humans, especially if they sleep near bird nests (5,15) (*Fig. 2*).

Considering the ectoparasites features and the most common cutaneous reactions, our tool (Table II) can help commanders and military doctors to easily understand where the ectoparasites live and come from and which part of quarters needs to be checked and possibly fumigated first. The direct indoor dust examination can be used as confirmation test since it needs a laboratory and it is a time-consuming procedure (1).

Additionally, if the arthropod can transmit an infectious disease, specific protocols must be followed to detect, eventually treat the infection, and limit its spread.

In the current politically unstable scenario, we need our service members to be perfectly healthy and ready to work; every delay can be risky.

Conclusion

The real impact of ectoparasitoses in military personnel is probably underestimated and further studies are needed to estimate the incidence of these dermatological issues in this specific population. Although direct indoor dust examination is still advisable, anamnestic and clinical data are crucial to quickly identify the responsible arthropod: the earlier we find the causative agent, the faster parasitized service members can recover.

Disclosures:

The Author declares that he has no relationships relevant to the contents of this paper to disclose.

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