



Check list of parasites and bacteria recorded from pangolins (*Manis* sp.)

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Abstract Sound knowledge on parasite fauna of pangolins is crucial for evaluation of their health status. In the present review, a checklist of 34 genera of parasites and bacteria, including 4 genera of protozoan, 13 genera of helminthes, 8 genera of ticks, 2 genera of mites and 7 genera of bacteria reported from pangolins was compiled and their zoonotic potential were discussed. The aim of this checklist is to underline the information gap and to provide a reference list of parasites and bacteria known for pangolins to assist in their further investigation.

Keywords Pangolin · *Manis* · Bacteria · Ecto-parasite · Endo-parasite, Zoonoses

Introduction

Pangolins are toothless placental mammals represented by eight species belonging to a single family Manidae of order

Pholidota. Four pangolin species viz. Chinese pangolin (*Manis pentadactyla*), Indian pangolin (*Manis crassicaudata*), Philippine pangolin (*Manis culionensis*) and Malayan pangolin (*Manis javanica*) are native to Asia, whereas, other four pangolin species viz. Temminck's ground pangolin (*Manis temminckii*), giant ground pangolin (*Manis gigantea*), long-tailed pangolin (*Manis tetradactyla*) and tree pangolin (*Manis tricuspis*) occur in Africa. The Asiatic pangolins such as *M. javanica* and *M. pentadactyla* are classified as critically endangered, while *M. culionensis* and *M. crassicaudata* are classified as endangered and all African pangolin are classified as vulnerable by the International Union for Conservation of Nature (Challender et al. 2014). Limited information are available about the biology, ecology, behaviour, diseases and parasites of pangolins both in captivity as well as in wild (Narayanan et al. 1977; Acharjyo 2000; Lim and Ng 2008; Challender 2009; Clark et al. 2009; Bao et al. 2013; Mohapatra and Panda 2014). Therefore, it is necessary to collect more data and carry out more field research on these animals, to promote their conservation. Considering the above necessities, the present communication is intended to compile all the available published literature on parasites and bacteria recorded from pangolins. The aim of this review is to prepare a single source to provide informations to researchers and veterinarians concerned with the parasitological and bacteriological aspects of pangolins as the pertinent sources reporting parasites and bacteria from pangolins were scattered over a number of publications covering about nine decades.

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Materials and methods

Available published literatures were reviewed for compilation of informations on parasites (ecto and endo) and

bacteria reported from pangolins. Many of the report on these parasites was found incidental or constitute a part of the other studies. Inspection of wild, confiscated and captive pangolins, their routine health examinations and post mortem findings contributed to the parasitological profile of pangolins. A checklist was prepared basing on these published literatures. The major listing is grouped into endo-parasites (i.e., protozoa and helminthes), ecto-parasites (i.e., ticks and mites) and bacteria. Within these groups the parasites and bacteria species were arranged in order of their host pangolin species. Parasite species identified up to genus level (undetermined species) were also included in the checklist. In addition, the parasites and bacteria common to both pangolins and human, and their zoonotic significance were also reviewed and discussed. A draft checklist was circulated among IUCN-SSC Pangolin Specialist Group to give their comments and further information on this subject, if any. The new informations received were included in the final checklist.

Results and discussion

A total of 34 genera of parasites and bacteria, including 4 genera of protozoan, 13 genera of helminthes, 8 genera of ticks, 2 genera of mites and 7 genera of bacteria were check listed in the present review (Table 1). Out of eight pangolin species, parasites had been reported from seven species and no parasites were reported from one pangolin species (*Manis culionensis*). Even though pangolins had been on exhibits since 1892 (Sanyal 1892), the first report on parasites on pangolins dated back only to 1927 (Neveu-Lemaire 1927) and the first report on bacteria dated back to 1977 (Narayanan et al. 1977). Parasites reported from pangolins were identified to their species level in most of the cases, except eight cases where they were identified to their genus level. There were reports of six new parasite species described from pangolins, including two protozoan parasites (*Eimeria tenggilingi* and *Eimeria nkaka*), three helminth parasites (*Dipetalonema fausti*, *Leiperinema leiperi*, *Prolospirura hamospiculala*) and one mite species (*Manisicola africana*) (Else and colley 1976; Kvicerova and Hypsa 2013; Esslinger 1966; Singh 1976; Neveu-Lemaire 1927; Lawrence 1939). It appears that the present checklist is the first comprehensive review of parasites and bacteria of pangolins.

Out of four genera of protozoan parasites reported from pangolins, *Eimeria* was intestinal parasite and *Trypanosoma* and *Toxoplasma* were haemo-protozoan parasite and the site of parasitism for *Piroplasma* in pangolins could not be found from available literature (Rewell 1950; Kageruka and Willaert 1971; Else and Colley 1976; Njiokou et al. 2004, 2006; Jirku et al. 2013). Clark et al. (2009) reported

death of pangolin (*M. javanica*) secondary to gastrointestinal coccidiosis. Clinical coccidiosis is most commonly seen when animals are kept in overcrowded conditions with poor sanitation and poor nutrition (Kahn 2008). The conditions in which pangolins transported in the illegal wildlife trade are highly suited to the development of clinical coccidiosis (Clark et al. 2009). Njiokou et al. (2004) reported the occurrence of *Trypanosoma brucei* and *T. vivax* in different wild animals of Cameron including primates, artiodactyls, rodents, carnivores and pangolins. Such observations strengthen the hypothesis that wild animals including pangolins may serve as reservoirs for Trypanosomiasis infections (Njiokou et al. 2004). Toxoplasmosis caused by *Toxoplasma gondii* is a potential zoonotic disease reported from animal hosts including human and pangolin (Kageruka and Willaert 1971; Tenter et al. 2000; Hill and Dubey 2002).

Out of 13 reported helminth parasites from pangolins, eight genera of helminths including, *Cylicospirura*, *Leiperinema*, *Manistrongylus*, *Necator*, *Strongyloides*, *Trichochoenia*, *Ancylostoma*, *Gendrespirura* were intestinal parasites, occurring in stomach, small intestine and large intestine (Naidu and Naidu 1981; Sharma 1955; Heath and Vanderlip 1988; Baylis 1933; Hanna 1933; Esslinger 1966) and three genera including *Dipetalonema*, *Brugia* and *Microfilaria* were blood parasites (Pais Caeiro 1959; Laing et al. 1960). The helminth *Brugia malayi* was reported in a wide range of hosts including long tailed macaque, leaf-monkey, cat, civet cat, pangolin (*M. javanica*) and human in Southeast Asia (Wilson 1961; Kazura 2002). Similarly *Brugia pahangi* was reported from cat, civet cats, dog, tiger, slow loris, moonrat, giant squirrel and pangolin (*M. javanica*) in Malaysia (Wilson 1961). The helminth *Necator americanus* was reported both from pangolin (*M. crassicaudata* and *M. javanica*) and human (Baylis 1933; Sharma 1955; Ashford and Crewe 2003; Hasegawa et al. 2014). Besides, there were records of *N. americanus* as an occasional parasite of the chimpanzee, gorilla, monkey, dog, pig and rhinoceros (Hanna 1933). Hydatid cysts by the *Echinococcus* sp. also reported from lungs of an Indian pangolin (Rao et al. 1972; Acharjyo 2013).

Ticks are well represented in pangolins comprising 8 genera and 20 species reported from six pangolin species (*M. crassicaudata*, *M. pentadactyla*, *M. javanica*, *M. temminckii*, *M. tricuspidis*, *M. gigantea*). Genus *Amblyomma* was reported from all the above six pangolin species. It is interesting to know that unidentified ticks had been reported from *M. tetradactyla* (Robinson 1983). Three genera of ticks (*Amblyomma*, *Rhipicephalus* and *Aponomma*) reported from both Asian and African pangolin species. *Amblyomma javanense* found to occur in three Asian pangolins (*M. crassicaudata*, *M. pentadactyla*, *M. javanica*). Similarly *Amblyomma compressum* recorded

Table 1 Parasites and bacteria reported from pangolins (*Manis* sp.)

| Pangolin host (scientific name) | Parasite species | Reference (s) |
|--|--|---|
| Endo-parasites | | |
| Protozoa | | |
| Indian pangolin (<i>Manis crassicaudata</i>) | <i>Toxoplasma gondii</i> | Kageruka and Willaert (1971) |
| Long-tailed pangolin (<i>Manis tetradactyla</i>) | <i>Trypanosoma brucei</i> | Njiokou et al. (2004, 2006) |
| | <i>Trypanosoma vivax</i> | Njiokou et al. (2004) |
| Malayan pangolin (<i>Manis javanica</i>) | <i>Eimeria tenggilingi</i> (n. sp.) | Else and Colley (1976) |
| Temminck's ground pangolin (<i>Manis temminckii</i>) | <i>Piroplasma</i> sp. | Rewell (1950) |
| Tree pangolin (<i>Manis tricuspis</i>) | <i>Eimeria</i> sp. | Kvicerova and Hypsa (2013) |
| | <i>Eimeria nkaka</i> (n. sp.) | Jirku et al. (2013) |
| | <i>Trypanosoma brucei</i> | Njiokou et al. (2004, 2006) |
| | <i>Trypanosoma vivax</i> | Njiokou et al. (2004) |
| Helminths | | |
| Chinese pangolin (<i>Manis pentadactyla</i>) | <i>Cylicospirura</i> sp. | Heath and Vanderlip (1988) |
| | <i>Dipetalonema fausti</i> (n. sp.) | Esslinger (1966) |
| | <i>Leiperinema leiperi</i> (n. sp.) | Singh (1976) |
| Indian pangolin (<i>Manis crassicaudata</i>) | <i>Manistongylus meyeri</i> (Travassos 1937) | Cameron and Myers (1960) |
| Giant ground pangolin (<i>Manis gigantea</i>) | <i>Necator americanus</i> (Stiles 1902) | Cameron and Myers (1960) |
| Malayan pangolin (<i>Manis javanica</i>) | <i>Strongyloides</i> sp. | Singh (1976), Heath and Vanderlip (1988) |
| Temminck's ground pangolin (<i>Manis temminckii</i>) | <i>Echinococcus</i> sp. (Hydatid cysts) | Rao et al. (1972), Acharjyo (2013) |
| Tree pangolin (<i>Manis tricuspis</i>) | <i>Necator americanus</i> (Stiles 1902) | Sharma (1955) |
| | <i>Trichochenia meyeri</i> (Travassos 1937) | Naidu and Naidu (1981) |
| | <i>Ancylostoma</i> sp. (ova) | T-W-Fiennes (1968) |
| | <i>Brugia malayi</i> | Laing et al. (1960) |
| | <i>Brugia pahangi</i> | Laing, et al. (1960) |
| | <i>Necator americanus</i> (Stiles 1902) | Baylis (1933) |
| | <i>Gendrespirura</i> sp. | Gardiner and Werner (1984) |
| | <i>Protospirura (Habronema) hamospiculata</i> (n. sp.) | Neveu-Lemaire (1927), Baylis (1931) |
| | <i>Habronema hamospiculatum</i> (Neveu-Lemaire 1927) | Baylis (1931, 1936) |
| | <i>Microfilaria lukakae</i> | Pais Caeiro (1959) |
| | <i>Microfilaria lundae</i> | Pais Caeiro (1959) |
| | <i>Microfilaria nobrei</i> | Pais Caeiro (1959) |
| | <i>Microfilaria vilhenae</i> | Pais Caeiro (1959) |
| Ecto-parasites | | |
| Ticks | | |
| Chinese pangolin (<i>Manis pentadactyla</i>) | <i>Amblyomma javanense</i> (Supino 1897) | Li et al. (2010), Kollars and Sithiprasasna (2000) |
| Giant ground pangolin (<i>Manis gigantea</i>) | <i>Amblyomma compressum</i> (Macalister 1872) | Uilenberg et al. (2013) |
| Indian pangolin (<i>Manis crassicaudata</i>) | <i>Amblyomma javanense</i> (Supino 1897) | Sanyal et al. (1987), Nandi (1981), Acharjyo (2013) |
| Malayan pangolin (<i>Manis javanica</i>) | <i>Aponomma gerviasi</i> (Lucas 1847) | Seniviratna (1965), Pillai and George (1997) |
| | <i>Rhipicephalus</i> sp. | Anonymous (2010) |
| | <i>Amblyomma cordiferum</i> (Neumann 1899) | Hafiz et al. (2012) |
| | <i>Amblyomma javanense</i> (Supino 1897) | Kollars and Sithiprasasna (2000), Parola et al. (2003), Hafiz et al. (2012), Hassan et al. (2013) |

Table 1 continued

| Pangolin host (scientific name) | Parasite species | Reference (s) |
|--|---|--|
| Temminck's ground pangolin (<i>Manis temminckii</i>) | <i>Aponomma varanensis</i> (Supino 1897) <i>Amblyomma compressum</i> (Macalister 1872) <i>Ixodes rasus</i> (Neumann 1899) <i>Ornithodoros moubata</i> (Murray 1877) <i>Rhipicentor longus</i> Neumann 1907 <i>Rhipicentor muhsamae</i> (Morel and Vassiliades 1964) <i>Rhipicephalus simus</i> (Koch 1844) | Burridge (2001) Uilenberg et al. (2013) Uilenberg et al. (2013) Jacobsen et al. (1991) Uilenberg et al. (2013) Uilenberg et al. (2013) Tandon (1991) |
| Tree pangolin (<i>Manis tricuspidata</i>) | <i>Aponomma compressum</i> (Macalister 1872) <i>Aponomma exornatum</i> (Koch 1844) <i>Aponomma flavomaculatum</i> (Lucas 1846) <i>Aponomma latum</i> (Koch 1844) <i>Haemaphysalis parvata</i> (Neumann 1905) <i>Rhipicentor muhsamae</i> (Morel and Vassiliades 1964) | Ntiamoa-Baidu et al. (2005), Uilenberg et al. (2013) Burridge (2001) Burridge (2001) Burridge (2001) Ntiamoa-Baidu et al. (2005) Uilenberg et al. (2013) |
| Unidentified pangolin species (<i>Manis</i> sp.) | <i>Amblyomma arcanum</i> (Karsch 1879) <i>Amblyomma cordiferum</i> (Neumann 1899) <i>Amblyomma geoemydae</i> (Cantor 1847) <i>Amblyomma testudinarium</i> (Koch 1844) <i>Dermacentor (Indocentor) atrosignatus</i> (Neumann 1906) <i>Dermacentor (Indocentor) steini</i> (Schulze 1933) <i>Ixodes oldi</i> (Nuttall 1913) | Guglielmone et al. (2014) Guglielmone et al. (2014) Guglielmone et al. (2014) Durden et al. (2008) Durden et al. (2008) Durden et al. (2008) Guglielmone et al. (2014) |
| Mite | | |
| Temminck's ground pangolin (<i>Manis temminckii</i>) | <i>Manisicola africana</i> (n. sp.) <i>Manitherionyssus heterotarsus</i> (Vitzthum 1925) | Lawrence (1939) Jacobsen et al. (1991) |
| Bacteria | | |
| Chinese pangolin (<i>Manis pentadactyla</i>) | <i>Escherichia coli</i> <i>Klebsiella aerogenes</i> <i>Klebsiella pneumoniae</i> <i>Proteus vulgaris</i> <i>Pseudomonas fluorescens</i> | Heath and Vanderlip (1988) Heath and Vanderlip (1988) Heath and Vanderlip (1988) Heath and Vanderlip (1988) Heath and Vanderlip (1988) |
| Indian pangolin (<i>Manis crassicaudata</i>) | <i>Escherichia coli</i> <i>Klebsiella aerogenes</i> <i>Proteus vulgaris</i> <i>Pseudomonas aeruginosa</i> <i>Staphylococcus</i> sp. <i>Streptococcus faecalis</i> | Narayanan et al. (1977) Narayanan et al. (1977) |
| Malayan pangolin (<i>Manis javanica</i>) | <i>Mycoplasma</i> sp. | Jamnah et al. (2014) |

from three African pangolin species (*M. temminckii*, *M. tricuspidis*, *M. gigantea*). Ticks were reported to occur underneath the scales and ventral portions of the body in pangolins (Seniviranta 1965; Sanyal et al. 1987; Pillai and George 1997; Parola et al. 2003; Anonymous 2010; Hafiz et al. 2012). Apart from pangolins *Amblyomma javanense* ticks had been reported from water monitor lizard, python, skink, hill turtle, bat, wild boar, hyena, bear and sambar deer (Kollars and Sithiprasasna 2000; Hassan 2013). Similarly there were reports of *Amblyomma latum* ticks from Python; *Amblyomma exornatum* ticks from monitor lizards; *Rhipicephalus simus* ticks from dogs (Navajas et al. 2010; Reeves et al. 2006; Parola et al. 2013). Guglielmone et al. (2014) reported ten species of ticks found in pangolins also occur in different animal hosts (classified up to family level) including mammals, birds and reptiles. Some of the ticks reported from pangolins were also reported to feed on humans and may serve as potential vectors for transmission of disease. The tick *Ornithodoros moubata*, transmits *Borrelia duttoni*, the agent of African relapsing fever in human (Estrada-Pena and Jongejan 1999). In Sub-Saharan Africa, *Amblyomma compressum* ticks transmit African tick bite fever caused by *Rickettsia africae*; *Rhipicephalus simus* ticks transmit Mediterranean spotted fever caused by *Rickettsia conorii* subsp. *conorii*; *Rhipicephalus muhsamae* ticks transmit spotted fever caused by *Rickettsia massiliae* in human (Parola et al. 2013). The bacteria *Anaplasma* sp. strain AnAj360 associated with the ehrlichioses disease was also detected from the tick *Amblyomma javanense* collected from *Manis javanica* (Parola et al. 2003). Besides, *Aponomma latum*, *Amblyomma cordiferum*, *Amblyomma geoemydae*, *Amblyomma javanense*, *Amblyomma testudinarium*, *Dermacentor atrosignatus* and *Rhipicephalus longus*, recorded from pangolins, have also been reported to feed on human (Estrada-Pena and Jongejan 1999; Durden et al. 2008; Burridge 2001; Audy et al. 1960; Gould et al. 1970). Mites recorded from pangolins were reported from the body surface (Jacobsen et al. 1991).

Some bacteria were isolated and identified from faeces, blood and urine samples of the diseased Indian pangolin (Narayanan et al. 1977) and Chinese pangolin (Heath and Vanderlip 1988). The bacteria species *Escherichia coli*, *Klebsiella aerogenes*, *Proteus vulgaris* were recorded from both Indian pangolin (Narayanan et al. 1977) and Chinese pangolin (Heath and Vanderlip 1988). Bacteria *Escherichia coli* were recorded from faeces, blood and urine of diseased Indian pangolin (Narayanan et al. 1977). *Klebsiella aerogenes* and *Klebsiella pneumonia*, *Proteus vulgaris*, *Pseudomonas fluorescens*, *Pseudomonas aeruginosa* were isolated from faecal samples of pangolins (Narayanan et al. 1977; Heath and Vanderlip 1988). *Sterptococcus* was isolated from faeces and blood of Indian pangolins

(Narayanan et al. 1977). *Mycoplasma* was isolated from blood of Malayan pangolin (Jamnah et al. 2014). Bacteria are ubiquitous in nature and some bacteria reported from pangolin also found as commensal organisms of human gastrointestinal tract (e.g. *Proteus vulgaris*, *Klebsiella pneumonia*, *Escherichia coli*) (Muller 1986; Lightfoot 2003). *Pseudomonas aeruginosa* and *Klebsiella pneumonia* are opportunistic pathogen in human that causes a variety of bronchopulmonary infections including pneumonia (Domingo et al. 1998; Lightfoot 2003). Though most *Escherichia coli* are not pathogenic, but some serotypes possess virulence factors and cause gastroenteritis in humans (Lightfoot 2003).

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