

Ectoparasites and their effect on camels (*Camelus dromedarius*) in Ethiopia

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ABSTRACT

Ticks infesting camels in Ethiopia were reported in different magnitude ranges, from 28.5% to 100%. The three genera of ticks reported to occur on camels in Ethiopia are *Rhipicephalus*, *Amblyomma* and *Hyalomma*, and the subgenus *Boophilus*. Among these three genera of ticks infesting camels in Ethiopia, *Rhipicephalus* was the most predominant genus, followed by *Hyalomma*, *Amblyomma* and the subgenus *Boophilus*. The main tick species reported to infest camels in Ethiopia are *Rhipicephalus pulchellus*, *Hyalomma dromedarii*, *Amblyomma gemma*, *Hyalomma rufipes*, *Amblyomma variegatum*, *Hyalomma truncatum*, and *Rhipicephalus (Boophilus) decoloratus*, in order of predominance. The overall prevalence of mange mite infestation ranges from 10.7% to 94.1% in camels from Ethiopia. The main species of mite reported by different authors in Ethiopia is *Sarcoptes scabiei var. cameli*. The overall prevalence of *Cephalopina titillator* infestation in camels in Ethiopia ranges from 23.9% to 82.6%, whereas the overall prevalence of lice was 6.1%. The most abundant genus of biting flies reported was *Stomoxys*, followed by *Tabanus*, from Ethiopia. However, there is no report on flea infestation in camels from Ethiopia yet. *Trypanosome evansi* is a protozoan parasite that affects camels in different parts of Ethiopia outside of the tsetse fly belt areas. Information on *Theileria*, *Babesia*, and *Anaplasma* in camels is not available so far from Ethiopia. Only a preliminary report on *Theileria mutans* in camels was reported in Ethiopia. It concluded that ectoparasite infestation causes a serious economic loss in camel production and productivity, which warrants the institution of appropriate control strategies to improve the health and productivity of camels.

Keywords: *Camelus dromedaries*, *Cephalopina titillator*, Ectoparasites, Mites, Ticks.

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Introduction

Ethiopia is one of the countries with largest camel populations in the world. In Africa, it ranks third, next to Somalia and Sudan. The ability of camels to withstand torrid heat and extreme desiccation is of paramount importance in determining their distribution. Camels are normally distributed throughout subtropical dry areas in Africa and Asian countries (Jacob and Yalew, 2008). About 1.06 million camels are found in Ethiopia, distributed in arid and semi-arid parts of southern, eastern and north-eastern parts of the country, mainly in Borana, Ogaden and Afar regions (FAO, 1993).

Ethiopia is home to only dromedary (*Camelus dromedarius*) camels. One-humped camel (*Camellus dromedaries*) is an important livestock species in the pastoral economy in Ethiopia

because of its extraordinary ability to perform in arid and semi-arid environments where there is scant vegetation, which is not sufficient for other livestock species. The camel is a multi-purpose animal uniquely adapted to arid and semi-arid environments, enabling nomadic peoples of the world to live in a difficult environment. The camel is primarily kept for milk production, meat production, draft power, transportation, best of burden, and as an agricultural draft animal (Schwartz, 1992). The camel is also a financial reserve and plays an important role in social prestige and wealth. However, despite its significant contribution to the livelihood of pastoralist society, there is very little scientific information about the health and productivity of the camel (Yesihak and bekele, 2003).

The slow reproduction cycle, high calf mortality, and other health problems are major constraints that contribute to the decreasing camel herd population and productivity. Ticks, mange mites, and insects are among the most important

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health problems for camels in Ethiopia (Dioli, 1992). Ectoparasites are very common and widely distributed in all agro-ecological zones in Ethiopia (Kumsa et al., 2012). The ectoparasites of camels and their associated diseases transmission are important constraints to the production, productivity and performance of animals (Regassa et al., 2015). Ticks are one of most important factors affecting the health of camels and transmit various diseases by causing pathogens, causing blood loss, and causing damage to the hide and udder. The feeding activity of ticks is associated with several health problems in livestock, including camels (Wall and Shearer, 1997). In Ethiopia, ticks are common in all agro-ecological zones of the country (Kumsa et al, 2012).

The most important tick species reported to infest camels in different parts of Ethiopia include *Rhipicephalus pulchellus*, *Amblyomma gemma*, and *Hyalomma dromedarii* (Bekele and Zeleke, 2004, Dinka et al., 2010, Feyera et al, 2017 and Kiros et l., 2014). *Amblyomma variegatum*, *Rhipicephalus (Boophilus) decoloratus*, and some others with very low proportions (Bekele and Zeleke, 2004, Hussien, 2018, Kiros et al., 2014 and Taddese and Mustefa, 2013).

Camel mange is an extremely contagious ectoparasite caused by the parasitic mite, *Sarcoptes scabiei var. cameli*, which is transmitted by direct or indirect contact. Camel mange is often considered the most parasitic disease, second to trypanosomiasis 'surra', in affecting camel production and productivity (Feyera et al., 2017). *Cephalopina titillator* is also another ectoparasite affecting camels in Ethiopia (Bekele, 2001, Jabir et al., 2017, Kissi and Assen, 2017, Mumed and Gameda, 2015 and Regassa et al., 2015). *Cephalopina titillator* causes nasopharyngeal myiasis in camels and results in health hazards and severe economic losses in the camel industry (Hanem et al., 2013).

Countable previous reports are available on the lice and biting flies of camels from Ethiopia. Ectoparasites are very important economically on a global scale, and they are responsible for a great variety of livestock health problems. In addition to transmitting diseases, ectoparasites reduce milk and meat production and increase susceptibility to other diseases (Mekonnen et al., 2007). Comprehensive knowledge of the species' identity, composition, seasonal dynamics, variation, and epidemiology is critically important

to prevent and control (Desta, 2010). Despite the presence of a high population of camels in arid and semi-arid areas of Ethiopia and their great social and economic importance to their owners, there is very little information on the ectoparasites of camels in Ethiopia. Furthermore, the available information on ectoparasites of camels is fragmented in scope, coverage and quality is neither comprehensive nor well organized. Therefore, the present review is designed to compile the available information on ectoparasites and their impacts on camels in Ethiopia with the objectives to compile high quality information on the presence, identity and status of ectoparasites, their effect and associated pathogens of camels existing in different parts of Ethiopia based on the available previous information.

Ectoparasitism

Ectoparasites are organisms which inhibit the skin or outgrowth of the skin of the host for various periods (Taylor and Coop, 2016). The effect of ectoparasites usually depends on size of invading population, on the manner in which parasite ekes out its existence, and on nutritional and immunological state of the host animal when infested. External parasite infestation is complicated by the host's reaction to the parasite's presence, as well as its secretion and excretion. Young animals are generally more susceptible to ectoparasites because of a higher ratio of accessible surface to body volume and poor grooming behavior (Wilson et al., 1990).

Ectoparasitism is a serious threat to both animals and humans all over the world. The painful bites of ectoparasites could be a great nuisance, leading to loss of a large amount of blood (Alasaad et al., 2008). For instance, ticks alone transmit several important protozoal, rickettsial, bacterial and viral diseases to animals, thereby causing great economic losses. Lice and mites usually cause dermatitis which is characterized by alopecia and necrotic foci. There is also intense pruritus (especially with mange), which leads to biting and vigorous scratching of affected parts (Shiferaw, 2018).

Status of major ectoparasites of camels in ethiopia

Mites Infestation

Mange is highly contagious skin disease caused by one or combination of several species of mites. These include species from genera *Sarcoptes*, *Chorioptes*, *Psoroptus*, and *Demodex*. Some species are more globally distributed (Jarso et al., 2018).



Fig. 1

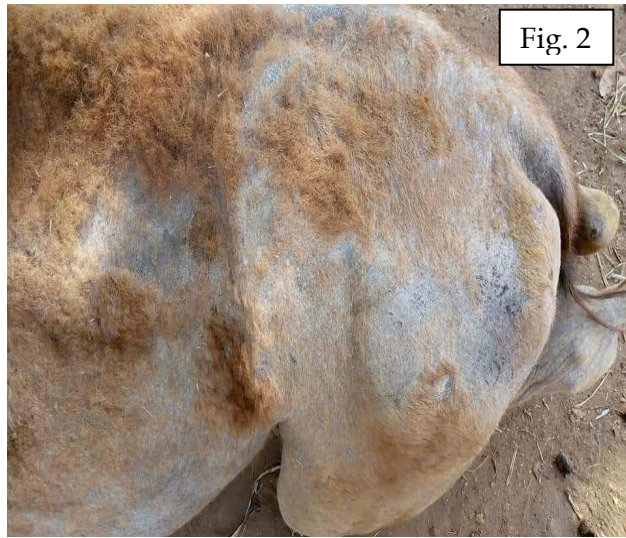


Fig. 2



Fig. 3

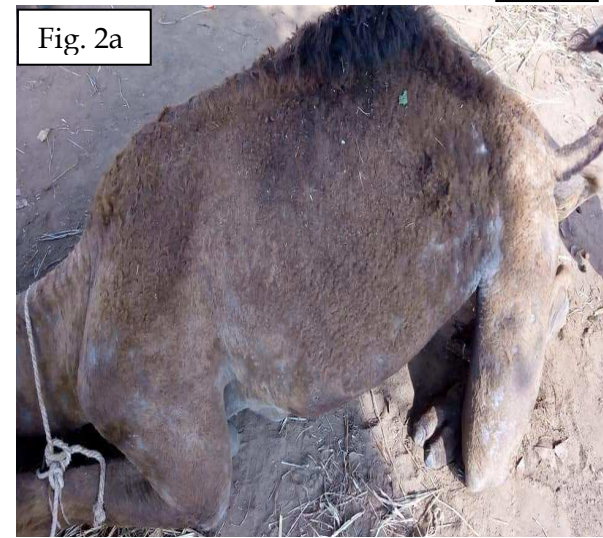


Fig. 2a

Fig. 1: Skin scrapping revealed *Sarcoptes scabiei cameli* (Source: Bhagat et al., 2017), Fig 2: *Microthoracius spp*, sucking lice in camels (Source: Taylor et al., 2016), Fig 3: Showing alopecia, erythma, dry and rough hair coat with crust formation (Source: Bhagat et al., 2017)

The common species of mites which affect dromedary camels are *sarcoptic* and *psoroptic* mites (Mouchira, 2009). *Sarcoptic* mange in camels caused by *Sarcoptes scabiei var. cameli* (Fig. 1) is considered to be the most serious zoonotic mange (Singh and Momin, 2001).

Sarcoptes scabiei var. cameli is one of the most commonly encountered camel diseases in Borana with severe clinical manifestations. Infestation of skin caused by mites is a serious problem in camels and may lead to death. Moreover, the disease is more severe in females and young animals. Mite infestation causes a highly contagious disease which can spread to animals sharing grazing areas and the environment with infested animals. Mites may be transmitted directly by contact or indirectly through objects such as the harnessing materials, saddle, bedding and tree trunks (Lawal and Ameh, 2007 and Megersa, 2014). Close contact with camels, particularly at watering points, could be responsible for increased exposure during the dry

period. Moreover, feed shortages that reduce the immunity of the animals may also account for the increased prevalence and severity of the disease during the dry periods (Tefera and Getachew, 2012).

Transmission is common during suckling; hence, the head of the young and genitalia of the female were the most infested sites. It was observed a prevalence of more than 50% and reported concomitant occurrence with other diseases such as contagious skin necrosis, contagious ecthyma, and abscess (Bekele, 2010). *Sarcoptes scabiecameli* is very difficult to detect in skin scrapings boiled with 10% potassium hydroxide. One has to leave the sample in the boiled solution for longer than 3 hours after boiling in order to observe the mange mites under a microscope (Tefera and Getachew, 2012).

The preferred site of the burrowing mite of the genus *Demodex* is at the sebaceous glands of the skin and hair follicles. These follicular mites mainly lived as commensals in the skin. In some animals, these mites may cause mange, which leads to

causing economic loss (Wilson et al., 1990). The mite is can be transmitted from the dam to the offspring during nursing (Jarso et al., 2018).

Mange is a term used to describe mite-associated skin disease in livestock. The occurrence of mange mite depends on the following factors. In wet season camel mange mites is higher relative to dry season (Megersa, 2014). Some authors reported young and old animals were more affected due to lower immunity than adult camels (Awol et al., 2012 and Saber, 2015). However, other authors stated females are more affected than males (Ashraf et al., 2014 and Megersa, 2014). The economic significance of mange infested animals arose from decreased body weight, therapy costs, skin deterioration due to perforation of the skin and intense pruritus as skin lesions may cover nearly the entire body, and occasional mortalities in untreated and young animals (Singh, 2005).

Mange can severely compromise the welfare of milking animals by increasing susceptibility and reducing their vitality to other diseases as a result of secondary bacterial infection. During the development of mange, itchiness distracts the animals from eating, so that they often become emaciated. Mange mite infestation can cause alopecia, dry erythma, and rough hair coat with crust formation in camels (Fig. 2) (Bhagat et al., 2017). The majority of the lesions is confined to the integument and comprises anemia, hyperkeratosis, general loss of productivity and body weight (Jarso et al., 2018).

Previous study reports indicated that mites are the most economically important ectoparasites affecting camels in Ethiopia. An overall prevalence of mites on camels was reported with various magnitudes from different parts of Ethiopia as indicated. In camels, the overall prevalence of mange mite infestation ranges from 10.7% to 94.1%, as indicated (Table 1) (Dinka et al., 2010 and Rirash et al., 2017).

The highest prevalence (94.1%) of mange mite infestation in camels was reported in claves of camels in Eastern Ethiopia, Somalia region, Fafen zone (Rirash et al., 2017). It was argued that this high prevalence was due to important epidemiological determinants including inadequate early colostrums feeding, poor health and hygiene management, and premature herd mixing and release to range lands. Various studies report indicated that *Sarcoptes scabiei var. cameli* as

the main species of mange mites infested camels in Ethiopia (Awol et al., 2012, Dinka et al., 2010, Feyera et al., 2017, Megersa et al., 2012 and Regassa et al., 2015).

Table 1. Overall prevalence of mange mite infestation of camels in different parts of Ethiopia

Study area	Prevalence (%)	Reference
Somalia Region (Fafen Zone)	94.1	Rirash et al. (2017)
Addis Ababa Abattoir	35.4	Regassa et al. (2015)
Somali Regional State	32.4	Feyera et al. (2017)
Eastern Ethiopia (Hararghe at Errer Valley)	27.7	Bekele and Zeleke (2004)
Borana	25.9	Megersa et al. (2012)
Northern Ethiopia(Raya-Azebo district)	16.7	Awol et al. (2012)
Dire Dawa	13.5	Jabir et al. (2017)
Dire Dawa	10.7	Dinka et al. (2010)

On the other hand, a lower prevalence of (10.7%) was reported from Eastern Ethiopia, Dire Dawa (Dinka et al., 2010). It was suggested that the variation in prevalence among different parts of the country and regions may be attributed mainly to differences in management, agro-ecological zones, co-infection with other ectoparasites, seasonal variation, and the availability of conducive environments for the survival of ectoparasites in the area (Feyera et al., 2017 and Rirash et al., 2017).

Variation in the prevalence of mange mite infestation based on factors like site of attachment, sex, age, body condition, and herd size was reported. For instance, the lesions of mange mite infestation were reported most commonly on the head, neck, abdominal regions, inner surface of the thighs, and inguinal region of infested camels. Camel mange mite infestation generally starts in the head region, extending through the neck to other areas with thin skin, such as the penile sheath and the udder. The whole body may become infested within a month. Also, camel mange infestation commences at areas of thin skin: the head, base of the neck, udder, prepuce, and flank. The head becomes affected rapidly in every case because the animal uses its teeth to scratch the affected areas (Awol et al., 2012).

A higher prevalence in female camels than in male camels was reported and its finding was associated with a higher level of prolactin and progesterone hormones that could make the females more susceptible to infestation. Additionally, pregnancy and lactation stress could also aggravate the susceptibility of the female camel (Awol et al., 2012, Feyera et al., 2017, Megersa et al., 2012 and Regassa et al., 2015). Higher prevalence in camels with poor body condition (Aboma et al., 2014) may be attributed to severe allergies and itching due to the outcome of histamine liberated from damaged body cells, which are compelling allergens (Fowler, 2010). Furthermore, trypanosomosis, worm burden, and poor nutritional status can all be risk factors for *sarcoptic* mange (Parsani and Veer Singh, 2008).

The higher prevalence of mange mite infestation in camels with a herd size of more than 40 indicates that camels with a herd size of less than 20 (twenty) and between 20 (twenty) and 40 (fourty). This could be attributed to the fact that camels from large herd sizes are more prone to being exposed to diseased animals due to the contagious nature of mite infestation. Contact during herding, housing, and suckling is the most important means of transmission. Contact beddings and camels rub themselves on tree trunks, leaving the mites where the next animal may pick them up when rubbing on tree trunks, which are the other sources of transmission (Megersa et al., 2012 and Feyera et al., 2017).

Since dairy camels are usually kept indoors and in close proximity, this contact favors transmission of the causative agent of mange and hence easy establishment of the disease in the herd. As herd size increases, the prevalence of *S. scabiei* var. *cameli* also increases significantly (Feyera et al., 2017). Therefore, considering the zoonotic importance and the great economic impact of *Sarcoptes scabiei* var. *cameli* on camel production and productivity, more detailed investigation into the epidemiology, economic significance, and species composition of this disease should be conducted to design and implement an effective control program and improve camel production and productivity (Awol et al., 2012). High mange mite infestations are generally observed during the rainy season, in young camels, in camels with poor body condition, and in large herd sizes (Jarso et al., 2018).

Tick infestation

Ticks are hematophagous arthropods belonging to class Arachnida. These are major vectors of pathogens in animals and humans. Most important tick species reported to infest camels in Ethiopia belong to genera *Ambylomma*, *Hyalomma*, subgenus *Boophilus* and *Rhipicephalus* (Kiros et al., 2014 and Taddese and Mustefa, 2013). The occurrence of ticks in dromedary camels was associated with factors like age, sex, body condition, herd size, herd composition and season which affect mean tick burden of camels (Regassa et al., 2015).

Wet season, high humidity and high temperature; facilitate the growth and survival of tick at all different developmental stages (Latif and Walker, 2004). Ticks are one of the most serious ectoparasites in Ethiopia. The causes the greatest economic losses in livestock production and productivity. The main effect of tick infestation in animals includes mild to severe anemia, loss of appetite, leading to a reduction in growth rate and decreased productivity. Additionally, ticks are responsible for direct damage to the camels through their feeding habits, damage to udders, teats and scrotum (Jabir et al., 2017).

The specific site of tick attachment is one of the population limiting systems that operate through the restriction of tick species to certain parts of the host body. The ticks grab on to the hosts using their front legs and then crawl over the skin to find a suitable place to attach and feed (Latif and Walker, 2004). Depending on the tick, site preference on the host depends on the accessibility for attachment, to get blood, and protection to overcome the environmental damage that inhibits its existence and grooming activity (Wall and Shearer, 1997).

An overall prevalence of ticks on camels was reported with different magnitudes as indicated (Table 2). Tick infestations in camels were reported from different parts of the country with different prevalences ranging from 28.5% to 100% as indicated (Table 2) (Jabir et al., 2017 and Regassa et al., 2015).

Ticks are one of the major ectoparasites affecting the health and productivity of camels in Ethiopia.

The prevalence of tick infestation in camels is varies from one site to other in Ethiopia. Factors like age, sex, body condition, herd size and herd composition also affect the prevalence and burden of ticks in camels. For instance, higher prevalence of tick infestation (100%) has been reported from Addis Ababa Abattoir in camels originated from

Borna and kerayu origin (Regassa et al., 2015). On the other hand, lower prevalence of (28.5 %) was reported from eastern Ethiopia, Dire Dawa. It was suggested that the variation in prevalence among different parts in Ethiopia might be attributed to differences in geographical situations agro ecological zones, seasonal variation and the availability of conducive environments' for survival of ectoparasites in the areas. Also this variation could be due to the management practices provided to these animals by their owners particularly with regards to ectoparasites control (regular use of acaricides) and also due to lack of veterinary services in distant areas (Dinka et al., 2010).

Table 2. Overall prevalence of tick infestation in camels in different parts of Ethiopia

Study area	Prevalence (%)	Reference
Addis Ababa Abattoir	100	Regassa et al. (2015)
Somali Region	98.2	Rodighiero et al. (2012)
Borena	97.7	Megersa et al. (2012)
Tigray	96.6	Kiros et al. (2014)
Dire Dawa	94	Taddese and Mustefa (2013)
Eastern Ethiopia (Hararghe)	87.36	Bekele and Zeleke (2004)
Somalia Region(Fafen Zone)	86.3	Rirash et al. (2017)
Jijjiga	82.8	Hussen (2018)
Somalia State Ethiopia	78.6	Feyera et al. (2017)
Dire Dawa	58.32	Dinka et al. (2010)
Dire Dawa	28.5	Jabir et al. (2017)

The three genera of ticks reported to occur on camels in Ethiopia are *Rhipicephalus*, *Amblyomma*, and *Hyalomma*, and the subgenus *Boophilus*. Among these three genera of ticks infesting camels in Ethiopia, *Rhipicephalus* was the most predominant genus, followed by *Hyalomma*, *Amblyomma*, and the subgenus *Boophilus*.

The main tick species reported from camels in different parts of Ethiopia by different researchers are reported *Amblyomma gemma*, *Amblyomma variegatum*, and *Rhipicephalus (Boophilus) decoloratus* from Northern Ethiopia, Tigray region, Eastern Ethiopia, in and around Dire Dawa, and Somalia region, respectively. It was also reported *Rhipicephalus evertsi* and *Amblyomma cohaerens* from Northern Ethiopia's Tigray region and *Amblyomma lepidium* in Northern Ethiopia's Tigray region. *Rhipicephalus pulchellus*, *Hy. dromedari*, and

Am. gemma were reported by Feyera et al. (2017) and Dinka et al. (2010) in Eastern Ethiopia, Somalia region, and Eastern Ethiopia, in and around Dire Dawa. *Hy. truncatum* was additionally reported by Feyera et al. (2017) from eastern Ethiopia, Somalia region.

The prevalence and burden of tick infestations were affected by various factors. For instance, some studies revealed that male camels carried significantly more ticks than females, which was suggested to be due to the fact that female camels are restrained for daily milking, and during this time the milkers might remove ticks by hand, and this could lead to a gradual reduction in the average tick load. Similarly, some authors reported that the higher prevalence in adult camels was probably attributed to the fact that adult camels do not lie on the ground for much of their time but search the higher plant strata for their feeding, whereas the young ones lay on the ground for a longer period of time and easily acquire tick infestation (Megersa et al., 2012).

Furthermore, a higher tick burden was reported on camels with poor body condition than on those with other body condition scores. This was due to the fact that the resultant worry due to tick attachment might interfere with feeding and lead to loss of condition (Megersa et al., 2012). Also, many reports indicate that when the camel herd size increases to more than 40, the average tick load increases. In both conditions, there is temporary crowding at grazing areas and watering points, which could facilitate the attachment and infestation of ticks and increase the infestation level. Frequent contact among camels, cattle, and small ruminants sharing the same grazing area might also contribute to the abundance of *Rh. pulchellus* and *Am. variegatum* (Feyera et al., 2017).

Herd composition is also the other factor that affects tick burden in camels. Camels kept and grazing mixed with small ruminants were reported to harbor more tick burden (Megersa et al., 2012). According to Regassa et al. (2015), the main tick attachment sites were the anal area, brisket, and scrotum in males and the udder in females. A similar report was provided (Yacob and Yalew, 2008). These sites provide the highest moisture, favorable for growth, and the skin is easily penetrated for sucking blood (Regassa et al., 2015).

Flea infestation

Fleas are insects forming the order Siphonaptera. They are wingless, with mouthparts adapted for

piercing skin and sucking blood. Fleas are external parasites, living by hematophagy of the blood of mammals and birds. Historically, fleas are among the most important ectoparasites of humans in that several species are the natural vectors of several important infectious diseases, like plague. Today, some 15 families with a total of about 220 genera and some 2,500 species of fleas were described (Shiferaw, 2018). Of the 2500 species described to date, over 70% are parasitic on rodents.

Fleas feed on blood and adult fleas remain permanently on their host but usually move around upon it and feed periodically. However, fleas like the 'stick-tight fleas' such as the rabbit flea, *Spilopsyllus cuniculi*, tend to remain attached for long periods of time after firmly anchoring themselves in place with their mouthparts. Movement of adult fleas between hosts occurs when there is close physical contact. The sexes are separate and male fleas are alleged to have the most complex genitalia in the animal kingdom. Most fleas are associated with a particular host species but this is seldom a highly specific relationship and a hungry flea is liable to feed on any warm-blooded animal. Flea bites can prove intensely irritating and in sensitive individuals and domestic animals they induce flea-bite dermatitis (Gunn and Pitt, 2012). Information on flea infestation in camels is not yet documented so far from other country as well as in Ethiopia.

Louse infestation

Lice are small wingless insects with dorsoventrally-flattened bodies which are classified into a single order (Phthiraptera) and in two suborders namely, *Anoplura* (sucking lice) and *Mallophaga* (chewing/biting lice). Approximately, 540 valid species of sucking lice are recognized, all of which are obligate haematophagous ectoparasites of mammals. Although only about 20 of these species are pests of domestic animals, they can occur in huge numbers which may result in host irritation, anemia or dermatitis (Shiferaw, 2018 and Taylor et al., 2016).

Biting lice graze on epidermal tissue, hair and other organic waste. They cause intense itching by their feeding and egg laying activities. Sucking lice have a narrow head with mouthparts adapted for penetrating the skin of the host and sucking blood. Both immature and adult stages suck blood or feed on the skin. The sucking louse of the camel, *Microthoracius cameli* (Fig. 3) is an obligate parasite

which seems to be species specific. Infestation, as with other host species, is more common where camels grow long winter coats.

Lice spread to non-infested animals by close contact, either direct or via fomites but the parasite does not survive long off its host. Lice may occur anywhere on the body of an affected camel but are often first seen on the shoulder and neck areas (Jabir et al., 2017). Mouthparts are adapted for sucking blood and tissue fluids, and, if large numbers of lice are present, considerable irritation can be caused by feeding and by their claws digging into the skin (Shiferaw, 2018).

The saliva and feces of lice contain substances capable of causing allergies giving rise to severe irritations to the skin. This is usually shown by the animal rubbing itself against objects. Lice infestations are associated with development of cockle. Cockle is an inflammatory response of the skin to the presence of lice and their saliva. This is seen after the wool or hair has been removed from the skin. Animals in poor body condition are likely to be seriously affected (Pence, 2002)

Generally, infested camels may stop feeding and bite, rub, or scratch affected areas. Unthriftiness, matted, dull fleece, or tufts of wool may indicate lice infestation. Milk production may decline as a result, and the coat may become shaggy and matted. There are only a few previous reports on the prevalence of lice infestation in camels in Ethiopia. The study reports indicated that camel lice infestation is also another ectoparasite affecting camels in Ethiopia. The overall prevalence of lice infestation according to this sole previous study was 6.1% in camels in Eastern Ethiopia, Dire Dawa Administration Council (Jabir et al., 2017).

Flies

Many species of flies can pose threats to animals by their direct effects and by the transmission of pathogenic agents from one animal to another. Flies are also important vectors of humans' and animals' zoonotic diseases. Veterinary-important biting, non-biting, and larvae-producing flies of camels, wild animals, and other domestic animals indicated (Table 3) are present in different parts of the world as well as in Ethiopia (Taylor et al., 2016). The presence of flies on camels can cause considerable health and economic importance in camel production. Biting and nuisance flies cause irritation and, if prolonged, may prevent birds from feeding, inevitably leading to decreased productivity.

Table 3. List of biting, non-biting, and larvae of flies with veterinary importance to camels, domestic animals, and other wild animals

Family	Genus	Species	Common name	Host	Type of flies
Hippoboscidae	<i>Hippobosca</i>	<i>Camelina</i>	Camel fly	Camels	Biting
Oestridae	<i>Cephalopina</i>	<i>titillator</i>	Camel nasal botfly	Camels	Myiasis
Tabanidae	<i>Tabanus</i>	<i>T. fuscicostatus</i> and <i>T. atratus</i> .	Horse fly	All animals	Biting
Muscidae	<i>Stomoxys</i>	<i>Calcitrans</i>	Stable fly	All animals	Biting
Muscidae	<i>Musca</i>	<i>Autumnalis</i>	Face fly	All animals	Non biting
Muscidae	<i>Musca</i>	<i>Domestica</i>	House fly	All animals	Non biting
Glossinidae	<i>Glossina</i>	<i>Fusca, morsitans</i> <i>Palpalis</i>	Tsetse Flies	All animals	Biting

Source: Taylor et al. (2016)

Biting flies pose a particular risk to camels in trypanosomiasis-endemic areas if they are known to be mechanical vectors of *Trypanosoma evansi* (Enwezor and Sackey, 2005).

Biting flies on camels

Biting flies are common in camels. Among biting flies, horse flies (*Tabanus*) and stable flies (*Stomoxys*) are hematophagous flies which are responsible for mechanical and non-cyclical transmission of trypanosomiasis in camels in different parts of the world (Walker et al., 2003). *Trypanosoma evansi* in camels is transmitted mechanically by the bites of haematophagous flies such as *Tabanus* and *Stomoxys*. The most important biting flies for transmission of *T. evansi* are species of the genus *Tabanus* (Enwezor and Sackey, 2005). It's the major problem for the occurrence and transmission of trypanosomiasis in areas outside of the tsetse fly belt in Africa as well as in Ethiopia (Eyob and Matis, 2013). Biting flies can cause severe irritation in domestic animals, and they are vectors for bacteria, viruses, spirochetes, chlamydiae etc. However, because they feed on blood, they can also cause anemia and hypersensitivity (Awol et al., 2012)

Only a very few reports are available on the biting flies of camels from Ethiopia. The camel biting flies that have been reported in Ethiopia belong to the genus *Tabanus*, *Stomoxys*, *Chrysops*, *Hippobosca*, and *Lyperosia* (Lemecha et al., 2008 and Kassa et al., 2011). *Stomoxys* (99.8%) was the most abundant genus of biting flies of camels and other genera like *Tabanus*, *Chrysops*, and *Lyperosia* were reported to exist in smaller proportions than *Stomoxys* in central Ethiopia, East Shoa, Zone Fentale, District. According to

Kassa et al. (2011), the prevalence of biting flies in Ethiopia showed variations among different months of the year (season). The flies were most abundant during September and least abundant during December. It was suggested that the possible reason was due to differences in the microclimates during different seasons in different study areas.

Non-biting/ Nuisance flies

Non-biting flies include the face fly, head fly, and house fly. Non-biting flies may feed on the secretions from the eyes, nose, and any small wounds. This distracts animals from grazing, causing a reduction in growth and productivity. Non-biting flies are not key biological vectors of any specific disease organisms, but because of their feeding and reproduction habits and the structure of their feet and mouthparts, they can act as mechanical vectors for a whole range of pathogens, from viruses to helminthes (Agrawal and Gupta, 2010). So far, information on non-biting fly infestation in camels is not documented from Ethiopia.

Nasal botfly of camels

The camel nasal botfly, *Cephalopina titillator* (Diptera: Oestridae), occurs worldwide (Brown, 2004). Nasopharyngeal myiasis caused by Oestridae is very common in old world camelids. The camel nasal bot (*Cephalopina titillator*) is usually found at necropsy or during meat inspection (Sazmand and Joachim, 2017). It causes nasopharyngeal myiasis in camels and results in camels' health hazards and severe economic losses in the camel industry (Hanem et al., 2013). The adult fly deposits larvae as obligate parasites of camels in the nasal cavity, which is known to

parasitize the animal for a substantial period of time (Rahman et al., 2001), where it causes irritation of the nasal cavity and predisposes the camel to secondary bacterial infections and is usually found at post-mortem inspection (Brown, 2004). It also impairs animal welfare, reduces host physiological functions (Bassiony et al., 2005), destroys host tissues and causes significant economic losses through reductions in milk production and losses in terms of weight gain (Duaa et al., 2015).

Several factors contribute to infestation by *Cephalopina titillator*, including the free movement of camels between different localities due to the lack of closed-farm systems for camel breeding; the absence of strict control methods on imported animals; and the absence of specific and sensitive techniques for routine diagnosis of infestation in living camels (Nasr et al., 2013).

Reports from different study areas indicated that *Cephalopina titillator* is also another ectoparasite affecting camels in Ethiopia. An overall prevalence of *C. titillator* on camels was reported with different magnitudes from different parts of Ethiopia, as indicated (Table 4). The overall prevalence of *Cephalopina titillator* infestation ranged from 23.9% to 82.6% in camels (Kissi and Assen, 2017 and Jabir et al., 2017), in eastern Ethiopia, Dire Dawa, and central Ethiopia, Addis Ababa Abattoir, respectively.

According to Kissi and Assen (2017), among the *Cephalopina titillator* infested camels, the larvae were found in the turbinate only, the nasal cavity and turbinate, and the nasopharynx and turbinate were reported from central Ethiopia, Addis Ababa Abattoir Akaki branch. The prevalence of *C. titillator* infestation in camels differs among different study areas in Ethiopia. Several factors like origin of camels, sex, age and body condition score, were suggested to affect the prevalence and burden of *C. titillator* larvae in camels (Bekele, 2001, Kissi and Assen, 2017, Mumed and Gemed, 2015 and Regassa et al., 2015).

Various studies reported that female camels were found to harbor the larvae of *C. titillator* when compared to male camels (Kissi and Assen, 2017 and Mumed and Gemed, 2015). This was due to the fact that female camels were kept not very far from the villages, even during the dry season, because they supplied milk for the family, which was supposed to expose female camels to heavier fly challenge in the valleys near the

villages. On the other hand, the males move far from fly challenge areas due to the course of continuous movement as pack animals.

Table 4. Overall prevalence of *Cephalopina titillator* of camels in different parts in Ethiopia

Study area	Prevalence (%)	Reference
AddisAbaba	82.6	Kissi and Assen (2017)
Abattoir (AKaki)		
Dire Dawa	81.1	Mumed and Gemed (2015)
Abattoir		
Somalia State	71.7	Bekele (2001)
Addis Ababa	68.2	Regassa et al. (2015)
Abattoir		
Dire Dawa	23.9	Jabir et al. (2017)

Moreover, female camels are under continuous stress, which may suppress their immunity (Bekele, 2001). On the other hand, Regassa et al. (2015) have reported that the rate of larvae infestation was significantly higher in males than female camels. This study failed to clearly indicate or suggest why the male camels were more infected than females. However, other authors argue that these variations could be due to the differences in management practices of nomads (Oryan and Valinezhad, 2008 and Regassa et al., 2015). Normally, the owners use the male camels for transportation. It happens that male camels make journeys of hundreds of kilometers and visit many new places, so they are easily exposed to new epidemic areas of *C. titillator* (Oryan and Valinezhad, 2008). A higher prevalence of *C. titillator* in the old group of camels than in young (camels less than 7 years old) camels and adult (camels greater than 7 years old) camels was reported by many authors in Ethiopia. This was suggested to be due to the fact that older camels may be more tolerant to flies and allow the deposition of a higher number of larvae around the nostrils, while the younger camels actively seek to prevent the flies settling around the nostrils (Shakerian and Hosseini, 2011).

Cephalopina titillator: higher infestation was reported in camels with poor body condition than in those camels with both medium and good body condition scores (Kissi and Assen 2017, Mumed and Gemed, 2015 and Regassa et al., 2015). It was argued that it might be due to the interference of

larval infestation with feeding behavior of camels and respiration, which leads to starvation and lack of oxygen to cells and tissue. It was also suggested that *C. titillator* larvae infestation has a severe impact on the body condition of camels and causes losses in terms of body weight gain. In addition, it was reported that *C. titillator* larvae infestation has several negative impacts on respiratory function, feeding, health, and productivity of camels, which lose their appetite and show respiratory problems and abnormal behavior resembling cranial coenuriasis (Kissi and Assen 2017). Several studies have revealed that *C. titillator* is one of the most common ectoparasites of camels in Ethiopia.

Clinical signs of ectoparasite infestation

Clinical features of ectoparasite infestation in camels include pruritic dermatosis with papules, crusts, anemia, excoriation, secondary alopecia, and lichenification. The lesions tend to occur on the face, neck, shoulders and across the rump, especially in cases of lice, fleas and mange mite infestations (Wernery, 2002). Hemorrhage, collagen degeneration, and a wedge shaped area of necrosis can occur due to tick mouthparts penetrating the epidermis and becoming lodged in dermis. Tick feeding can introduce cutaneous bacteria into the skin, causing abscesses, or into circulation, leading to bacteraemia and septicaemia (Taylor et al., 2016 and Wall and Shearer, 1997).

Biting flies, particularly stable flies, horn flies, and tabanids can cause severe disturbance and annoyance to camels, leading to reduced weight gain, reduced milk production and hide damage. Fly bites may cause pruritic papules and wheals. Blood-feeding flies may also be important pathogen vectors (Agrawal and Gupta, 2010). The activity of nuisance flies, such as face fly, house flies and other muscids leads to disturbance and irritation. These flies may also be mechanical vectors of disease (Wernery, 2002).

Irritation, bleeding from nostrils, fever, emaciation, loss of appetite, congestion of mucous membrane, enlargement of lymph nodes, nasal discharge, lack of coordination (neurological signs), increased respiratory rate, frequent sneezing and snoring during breathing were most common clinical signs of *Cephalopina titillator* infestation. It leads to reduced production of milk and body weight gain in camels (Tareq et al., 2018).

Diagnosis of ectoparasites

Diagnosis of ectoparasitic infestation or ectoparasite-associated dermatosis requires knowledge of the parasite involved and its life cycle. This can be achieved in many cases, including direct collection of the parasites or examination of an animal's hair. For instance, lice live in an intimate relationship with the host's skin and can easily be found there (Table 5). However, visiting ectoparasites, such as biting flies, may be on the skin for only a short period of time each day, and a diagnosis is often made by implication. Hence, knowledge of the clinical signs of skin diseases is usually required (Wernery, 2002).

Examination of *Cephalopina titillator* larvae in camels can be carried out by using a postmortem after the camels are slaughtered. The larvae of the parasites were detected after dissection and gross examination of the heads of camels, including the nasal cavity, frontal sinuses, turbinate bones, and nasopharynx for the presence of *C. titillator* larvae. Diagnosis of this parasite is very difficult in living animals (Regassa et al., 2015).

Prevention, control and treatments of ectoparasites

Early detection and taking major action is important rather than waiting until the problem of ectoparasites becomes serious. At least once a week, thorough physical observation of animals by their owners is important. Owners need to run their hand over each animal's hair coat, visually inspecting for excessive hair loss, flakes of loose skin, areas of skin irritation, and any crusty lesions or bumps that might indicate infestation with ectoparasites. Immediately separate and confine any animal that shows signs of ectoparasite infestation or seems to be unthrifty. This helps to reduce the chances of transmission of ectoparasites to the rest of their animals. Quarantined animals should not be mixed with the main herd until treatment is complete and the ectoparasites are eradicated. Isolate newly introduced animals and treat them for ectoparasites before mixing them with other animals (Desta et al., 2010 and Dia, 2006).

Ectoparasites can be controlled by treatment of affected animals. As a strategic treatment approach, treating animals at least during the two seasons (dry and wet) is vital. Treatment during the dry period reduces the overall stress on animals associated with malnutrition and further prevents

Table 5. Diagnosis of ectoparasites and laboratory examination techniques

Ectoparasites Name	Anatomical site	Laboratory Techniques for examination
Mites	Hair, hair follicle, surface, Epidermis	Skin scraping, hair plucks, hair brushings, Acetate strip, serology and Biopsy
Lice	Hair	Skin scraping, hair plucks and Acetate strip
Fleas	Hair, surface, Environments	hair plucks and hair brushings
Ticks	Surface, Environments	Visual examination
Flies	Surface, Environments	Biopsy, observation whilst feeding and postmortem examination

the occurrence of concurrent infections. Secondly, wet season treatment is also helpful to prevent re-infestations and propagation of different stages of ectoparasites or hinder the life cycles of ectoparasites (Bekele, 2001 and Bekele, 2010). A selected drug for ectoparasites is insecticides or acaricides, while ivermectin given as a subcutaneous injection is a drug of choice for sarcoptic mange treatment. Infested and sick animals may be treated with effective curative agents like Cymerlarsan and quinapyramine methyl sulfate. Treatment of ectoparasites should be viewed not only in terms of curing sick animals, but also in terms of improving body conditions and enhancing body defense (Bekele, 2010).

Major arthropod-borne pathogens of camels in Ethiopia
Ticks, fleas, lice, and flies are arthropods that live all over the world and infest all types of wild and domestic animals, as well as humans (Jongejan and Uilenberg, 2004). Arthropods are important for the maintenance and transmission of many pathogens, including several species of bacteria, viruses, protozoa, and helminthes, causing diseases in humans, pets, and domestic animals worldwide (Billeter et al., 2008). Vector-borne diseases cause significant morbidity and mortality in both humans and animals around the world and affect the global economy, representing approximately 17% of the burden of all infectious diseases and also causing millions of dollars in losses to the livestock industry (Dantas-Torres et al., 2012).

Ticks and biting flies are the major causes of vector-borne diseases in camels. The common vector-borne diseases in camels are Theileriosis, Babesiosis, Anaplasmosis, and Trypanomosis. These vector-borne diseases are caused by organisms like *Theileria*, *Babesia*, *Anaplasma*, and *Trypanosoma evansi*, respectively (Mohammed et

al., 2017). The former three diseases are transmitted biologically by different species of ticks, and the latter two are transmitted mechanically by biting flies, mainly *tabanus* and *stomoxys*. *Babesia caballi* was molecularly detected from Sudanese camels by Abdelrahim et al. (2009) using Reverse Line Block (RLB). Both *Babesia caballi* and *Theileria equi* were molecularly confirmed in camels from Iraq using PCR (Jasim et al., 2015).

According to various research reports, *Trypanosoma evansi* is a common protozoan disease that affects camels in different parts of Ethiopia that are not tsetse fly belt areas (Eyob and Matios, 2013, Jilo and Abdela, 2017 and Kassa et al., 2011). Information on vector-borne diseases, namely *Theileria*, *Babesia*, and *Anaplasma*, in camels is not available so far from Ethiopia. Only a preliminary report on *Theileria mutans* in camels was reported from Eastern Ethiopia's Somali region. This report can help plan long-term tick and tick-borne pathogen control strategies in the study area and neighboring areas with similar socio-ecological characteristics (Rodighiero et al., 2012).

Conclusion

In Ethiopia, the contribution of camels to the economy of pastoralists is high when compared with other livestock species. However, ectoparasites and associated pathogens are still one of the major constraints to the productivity, production, and health problems of camels. Ticks, mites, and myiasis producing flies, especially *Cephalonia titillator*, are among the major health problems of camels in Ethiopia. Ectoparasites are also responsible for the transmission of highly pathogenic agents to camels. Ectoparasites of camels are currently responsible for considerable economic losses due to the degradation of skin quality, reduced productivity, and performance of the animal in Ethiopia. The prevalence and burden of ectoparasites in camels is affected by different risk factors such as poor management, season, herd

size, herd composition, co-infection, poor nutrition, and hygienic conditions. Therefore, improving husbandry practices and veterinary services may reduce the level and burden of ectoparasites in camels. The economic losses due to ectoparasites in camels result in a reduction in productivity, decreased reproductive performance, and the death of the affected animals. Overall, this review showed that ectoparasites are important problems in camels of all age groups, body condition scores, both sexes, and different agro-ecological zones and harbor a considerable level of ectoparasites, which warrants the institution of appropriate control strategies to improve the health and productivity of camels.

Based on the above conclusion, the following recommendations are forwarded:

- Appropriate control interventions need to be implemented to reduce the negative impacts of ectoparasites on camels in Ethiopia.
- Awareness creation about the economic importance of ectoparasites of camels in Ethiopia is very important.
- Improving husbandry practices and veterinary services that help to reduce the level of ectoparasites is urgently needed.

In-depth studies on ectoparasites and associated pathogens of camels should be conducted in different parts of Ethiopia.

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