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Insects and SARS-CoV-2: Analysis of the Potential Role of Vectors in European Countries

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Abstract

SARS-CoV-2 is a coronavirus responsible for the pandemic that developed in China in late 2019. Transmission of the virus is predominantly direct, through exposure to infected respiratory secretions. As far as we know, arthropods play a key role in the transmission and spread of several viruses, and thus their role in the spread of COVID-19 deserves to be studied.
The biological transmission of viral agents through insects is very complex. While mechanical transmission is more likely to happen, biological transmission is possible via blood-sucking arthropods, but this requires a high grade of compatibility between the vector and the pathogen. If the biological and mechanical transmission of SARS-CoV-2 by blood-sucking arthropods is excluded, a mechanical transmission by urban pests could take place. This risk is very low but it could be important in isolated environmental conditions, where other means of transmission are not possible. The presence of SARS-CoV-2 in non-blood-sucking arthropods in infected buildings, like hospitals and retirement homes, should be investigated.

Introduction

SARS-CoV-2 is a coronavirus responsible for the pandemic that developed in China during the latter part of 2019, where it is assumed that the virus spilled over from an animal reservoir (1). Human infection has a particularly variable clinical course, which in many cases is found to be asymptomatic. Symptomatic individuals experience flu-like symptoms, up to developing a severe form of interstitial pneumonia with respiratory distress (2). The death-to-case rate is around 2-3% (2), although this may vary geographically on the basis of the characteristics intrinsic to the population and the level of organization and the response of the health system.

The transmission of the virus is predominantly direct through exposure

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to infected respiratory secretions, specifically droplets (2), while the indirect transmission via vehicles (objects and/or food contaminated with infected secretions/ excretions) is a means of spread that has minor epidemiological significance and requires further assessments (3-6).

The efficiency of the indirect transmission is strongly influenced by the persistent capacity of the virus outside the host and by the environmental conditions, such as temperature and humidity (7). SARS-CoV-2 has been experimentally found viable for up to 72 hours on various surfaces, although the substrate material also affects virus survival (8).

The insects play a key role globally in the transmission and spread of infectious and parasitic diseases for which they can act as biological or mechanical vectors, depending on the pathogens (9-11).

The biological transmission of viral agents through insects is very complex and requires an affinity between the surface viral components and cell receptors in order to allow viral replication within the vector (12). Mechanical transmission is much simpler, as the vector can acquire the virus simply through body contact or food, but diffusion is less effective. The ability of an insect to mechanically transmit the virus depends on the resistance of the virus outside the host, on the acquired viral load and on the dilution phenomena of the viral load related to the activity of the vector in the environment.

Role of Hematophagous Arthropods

The blood-sucking arthropods are of great interest to the European epidemiological scenario of human vector-borne diseases, and those of particular importance are ticks (Acari, Ixodidae) and mosquitoes (Diptera, Culicidae). Mosquitoes represent a particular problem in Europe for the autochthonous transmission of the West-Nile virus and various other viruses, such as Zika virus and Chikungunya virus, that can be imported from tropical regions through viremic subjects (13-15). In the SARS-CoV-2 epidemic scenario, mosquitoes represent the only group of insects that has prompted interest due to their ability to move around the urban environment. Other important blood-sucking arthropods that can be found in urban environments, such as *Cimex lectularius* (Rhynchota, Cimicidae) and various species of fleas (Siphonaptera, Pulicidae) and Phlebotomidae (Diptera), have a lesser significance, given their limited ability to spread throughout the territory.

Regarding SARS-CoV-2, although it mainly involves tissue cells of the upper and lower respiratory tract, blood diffusion takes place during the viremic phase (16), which is true also for the SARS virus that has the ability to infect different types of cells and tissues (17).

The hematophagous arthropods occurring in human contexts can therefore acquire the virus from viremic subjects through blood and assume the potential role of biological and mechanical vectors. To date, there are neither recorded data in the literature that indicate replication of the SARS group viruses within arthropods nor proofs of transmission phenomena (18, 19).

Additional studies investigated the replicative ability of the SARS-CoV-2 virus in *Aedes albopictus, Aedes aegypti* and *Culex quinquefasciatus* (Diptera) following intrathoracic inoculation, demonstrating the inability of the virus to replicate in the tissues of the tested arthropods and therefore excluding them as biological vectors (20). The potential role of mosquitoes as mechanical vectors of the virus through the contaminated mouthparts used for feeding on infected blood was also investigated and the unsuitability of this transmission route demonstrated (21).

Role of Non-Hematophagous Arthropods

Non-blood-sucking insects can acquire potential pathogens through contact with infected substrates or through the ingestion of secretions and/or excrement from infected subjects (9).

Once the pathogen is acquired, mechanical vectors can transmit it through subsequent contact with surfaces, mucous membranes, foods, and the like; or during trophic activity through regurgitation and/or fecal material. For this reason, SARS-CoV-2, in addition to being expelled through the secretions of the respiratory system, can likewise be found in feces (18, 22) and vomit.

The survival of viruses ingested by insects is linked to various factors, including digestive enzymatic capacity. For example, the Poliovirus survives up to 50 days in *Periplaneta americana* (Blattodea, Blattidae) and up to 13 days in *Lucilia sericata* (Diptera, Calliphoridae) (23) and the hepatitis-B virus could potentially be transmitted through *Cimex lectularius* (24).

Concerning the presence of viral agents on insects' bodies, a study highlighted the presence of porcine enteroviruses on the body of *Musca domestica* (Diptera, Muscidae) (23) and its ability to be a mechanical vector of the turkey coronavirus (25).

Research on SARS coronavirus in animal vectors, relative to Blattaria, have given positive results on a small number of specimens investigated (18, 26). Regarding SARS-CoV-2, no study has investigated the mechanical vector capacity of synanthropic pests, although there are suspicions about *Musca domestica* (Diptera) under this aspect (18, 27).

Final Considerations

The role of mosquitoes in the spread of SARS-CoV-2, both as biological and mechanical vectors, has been excluded. However, it could be useful at an epidemiological level to use blood-sucking insects (e.g. Diptera: Culicidae) for the purpose of surveillance of viral circulation in analogy with what has been highlighted regarding the H5N1 influenza virus (28). In particular, it might be interesting to use engorged females of species particularly suited to a human environment, such *as Aedes albopictus* (Diptera), to search for the presence of the virus in seasonal periods (like summer) when circulation of the virus among the population can be reduced by climatic and social conditions.

Even more interesting and difficult to examine is the aspect related to the potential mechanical transmission of the virus through vectors. Non-blood-sucking insects can potentially become contaminated through surface droplets, secretions (e.g. spit) and excretions (e.g. feces and vomit) (18, 29), transmitting the virus to surfaces and foods or directly onto the oral mucous membranes or conjunctival tissues of healthy subjects. This could be possible given the rather long survival time of SARS-Cov-2 in the environment (8).

The potential interest of insects, conventionally defined as urban pests (e.g. Diptera: Muscidae, Calliphoridae and Blattaria: Blattidae, Blattellidae), in the transmission of SARS-CoV-2, considering current knowledge and the health organizations of Western European countries, can be relegated to closed environments, such as houses, retirement homes, etc. In these situations, the infected insect can hypothetically favor circulation of the virus in the absence of alternative attractive sources of food that could contribute to a dilution, or even to the inactivation of the viral load in the vector. If alternative sources of food are not available, the fly has no alternative than to suck the excretions from mucous or conjunctival tissues, causing transmission of the virus between persons.

If food is abundant in the environment, the flies can feed in many places releasing the virus in a very small quantity, progressively reducing the viral charge present on the body and mouth parts. In community settings, particularly in healthcare facilities for the elderly and disabled, contaminated flies (Diptera: Muscidae, Sarcophagidae and Calliphoridae) could transmit the virus to healthy individuals by landing directly on oral mucous membranes and ocular adnexa.

From an epidemiological point of view, the impact of mechanical vectors such as flies (Diptera: Muscidae, Sarcophagidae and Calliphoridae) and cockroaches (Blattaria), could be particularly relevant in conditions of poor environmental hygiene and associated with a particularly high density of potential mechanical vectors favoring fecal-oral virus circulation.

As already indicated by other Authors (18), in epidemic conditions it is appropriate to guarantee measures to combat urban pests in order to eliminate any possible source of mechanical transmission. In epidemic scenarios linked to airborne viruses, there is a tendency to reduce or eliminate the disinfestation activities aimed at crawling and flying insects. However, given the potential implications of insects as mechanical vectors and the possibility that the epidemic event reduces the staff assigned to essential services, such as waste collection, this favors both the proliferation of pests and the possibility of infection by insects on the waste, confirming the need to maintain a high level of pest control interventions in an urban environment.

With regard to blood-sucking arthropods, and in particular mosquitoes, although the extraneousness of the transmission of SARS-COV-2 has been demonstrated by several studies, in a pandemic situation, it is strongly recommended to keep control and monitoring plans active, as the onset of arbovirus epidemics can further stress the local and hospital health services at all levels (diagnostic, treatment and follow-up). The concomitant territorial circulation of pathogenic arboviruses and pandemic viruses also contributes to making diagnosis more difficult, particularly if characterized by common clinical symptoms, such as Chikungunya fever (30).

Finally, as discussed above and to complete the missing information, the presence of SARS-CoV-2 in blood-sucking and non-blood-sucking arthropods in infected buildings like hospitals, retirement homes, etc., as well as in outdoor places in infected areas, should be investigated.

Riassunto

Insetti e SARS-CoV-2: analisi del potenziale ruolo dei vettori in Europa

SARS-CoV-2 è un coronavirus responsabile della pandemia che si è sviluppata in Cina alla fine del 2019. La trasmissione del virus è prevalentemente diretta, attraverso l'esposizione a secrezioni respiratorie infette. Gli artropodi svolgono un ruolo chiave nella trasmissione e diffusione di diversi virus, e quindi il loro ruolo nella diffusione di COVID-19 merita di essere considerato e valutato.

La trasmissione biologica di agenti virali attraverso gli insetti ematofagi è molto complessa e richiede un certo grado di compatibilità fra agente patogeno e vettore, mentre è più facilmente realizzabile la trasmissione meccanica e gli infestanti sinantropi potrebbero potenzialmente essere responsabili della trasmissione meccanica.

Se si esclude la trasmissione biologica e meccanica di SARS-CoV-2, da parte di artropodi succhiatori di sangue, è comunque necessario valutare la potenziale trasmissione meccanica operata dagli infestanti urbani. Questo rischio è sicuramente molto basso e di scarsa rilevanza epidemiologica, ma potrebbe assumere un certo interesse in condizioni ambientali isolate, dove non sono possibili altri modi di trasmissione. La presenza di SARS-CoV-2 in artropodi non ematofagi in strutture di ricovero, come ospedali e case di riposo, dovrebbe essere studiata.

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