COMMENTARY

Are insects the future vectors of COVID-19?

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Insects are affected by a diverse combination of viruses. Majority of the viruses affecting insects are host-specific and non-pathogenic to humans. While blood-sucking insects do not transmit COVID-19, those feeding on human and animal wastes like houseflies and cockroaches may be capable of transmitting SARS-CoV-2 coronavirus. However, studies monitoring adhesion capacity, permanence and active dissemination of SARS-CoV-2 coronavirus in houseflies and cockroaches are yet to be assessed. Further studies are needed to explore the transmission and pathogenicity mechanism of COVID-19 by different insect vectors.

The ongoing novel coronavirus outbreak is amongst the major infectious diseases that have emerged at an animal–human interface. The virus was named as 'severe acute respiratory syndrome coronavirus-2' (SARS-CoV-2) by the International Committee on Taxonomy of Viruses. The virus belongs to genus *Betacoronavirus* (betaCoVs) of subfamily Orthocoronavirinae and family Coronaviridae (order Nidovirales), and the disease caused by it is known as COVID-19 (coronavirus disease-2019). The virus has a single-stranded RNA (+ssRNA) and a crown-like appearance ('corona' is the Latin term for 'crown') due to the presence of spike glycoproteins on its envelope[1]. After binding to the cellular receptors, the spike glycoproteins allow fusion of viral and host membrane. As a consequence, RNA genome enters the cytoplasm of target cells. Fever, cough, fatigue, headache, sore throat and shortness of breath are the major symptoms of COVID-19. In severe cases pneumonia, acute respiratory distress syndrome, multiple organ failure and death are also reported[1].

Since insects are affected by a diverse combination of viruses, exploring possibilities for transmission of SARS-CoV-2 coronavirus and pathogenicity mechanism of COVID-19 by insect vectors is highly essential. The pathogenic RNA viruses infecting insects belong to three orders, viz. Mononegavirales, Nidovirales and Picornavirales. Amongst them, Nidovirales is of great importance, as it comprises the family Coronaviridae to which SARS-CoV-2 coronavirus belongs[2]. According to WHO reports, there is no information or evidence which suggests that SARS-CoV-2 could be transmitted by mosquitoes. Till date there is no evidence that any insect species has transmitted SARS-CoV-2 to humans because the mammalian receptor, i.e. angiotensin-converting enzyme (ACE2) that binds to SARS-CoV-2 is present in limited vertebrate species[3]. Although insects have angiotensin-converting enzymes (ACEs), they are different from the ones found in humans and are unable to bind to SARS-CoV-2 (ref. 4). Thus, the virus cannot replicate in insects, including edible insects that are actively produced for food and feed[5].

The virus is transmitted through: (i) unprotected coughing and sneezing by SARS-CoV-2 patients; (ii) direct contact of hands with nose, eyes or mouths of SARS-CoV-2 patients, or (iii) contact with surfaces of objects and equipment used by SARS-CoV-2 patients[1]. While SARS-CoV-2 can remain on surfaces for several days depending upon the surface type and the temperature and humidity of the environment, in many cases live viruses have been recovered from the faeces of patients. Faeces may therefore be considered as a possible source for COVID-19 transmission. Under such circumstances, both houseflies (*Musca domestica*) and cockroaches (*Blatella* spp.) may play key roles in transmission of the disease[6,7]. However, studies monitoring adhesion capacity, permanence and active dissemination of SARS-CoV-2 in houseflies and cockroaches are yet to be assessed.

In view of the above information, it is clear that so far we have no evidence that SARS-CoV-2 can be transmitted by insects. However, we cannot deny that insects may not be potential vectors of SARS-CoV-2. Therefore, assessing the phylogenetic relationships of insects with viruses may be helpful in understanding the viral evolution and ways by which viruses become pathogens. Studies on evolving and re-evolving of viruses under changing climatic conditions, their development and adaptations within the hosts, and palaeoentomological investigations on phylogeny and evolution of insect vectors of these viruses could be the areas of scientific research that may support the long-term survival of humanity. Since ACEs incapable of binding to SARS-CoV-2 are found in insects, the insects like *Drosophila melanogaster* and *Anopheles stephensi* may be utilized for developing vaccines against SARS-CoV-2 employing biotechnological tools. While we are still learning about the SARS-CoV-2 severity, transmissibility, controllability and identification of presumed animal reservoir, more studies are needed to explore the transmission and pathogenicity mechanism of the disease by insect vectors.

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