Minireview Article

Delicious To The Last Piece: Why Ectoparasite Prefer Human Skin

ABSTRACT

The interaction of ectoparasite in correlation to its host's skin is important. The extent of interaction somewhat makes these parasites able to survive in the harsh conditon of the host's skin. Their existence mostly in the context of gaining their nutrition and perhaps continue its regeneration. Because these diseases caused by ectoparasite are easility transmitted, widespread, and the state of polyparasitism is often took place in a single vulnerable host, and significant primary and secondary morbidity and or complication occurs, which can worsen the course of the inital disease. This minireview aim to discuss about the interlinkage of some EPSD agents in correlation to its host's skin, their interaction and what makes these endoparasites able to survive in the skin in the context of gaining their nutrition.

Comment [CM1]: What mean this abbreviation?

Keywords: arthropods, vulnerable, food seeking behaviour, human louse, myasis

1. INTRODUCTION

Based on its prey seeking behaviour, parasites have a tendency or predilection for certain anatomical locations in their host.[1] The causes can vary, but in general it can be said that by inhibiting certain the anatomical location, the parasite will get the greatest benefit.[2] Most often, it is in the context of getting in the context of obtaining more certain food sources. To some extent, many multicellular parasites ~~actually~~ pursue their potential hosts by following trails of host-emitted 'pheromenon' that attracts parasite. Host seeking is a built-in survival feature of parasite; endoparasites as well as ectoparasites such as mosquitoes and ticks. Many of these parasites use carbon dioxide (CO_2), a respiration byproduct, in combination with host-specific chemicals for targetting host location.[3]

The skin is the largest organ of the human body, and it serves as physical barrier and represents the first line of immunological defence against many infections, including parasitic agent.[4] As most parasites spend at least part of their existence there and often initiate a first host response.[4,5] The skin can also serve as an anatomical reservoir of ectoparasites and is a recurring theme in the transmission of arthropod-borne human pathogens ~~illness~~, probably because skin penetration and followed by its invasion for enhanced preparation of transmission to the next poor and vulnerable host, immunologicaly, is probably a significant evolutionary force.[6] However, we must kept in mind that the skin is much more than just a *porte d'entrée* of entry into the host, *e.g.*, vector borne malaria transmitted through the bite of female mosquito, Anopheles spp.

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Ectoparasites ~~actually~~ are a taxonomically diverse group of micro-organisms that infiltrate the skin of human beings, and other higher ranks-animals.[7] Ectoparasitic arthropods and nematodes are indistinguishable in the way they causing disease; that such a tiny parasitic micro-organism can create skin derangements that are large enough in size that doctor or other people can easily see with unaided eye.[8] Clinical manifestations of ectoparasite invasion are often marked by intense itching, scratch related excoriation, sizeable displeasure and tenderness.[9,10] It can also caused indirect effect to the patient, *e.g.*, sleep disturbance and derangement of academic/working performance.[7,8,10] From that perspective, parasitic infection also has a direct physiological cost to their hosts but may also modify the hosts's reciprocity with other individuals in selected environment.[10] This endless vicious circle is frequently found focally hyperendemic in poor and low-income countries where impoverished communities are still present in society, with a distinctly high incidence in certain prone individuals, families, households, and perhaps neighborhoods.

The skin, a~~A~~part from being an entry point for endoparasites, there are also 'real' parasites that live on the skin. Epidermal parasitic skin diseases (EPSD) are a spectrum of heterogeneous categorization of transmittable infectious illness in which parasite-host interactions are limited to the region of outer layer of the skin.[11] The seven major EPSD are scabies, pediculosis capitis and pediculosis corporis, pthyriasis pubis, tungiasis and hookworm-related cutaneous larva migrans and myasis due to fly larvae; all of these parasites inhabit and live on the skin and get its daily nutrients to survive.[5,6] Pediculosis (infestation by head and body lice) and scabies can be found in all human populations, in various part of the world, but in specific cases of myiasis (fly larva infestation), tungiasis (sand flea disease), and cutaneous larva migrans occur geographically in tropical and subtropical area.[12] Except for head lice and body lice, the organisms discussed in this article are never reported as vectors of pathogenic microorganisms, previously.[13] Most ectoparasites do not act as vector for their host; they are, instead, the direct causative agent of disease.[7] Eventhough the Mortality rate due to these ectoparasite is without a doubt very limited, but the effect of cumulative morbidity percentage from the direct tenderness, derangement of academic/working performance, secondary bacterial infections, and sequelae related to those ectoparasite infestations and infections.[8-10,13]

This minireview aim to discuss about interaction of some EPSD agents in correlation to its host's skin, their interaction and what makes these endoparasites able to survive in the skin in the context of gaining their nutrition.

2. SKIN HOMEOSTASIS

Anatomically, the skin can be classified into three distinct compartments: (1) the epidermis, which is an avascular layer mostly composed of keratinocytes and Langerhans cells; (2) the dermis, which is highly perfused by blood and draining lymphatic vessels; and (3) the subcutaneous adipose tissue.[14-16] The structure of the skin provides an interface between the vascular and lymphatic circulations, as well as the interstitial space.[15] The lymph system is a fluid-filled anatomical compartment defined by a complex lattice of collagen bundles, found within and between tissues including the dermis. Until recently, the physiological importance and extent of the interstitium had been largely understudied, yet this compartment is very likely to be of relevance for host–pathogen interactions defining phenomena such as extravasation and sequestration of different parasites.[17] Or in a more short and simple word to say, is to provide a good shelter for any invading ectoparasite to establish its existence.[8,9]

To ensure homeostasis, actually there is always an extensive crosstalk happened between epithelial, stromal, and immune cells.[7,8,18] Unfortunately, most parasites have developed

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Do you mean economical impact?

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In some myiasis larvae, they start in the skin and penetrate deep into the muscle e.g. cochliomyia hominivorax or Chrysomya Bezziana. So it is not a skin myiasis but a deep myiasis?

mechanisms to evade detection and successfully establish an infection either in the skin itself or elsewhere in the host.[8,18]

3. RESULTS AND DISCUSSION HOW DO PARASITES SURVIVE IN THEIR HOSTS?

Parasites vary in the number of hosts they need to survive, a phenomenon which demonstrated through the complexity of their life cycle.[19] Ecological condition combined with the host's behaviour favoured its transmission, While definite parasites need only a single host, other type of parasites use numerous hosts to veritable their complex life cycles.[20]

Parasitism is a constant confrontation for survival between the parasite and its host; whether the parasite lives inside or on the surface of the host's vulnerable body.[21,22] Parasites rely on their host for nourishment as their source of nutrition and also for shelter to ensure its survival without compromising the host's immune system alertness.[2] they must make sure the host is not demolish until they are reaching the phase of readiness to proceed to the next vulnerable host. On the other hand, the hosts themselves must preserve themselves from threats and dangers caused by direct activity of the parasite or secondary due to parasite's metabolite products and or immune arousal. To protect themselves, the hosts continuously defiance any *corpus alienum* parasitic organisms by producing harsh and unfavorable *milieu*.[23] The host will make an effort to minimize the parasites access to nutrients, systematically starving them to death, or even will directly ambush the parasites with the arousal of suffcient immune responses.[23] In order to succesfully maintaining their lives in such a difficult habitat, each parasite has developed different survival strategies.[24]

As parasites directly harm their hosts, the host may respond with development of counteradapt mechanism that diminished the fitness costs of parasitism.[22] But over millions of years of evolution, parasites have acquired lots of unique but useful properties to help them adapt or counter adapt to specific conditioned environments built by their hosts.[25] Some examples of those features are as follows:

1. The ability to evade or modify the host's immune responses. Each type of parasite, as long as it is in the body of its host, will definitely experience persistent exposure and even challenged by the host's immune armamentarium as part of their natural defenses and also other unfavorable conditions, such as internalization by host's macrophage or other type of phagocytic cells for small intracellular parasitic organism.[26-28] Nutrient, including mineral, limitation and deprivation also a milleu conditioned by a coordinated set of actions from cells, tissues and even host organs as a response to parasite invasion.[24,29] Parasites have developed unique ways to respond to such attacks by several types of immune cells that belongs to their hosts. For example, the formation of parasitophorous vacuole (PV) in host cells (HC) harbouring different intracellular protozoan parasites during internalization by host cells, *e.g*., in cases of the trypanosomatid (protozoan) parasites infection, *Trypanosoma cruzi* and *Leishmania* spp. that causes Chagas disease and Leishmaniasis. Other example respectively, is the Plasmodium species, which cause malaria in humans, which developed their ability to shift their 'macros' appearances by switching their surface proteins and thereby avoiding recognition by the host's immune system.[30] Other parasites have acquired the ability to directly inhibit activation of certain cells and or making the condition is not favorable to the host,[31-33]

2. Modifying their reproductive ~~game~~ plan. Parasites have evolved host specialization, in which they live and reproduce within the mil~~l~~eu of one particular host, actually this option is a two sided sword because eventhough this strategy allows the parasite to be more established inside that particular host, the host specialization also has several limitations for the parasite, including reducing the parasite's chances of finding equivalent mate.[19,34] Parasitic organisms have evolved different ways to solve this problem. For the blood flukes, Schistosoma spp., once the male meets female worm inside their host, they will modify their existence, from initially single and solitary they then stick with each other for as long as they are alive, unless another male is present nearby which allow sexual selection via male-male competition and female choice for large males.[35] Another example are the hermaphrodite tapeworms, ~~–~~where both reproductive organs are installed on the same worm, so that the urgency of finding a tantamount mate is not necessary,

3. Limiting potential harm to the host; because no matter what parasite invade their hosts, they still need at least nutrition for their ~~own~~ fitness, and this might caused problem for their host. If this activity is too active, the stake is the host's life.[2] So, from the point of view of the parasites, it is important to limit the harm they cause, so that the host stays alive for a long ~~period of~~ time. In response to this situation, this clever parasite able to dictate their host's reaction named tolerance. Classically, a reaction norm defines host tolerance because it depicts the change in host fitness as a function of parasite load, where a shallow negative slope indicates that host fitness slowly deteriorates as parasite load increases (*i.e*., high tolerance).[36] Three further novel advancements in the tolerance field are the appreciation of the role of (1) extrinsic, environmental factors on tolerance, (2) host tolerance in multi-host–parasite systems and (3) individual-based approaches to tolerance measures.[36]

So it is clear that the parasite develops several different strategies to maintain its survival in the body of its host. This strategies are not uniform for all parasite, each develop their ~~own~~ way of surviving from the potentially dangerous environment and maintaining their existence and well-being. Further we are going to discuss about how skin as a specific niche for ectoparasite contributes for their source of nutrition and shelter.

3.1 skin give food and shelter for ectoparasite

The skin, as an organ, ~~actually~~ is relatively open and exposed to outer world~~, directly~~. Arthropods are the most commonly encountered parasites in the skin and subcutaneous tissues and in this group there are several ~~a number of~~ parasitic organisms, namely: *Sarcoptes scabei*, *Demodex* spp~~species~~, *Tunga penetrans*, and myiasis-causing fly larvae.[37]

If we focus on the context of EPSD, their host's skin provides many~~a number of~~ important resources for their well-being. Most vitally once again, the host supplies a guaranteed supply of good quality of nutrient for the survival~~life~~ of the parasite, no matter if they exist temporarily or permanently. Debris of the skin, sweat, blood, other kind of superficial dead cells are some example of source of nutrition made available by their human host.[38]

Beside food, human as host also provide suitable environment for the parasite's life sustainability.[39] The host's body actually and unintentionally provide the condition is suitable for parasite to reach its optimum development, in number and in size or proportion.[39,40] In those environment, in which ectoparasites live, generating warmth, moisture and within the skin, or hair or even nail (in the context of fungus) and these three organs give these parasites, to some extent, protection from the harsh environment.[40] in

Comment [CM8]: Parasitism is a way of life that has prepared the parasite in the course of evolution for a defined mode of reproduction. Therefore, it does not prevent the parasite to chose the partner, given the intervention of attraction and repulsion pheromones.
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other context, the host's even provide a safe first class transportation for the parasite, and by facilitating this, it allows them to spread even to far away places from the initial infection. and perhaps a perfect site at which to mate, and in many cases, the means of transmission from host to host.[41,42]

3.2 how the parasite feed

Sarcoptes scabies. Scabies mites consume cell liquids and dead skin cells from their hosts.[43-45] Although infestation of multiple mites is possible, acrually in terms of its virulence, they do not evince any social or colonial etiquette. *Mr. Sarcoptes scabiei* only generate burrows ~~in order~~ to continue the descent by meeting his perfect mate, and are generally believed that it only found wandering and feeding on the host's skin.[45,46] Once they have copulated, *Mrs. Sarcoptes scabiei* use their built-in mouthparts to consume the remains of dead tissue in an attempt to prepare itself for regeneration; and while doing that it gradually generates the extension of their molting tunnels in a characteristically serpentine pattern.[45,47] On her odyssey, *Mrs. Sarcoptes scabiei* also helps lay eggs along the way in the direction of its motion.[48] Some variants of scabies mites are capable of detecting particular odor and thermal; these two considered as stimuli for their well-being, enabling them to find a host again quickly should they be removed.[45-48] They may also be attracted to lipid compounds found on host's skin.[46] Scabies mites ingest cell liquids and skin cells from their hosts.[45-48]

Data acquired from the extensive study of *Sarcoptes scabiei var. ~~C~~canis* provided us information about this variant's inability to sorb sufficient proportion of water vapor from unsaturated air ~~in order~~ to compensate for water loss ~~in~~ despite of an active uptake mechanism, both actively or passively.[46] The maintenance effort of balancing the water needs in this mite is supported primarily by its preference position at the dry stratum corneum–stratum lucidum and stratum granulosum interface; and this is done by its ingestion of intercellular fluid that oozes into the burrow or around its mouth portion.

Water loss rate constants for *Mrs. Sarcoptes scabiei*. Rate constants for uptake of tritiated water and approach of equilibrium tritiated body water content for both sexes ~~(males and females)~~ were independent of external relative humidity. Fast water loss and uptake rates, uptake rate constants independent of relative humidity, and the observation that isolated mites produce an external fluid secretion suggest that these mites, during its lifetime, actively attain water byconsuming a hygroscopic solution provided by the host. However, ~~actually~~ this action is not completely appropriate to compensate its water loss.[46]

Pediculus spp and *Pthyrus pubis*. *Pediculus humanus*, the human body louse, is widespread where overcrowding and lack of hygiene are present, in areas of the world affected by poverty, war, famine and presence of refugees. It has recently been considered re-emerging among homeless populations in developed countries.49 Pediculus humanus is a vector of highly relevant human pathogens.[51] Pthyriasis is considered as sexually transmitted disease.[52]

These louse has a built-in armamentarium or equipment, which supports them to survive in unfavorable conditions on the surface of the host's body.[50] There are at least three elements of the body that facilitate its existence, namely (1) long and narrow sucking mouth parts covered within the head, (2) short antennae, and (3) three pairs of clawed legs adapted for holding and grabbing the host's hair.[53]

A louse gets its nutrient by way of penetrating the host's skin, reaching the superficial vessels of the skin and sucking blood, while doing so its also simultaneously injecting its

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Comment [CM11]: A sexually transmitted disease means that the pathogen is transmitted after penetration of the penis into the vagina.Unlike pthyriasis, which is transmitted by bodily contact between a man and a woman during sexual intercourse. The latter is completely different from the former.

Rewrite this sentence

Comment [CM12]: The louse didn't penetrate the host skin. But she use the haustellum for sucking blood.

Rewrite this senstence

saliva which contain vasodilatory and anticoagulation properties into the host.[54,55] Human louse are obligate ectoparasites. They live off of the blood of humans.[50] They have specially designed mouth parts for piercing the skin of humans and retrieving the blood that is present.[51,53] It is very interesting to seek for the parasite's basic nutrition daily need, and wether this also affect the parasite's host seeking pattern.[50-55]

Myiasis (fly larva infestation). Beside their role as potential vector,the adult flies are not true parasitic, but when they lay their eggs in open wounds and these hatch into their larval stage (also known as maggots or grubs), the larvae feed on live or necrotic tissue, causing myiasis to develop.[56] They may also be ingested or enter through other body apertures.[56,57] Myiasis is defined as the infestation of live vertebrates (humans and/or animals) with dipterous larvae. In mammals (including humans), dipterous larvae can feed on the host's living or dead tissue, liquid body substance, or ingested food and cause a broad range of infestations depending on the body location and the relationship of the larvae with the host.[57] By knowing the basic daily need of this larvae, perhaps in the future this can be an option to do the wound debridement in an open lesion, without compromising the safety and efficacy.

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To ours knowledge, the fly larva are not vector of pathogens!

4. CONCLUSION

We summarize the current knowledge on interaction of EPSD agents in correlation to its host's skin, their interaction and what makes these ectoparasites able to survive in the skin in the context of gaining their nutrition. Because these diseases are widespread, and the condition of polyparasitism is often found, and significant primary and secondary morbidity (complication) occurs.

CONSENT (WHERE EVER APPLICABLE)

No necessary

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Not necessary

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