Twin Mammals and COVID-19: Life and Science of the Suspects

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Abstract

The world is puzzling over the origin of the current outbreak of the coronavirus disease (COVID-19) that is caused by a novel coronavirus-2019 (2019-nCoV). As of 25th March 2020, the World Health Organization has reported 4,14,179 confirmed cases and 18,440 confirmed deaths in total due to COVID-19. To this end, two unique mammals namely bats and pangolins are being investigated for their potential link to COVID-19. However, the evidence so far gathered in this context is far from clear. This paper aimed to: (i) enlighten the major aspects of life of bats and pangolins; (ii) briefly discusses their potential link to COVID-19; and also (iii) to highlight the way forward. The outcomes may contribute to future research on the subject.

Keywords Coronavirus; 2019-nCoV; COVID-19; bat, pangolin

1. Introduction

In humans, several respiratory infections ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS) are known to be due a large family of viruses called as coronaviruses. On 31st December 2019, the World Health Organization (WHO) was informed of a cluster of cases of pneumonia of unknown cause detected in Wuhan City, Hubei Province of China. Later, the WHO named an infectious disease as the coronavirus disease (COVID-19) and confirmed as to worldwide pandemic outbreak caused by a newly discovered coronavirus the novel coronavirus (2019-nCoV). The world is puzzling over the origin of COVID-19. In fact, COVID-19 is one of the infectious diseases (zoonotic diseases or zoonoses) that are transmitted between species from animals to humans (or from humans to animals). As of 25th March 2020, the World Health Organization has reported 41,4,179 confirmed cases, 18,440 confirmed deaths in total due to COVID-19 (WHO 2020[a]) (Table 1). The WHO has declared the COVID-19 outbreak a global health emergency. Notably, two unique mammals namely bats and pangolins are being investigated for their potential link to COVID-19. However, the evidence so far gathered in this context is far from clear. Given above, in this paper, the major aspects of life of bats and pangolins are enlightened; recent reports on the potential link of bats and pangolins to COVID-19 are briefly discussed; and also the way forward is highlighted.

2. Bats

Bat is an exceptional creature and remarkable flying social mammal, and belongs to order Chiroptera and family Microchiroptera. Bats are divided into two main types: megabats (sub-order: Megachiroptera) and microbats (sub-order: Microchiroptera). Megabats include flying foxes and Old-World fruit bats, roost in trees, are the largest type of bats, have great eyesight and most eat fruit or nectar.

On the other, microbats are smaller in size; most live in the Western Hemisphere and most eat insects (insectivorous) using their echolocation ability.

Bats have true wings and flight, where wings are modified forelimbs; four fingers support and skin covers the flight surface/ a wing membrane (patagium). With over 1300 species distributed across six continents, Indonesia hosts 219 bat species, 114 species are found in India, and about 50 bat species live in national parks across the United States. In India, Andhra Pradesh state is home to 38 species, 17 species of bats found in Hyderabad. Overall, bats make up one-fifth of the mammal population on Earth (Bat Conservation International 2020) . Bats can be found in many parts of the world. Missing only from Polar regions and from some isolated islands, bats live in cities, deserts, grasslands and forests in tropical and temperate regions of the globe (Wund and Myers 2005). Bats are social animals and stay together in large groups. About 1.5 million bats are supposed to live under the Congress Avenue Bridge in downtown Austin, Texas (Simmons and Conway 1997).

Bats exhibit a great variation in body size, weight, lifespan and food habit. The body size of bats greatly varies. *Craseonycteris thonglongyai* (Microchiroptera) is the smallest bat, 29–34 millimetres (1.1–1.3 inches) long with a 150 millimetres (5.9 inches) wingspan and weighs between 2–2.6 grams (0.071–0.092 oz) (Wikipedia, *https://en.wikipedia.org/wiki/Kitti%27s_hog-nosed_bat*). On the other, with 1.6 kilograms (3.5 lb) body weight and a wingspan of 1.7 metres (5.6 ft) few species of genus *Pteropus* megabats (such as *Pteropus poliocephalus*; *Pteropus conspicillatus*; *Pteropus melanotus*) and the giant golden-crowned flying fox (*Acerodon jubatus*) are the largest bats (Nowak 1999).

There occurs a relationship between the body size and the lifespan of mammals, where, the larger mammals are assumed to live longer lives. Against this relationship, the lifespan of bats may range between 10 - 25 years, and can live over 30 years in the wild (Wund and Myers 2005). Additionally, hibernating bats have a tendency to live longer than non-hibernating ones; and the females live

longer than males depending on their species. Bats are omnivores and most bats eat insects, but many feed on leaves, pollen, nectar, petals, bracts, fruits (such as avocados, mangoes, bananas and wild dates) or seeds. Three species of vampire bats (the common vampire bat, *Desmodus rotundus*; the hairy-legged vampire bat, *Diphylla ecaudata*; the white-winged vampire bat, *Diaemus youngi*), all native to the Americas, ranging from Mexico to Brazil, Chile, Uruguay and Argentina, depend on blood as their food source (blood mostly that of other mammals); a dietary trait called hematophagy (Wikipedia, *https://en.wikipedia.org/wiki/Vampire_bat*).

Humans are varyingly benefitted with bats. For example, procured from caves, bat dung is used as fertilizer; bats reduce the use of pesticides; and are also used as food across Asia and the Pacific Rim. Bats have immense ecological and economic importance and the most bat populations are important for agriculture and the environment. Due to their unique echolocation ability to find flying or crawling insects and their superb flying skills to catch them, the most bats are insectivores and are voracious predators of nocturnal insects, including many crop and forest pests. It has been estimated that insect-eating bats can catch and eat 600 mosquitos in an hour and thereby control their population and impacts (Simmons and Conway 1997). Researchers have also anticipated agricultural losses of > $3.7 billion/year year in pest-control costs due to loss of bats in North America (Boyles et al. 2011). In addition, bats have aesthetic values and are equally important in tourism, and education and research (Kasso and Balakrishnan 2013). Regarding the role of bats in pollination (act of transferring pollen grains from the male anther of a flower to the female stigma) > 528 species of 67 families and 28 orders of angiosperms worldwide are benefitted with bat pollination (Fleming et al. 2009). In particular, Pteropodid bats from bat-family Pteropodidae are usually fruit-eaters (frugivorous), known to pollinate flowers of about 168 species of 100 genera and 41 families (Fleming et al. 2009) and are responsible for propagating at least 289 species of plants. The most of these bat-pollinated plants (about 186)

provide economically important resources and products including fruits, drinks, foods, ornamental plants, timbers, fibres, tannins, dyes, medicines, and animal fodder (Sudhakaran and Doss 2012; Aziz et al. 2016). On the other, the leaf-nosed bats (with elongated snout and tongue) from bat-family Phyllostomidae are also nectivorous and known to pollinate flowers of about 360 species of 159 genera and 44 families (Fleming et al. 2009). Notably, bats are also traditionally eaten in Indonesia by the Minahasan people from North Sulawesi as whole bats including the head and wings in the form of a curry-like dish called Paniki (Reuters News*, https://www.reuters.com/article/us-china-health-indonesia-bats/bat-meat-still-popular-in-parts-of-indonesia-despite-coronavirus-fears-idUSKBN20511R*).

Taking into account the ecological and economical importance, the United Nations Environment Programme (UNEP), the Convention on the Conservation of Migratory Species and many bat conservation organizations had declared the year 2011 as the Year of the Bat. Additionally, the International Union for the Conservation of Nature (IUCN) has considered approximately 25% of all species bats (within Chiroptera; nearly 240 species) as threatened.

3. Pangolins

The solitary, primarily nocturnal and scaly anteaters, pangolins are mammals and belong to the order Pholidota and family Manidae. The genus Manis has eight species distributed on two continents namely Africa and Asia. In Africa, black-bellied pangolin (*Phataginus tetradactyla*), white-bellied pangolin (*Phataginus tricuspis*), giant ground pangolin (*Smutsia gigantea*) and Temminck's ground pangolin (*Smutsia temminckii*) are found. Asia is the house of the other four species namely Indian pangolin (*Manis crassicaudata*), Philippine pangolin (*Manis culionensis*), Sunda pangolin (*Manis javanica*) and the Chinese pangolin (*Manis pentadactyla*). Exhibiting 30 to 100 cm (12 to 39 in) size range, these species possess a range of adaptive features (long sharp claws, strong forelimbs, an elongated tongue for probing help pangolins to dominantly insectivorous; and

this unique mammal is protect against bites and stings being decorated with fibrous hair and keratinized scales (Ashokkumar et al. 2017).

Pangolins help to keep insect and termite populations under control, aerate soil by digging burrows; and also serve as a host for several organisms including *Amblyomma javanese*, *Cylicospirura* species, and *Strongyloides* species (Thapa 2013; Li et al. 2010; Escobedo 2019). Despite their aforesaid economic importance for humans, all the eight species of pangolins are one of the most highly trafficked mammals in the world, and are hunted primarily for their scales, carcasses and also for their delicacy meat (bush meat) and other body parts. Pangolin scales are believed to have curative medicinal properties and are used in traditional medicine throughout China and Southeast Asia (Mohapatra et al. 2014; EcoHealth Alliance*, https://www.ecohealthalliance.org/2018/02/the-plight-of-the-pangolin*). The list of countries where pangolins are smuggled and poached for their live use and/or body parts includes China, Indonesia, India, Nigeria, USA and Europe. In terms of the trade of scales, China was the most common destination as part of large-quantity shipments of pangolin scales; whereas, whole pangolins are mostly traded within Asia (maximally in Indonesia) followed by the United States and Europe (*https://www.aa.com.tr/en/environment/pangolins-still-under-global-threat-in-2020/1734744*). India is among the major countries where pangolins are smuggled and poached, where nearly 6000 pangolins were poached between 2009 and 2017. In addition, considering the China's voracious appetite for the mammal live pangolins are also being smuggled to this country (Choudhary et al. 2018; Ghosh 2019). Given these, pangolins are protected under national and international laws owing to their Vulnerable to Critically Endangered status on the IUCN Red List of Threatened Species (*https://www.worldwildlife.org/species/pangolin*; Escobedo 2019). In January 2020, the Nigerian customs officers have seized a staggering 9.5-tonne shipment of poached pangolin scales (Environmental Investigator Agency*, https://eia-*

international.org/news/huge-9-5-tonne-bust-of-pangolin-scales-must-sharpen-nigerias-appetite-to-tackle-wildlife-crime/).

4. Potential link of bats and pangolins to COVID-19

The novel coronavirus (2019-nCoV), the cause of the recent outbreak COVID-19 is a zoonotic virus, and like SARS, nCoV-2019 also belongs to genera betacoronaviruses of the sub-family Orthocoronavirinae in the family Coronaviridae, of the order Nidovirales. Notably, these types of viruses are enveloped, positive-sense, single-stranded RNA viruses of zoonotic origin. There is strong indication of the animal origin of this virus. Evidences demonstrated the link between the 2019-nCoV and other similar known coronaviruses (CoV) circulating in bats, and more specifically those of the *Rhinolophus* bat sub-species abundant and widely present in Southern China, and across Asia, the Middle East, Africa and Europe (Salata et al. 2019; WHO 2020[b]).

The link of the twin mammals (bats and pangolins) and a reptile (snake) to COVID-19 has been suspected. However, the claim of Ji et al. (2020) regarding the snakes as the source of nCoV-2019) has been rejected by researachers. In support of the rejection of this claim, lack of evidence regarding the capability of 2019-nCoV for infecting snakes and weak evidence in support of the snakes serving as a host of the virus (Callaway and Cyranoski 2020). Nevertheless, bats are mostly seen as a transmitter of the coronavirus, pangolins have also been argued as potential intermediate hosts of the virus (Bir 2020). Theory behind the relation of the twin mammals is that the insectivore bats flit across the sky; leave a trace of potential 2019-nCoV in its droppings, which reach to the forest floor, where the soil/leaf-insect/termite-eating pangolins pick up the infection from the excrement. Eventually, pangolins and/or bats are captured and eaten by humans, and the spread of disease occurs from infected person to heath person, and a global outbreak is born (Fig. 1).

A large variety of zoonotic viruses are known to naturally house bats. In a recently study, Mendenhall et al. (2019) reported up to 47 different virus families were detected from bat fecal samples). Moreover, as of 2017, over 130 virus species including several emergent human pathogens have been detected in bats (cited in Liu et al. 2019; Hu et al. 2017). In particular, bats act as reservoirs for more than 60 different viruses that can infect humans (Live Science 2013). Bats have also been reported to carry significantly more viruses than any other mammal species on planet (Olival et al. 2017). Notably, bats have been argued in several studies as the main reservoir of the major historic outbreaks of Nipah virus infection in Malaysia (1998–1999) and Bangladesh (2001), Hendra virus infection in Australia (1994), the severe acute respiratory syndrome (SARS) (2003), Middle East respiratory syndrome (MERS) and recent ongoing COVID-19, epidemic of acute respiratory syndrome in China and other countries (Li et al. 2005; Zhou et al. 2020). Bats are known to harbor 61 zoonotic viruses; on average, each bat species hosts 1.79 zoonotic viruses, compared with rodents' 1.48 viruses per species (Live Science, *https://www.livescience.com/12951-10-infectious-diseases-ebola-plague-influenza.html*). The first metagenomic study of virus diversity done in endangered pangolin species in China and also speculated the capability of direct or indirect crossing over of coronaviruses into other mammals (Liu et al. 2019).

On the other, pangolins themselves are not known to carry any viruses, which can infect humans; however, pangolins do carry parasites in their scales like ticks, which can spread vector-borne diseases (EcoHealth Alliance, *https://www.ecohealthalliance.org/2018/02/the-plight-of-the-pangolin*). The major ectoparasites housing in the pangolin scales include *Amblyomma javanese*, *Cylicospirura* species, and *Strongyloides* species (Thapa 2013; Li et al. 2010; Escobedo 2019). Earlier, Liu et al. (2019) have argued coronaviruses as dominant pathogens responsible for the death of Malayan pangolins (*Manis javanica*) (Liu et al. 2019). Using genomic sequencing to compare the DNA of 2019-nCoV in infected people with that in animals researchers Shen Yongyi and Xiao Lihua

found a 99% match with pangolins and argued pangolins as an intermediate host of the virus (Cyranoski 2020).

To varying extents, both pangolins and bats are eaten in China and other parts of world. As mentioned also above that pangolins are highly sought-after in China for their meat and their scales; the latter are used in traditional medicine. Bats are also traditionally eaten in Indonesia by the Minahasan people from North Sulawesi as whole bats including the head and wings in the form of a curry-like dish called Paniki (Reuters News, *https://www.reuters.com/article/us-china-health-indonesia-bats/bat-meat-still-popular-in-parts-of-indonesia-despite-coronavirus-fears-idUSKBN20511R*).

In the present context, series of studies have been done in order to reveal the connection of bats with the mentioned COVID-19. However, the transmission routine of COVID-19-causing 2019-nCoV virus among hosts is yet to reveal (Zhou et al. 2020). Mystery deepens also over animal source of coronavirus, where both the mammals, namely ant-eating pangolins and mostly-insect eating bats are considered as prime suspects (Cyranoski 2020; Zhou et al. 2020). Notably, both pangolins and bats are unique in the sense that the former is the only known mammal with large, protective keratin scales covering their skin. On the other, bats are remarkable flying social mammals with true wings and flight. Additionally, a slew of genetic analyses have yet to find conclusive proof (Cyranoski 2020; Hollingsworth et al. 2020; Kaba and Kitaw 2020; Zhou et al. 2020).

5. Conclusions and the way forward

Earlier, a number of major outbreaks including Ebola, HIV, Severe Acute Respiratory Syndrome (SARS) have crossed over from wild animals. A range of wild animal species could be the host of corona virus; however, owing to their known role in harboring a large number of different coronaviruses particularly bats could be prime suspect in context with animal origin of 2019-nCoV. Getting

rid of pangolins and/or bats such as through their killings is not the way to avoid disease or for reducing the disease transmission. Due to their smugglings and poaching, and also due to habitat alteration and loss of life of both bats (Jones et al. 2003; Wund and Myers 2005) and pangolins (Challender et al. 2015; Choudhary et al. 2018) are at great risk. Hence, restriction and/or a permanent ban must be called for on trade in wildlife and closure of the markets where wild animals including pangolins and bats are sold for food and medicines. The intensive research and critical discussion are in progress. If not exactly the cause and/or transmission of the current outbreak of COVID-19 are revealed the future outbreaks of new or emerging human diseases could be prevented with the major outcomes of the ongoing global efforts. At this moment, we must rely only on concrete evidence and avoid rapidly increasing speculations. We should also be very cautious about claims of blaming bats, pangolins or other organisms as the prime suspects unless the researchers over the globe are able to establish to a plausible extent genetic match between coronavirus in bats and pangolins with humans. Overall whoever may be the reservoir for new viruses (such as 2019-nCoV) having capability of infecting humans, studies can be designed and the outcomes of these studies can be used as strategy for preventing the future emergence of new zoonotic agents.

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Figure legends

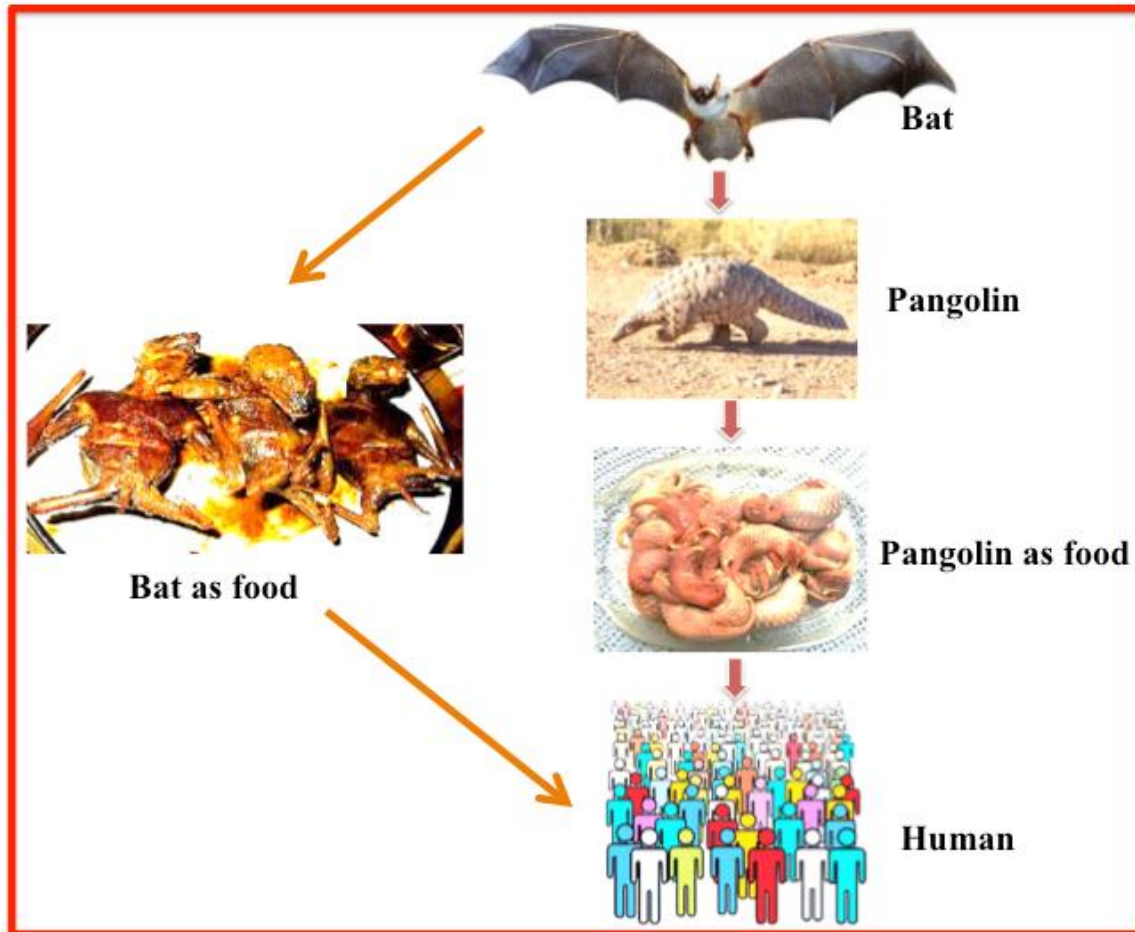
Fig. 1 Diagrammatic representation of the theory behind the potential link of the twin mammals (bats and pangolins) with COVID-19 in human.

(**Photo credits:** *https://www.dkfindout.com/uk/animals-and-nature/bats/*; *https://wildlifejustice.org/no-rest-for-pangolins-trafficking-rates-spike/*;
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.cnn.com%2Finteractive%2F2014%2F04%2Fopinion%2Fsutter-change-the-list-pangolin-trafficking%2Findex.html&psig=AOvVaw1D3IsbeOvsvv4fPlAyXnAU&ust=1585208281285000&source=images&cd=vfe&ved=0CA0QjhxqFwoTCNjjxJaPtegCFQAAAAAdAAAAABAH;
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DKcsRBFmyMcg&psig=AOvVaw11QUREGDqiw-pcAfYExob2&ust=1585208065406000&source=images&cd=vfe&ved=0CA0QjhxqFwoTCIiytLCOtegCFQAAAAAdAAAAABAD;

Table 1. COVID-2019 confirmed cases and deaths as of 25th March 2020[1]

Region	Confirmed cases of COVID-2019	Confirmed death
Global	41,4,179	18, 440
European Region	2,20,516	11,986
Western Pacific Region	97,766	3,518
Eastern Mediterranean Region	29,631	2,008
Region of the Americas	60,834	813
South-East Asia Region	2,344	72
African Region	1,664	29

[1]*WHO - Coronavirus disease 2019 (COVID-19) Situation Report – 65 (https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200325-sitrep-65-covid-19.pdf?sfvrsn=2b74edd8_2; accessed on 26 March 2020).*