ECTOPARASITES OF DOMESTICATED ANIMALS IN A RURAL BARANGAY, DAVAO CITY, MINDANAO ISLAND, PHILIPPINES

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ABSTRACT

As the reemergence of maladies in humans caused by bacterial species continues, the need to identify and determine possible routes of infection of bacterial pathogens is necessary. Special focus on the contribution of ectoparasites that infest domesticated animals appears timely especially in suburban or rural settings where domesticated animals form part of their communities. It is for this purpose that infested domesticated animals and their associated ectoparasites of a rural community in Davao City, Mindanao, Philippines were accounted. Ectoparasites were sourced from domesticated animals with hair, feather, and fur and were extracted manually from the hosts and identified based on morphological features. Fifty host domesticated animals were inspected, 41 of which were infested with ectoparasites. A total of 433 individuals of ectoparasites were found: 87 (in chicken), 199 (in dogs), 94 (in cat), nine (in dove), and 44 (in goat) representing 10 species. Except for goats, 41% of the domesticated animals were infested with more than one species of ectoparasite. Ten species of ectoparasites were identified with lice species dominating the pool of ectoparasites identified: Lice- 8; flea - 1; tick -1. All host domesticated animals were infested with at least one louse species while ticks were found only in dogs, and the flea species extracted only from dogs and cats. Data suggest the differential distribution of ectoparasites among domesticated animals in this rural barangay. Moreover, ectoparasites may transfer from one domesticated animal to another given the occurrence of several ectoparasite species in more than one inspected domesticated animal.

Keywords: Disease, microbiology, parasites, pets, zoonosis

ABSTRAK

Apabila kemunculan semula penyakit malaria pada manusia yang disebabkan oleh spesies bakteria terus berlaku, keperluan untuk mengenal pasti dan menentukan kemungkinan jangkitan patogen bakteria adalah diperlukan. Tumpuan khusus terhadap peranan ektoparasit yang menjangkiti haiwan domestikasi muncul tepat pada masanya terutama di kawasan sub urban atau luar bandar di mana haiwan domestikasi dijadikan sebahagian daripada komuniti manusia. Untuk tujuan ini, haiwan domestikasi dan ektoparasit yang berkaitan dengan masyarakat luar bandar di Davao City, Mindanao, Filipina telah diambil kira. Ektoparasit diperolehi daripada haiwan domestikasi dari rambut, sayap, dan bulu dan diekstrak secara

manual dari perumah dan dikenal pasti berdasarkan ciri morfologi. Sebanyak 50 haiwan domestikasi diperiksa, 41 daripadanya telah dijangkiti oleh ektoparasit. Sebanyak 433 individu ektoparasit ditemui: 87 (pada ayam), 199 (pada anjing), 94 (pada kucing), sembilan (pada merpati), dan 44 (pada kambing) mewakili 10 spesies. Kecuali untuk kambing, 41% daripada haiwan domestikasi dipenuhi lebih daripada satu spesies ektoparasit. Sepuluh spesies ektoparasit telah dikenalpasti dengan spesies kutu yang menguasai kumpulan ektoparasit yang dikenal pasti: Kutu-8; hama - 1; sengkenit -1. Kesemua haiwan domestikasi di infestasi dengan sekurang-kurangnya satu spesies kutu manakala sengkenit hanya terdapat pada anjing, dan spesies hama diekstrak hanya dari anjing dan kucing. Data menunjukkan wujud perbezaan taburan ektoparasit di kalangan haiwan domestikasi di kawasan barangay. Selain itu, ektoparasit boleh dipindahkan dari satu haiwan domestikasi kepada yang lain memandangkan berlakunya beberapa spesies ektoparasit dalam lebih daripada satu haiwan yang diperiksa.

Kata kunci: Penyakit, mikrobiologi, parasit, haiwan peliharaan, zoonosis

INTRODUCTION

The nomadic way of life was soon replaced by a stationary community and the need to domesticate food sources like animals was so pronounced that it became a necessity. Up until today, this practice is very rampant to which animals live very close to humans and contact with them becomes more frequent. The practice of backyard animal raising addresses two major concerns: elimination of the difficulty of finding animal food sources and ease of animal husbandry (Diamond 2002). Other animals are also taken care of by humans as pets, becoming a significant companion in most domesticated set up (Murugan et al. 2015). Domesticated animals that are used as pets often have significant contributions to the physical, social, mental and emotional development of growing kids and even adults (Jennings 1997).

Although animal domestication to some extent has contributed in the eradication of food security concerns, it could also have augmented possibilities of disease transmission (Sheahan et al. 2008) as domesticated animals are not free from parasitic infestation, some of which like the ectoparasites are known vectors of diseases in humans (Jongejan & Uilenberg 2004). Several species of ectoparasites that infest domesticated animals were observed to switch hosts from domesticated animals to humans (Karaer et al. 2011). During the occurrence of close contact such as animal grooming or feeding, these ectoparasites which may harbor pathogenic microorganisms can easily transfer to humans, accidentally or intentionally biting/piercing the skin of humans, acting as a vector where pathogens can be transferred to another animal hosts or infecting directly the person that came in contact with the ectoparasites (Aktas et al. 2012; Gortazar et al. 2014; Hopla et al. 1994). Disease transmission can be hastened as ectoparasites feed on blood meal and therefore introduce pathogens to the circulating blood of other hosts like humans (Goater et al. 2013). Studies focused on the determination of associated parasites of domesticated and companion animals reveal several ectoparasites that infect animal hosts and carry pathogens that infect humans such as ticks that carry *Babesia* species (Johnson et al. 2009), ticks that carry *Borrelia* species that infect human hosts (Park et al. 2004), and lice species that contain *Anaplasma* species which are known causative agents of granulocytic anaplasmosis in humans (Chocklakis et al. 2010).

Documentation of pathogen transfer from animals to humans is well pronounced in first world continents like Europe and the United States of America and other developed countries. Aktas et al. (2010) reported the presence of tick parasites in humans which are positive with *Anaplasma phagocytophilum*, the bacterial species also known to infest domesticated and companion animals. In Hungary, the prevalence of *Rickettsia* infection in humans is associated with the increased presence of tick infected synanthropic birds that frequent areas near human habitations (Hornok et al. 2013). *Babesia* spp. and *Rickettsia* spp. isolated from ticks that infested migratory birds in North-Western Russia showed very high genetic similarity to the same bacterial species that infect humans (Movila et al. 2011). The same extent of documentation on bacterial species that are pathogenic to humans and associated with ectoparasites of domesticated animals appears very limited in developing and third world countries (Murugan et al. 2015). In the Philippines, studies that document ectoparasites infesting domesticated and companion animals are available yet limited (Ancheta et al. 2004; Claveria et al. 2004; Portugaliza & Bagot 2015). Most of these focus solely on ectoparasite infestation primarily for veterinary purposes. As there is no current published data about ectoparasites infesting domesticated animals in Davao City, thus the conduct of this study.

MATERIALS AND METHODS

Study Design and Research Sites

This is a non experimental, exploratory, quantitative research. Domesticated animals inspected for ectoparasites were from three sites of a rural barangay situated in Tugbok District, Davao City, Mindanao Island, Philippines (7 11.012, 125 31.040; 5.18 meters above sea level). The barangay is relative of flat terrain and conforms to Davao City's tropical climate. At the time of sampling, the area was relatively humid. Except for fruit trees planted within private-owned lots, no other traces of forested vegetation were observed in the areas visited. This barangay was chosen as the study site because it is one of the adopted communities of San Pedro College, thereby entry to the area can be easily facilitated due to prior community-institution engagements. Moreover, previous visits to the site reveal the presence of several domesticated animals. Baseline information also implied of non-access to animal anti-parasite programs. Although the site is an hour and a half ride from the city center, the barangay, is progressive and is readily accessible.

Acquisition, Isolation, Identification of Ectoparasites

For ectoparasite sampling, a purposive, convenience sampling was employed such that only those owners of domesticated animals who allowed the research team to check their animals were sampled. Moreover, for the safety of the team, only the homeowners residing within the suggested sitios of the barangay captain were asked to participate. Animals inspected for ectoparasites include only those which are domesticated, active, and have either hair, fur, and feather. The species of each inspected animal hosts were identified and probable age (young and adult) were also noted. Ectoparasites that were adhering to the fur, hair, or feather of active, and/or playful domesticated animals, were collected. Owners held the animals while the research team collected the ectoparasites. The protocol of Adang et al. (2015) and Israel et al. (2015) were followed for ectoparasite collection. All ectoparasites, regardless of age, were brushed off from the animal's fur, hair, feather and extracted manually using forceps and were sorted only in the laboratory. Ectoparasites from each host animal were placed in separate cryovial tubes with absolute ethanol and transported for subsequent processing. Ectoparasites were individually examined under a dissecting microscope (Ceti 4x) for morphological features and age determination. Only adult forms of the ectoparasites were

included in the study. Non-adult forms of the ectoparasites where distinguished from its adult form based on coloration, appendages, and size (Triplehorn & Johnson 2005). Non-adult forms were killed and disposed of appropriately. The morphological basis of ectoparasites identification was grounded on the following inspected features: size, color, presence of wings, placement of eyes, division of the body, presence of spines and brittle, cuticle, prenatal combs, number of legs, mouthparts, and antenna (Goater et al. 2013; Triplehorn & Johnson 2005). The total count of ectoparasites collected is presented per infected host companion animal in the sites visited. Species identification of the ectoparasites was confirmed by Dr. Melvin Bagot of Visayas State University, Philippines.

Data Analysis

The prevalence of ectoparasite infestation among each domesticated animal hosts inspected was computed following the formula used by Mohd-Taib et al. (2018).

Prevalence of ectoparasite infested domesticated animal

$$= \frac{\text{total number of infested domesticated animals}}{\text{total number of domesticated animals inspected}} \times 100\%$$

Whereas the prevalence of infestation of ectoparasite species was computed following the formula used by Razali et al (2018).

Prevalence of domesticated animal infested with ectoparasite X

$$= \frac{\text{total number of domesticated animals infested with ectoparasite X}}{\text{total number of domesticated animals infested with all ectoparasites}} \times 100\%$$

RESULTS AND DISCUSSIONS

Domesticated Animals in The Rural Barangay

Fifty host domesticated animals were inspected for ectoparasites (Table 1) with three representative species of mammals and two species of birds. The most sampled were dogs while the least sampled were doves. Forty-two percent of the inspected host domesticated animals are not yet adults. Domesticated animals appear to be a significant component of rural communities. Woods et al. (2007) reported that domesticated animals depict a special bond between humans and nonhuman animals. The presence of domesticated animals is correlated with positive social interactions among humans in small communities. Moreover, having domesticated animals may facilitate civic engagement, social interactions, and overall promote a sense of community oneness. Dogs and cats are reported to be the most commonly owned domesticated animals across the globe (Moriello 2003). In the barangay sampled, dogs compose 32% while cats compose 24% of the domesticated animals surveyed for ectoparasites. Residents mentioned that they raised dogs primarily for security. Since dogs detect individuals who are not familiar to them, it gives the members of the household a sense of assurance especially during the wee hours of the day. Such a reason for raising dogs has also been earlier reported in Australia (Woods et al. 2007) and Ethiopia (Yacob et al. 2008). Class aves ranked second in terms of domesticated animals in Talandang, represented mostly

by chickens and a few households who raised other bird species like the rock pigeons. Chickens were raised primarily for their economic value as some sell either the chicken meat or its eggs. Rock pigeons documented here were raised for aesthetic value only.

Table 1. Domesticated animals and their ectoparasites sampled from a rural barangay.

Domesticated Animals (Host)	**Site (Sites)/No of domesticated animals**	**No of domesticated animals with ectoparasites/No of ectoparasites collected**	**Ectoparasites**	**Ectoparasite Classification**
Dog (*Canis lupus familiaris*)	Site1 (n=6; 1 young)	3 (41)	*Heterodoxus spinigera*	Louse (Phthiraptera)-Ambylcera
		4 (23)	*Ctenocephalides felis*	Flea (Siphonaptera)
		3 (3)	*Rhipicephalus sanguineus*	Tick (Ixodida)
	Site 2 (n=6; 1 young)	2 (16)	*Heterodoxus spinigera*	Louse (Phthiraptera)-Ambylcera
		6 (65)	*Ctenocephalides felis*	Flea (Siphonaptera)
		3 (13)	*Rhipicephalus sanguineus*	Tick (Ixodida)
	Site 3 (n=4; 1 young)	2 (8)	*Ctenocephalides felis*	Flea (Siphonaptera)
		1 (2)	*Heterodoxus spinigera*	Louse (Phthiraptera)-Ambylcera
		3 (28)	*Rhipicephalus sanguineus*	Tick (Ixodida)
Cat *(Felis catus*)	Site 1 (n=4; 3 young)	4 (51)	*Ctenocephalides felis*	Flea (Siphonaptera)
	Site 2 (n=3; 2 young)	2 (2)	*Ctenocephalides felis*	Flea (Siphonaptera)
		3 (5)	*Felicola subrostratus*	Louse (Ischnocera)
	Site 3 (n=5; 3 young)	4 (36)	*Ctenocephalides felis*	Flea (Siphonoptera)
Goat (*Capra aegagrus hircus*)	Site 1 (n=5; 2 young)	4 (44)	*Linognathus* sp.	Louse– Anoplura
Rock Pigeon (*Columba livia*)	Site 2 (n=3)	2 (8)	*Columbicola columbae*	Louse (Phthiraptera)-Ischnocera
		1 (1)	*Menacanthus stramineus*	Louse (Phthiraptera)-Ambylcera

Cont. Table 1

Domesticated Animals (Host)	**Site (Sites)/No of domesticated animals**	**No of domesticated animals with ectoparasites/No of ectoparasites collected**	**Ectoparasites**	**Ectoparasite Classification**
Chicken (*Gallus gallus domesticus*)	Site 1 (n=5, 3 young)	1 (5)	*Goniodes dissimilis*	Louse (Phthiraptera)-Ischnocera
		1 (13)	*Columbicola columbae*	Louse (Phthiraptera)-Ischnocera
		1 (4)	*Menacanthus stramineus*	Louse-Amblycera
		2 (23)	*Lipeurus caponis*	Louse (Phthiraptera)-Ischnocera
		1 (3)	*Chelopistes meleagridis*	Louse (Phthiraptera)-Ischnocera
	Site 2 (n=3)	1 (9)	*Goniodes dissimilis*	Louse (Phthiraptera)-Ischnocera
		1 (2)	*Menacanthus stramineus*	Lice- Amblycera
		1 (10)	*Lipeurus caponis*	Louse (Phthiraptera)-Ischnocera
	Site 3 (n=6, 5 young)	1 (2)	*Goniodes dissimilis*	Louse (Phthiraptera)-Ischnocera
		1 (16)	*Lipeurus caponis*	Louse (Phthiraptera)-Ischnocera

Ectoparasites Associated with Domesticated Animals

Forty one individuals out of the 50 domesticated animals inspected were positive for ectoparasites, 41% of the host individuals are infected with more than one species of ectoparasites while only the goats' samples were infested with a single ectoparasite species (Table 1). Nine host domesticated animals inspected did not contain any ectoparasites: six chickens, one cat, one dove, and one goat. Nine domesticated animals were negative for ectoparasites, and the samples obtained were mere debris. Chickens that were devoid of ectoparasites are the ones that were placed in separate cages whereas the bulk of the samples which were infested with ectoparasites were either free roaming or those that were placed in the main cage were hens are laying their eggs. The dove and goat samples were also placed in isolation from other domesticated animals while the cat that turned negative was the only domesticated animal kept by one resident and is prevented from roaming around frequently. Isolation of possible hosts may lessen the chances of acquiring ectoparasites as contact with potential sources is reduced (Adang et al. 2015). Aside from isolation, self-grooming which could have been done frequently by the cat and the goat that turned negative for ectoparasites could be influential in the ectoparasitic load of host animals. Self grooming in cats and goats is previously reported to reduce ectoparasites among these animals (Eckstein & Hart 2000; Hart & Pryor 2001).

A total of 433 individuals of ectoparasites were found: 87 (in chicken), 199 (in dogs), 94 (in cat), nine (in dove), and 44 (in goat). Ten species of ectoparasites were identified with lice species dominating the pool of ectoparasites identified: Lice- 8; flea - 1; tick -1 (Table 2, Figure 1) showing an 82% ectoparasite infestation prevalence. All host domesticated animals were infested with at least one louse species while only while ticks were found only in dogs, and the flea species extracted only from dogs and cats. Only the flea species *Ctenocephalides felis* and the lice species: *Columbicola columbae* and *Menacanthus stramineus* were found on more than one host domesticated animal (Table 3). Although 18% of the inspected host animals turned negative for ectoparasites, the bulk was infested with arthropod parasites. The ectoparasite species identified to be associated with domesticated animals in this study were already accounted for by previous researchers. Dogs from this rural barangay are infested with *Heterodoxus spinigera* (louse), *Ctenocephalides felis* (flea), and *Rhipicephalus sanguineus* (tick). The cats were infested with *Felicola subrostratus* (louse), and *C. felis* (flea). *H. spinigera*.Kumsa and Mekonnen (2011) also reported the presence of *H. spinigera* from dogs in southern Ethiopia. *C. felis*, found in both dogs and cats as reported in the present study, is consistent with earlier observation (Portugaliza & Bagot 2015). This flea species is a common inhabitant of cats but not in dogs and finding them in both hosts supports the facultative nature of flea ectoparasites (Bowman 2009; Sofer et al. 2015). Lledo et al. (2009) also noted that this ectoparasite can also seek humans as a possible food source especially those that are associated with pets. The tick *R. sanguineus* is a common tick infesting dog (Portugaliza & Bagot 2015; Shoorijeh et al. 2007;) and the presence of this species in dogs from the surveyed rural barangay conforms to these earlier reports. The presence of *F. subrostratus* parallels observations of Knaus et al. (2014) from cats in Albania. Beyecha et al. (2012) reported the presence of several ectoparasites in goats from agro ecologies of Ethiopia including *Linognathus* spp. They also reported the presence of flea (*Ctenocephalides* spp) which was not found in the goats inspected for the current study. One possible reason is the low number of inspected goats for this study whereas Beyecha et al. (2012) inspected 979 goats which could have reduced the encounter of goats infected with other ectoparasites. The presence of *Columbicola columbae* from Rock pigeons in this rural barangay conformed to the earlier report of Portugaliza and Bagot in 2015 where they documented the same ectoparasite from rock pigeons in Leyte. They also reported the presence of *Menacanthus stramineus* from chickens which are consistent with the current study's result. However, Portugaliza and Bagot (2015) did not report the presence of *C. columbae* in chickens and *M. stramineus* in rock pigeons, which were noted in the results of the current study. Such could be attributed to the proximity of the cages of the chickens and the rock pigeons which turned positive for these ectoparasites.

The presence of *Goniodes dissimilis* and *Lipeurus caponis* were reported to be associated with captive wild birds (Sia Su et al. 2013) while *Chelopistes meleagridis* found in chickens of this study's site was accounted from turkeys of Leyte (Portugaliza & Bagot 2015). Although there appears to be a disparity in the observation of which hosts are infested by these lice species, such is not surprising since these lice species can infest several species with their ability to transfer in varied available avian hosts including chickens and pigeons as long as the hosts are near each other to facilitate the transfer of these lice species (Brooke & Nakamura 1998).

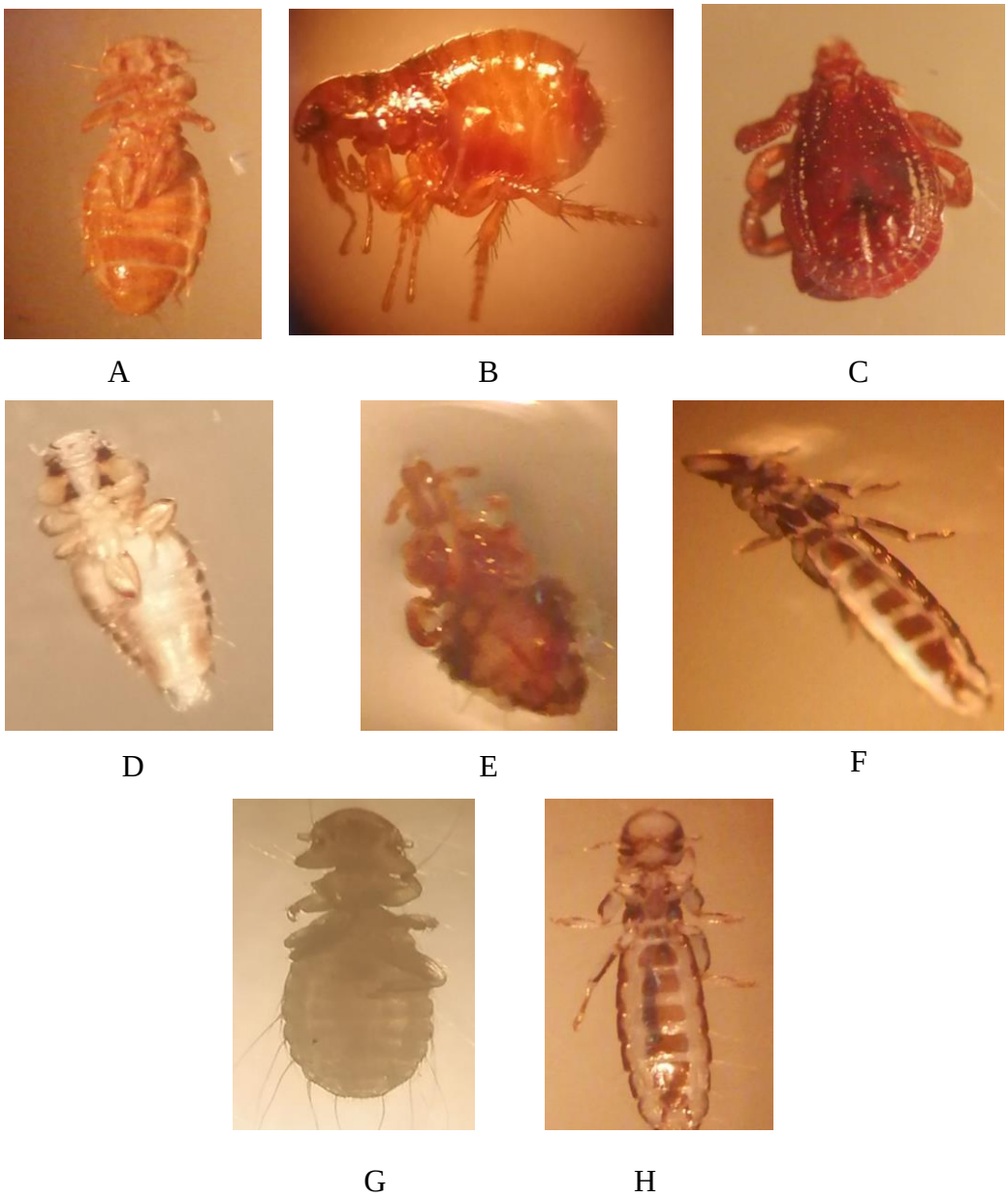

Figure 1. Ectopasites collected from domesticated animals in a rural Barangay in Davao City. (A) *Heterodoxus spinigera*; (B) *Ctenocephalides felis*; (C) *Rhipicephalus sanguineus*; (D) *Felicola subrostratus*; (E) *Linognathus* sp.; (F) *Columbicola columbae*; (G) *Goniodes dissimilis*; (H) *Lipeurus caponis*. All photos taken at 40X magnification using a dissecting microscope (Ceti).

Sources: CARuales 2018.

Table 2. Prevalence of ectoparasite infestation among inspected domesticated animals.

Domesticated animal	**Total number of individuals inspected**	**Number of individuals infested with ectoparasites**	**Prevalence of ectoparasite infestation (%)**
Canis lupus familiaris	16	16	100
Felis catus	12	11	92
Capra aegagrus hircus	5	4	80
Columba livia	3	2	67
Gallus gallus domesticus	14	8	57
Total	50	41	**82**

Total number of domesticated animals inspected: 50, 41 infested

Table 3. Prevalence of domesticated animals infested with specific ectoparasite.

Domesticated animal host	**Ectoparasite species**	**Number of individuals infested with ectoparasites**	**Ectoparasite Load (total no of ectoparasites)**	**Prevalence of ectoparasite X infestation per host (%)**
Canis lupus familiaris (16)	*Heterodoxus spinigera*	6	59	38
	Ctenocephalides felis	12	96	75
	Rhipicephalus sanguineus	9	44	56
Felis catus (11)	*Ctenocephalides felis*	10	89	91
	Felicola subrostratus	3	5	27
Capra aegagrus hircus (4)	*Linognathus* sp.	4	44	100
Columba livia (2)	*Menacanthus stramineus*	1	1	25
	Columbicola columbae	2	8	50
Gallus gallus domesticus (8)	*Goniodes dissimilis*	3	16	38
	Columbicola columbae	1	13	13
	Menacanthus stramineus	2	6	25
	Lipeurus caponis	4	49	50
	Chelopistes meleagridis	1	3	13

( ) – total number of individuals infested with ectoparasit

CONCLUSIONS

Results of the current study show that different species of domesticated animals in a rural barangay harbor different species of ectoparasites. The prevalence also varies in terms of species of an animal host, and the ectoparasite species. Since some ectoparasites species were collected in different domesticated animal hosts, results are suggestive of the capability of different ectoparasites to perform potential host switching. This assumption needs to be further verified with more studies in the future to include more species of domesticated animals. Documentation also of how the domesticated animals are kept and groomed and what food is given to them may also help clarify if ectoparasites do perform host switching.

ACKNOWLEDGEMENTS

Funding support for this study is generously provided by San Pedro College through the initiative of the Innovation, Research, and Publication Office Headed by Prof. Jasmen Pasia, RMT. The author is also grateful to Mrs. Cinderella Hiyas, the barangay captain of the study site, her barangay officials and the residents who generously allowed the researcher and her team to collect ectoparasites from their domesticated animals**.** Confirmation of the identification of ectoparasites was generously provided by Dr. Melvin Bagot of Visayas State University.

REFERENCES

Adang K.L., Ayuba, J. & Yoriyo, K.P. 2015. Ectoparasites of Sheep (*Ovisaries* L.) and Goats (*Capra hirus* L.) in Gombe State, Nigeria. *Pakistan Journal of Biological Sciences* 18: 224-231.

Aktas, M., Vatansever, Z., Altay, K., Aydin, M. & Dumanli, N. 2010. Molecular evidence for *Anaplasma phagocytophilum* in *Ixodes ricinus* from Turkey. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 104: 10-15.

Aktas, M., Altay, K., Ozubek, S. & Dumanli, N. 2012. A survey of ixodid ticks feeding on cattle and prevalence of tick-borne pathogens in the Black Sea Region of Turkey. *Vet. Parasitol* 187 (3-4): 567-571.

Ancheta, P.B., Dumilon, R.A., Venturina, V.M., Cerbito, W.A., Dobson, R. J., LeJambre, L. F., Villar, E.C. & Gray, G.D. 2004. Efficacy of benzimidazole antihelmetics in goats and sheep in Philippines using a larval development assay. *Veterinary Parasitology* 120: 107-121.

Beyecha, K., Kumsa, B. & Beyene, D. 2012. Ectoparasites of goats in three agroecologies in central Oromia, Ethiopia. *Comp. Clin. Pathol*. 23: 21–28.

Bowman, D. 2009. *Georgis' Parasitology for Veterinarians*. 9th Editions. USA: Saunders Elsevier.

Brooke, M. & Nakamura, H. 1998. The acquisition of host-specific feather lice by common cuckoos (*Cuculus canorus*). *Journal of Zoology* 244 (02): 167-173.

Chocklakis, D., Ioannou, I., Tselentis, Y. & Psaroulaki, A. 2010. Human anaplasmosis and *Anaplasma ovis* variant. *Emerg. Infect. Dis.* 16: 1031-1032.

Claveria, F., Lim, M., Tan, J. & Cruz, M. 2004. *Sarcocystis capracanis* infection in Philippine domestic goats (*Capra hircus*): Ultrastructural studies. *Philippine Journal of Science* 133 (1): 33-37.

Diamond, J. 2002. Evolution, Consequences and future of plant and animal domestication. *Nature* 418: 700-707.

Eckstein, R.A. & Hart, B.L. 2000. Grooming and control of fleas in cats. *Applied Animal Behaviour Science* 68: 141-150.

Goater, T.M., Goater, P.M. & Esch, G.W. 2013. *Parasitism: The Diversity and Ecology of Animal Parasites*. 2nd Edition. UK: Cambridge University Press.

Gortazar, C., Reperant, L. A., Kuiken, T., de la Fuente, J., Boadella, M., Martínez-Lopez, B., Ruiz-Fons, F., Estrada-Peña, A., Drosten, C., Medley, G., Ostfeld, R., Peterson, T., VerCauteren, K.C., Menge, C., Artois, M., Schultz, C., Delahay, R., Serra-Cobo, J., Poulin, R., Keck, F., Aguirre, A.A., Henttonen, H., Dobson, A.P., Kutz, S., Lubroth, J. & Mysterud, A. 2014. Crossing the interspecies barrier: Opening the door to zoonotic pathogens. *PLoS Pathogens*10(6): e1004129.

Hart, B. & Pryor, P. 2001. Developmental and hair-coat determinants of grooming behavior in goats and sheeps. *Animal Behaviour* 67: 11-19.

Hornok, S., Csorgo, T., de la Fuente, J., Gyunanecz, M., Privigyei, C., Meli, M., Kreizeinger, Z., Gonczi, E., Fernandez de Mera, I. & Lehmann, R. 2013. Synanthropic birds associated with high prevalence of tick-borne Rickettsiae and with first detection of *Rickettsia aeschlimanniii* in Hungary. *Vector-Borne and Zoonotic Diseases* 13(2): 77-83.

Hopla, C., Durden, L.A. & Keirans, J.E. 1994. Ectoparasites and classification. *Rev SciTech Off Int Epiz (Scientific and Technical Review of the Office International des Epizooties (Paris)* 13(4): 985-1017.

Israel, Y., Tsegalem, A. & Wakayo., B.U. 2015. Epidemiological study on ectoparasite infestation of small ruminants in Sodo Zuria District, Southern Ethiopia. *Journal of Veterinary Medicine and Animal Health* 7(4): 140-144.

Jennings, L.B. 1997. Potential benefits of pet ownership in health promotion. *J. Holist. Nurs.* 15(4): 358-372.

Johnson, S.T., Cable, R.G., Tonnetti, L., Spencer, B., Rios, J. & Leiby, D.A. 2009. Seroprevalence of *Babesia microti* in blood donors from Babesia endemic areas of the north-eastern United States: 2000 through 2007. *Transfusion* 49(12): 2574–2582.

Jongejan, F. & Uilenberg, G. 2004. The global importance of ticks. *Parasitology* 129: 3-14.

Karaer, Z., Guven, E., Nalbantoglu, S., Kar, S., Orkun, O., Ekdal, K., Kocak, A. & Ackay, A. 2011. Ticks on humans in Ankara, Turkey. *Exp. Appl. Acarol*. 54(1): 85-91.

Knaus, M., Rapti, D., Shukullari, E., Kusi, I., Postoli, R., Xhaxhiu, D., Silaghi, C., Hamel, D., Visser, M., Winter, R. & Rehbein, S. 2014. Characterisation of ecto- and endoparasites in domestic cats from Tirana, Albania. *Parasitology Research* 113(9): 3361-3371.

Kumsa, B. & Mekonnen, S. 2011. Ixodid ticks, fleas, and lice infesting dogs and cats in Hawassa, Southern Ethiopia. *Onderstepoort Journal of Veterinary Research* 78(1): 1-4.

Lledo, L., Pardo, G., Penafiel, G., Sousa, R., Gegundez, M., Casado, N. & Criado, A. 2009. Molecular detection of Hemoprotozoa and *Rickettsia* sp in arthropods collected from wild animals in the Burgos Province, Spain. *Vector-Borne Zoonotic Diseases* 10(8): 735-738.

Mohd-Taib, F.S., Lasim, A.M., Asyikha, R., Ali, R. & Ishak, S.N. 2018. A preliminary survey of ectoparasites of small mammals in Pangkor Island, Perak, Malaysia. *Serangga* 23(2): 73-82.

Moriello, K.A. 2003. Zoonotic skin diseases of dogs and cats. *Animal Health Research Reviews* 4: 157–168.

Movila, A., Reye, A., Dubinina, H., Tolskenkov, O., Toderas, I., Hubschen, J., Muller, C. & Ateeksev, A. 2011. Detection of *Babesia* Sp. EU1 and members of spotted fever group Rickettsiae in ticks collected from migratory birds at Curonian Spit, North-Western Russia. *Vector-Borne and Zoonotic Diseases* 11(1): 89-91.

Murugan, M., Arunvikram, A., Pavulraj, S., Milton, A., Sinha, D. & Singh, B., 2015. Companion animals: A potential threat in emergence and transmission of parasitic zoonoses. *Advances in Animal and Veterinary Sciences* 3(11): 594-604.

Park, H., Lee, J., Jeong, E., Koh, S., Park, T., Jang, W., Park, K., Kim, B., Kook, Y. & Lee, S. 2004. Evaluation of *groEl* gene Analysis for identification of *Borrelia burgdorferi* Sensu Lato. *Journal of Clinical Microbiology* 42(3): 1270-1273.

Portugaliza, H. & Bagot, M. 2015. Different species of lice (Phthiraptera), fleas (Siphonaptera), and ticks (Ixodida) collected from livestock, poultry, reptile, and companion animal in Leyte Island, Philippines. Livestock Research for Rural Development 27(8): #Article151.

Razali, N.B., Shamsudin, N., Rahaniza, A.M. ., Yaakop, S., Khoo, JJ. & Mohd-Taib, F.S. 2018. Ectoparasites (Ticks and Mites) prevalence on small to medium-sized mammals associated with habitat condition in Kemasul, Pahang. *Serangga* 23(1): 72-88.

Sheahan, T., Rockx, B., Donaldson, E., Sims, A., Pickles, R., Corti, D. & Baric, R. 2008. Mechanisms of zoonotic severe acute respiratory syndrome coronavirus host range expansion in human airway epithelium. *Journal of Virology* 82(5): 2274-2285.

Shoorijeh, S., Ghasrodashti, A., Tamadon, A., Moghaddar, N. & Behzadi, M. 2007. Seasonal frequency of ectoparasite infestation in dogs from Shiraz, Southern Iran. *Turk. J. Vet. Anim. Sci.* 32(4): 309-313.

Sia Su, G., Amil, C., San Juan, J., Sia Su, M., Maguad, G., Salinas, R., Ragragio, E., Santiago, A. & Ramos, G. 2013. Ectoparasite Survey of Quarantined Animals in a Wildlife Rescue Center in Quezon City, Philippines. *World Journal of Agricultural Research* 1(3): 44-47.

Sofer, S., Gutiérrez, R., Morick, D., Mumcuoglu, K. & Harrus, S. 2015. Molecular detection of zoonotic bartonellae (*B. henselae*, *B. elizabethae* and *B. rochalimae*) in fleas collected from dogs in Israel. *Medical and Veterinary Entomology* 29(3): 344-348.

Triplehorn, C. & Johnson, N. 2005. *Borror and Delong's Introduction to The Study of Insects.* Australia: Thomson Brooks.

Woods, L., Corti, B., Bulsara, M. & Bosch, D. 2007. More than a furry companion: The ripple effect of companion animals on neighborhood interactions and sense of community. *Society and Animals* 15: 43-56.

Yacob, H.T., Ataklty, H. & Kumsa, B. 2008. Major ectoparasites of cattle in and around Mekelle, northern Ethiopia. *Entomological Research* 38: 26−30.