Ectoparasites of Commensal Rodents from Backyard Farmlands in Baguio City, Philippines

JOHN EDWARD L. FELIPE *[1], IMEE ROSE E. FELIPE[1], and ARIS A. REGINALDO[1]

[1]*University of the Philippines Baguio, Baguio City, Philippines*

Abstract

Ectoparasites associated with rodents generally transmit vector-borne diseases to humans. This study aimed to determine the assemblage of ectoparasites and the conditions of ectoparasite infestation at both the levels of population and species of rodent hosts collected from private backyard farmlands in Baguio City, Northern Luzon, Philippines. Forty rodents were captured and identified as *Rattus tanezumi*, *Rattus exulans*, *Suncus murinus*, and *Mus musculus*. A total of 35 rodents were found to harbor 1,658 ectoparasites represented by eleven species. These species generally grouped as mites (*Laelaps nuttalli*, *Laelaps echidninus*, *Ornithonyssus bacoti* and three other *Laelaps* species), lice (*Polyplax serrata*, *Polyplax spinulosa* and *Hoplopleura pacifica*), ticks (*Ixodes granulatus*), and fleas (*Xenopsylla cheopis*). *L. nuttalli*, which had never been found to be associated with any vector-borne disease in humans, had the highest prevalence. The most notable rodent ectoparasites (*X. cheopis*, *O. bacoti* and *H. pacifica*, *P. spinulosa* and *P. serrata*) responsible for diseases such as bubonic plague, dermatitis, and murine typhus had relatively low prevalence, and therefore had low probability of disease transmission. The condition of ectoparasite infestation varied among the rodent species, in which infestation was found to be more common in the *Rattus* species. Results suggest that in Baguio City, the present condition of ectoparasite infestation does not pose a risk of vector-borne disease transmission to people living near the farmlands.

Keywords: zoonosis, *Rattus*, *Mus musculus*, plague, typhus, dermatitis, medical parasitology

Introduction

Ectoparasites associated with rodents may carry with them pathogens than can cause zoonosis—diseases transmissible between animals and humans. The possibility of disease transmission depends mainly upon the abundance of hosts and ectoparasites (Sohrab et al., 2011) and the proximity of infested hosts to human habitations (Kia et al., 2009).

Rodents thrive on areas with a variety of potential resources. Human habitations provide an all-year round easy food and water access to rodents (Petrovic et al., 2008). Croplands, although only seasonally, provide rodents rich food supply (Stenseth et al., 2003). Each habitat alone is at a high risk for zoonosis primarily facilitated by rodents. A higher risk is posed on communities with both human habitations and croplands, such as those found in Baguio City, Northern Luzon, Philippines.

Baguio City has geographic plains and a climate conducive for the production of some highland fruits and vegetables such as strawberries, cabbages, and potatoes. Farming has been a common activity in the city, mainly for personal consumption; however, due to urbanization and limitations in spaces at present, farming has been reduced to a small garden-type system. Such croplands are situated very near the houses and are described as backyard farmlands.

Several studies have confirmed the presence of rodent-ectoparasite association in Baguio City. In 2012, two studies have been conducted to determine the condition of infestation and the diversity of ectoparasites of the rodents found in the urban areas (Iglesia and Vertudes, 2012) and pine forests (Castaneda et al., 2012) of the city. Iglesia and Vertudes (2012) have reported seven ectoparasites species (*Polyplax spinulosa*, *Hoplopleura sp.*, *Xenopsylla cheopis*, *Pulex irritans*, *Laelaps echidninus*, *Laelaps nuttalli* and *Haemogamasus* sp.) in close association with the common urban rat (*Rattus tanezumi*). In the pine forests, Castaneda et al. (2012) have reported six different ectoparasites species (*Ixodes granulatus*, *Polyplax spinulosa*, *Hoplopleura sp.*, *Laelaps echidninus*, *Laelaps nuttalli* and Haemogamasus sp.) infesting the captured rodents (*Rattus tanezumi*, *Rattus exulans* and *Suncus murinus*). However conclusive and extensive these previous studies maybe, none of the two studies necessarily represents the assemblage of ectoparasites and the conditions of infestations in the farmlands of Baguio city. Differences in the availability and accessibility of food resources, predation and human rodent control, degree of stress and disturbance and the presence and suitability of host and ectoparasite breeding sites all contribute to the differences in ecological dynamics among the three habitat types—pine forest, urban areas and farmlands (Chernousova, 2010; Petrovic et al., 2008; Pucek et al., 1993). Therefore, there is a need to conduct a separate study on the ectoparasites of rodents from backyard farmlands of Baguio City.

The account on the occurrence of ectoparasites in their hosts may have implications on the future prevention and control of zoonotic diseases in the communities of Baguio City associated with backyard farmlands. With the urban and pine forest habitat documented (Castaneda et al., 2012; Iglesia and Vertudes, 2012), it may provide additional information on the infestation, host-ectoparasite association, and distribution of ectoparasites in rodent hosts in the entire city. This study aimed to determine the species of ectoparasites and the conditions of ectoparasite infestation at the level of both population and species of rodent hosts found in communities with backyard farmlands of Baguio City.

* **Correspondence**: John Edward L. Felipe; *Address*: Department of Natural Sciences, College of Arts and Sciences, Tarlac Agricultural University, Camiling, Tarlac, Philippines *Email:* jlfelipe@tau.edu.ph;

Figure 1. Satellite map showing the location of collection areas: South Sanitary Camp, Brookside, and Loakan Proper Barangays. Residential areas cover most parts of the city while some patches of pine forests (dark green areas) are scattered within and around the city. Inset map of Luzon Island showing the location of Baguio City

Methodology

Study Sites

Baguio City occupies an area of 57.49 square kilometers (22.2 sq. mi) at an elevation of about 1000-1600 meters above sea level. The highly urbanized city lies at the southernmost part of the Cordillera Administrative Region (CAR) and is situated about 203 km northwest of Manila. Host collection sites were determined based on the definition of backyard farmlands and recommendation of the Department of Agriculture – Cordillera Administrative Region (DA-CAR). Two privately-owned backyard farmlands were used as collection sites in each of the three recommended Baguio City barangays – South Sanitary Camp (16°25'36" N 120°35'48" E), Brookside (16°25'15.34" N, 120°36'29.62" E) and Loakan Proper (16°22'25.44" N, 120°37'0.56" E) – where most backyard farmlands are situated and were reported to have experienced rodents pestering the crops (Figure 1).

Host Collection

The study adopted the techniques and methods of Heaney et al. (1999) and Reginaldo (2011) for capturing rodents. Some modifications were made to become more appropriate for the study including setting all the traps on the ground randomly at a minimum of only 3-meter distance from each other. At least 400 cage and snap traps were deployed with food baits (sweet potato and grilled coconut coated with peanut butter) for a minimum of 4 days in each sampling site. Captured rodents were retrieved immediately early in the morning of the next day. In the absence of a rodent, traps with fresh bait were left in place for at least two more days before transferring them to another location.

All captured rodents were collected, euthanized through cervical dislocation if captured alive, and placed in properly labeled tightly-bound bags to prevent the transfer and loss of ectoparasites. For identification purposes, all specimens were preserved in formalin after ectoparasite collection as voucher specimens.

Rodent Identification

For each individual caught, the total length, hind foot length, tail vertebra and ear length, and weight of the specimens were measured. Based on these external measurements and other physical characteristics, the specimens were identified using available literatures (Barbehenn et al., 1972; Heaney, 1998; Heaney et al., 2010). For supplemental information, age and sex of the rodent hosts were also recorded.

Ectoparasite Collection and Identification

To facilitate ectoparasite collection, the use of crushed naphthalene balls was placed inside the airtight bags of each rodent specimen, which rendered the ectoparasites inactive. The snout, ears, limbs, and axillary regions of rodents were checked thoroughly. The ectoparasites were collected and preserved in 70% alcohol.

Ectoparasite specimens were characterized morphologically for identification. Several available literatures (Baker, 2008; Strandtmann and Mitchell, 1963) were used as guides to identify the ectoparasite specimens.

Data Gathering and Analysis

Common indices such as Prevalence (P), Mean Intensity (MI), and Mean Abundance (MA) were calculated based on the definitions of Bush et al. (1997) to assess the percentage of infested hosts, load of parasites, and dispersion of parasites among hosts, respectively. Confidence intervals for the mean intensity and mean abundance were constructed at 95% confidence level ($Z_{\alpha/2}$ =1.960). The variance to mean ratio (VMR) by Rózsa et al. (2000) was used to characterize the distribution of each ectoparasite species.

Results and Discussion

A total of 1,658 ectoparasites was collected and identified comprising 11 different species. They were generally grouped as mites (*Laelaps nuttalli*, *Laelaps echidninus*, *Ornithonyssus bacoti* and three other unidentified *Laelaps* species), lice (*Polyplax serrata*, *Polyplax spinulosa* and *Hoplopleura pacifica*), ticks (*Ixodes granulatus*) and fleas (*Xenopsylla cheopis*) (Figure 2-5). The ectoparasites were collected from 35 of the 40 rodents captured – *Rattus tanezumi* (22), *Suncus murinus* (9), *Rattus exulans* (7), and *Mus musculus* (2) – resulting into an overall infestation prevalence (P) of 87.5%, mean intensity of 47.37 ectoparasites per infested host, and mean abundance of 41.45 ectoparasites per examined host.

The most abundant ectoparasite species was *H. pacifica* (750), followed by *L. nuttalli* (429), *L. echidninus* (189), *O.*

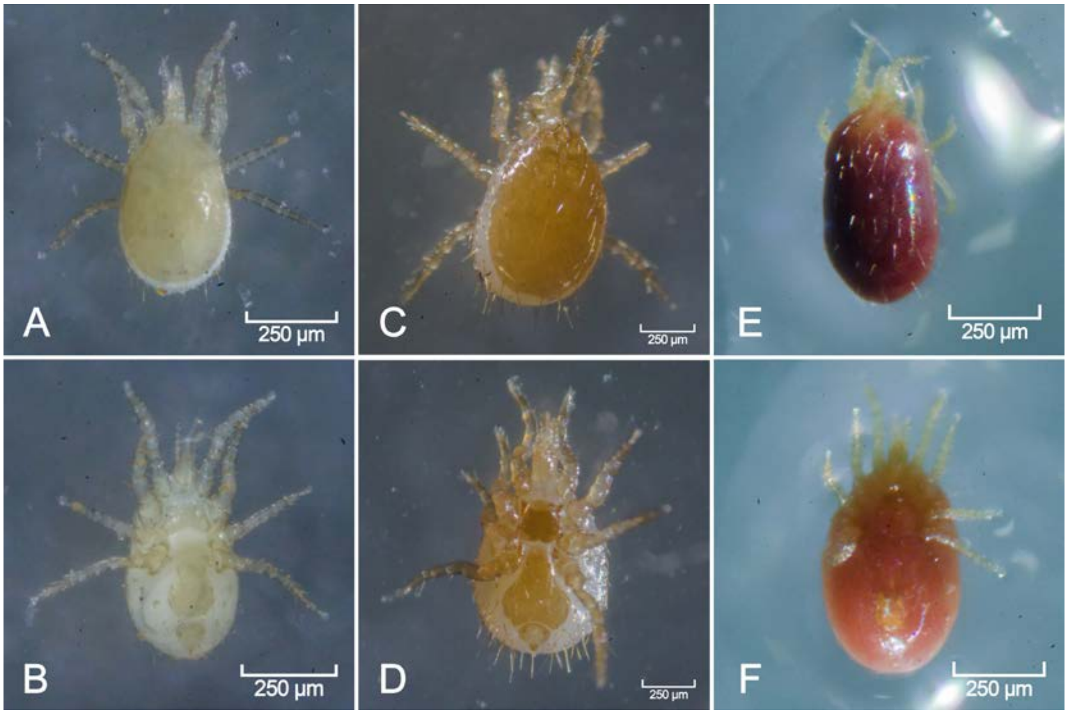

Figure 2. Ectoparasites collected from rodent hosts of backyard farmlands in Baguio City. *Laelaps nuttalli*, dorsal (A) and ventral (B) view; *Laelaps echidninus*, dorsal (C) and ventral (D) view; and *Ornithonyssus bacoti*, dorsal (E) and ventral (F) view.

Figure 3. Ectoparasites collected from rodent hosts of backyard farmlands in Baguio City. *Laelaps* sp. 1, dorsal (A) and ventral (B) view; *Laelaps* sp. 2, dorsal (C) and ventral (D) view; and *Laelaps* sp. 3, ventral (E, F) view.

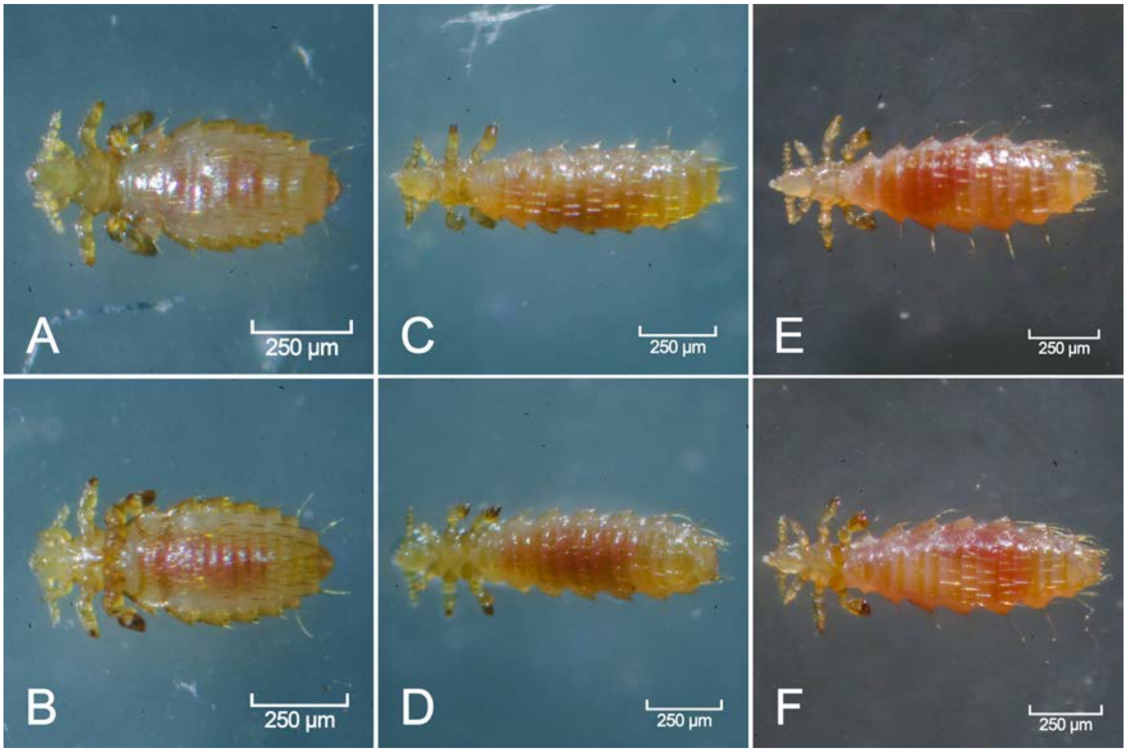

Figure 4. Ectoparasites collected from rodent hosts of backyard farmlands in Baguio City. *Hoplopleura pacifica*, dorsal (A) and ventral (B) view; *Polyplax spinulosa*, dorsal (C) and ventral (D) view; and *Polyplax serrata*, dorsal (E) and ventral (F) view.

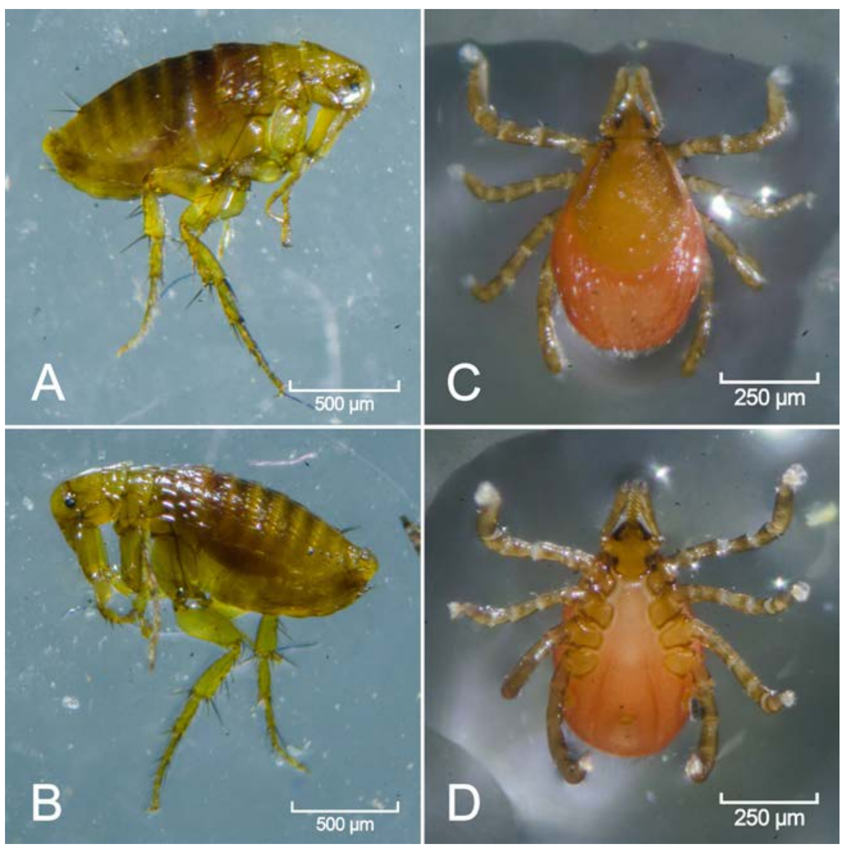

Figure 5. Ectoparasites collected from rodent hosts of backyard farmlands in Baguio City. *Xenopsylla cheopis*, (A & B); and *Ixodes granulatus*, dorsal (C) and ventral (D) view.

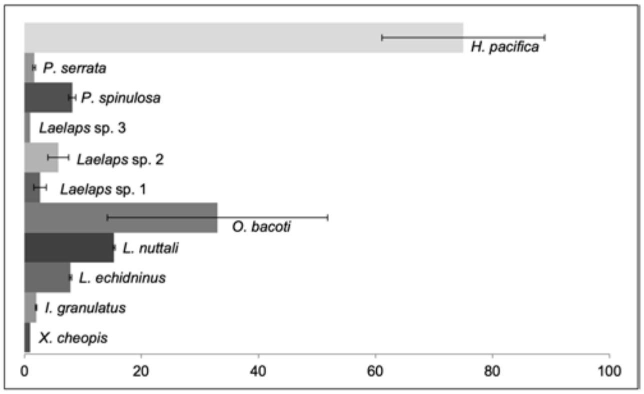

Figure 6. Mean intensity (MI) of the 12 ectoparasite species with confidence intervals at 95% confidence level ($Z_{a/2}$=1.960)

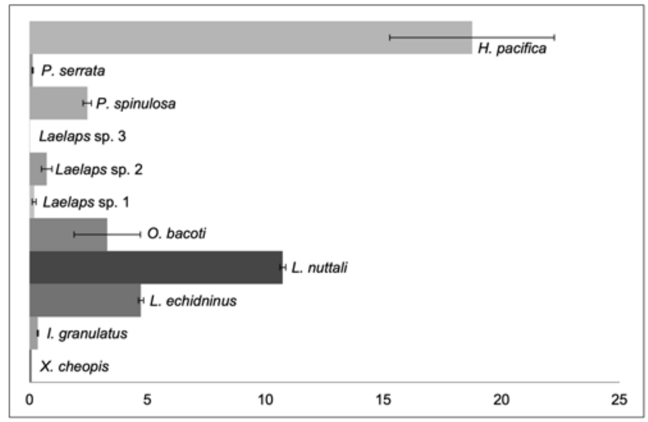

Figure 7. Mean abundance (MA) of the 12 ectoparasite species with confidencintervals at 95% confidence level ($Z_{a/2}$=1.960)

bacoti (132), and *P. spinulosa* (98). The rest of the species occurred in much lower numbers (Table 1).

The ectoparasite species collected and identified in the present study were all common parasites of rodents (Baker, 2008; Huang et al., 2013; Kia et al., 2009; Strandtmann and Mitchell, 1963). Some of the reported ectoparasites were similar to the findings of the studies conducted in the pine forests (Castaneda et al., 2012)) and urban areas (Iglesia and Vertudes, 2012) of Baguio City. In particular, *L. nuttalli*, *L. echidninus*, *P. spinulosa* and *I. granulatus* were similar to those reported by Castaneda et al. (2012). Further, *X. cheopis* and all the previously mentioned species, except for *I. granulatus*, were recorded by Iglesia and Vertudes (2012). These similarities further support the widespread distribution of the collected ectoparasites.

In terms of prevalence, the ectoparasite species infesting the most number of rodents was *L. nuttalli* (70%), followed by *L. echidninus* (60%), *P. spinulosa* (30%), and *H. pacifica* (25%). The other species had less than 20% prevalence. Most of the ectoparasites showed an aggregated and random distribution pattern (VMR¿1). *H. pacifica* had the highest variance to mean ratio (678.18), while *X. cheopis*, *I. granulatus*, *Laelaps* sp. 3, and *P. serrata* had VMR values close to 1 (Table 2).

Mean intensity was significantly highest in *H. pacifica*, fol-

,

lowed by *O. bacoti*, *L. nuttalli*, *P. spinulosa*, and *L. echidninus* (Figure 6). Mean abundance was also significantly highest in *H. pacifica*, followed by *L. nuttalli*, *L. echidninus*, *O. bacoti* and *P. spinulosa* (Figure 7).

The condition of ectoparasite infestation varied among the rodent species. The prevalence of ectoparasite infestation was highest in the *Rattus* species; each with 100% prevalence, while only 66.67% of *S. murinus* and none of the *M. musculus* was infested (Table 3). In *R. tanezumi*, *L. nuttalli* had the highest prevalence (95.45%), while *H. pacifica* had the highest mean intensity (122.17) and density (34.90). In *R. exulans*, *L. echidninus* had the highest prevalence (85.71%), while *L. nuttalli* had the highest mean intensity (7.2) and density (5.14). In *S. murinus*, *I. granulatus* had the highest prevalence (44.44%), while

(2.78) (Table 3).

The observed occurrence of *Laelaps nuttalli* on a variety of host species and in large-, medium- and small-sized hosts (*R. tanezumi*, *R. exulans* and *S. murinus*, respectively) suggests the ectoparasite's broad range of hosts. Previous studies have reported its infestation on different rodent species such as *R. norvegicus* and *R. argentiventer*, and the same species as those captured in the present study (Huang et al., 2013; Iglesia and Vertudes, 2012;Kia et al., 2009; Luyon and Salibay, 2007). A comparison of measures of prevalence, and mean intensity and density among host species revealed the ectoparasite's high preference to *R. tanezumi*. No *L. nuttalli* was found on *M. musculus* in the present study; however, the association of *L. nuttalli* and *M. musculus* has been reported in earlier studies in Egypt and Iran (Kia et al., 2009; Yassin, 2009). The absence of *L. nuttalli* and all the other ectoparasite species on the collected *M. musculus* may be due to the small number of captured *M. musculus*.

Studies have shown a close relationship between *L. nuttalli* and *L. echidninus*, such that an infested rodent with one of the mites is usually also infested with the other. The prevalence and abundance of the mites only differ slightly (Huang et al., 2013; Kia et al., 2009; Solanki et al., 2013), an observation similar to

the findings of the present study. Comparable to *L. nuttalli*, *L. echidninus* also has a wide range of host preference and previous studies have reported the mite's association to common wild rats and mice, including *M. musculus* (Baker, 2008; Castaneda et al., 2012; Strandtmann and Mitchell, 1963). Interestingly, *Laelaps* sp. 2 had the highest mean intensity (12.5) and density

L. nuttalli has been previously noted to infest *S. murinus* (Kia
et al., 2009); while to date, there has been no reported case of infestation of *L. echidninus* on *S. murinus*. Studies have yet to be done to investigate on the previously mentioned observation.

Ornithonyssus bacoti is referred to as the tropical rat mite (Beck, 2007). The present study has recorded its occurrence only on *R. tanezumi*. However, literature notes that *O. bacoti* in- fests various species of small mammals and avian hosts (Baker, 2008). This ectoparasite species spends relatively short time on a host's skin and was previously reported to be found much of

Table 1. Abundance of ectoparasite species collected among rodent hosts from backyard farmlands of Baguio City

ECTOPARASITE SPECIES	FAMILY	HOSTS *			TOTAL
		R. tanezumi (n=22)	*R. exulans* (n=7)	*S. murinus* (n=9)	
Mites (Mesostigmata)					
Laelaps nuttalli	Laelapidae	391	36	2	429
Laelaps echidninus	Laelapidae	164	25	0	189
Ornithonyssus bacoti	Macronyssidae	132	0	0	132
Laelaps sp. 1	Laelapidae	8	0	0	8
Laelaps sp. 2	Laelapidae	4	0	25	29
Laelaps sp. 3	Laelapidae	1	0	0	1
Total		702	61	27	790
Ticks (Ixodida)					
Ixodes granulatus	Ixodidae	3	2	9	14
Lice (Anoplura)					
Hoplopleura pacifica	Hoplopleuridae	733	17	0	750
Polyplax spinulosa	Polyplacidae	90	5	3	98
Polyplax serrata	Polyplacidae	2	1	2	5
Total		825	23	5	853
Fleas (Siphonaptera)					
Xenopsylla cheopis	Pulicidae	2	0	1	3
TOTAL		**1532**	**86**	**42**	**1658**

* *Mus musculus* was not included in this table because no ectoparasite was collected from individuals of this species.

Table 2. Infestation prevalence (*P*) and variance to mean ratio (*VMR*) of the 12 ectoparasite species collected

Ectoparasite species	*P* (%)	*VMR*
L. nuttalli	70	15.54
L. echidninus	60	17.84
O. bacoti	10	107.46
Laelaps sp. 1	7.5	4.67
Laelaps sp. 2	12.5	19.88
Laelaps sp. 3	2.5	1
I. granulatus	17.5	2.28
H. pacifica	25	678.18
P. spinulosa	30	25.2
P. serrata	7.5	1.72
X. cheopis	7.5	0.95

the time on the host's nest (Baker, 2008; Beck, 2007). This may explain the observed low prevalence of the ectoparasite among the captured rodents. However, a more informative measure of infestation of *O. bacoti* is the mean intensity and relative abundance (Baker, 2008), which, in the present study, was high. If the ectoparasites seldom occur on rodent host and yet their number is high, this may indicate a large total population of *O. bacoti* in the area. *O. bacoti* are known to travel hundreds of feet on their own (Beck, 2008), enough to reach the houses situated adjacent to the backyard farmlands. The ectoparasites have been reported to cause murine typhus and dermatitis on both rodent hosts and humans around the world (Baker, 2008; Beck, 2008; Rahdar and Vazirianzadeh, 2009).

The most abundant ectoparasite was the tropical rat louse, *Hoplopleura pacifica*. However, it was only distributed to a small number of hosts, as indicated by the relatively low prevalence (25%) and very high variance to mean ratio (678.18). A similar observation was obtained by Guo et al. (2003), describing it as a "congregated distribution". This aggregated nature of distribution and the need for a direct contact between hosts may account for the relatively low prevalence but high abundance of *H. pacifica*, which is an advantage for humans because of a low chance of murine typhus transmission (Chien et al., 2012). In the present study, it was associated only with the *Rattus* species collected, in which it is more prevalent in *R. exulans* but is more abundant in *R. tanezumi*. The results are inconclusive as to which of the two host species the ectoparasite prefer. *H. pacifica* is known to be a parasite of pest and wild rats throughout the world (Baker, 2008; Guo et al., 2003), and is found to be infesting *R. tanezumi* in the pine forests of Baguio City as well (Castaneda et al., 2012). There has been no reported case of association of *H. pacifica* to *S. murinus* or *M. musculus*. This may imply a high host-preference of the ectoparasite to *Rattus* sp. However, an unidentified *Hoplopleura sp.* was reported to be in association with *S. murinus* collected on the urban areas of Baguio City (Castaneda et al., 2012).

Polyplax serrata is commonly known as common mouse louse because it is typically associated with mice (Baker, 2008; Štefka and Hypša, 2008). However, the present study found the louse on three non-mouse hosts, each identified as *R. tanezumi*, *R. exulans* and *S. murinus*. The association of *P. serrata* and rats has also been observed by Yassin (2009). In the present study, two of the rodent species (*R. tanezumi* and *R. exulans*) found to harbor *P. serrata* were collected on the same site and on the same day. It may be inferred that due to the more limited spatial dimension, or "smaller habitat" caused by farming (Luyon and Salibay, 2007), there are more chances of direct contact

Table 3. Mean intensity (MI), density (D) and prevalence (P) of ectoparasite species in each rodent host: *R. tanezumi*, *R. exulans*, and *S. murinus*

ECTOPARASITE SPECIES	HOST								
	R. tanezumi (n=22)			*R. exulans* (n=7)			*S. murinus* (n=9)		
	MI	D	P (%)	MI	D	P (%)	MI	D	P (%)
Mites									
Laelaps nuttalli	17.77	18.71	95.45	7.2	5.14	71.43	1	0.22	22.22
Laelaps echidninus	9.11	7.81	81.82	4.17	3.57	85.71	0	0	0
Ornithonyssus bacoti	44	6.29	18.18	0	0	0	0	0	0
Laelaps sp. 1	2.7	0.38	13.64	0	0	0	0	0	0
Laelaps sp. 2	1.33	0.19	13.64	0	0	0	12.5	2.78	22.22
Laelaps sp. 3	1	0.048	4.55	0	0	0	0	0	0
Ticks									
Ixodes granulatus	1.5	0.14	9.09	2	0.29	0	2.25	1	44.44
Lice									
Hoplopleura pacifica	122.17	34.90	27.27	4.25	2.43	57.14	0	0	0
Polyplax spinulosa	10	4.29	40.91	2.5	0.71	28.57	3	0.33	11.11
Polyplax serrata	2	0.10	4.55	1	0.14	14.29	2	0.22	11.11
Fleas									
Xenopsylla cheopis	1	0.10	9.09	0	0	0	1	0.11	11.11

* *Mus musculus* was not included in this table because no ectoparasite was collected from individuals of this species.

among hosts; thus, causing the ease of ectoparasite transmission (Stanko et al., 2002). This may also be the reason why a higher prevalence of infestation and ectoparasite diversity, in general, is observed in communities associated with farmlands than in urban areas and pine forests of Baguio City. Moreover, the absence of *P. serrata* in the urban areas (Castaneda et al., 2012) and pine forests (Iglesia and Vertudes, 2012) while there is an incidence of *P. serrata* infestation on rodents of farmlands may indicate no or very low incidence of direct contact among the rodents from different habitats.

A different louse species that morphologically resembles *P. serrata* is *P. spinulosa*. In contrast to the former, *P. spinulosa* is known as the common spiny rat louse. A more pentagonal sternal plate and setae located at the 4th and 5th paratergal plates of equal length differentiate the ectoparasite from *P. serrata*. In the present study, a higher prevalence of *P. spinulosa* than *P. serrata* was observed, even though both ectoparasites are found on the same species of hosts (*R. tanezumi*, *R. exulans* and *S. murinus*). The difference may be that *P. serrata* has a higher preference to mice than rats, which are more dominant in the collected rodents. Previous studies have also reported the presence of *P. spinulosa* on mice, including *M. musculus* (Štefka and Hypša, 2008; Yassin, 2009).

Ixodes granulatus is a common parasite of mammals worldwide (Guzmán-Cornejo and Robbins, 2010). They have been reported to be associated with *Rattus* species (Chien et al., 2012; Guzmán-Cornejo and Robbins, 2010; Solanki et al., 2013). In the present study, tick infestation occurred in *R. tanezumi*, *R. exulans*, and *S. murinus*. *I. granulatus* may infest a wide variety, but measures of prevalence, abundance and density in the present study revealed the ectoparasite's higher preference to *S. murinus*. The same observations were found in the urban areas of Baguio City (Castaneda et al., 2012).

Only one species of flea, *Xenopsylla cheopis*, was recorded in the present study. The species is commonly known as the tropical rat flea (Baker, 2008). Its low abundance recorded in the study does not necessarily mean a low total population count in the farmlands of the City. While adult species are known to spend most of their time on their hosts, they can survive for long periods (up to 38 days) in off-host environments (Baker, 2008; Marquardt, 2004). However, high prevalence and density means an increased potential plague risk for humans, because the flea population is high enough to support disease transmission (Gratz and Brown, 1983; Ibrahim et al., 2006). While the values of such measures recorded in the farmlands of Baguio City were low, this, however, provides a limitation on the present study in determining the host preference of *X. cheopis*. Nonetheless, many studies have provided an account on the said ectoparasite's wide range of host preference as a result of its high mobility and less-dependent nature on hosts (Baker, 2008; Ibrahim et al., 2006; Mears et al., 2002) .

Conclusions

A total of 35 out of the 40 captured rodents identified as *Rattus tanezumi*, *Rattus exulans*, *Suncus murinus* and *Mus musculus* were infested with a total of 1,658 ectoparasites represented by 11 species: mites (*Laelaps nuttalli*, *Laelaps echidninus*, *Ornithonyssus bacoti*, and three other species under the genus *Laelaps*), lice (*Hoplopleura pacifica*, *Polyplax spinulosa* and *Polyplax serrata*), ticks (*Ixodes granulatus*) and fleas (*Xenopsylla cheopis*). The overall infestation prevalence mean intensity and density were 87.5%, 47.37 and 41.45, respectively.

At the level of host population, *L. nuttalli* had the highest prevalence (70%) while *H. pacifica* was the most abundant and had the highest mean intensity and density. The high prevalence of *L. nuttalli* may be due to the ease of transmission of the ectoparasite and the mite's high dependence to hosts. The nature of *H. pacifica* to occur in aggregation allowed it to establish a large population, leading to high abundance and ectoparasite load per rodent. The prevalence, mean intensity and density of *X. cheopis*, *P. spinulosa*, *P. serrata*, *I. granulatus* and *O. bacoti*, which were ectoparasites noted for being associated with various vector-borne diseases, were low.

The condition of ectoparasite infestation varied among the rodent species. Ectoparasite infestation in both the *Rattus* species had 100% prevalence while infestation in *S. murinus* had a prevalence of 66.67%. These observations may be due to the differences in the preference of ectoparasites among host species and differences in host mobility, body size, and social behavior such as grooming and interaction with members of the social group. None of the captured *M. musculus* was infested. However, this finding is inconclusive due to the low number of captured *M. musculus* individuals.

Infestation by various species of ectoparasites on rodents found on communities with backyard farmlands in Baguio City was common. The resources provided by these communities support the growth of different rodent species, which frequently come into direct contact with each other and/or indirectly through contact with each other's nest, allowing the ease of ectoparasite transmission among them. The number of collected host sample, inherent host preference of ectoparasites, mobility and activity of hosts and ectoparasites, and number of total ectoparasite population influence the condition of infestation among host species. Results of the study suggest that the present condition of ectoparasite infestation does not pose a risk of vector-borne disease transmission to humans inhabiting near the farmlands in Baguio City.

References

Baker, D. G. (2008). *Flynn's Parasites of Laboratory Animals*. John Wiley & Sons.

Barbehenn, K. R., Sumangil, J., Libay, J., et al. (1972). Rodents of the Philippine croplands. *Philippine Agriculturist*, 61(7-8):217–242.

Beck, W. (2007). Tropical rat mites as newly emerging disease pathogens in rodents and man. *Travel Medicine and Infectious Disease*, 5(6):403.

Beck, W. (2008). Occurrence of a house-infesting tropical rat mite (*Ornithonyssus bacoti*) on murides and human beings. *Travel Medicine and Infectious Disease*, 6(4):245–249.

Bush, A. O., Lafferty, K. D., Lotz, J. M., and Shostak, A. W. (1997). Parasitology meets ecology on its own terms: Margolis et al. revisited. *The Journal of Parasitology*, pages 575–583.

Castaneda, L., Dela Cruz, M., and Gawiden, K. (2012). Hosts associations of small non-volant mammal ectoparasites in pine forests of Baguio City, Luzon Island, Philippines.

Chernousova, N. (2010). Population dynamics of small mammal species in urbanized areas. *Contemporary Problems of Ecology*, 3(1):108–113.

Chien, C.-H., Chiang, P.-F., Wang, H.-C., Chen, K.-Y., Lin, M.-C., and Wu, H.-S. (2012). Prevalence of ectoparasites and the seroepidemiology of murine typhus in murine-like animals at international ports in Taiwan, 2004-2011. *Epidemiology Bulletin*, 28(22):320–329.

Gratz, N. and Brown, A. (1983). Fleas: Biology and Control. *Geneva: World Health Organization, Vector Biology and Control Unit publication*, 83.

Guo, X.-g., Qian, T.-j., Guo, L.-j., Wang, J., Dong, W.-g., Zhang, L., Ma, Z.-m., and Li, W. (2003). Spatial distribution pattern of *Hoplopleura pacifica* (Anoplura: Hoplopleuridae) on its dominant rat host, *Rattus flavipectus* in Yunnan, China. *Insect Science*, 10(4):265–269.

Guzmán-Cornejo, C. and Robbins, R. G. (2010). The genus *Ixodes* (Acari: Ixodidae) in Mexico: adult identification keys, diagnoses, hosts, and distribution. *Revista mexicana de biodiversidad*, 81(2):289–298.

Heaney, L. R. (1998). A synopsis of the mammalian fauna of the Philippine Islands. *Fieldiana. Zoology. New Series*, 88:1–61.

Heaney, L. R., Balete, D., Rickart, E., Utzurrum, R., and Gonzales, P. (1999). Mammalian diversity on Mount Isarog, a threatened center of endemism on southern Luzon Island, Philippines. *Fieldiana. Zoology*, 95:1–62.

Heaney, L. R., Dolar, M. L., Balete, D. S., Esselstyn, J. A., Rickart, E. A., and Sedlock, J. L. (2010). Synopsis of Philippine Mammals ©The Field Museum of Natural History. http://archive.fieldmuseum.org/philippine%5Fmammals/.

Huang, L.-Q., Guo, X.-G., Speakman, J. R., and Dong, W.-G. (2013). Analysis of gamasid mites (Acari: Mesostigmata) associated with the Asian house rat, *Rattus tanezumi* (Rodentia: Muridae) in Yunnan Province, southwest China. *Parasitology Research*, 112(5):1967–1972.

Ibrahim, I. N., Winoto, I., Wongsrichanalai, C., Blair, P., and Stoops, C. (2006). Research note. Abundance and distribution of *Xenopsylla cheopis* on small mammals collected in West Java, Indonesia during rodent-borne disease surveys. *Southeast Asian Journal of Tropical Medicine and Public Health*, 37(5):932.

Iglesia, B. and Vertudes, C. (2012). Ectoparasites of the non-native *Rattus tanezumi* in urban areas of Baguio City, Luzon Island, Philippines.

Kia, E., Moghddas-Sani, H., Hassanpoor, H., Vatandoost, H., Zahabiun, F., Akhavan, A., Hanafi-Bojd, A., and Telmadarraiy, Z. (2009). Ectoparasites of rodents captured in Bandar Abbas, southern Iran. *Iranian Journal of Arthropod-borne Diseases*, 3(2):44.

Luyon, H. A. V. and Salibay, C. C. (2007). Ectoparasites on murid rodents caught in Mts. Palay-palay/mataas na Gulod National Park, Luzon Island, Philippines. *Southeast Asian Journal of Tropical Medicine and Public Health*, 38(1):194.

Marquardt, W. H. (2004). *Biology of Disease Vectors*. Elsevier.

Mears, S., Clarkl, F., Greenwood, M., and Larsen, K. (2002). Host location, survival and fecundity of the Oriental rat flea, *Xenopsylla cheopis* (Siphonaptera: Pulicidae) in relation to black *Rattus rattus* (Rodentia: Muridae) host age and sex. *Bulletin of Entomological Research*, 92:375–384.

Petrovic, A., Rajkovic, D., and Jurisic, A. (2008). The population dynamics and behavior of synanthropic rodents in the region of Subotica. *Proceedings of the III Congress of Ecologists of the Republic of Macedonia with International Participation*, 8:497–499.

Pucek, Z., Jedrzejewski, W., Jedrzejewski, B., and Pucek, M. (1993). Rodent population dynamics in a primeval deciduous forest (białowieża national park) in relation to weather, seed crop, and predation. *Acta Theriologica*, 38(2):199–232.

Rahdar, M. and Vazirianzadeh, B. (2009). A case report of tropical rat mite infestation *Ornithonyssus bacoti* (Dermanyssidae: Acarina) in Ahvaz, SW Iran. *Jundishapur Journal of Microbiology (JJM)*.

Reginaldo, A. (2011). Small non-volant mammals of Mt. Sto. Tomas, Benguet, Luzon Island, Philippines and their ectoparasites. Master's thesis, University of the Philippines Los Banos.

Rózsa, L., Reiczigel, J., and Majoros, G. (2000). Quantifying parasites in samples of hosts. *Journal of parasitology*, 86(2):228–232.

Sohrab, R., AliAsghar, T., Hale, H., Masume, A., Sadat, G., Hojjat, P., Ehsan, H., Esmail, G., et al. (2011). A report over the infection with the louse *Polyplax spinulosa* in typical rats belonging to the Wistar strain kept in the Laboratory Animal Breeding and Keeping Center of Urmia University. *Global Veterinaria*, 6(6):547–550.

Solanki, S. K., Chauhan, R., Rahman, A., and Solanki, K. (2013). Original research article prevalence of ectoparasites in commensal rats in Dehradun, India. *Int. J. Current Microbiol. Appl. Sci*, 24:38–41.

Stanko, M., Miklisová, D., De Bellocq, J. G., and Morand, S. (2002). Mammal density and patterns of ectoparasite species richness and abundance. *Oecologia*, 131(2):289–295.

Štefka, J. and Hypša, V. (2008). Host specificity and genealogy of the louse *Polyplax serrata* on field mice, *Apodemus* species: a case of parasite duplication or colonisation? *International Journal for Parasitology*, 38(6):731–741.

Stenseth, N. C., Leirs, H., Skonhoft, A., Davis, S. A., Pech, R. P., Andreassen, H. P., Singleton, G. R., Lima, M., Machang'u, R. S., Makundi, R. H., et al. (2003). Mice, rats, and people: the bio-economics of agricultural rodent pests. *Frontiers in Ecology and the Environment*, 1(7):367–375.

Strandtmann, R. and Mitchell, C. J. (1963). The Laelaptine mites of the Echinolaelaps complex from the Southwest Pacific area (Acarina: Mesostigmata). *Pacific Insects*, 5(3):541–576.

Yassin, M. K. (2009). Ectoparasites infesting rats at Mostorod and Bahteem Districts in Qualubiya Governorate, Egypt. *Egyptian Academic Journal of Biological Sciences, B. Zoology*, 1(1):95–101.