SPATIAL DISTRIBUTION PATTERN OF *HOPLOPLEURA PACIFICA* (ANOPLURA: HOPLOPLEURIDAE) ON ITS DOMINANT RAT HOST, *RATTUS FLAVIPECTUS* IN YUNNAN, CHINA

Xian-guo Guo[1,3)] *, Ti-jun Qian[1)], Li-jun Guo[1)], Jing Wang[1)], Wen-ge Dong[1)], Li Zhang[2)], Zhi-min Ma[2)] and Wei Li[1)]

1) *Laboratory of Vector and Pathogen, Faculty of Basic Medicine, Dali College*, Dali, Yunnan, 671000, China;
2) *Faculty of Clinical Laboratory, Dali College*, Dali, Yunnan, 671000, China;
3) *Department of Cell Biology and Genetics, Shantou University Medcial College*, Shantou, Guangdong, 515031, China.

(Received Aug. 14, 2003; accepted Dec. 3, 2003)

Abstract *Hoplopleura pacifica* is a dominant species of ectoparasitic sucking lice on the body surface of a common rat species, *Rattus flavipectus* in Yunan province of China. To illustrate the spatial distribution pattern of *H. pacifica* among the individuals of *R. flavipectus*, Iwao 's linear regression method and a significance test of random deviation for the method were used, and a regression equation was established in the light of Iwao 's method. The established equation is $M^* = 12.10 + 4.76M$ ($r = 0.75$, $P < 0.01$) where both α and β are considerably higher than 0 and 1, the border values for determining spatial pattern of populations. The calculated F value is $F = 6.07$ ($P < 0.05$) in the significance test of random deviation. The spatial distribution pattern of *H. pacifica* among the individuals of *R. flavipectus* is of aggregated distribution. The result suggests that the individuals of *H. pacifica* have a tendency to congregate together and form different individual groups instead of evenly distributing on the body surface of every rat host.

Key words anoplura, Hoplopleuridae, *Hoplopleura pacifica*, sucking louse, spatial distribution

1 INTRODUCTION

Hoplopleura pacifica Ewing 1924 is a dominant species of sucking lice on a common rat, *Rattus flavipectus* (Milne-Edwards 1871) in Yunnan province of China. Sucking lice are the permanent ectoparasites on the body surface of mammals (especially rodents), which belong to order Anoplura in the field of insects. Sucking lice are generally regarded as a category of medical insects and for example, *Pediculus humanus* (human louse) can be the transmitting vector of epidemic typhus, epidemic relapsing fever and trench fever, etc. mammals (especially rodents) have been found to have sucking lice on their body surface. Different mammals usually have different louse species on their body surface. Though the medical significance of the parasitic sucking lice on rodents remains to be further proved, some researches imply that the sucking lice on rodents may play an important role in preserving the pathogens of some zoonoses such as murine typhus (endemic typhus), rabbit fever (tularemia) and even plague, etc. (Chin and Li 1991, Chin 1999, Toshinori *et al*. 2002).

Ecological research is a very important issue for insects including ectoparasitic insects such as fleas and lice. With the development of ecology, some ecological techniques and methods have been introduced in the field of medical entomology with more and more reports on the spatial patterns of medical arthropods appearing (Guo *et al*. 1996, Kitron *et al*. 1989, Kitron *et al*. 1992, Kuno

* Corresponding Author: Xian-guo Guo. Present Address: Department of Cell Biology and Genetics, Shantou University Medcial College, 22 Xinling Road, Shantou, Guangdong, 515031, China. Email: xgguo@stu.edu.cn. Telephone: 0754-8900497

1991).

Researches on the spatial pattern of populations are to determine the distributing styles of certain populations among the sampling units. There are lots of methods to determine the spatial distribution pattern of arthropods (Guo *et al*. 1996). This paper is an attempt to use Iwao's method and a significance test of random deviation to analyze the spatial distribution pattern of *H. pacifica* on its dominant rat hosts, *R. flavipectus*, which is actually the spatial distribution among different individuals of the host. Iwao's method is of a linear regression equation between mean (M) and Lloyd's mean crowding (M^*), $M^* = \alpha + \beta M$, which has been commonly used in ecology for illustrating spatial distribution patterns of various populations. Through the values of α and β in the equation and the significance test of random deviation based on Iwao's method, spatial distribution patterns of populations can be precisely identified as random or aggregated distributions (Iwao 1968, Hong 1989). Guo once used Iwao's method and the significance test of deviation to study the spatial pattern of some species of gamasid mites and fleas and got a satisfied result (Guo 1997, Guo *et al*. 2000).

2 MATERIALS AND METHODS

2.1 Stratified investigation

Hoplopleura pacifica and its dominant rat host, *R. flavipectus*, were captured or collected from nine counties in Yunnan Province of China from 2001 to 2002. The nine investigated counties are Xianggelila (Zhongdian), Gongshan, Jianchuan, Lijiang, Dali, Yuanjiang, Puer, Simao and Menghai. According to the stratified sampling method, the field investigation for collecting the lice and rats was done in eight "sampling units" respectively. Each sampling unit is a combination of a certain region and habitat. The stratified regions are flatland region and mountainous region. The flatland and mountainous regions were further divided into four stratified habitats, indoor habitat, outdoor habitat near dwelling (garden, plowland, bush area and some other habitat near the houses, etc.), outdoor cultivated habitat far from dwelling and forest habitat. The combination of two regions (flatland and mountainous regions) and four habitats forms eight "sampling units", namely A1, A2, A3, A4, B1, B2, B3 and B4 (See Table 1 in "Results").

2.2 Collection and identification

The individuals of the rat host, *R. flavipectus*, were randomly captured alive with mouse traps while the individuals of the sucking lice (*H. pacifica*) on the body surface of each rat host were all collected and preserved in 70% of ethanol in the investigated field. Individual lice were dehydrated in 30%, 50%, 70%, 90% and 100% of ethanol at first and then made transparent in the mixed solution of pure ethanol and xylene (Xylol). After the dehydration and transparent process, the lice specimens were mounted on slides by using abienic balsam separately. Each individual louse specimen was finally identified under a microscope. Each rat host was mainly identified in the investigated filed according to its body size, shape and color, and the measured figures such as body length, ear length, the length of hind feet and so forth (Chin and Li 1991, Chin 1999; Guo *et al*. 2000).

2.3 Measurement of spatial pattern

Each individual of rat host, *R. flavipectus*, was considered as a "sampling point" in every "sampling unit". After the numbers of louse individuals on every rat host individual had been counted, the arithmetic mean (M_i) and Lloyd's mean crowding (M_i^*) in every "sampling unit" were then calculated and Iwao's regression equation was finally established based on eight sampling units according to the following formulae (Guo 1997; Guo *et al*. 2000, Iwao 1968, Kuno 1991):

$$M_i = \frac{1}{N}\sum_{j=1}^{N_i} M_{ij},$$

$$M_i^* = M_i + \left(\frac{\sigma_i^2}{M_i}\right) - 1,$$

$$M^* = \alpha + \beta M,$$

(Iwao's linear regression)

where M_{ij} stands for the numbers of louse individuals on rat host (*R. flavipectus*) individual j (sampling point j) in sampling unit i, N_i the total number of rat host individuals in sampling unit i (the total number of the sampling points in sampling unit i), M_i and σ_i^2 the mean and variance of the louse individuals in sampling unit i, and M_i^* the Lloyd mean's crowding in sampling unit i.

2.4 Significance test of deviation

The following formula was adopted to make the significance test for both α and β in Iwao's linear regression equation (Guo 1997, Guo *et al*. 2000, Hong 1989):

$$F = \frac{\frac{1}{2}\left[N \cdot \alpha^2 + 2\alpha(\beta - 1)\sum_{i=1}^{N} M_i + (\beta - 1)^2 \sum_{i=1}^{N} M_i^2\right]}{\frac{1}{N-2}\sum_{i=1}^{N}(M_i^* - \alpha - \beta M_i)^2}$$

where N stands for the total numbers of sampling units used to establish Iwao's linear regression and M_i, M_i^*, α and β the same as in the former formulae. When $\alpha = 0$, $\beta = 1$ ($F < F_{(2,N-2)}$, $P > 0.05$), the spatial pattern is considered to be a random distribution while the opposite situation ($F > F_{(2,N-2)}$, $P < 0.05$) to be an aggregated distribution.

3 RESULTS

3.1 Collection of lice and rat hosts

The individuals of the rat host, *R. flavipectus*, were randomly captured alive with mouse traps. In some sampling units, it was very difficult to capture the rat host alive. Therefore the collected numbers of *R. flavipectus* (host) and *H. pacifica* (louse) are quite different in eight sampling units (Table 1).

Table 1 Numbers of collected louse (*Hoplopleura pacifica*) and rat host (*Rattus flavipectus*) in different sampling units.

Sampling units			Numbers of rat host individuals (*Rattus flavipectus*)	Numbers of louse individuals (*Hoplopleura pacifica*)
Codes of sampling units	Corresponding regions	Corresponding habitats		
A1	Flatland region	Indoor habitat	6	0
A2	Flatland region	Outdoor habitat near dwelling	89	531
A3	Flatland region	Outdoor cultivated habitat far from welling	225	405
A4	Flatland region	Forest habitat	2	0
B1	Mountainous region	Indoor habitat	3	70
B2	Mountainous region	Outdoor habitat near dwelling	13	136
B3	Mountainous region	Outdoor cultivated habitat far from welling	77	169
B4	Mountainous region	Forest habitat	36	84
Total of all the sampling units			451	1395

3.2 Result of spatial pattern measurement

The arithmetic mean (M), variance (σ^2) and Lloyd's mean crowding (M^*) of *H. pacifica* in each sampling unit are calculated and summarized as in Table 2. In the light of M_i and M_i^* in Table 2, a linear regression equation based on Iwao's method, $M^* = 12.10 + 4.76M$ ($r = 0.75$, $P < 0.01$), is established. In the established linear regression equation, both α and β ($\alpha = 12.10$; $\beta = 4.76$) are beyond their border values, 0 and 1, with $F > F_{(2,6)}$ and $P < 0.05$ ($F = 6.07$; $F_{(2,6)} = 5.14$; $N - 2 = 8 - 2 = 6$) in the significance test of random deviation. The spatial distribution pattern of *H. pacifica* (sucking louse) on its dominant rat host, *R. flavipectus*, is therefore determined to be of an aggregated distribution.

Table 2 Some calculated parameters in the establishment of Iwao's linear regression equation and the significance test of random deviation

Codes of sampling units	M_i	σ_i^2	M_i^*	$(M_i^* - \alpha - \beta M_i)^2$
A1	0	0	0	146.43
A2	5.95	142.85	28.91	132.75
A3	1.80	20.36	12.11	73.30
A4	0	0	0	146.43
B1	23.33	1633.33	92.33	952.14
B2	10.46	1355.94	139.07	5954.25
B3	2.19	24.84	12.51	100.37
B4	2.33	69.66	31.19	63.92

Annotation: The establishment of Iwao's linear regression equation and the significance test of random deviation: 1) the linear regression equation: $M^* = 12.10 + 4.76M$ ($r = 0.75$, $P < 0.01$); 2) the result of the significance test of random deviation: $F_{(2,6)} > F > F_{(2,6)}$, $P < 0.05$ ($F = 6.07$; $F_{(2,6)} = 5.14$; $F_{(2,6)} = 10.92$).

4 DISCUSSION AND CONCLUSION

Iwao's linear regression ($M^* = \alpha + \beta M$) has long been used to analyze the spatial patterns of various populations in the ecological practice. According to the original definition of Iwao's method, the spatial pattern of a certain population could be directly determined through the values of α and β. When $\alpha > 0$, $\beta > 1$, the spatial pattern of the population would be determined as an aggregated distribution and when $\alpha = 0$, $\beta = 1$, a random distribution. In this way of determination, $\alpha = 0$ and $\beta = 1$ is to be considered as a border parameter for differentiating a random distribution from an aggregated one. This is very simple and easy to be adopted in ecological applications, but not always the case. The fact is that the possibility of exact 0 or 1 is very low and there is some deviation in the practical use (Hong 1989, Guo 1997, Guo 2000). The significance test of random deviation used in this paper has been regarded as a better way to solve the above problem, which is firstly deduced by Hong (Hong 1989).

Hoplpleura pacifica is a common species of sucking louse in Yunnan, China and *R. flavipectus* is its dominant rat host. This paper describes how the louse individuals (*H. pacifica*) distribute among different individuals of its rat hosts. The spatial pattern of *H. pacifica* in this study is actually the distribution pattern of the louse individuals among the different individuals of rat host, *R. flavipectus*.

The result concludes that the spatial pattern of *H. pacifica* among the different individuals of its dominant rat host is of aggregated distribution. This suggests that every individual within the population of *H. pacifica* does not exist independently. The existence of one individual louse would have more or less influence on the distribution of the others in the same population. As a result, the louse individuals in the same population would have a tendency to form various aggregated groups. The aggregated distribution pattern reveals that the louse individuals do not evenly distribute among the host individuals but gather as different size of groups on the body surface of some rat individuals.

Acknowledgment The authors thank all the Centers of Disease Control (CDC) in the field investigated counties. The project is imbursed by Natural Science Foundation of China (No.: 30060078) and Science Foundation of Education Department of Yunnan Province (Project No.:02zy132).

References

Chin, T. H. and Li, K. C. 1991 The Anoplura and Siphonaptera of Guizhou. Guiyang, China: Guizhou Science and Technology Publishing House, pp. 154-388.

Chin, D. X. 1999 Taxonomy and fauna of sucking lice (Anoplura) in China. Beijing, China: Science Press, pp. 1-132.

Guo, X. G., B. H. Ye, Y. M. Gu, and Y. M. Chen 1996 Preliminary analysis on population spatial pattern of ten species of gamasid mites on five species of rodents. *Journal of Dali Medical College* **5**(4) 4-7 (in Chinese with English abstract).

Guo, X. G. 1997 Spatial pattern analysis of *Laelaps echininus* and *Laelaps nuttalli* using Iwao's method and a significance test of random deviation (Acari:

Laelapidae). *Systematic and Applied Acarology* **2** 89-93.

Guo, X. G., , Z. D. Gong, T. J. Qian, X. G. Feng, X. D. Duan, W. Li, and X. K. Zhang 2000 Spatial pattern analysis of *Xenopsylla cheopis* (Siphonaptera: Pulicidae) on its dominant rat host, *Rattus flavipectus* in the foci of human plague in Yunnan, China. *Entomologica Sinica* **7**(1): 47-52.

Hong, W. 1989 Significance test of deviations from α, β values in Iwao's M^*-M model for determining the spatial distribution of insects. *Acta Phytophylacica Sinica* **16**(2): 107-112 (in Chinese with English abstract).

Iwao, S. 1968 A new regression method for analysing the aggregation pattern of animal populations. *Research of Population Ecology* **10**(1): 1-20.

Kitron, U. D., D. W. Webb, and R. J. Novak 1989 Oviposition behavior of *Aedes triseriatus* (Diptera: Culicidae): prevalence, intensity and aggregation of eggs in oviposition traps. *Journal of Medical Entomology* **26**(5): 462-467.

Kitron, U., C. J. Jones, and J. K. Bouseman, 1992 Spatial analysis of the distribution of *Ixodes damimni* (Acari: Ixodidae) on white-tailed deer in Ogle County, Illinois. *Journal of Medical Entomology* **29** (2): 259-266.

Kuno, E. 1991 Sampling and analysis of insect populations. *Annual Review of Entomology* **36**: 285-304.

Toshinori, S., K. Mutsuo, and A. Noriaki 2002 Detection of *Bartonella quintana* from body lice (Anoplura: Pediculidae) infesting homeless people in Tokyo by molecular technique. *J. Medical Entomology* **39**(3): 427-429.

太平洋甲胁虱(虱目:甲胁虱科)在其主要宿主黄胸鼠体表的空间分布格局

郭宪国[1,3] 钱体军[1] 郭利军[1] 王晶[1] 董文鸽[1]
张励[2] 马志敏[2] 李伟[1]

1) 大理学院基础医学部媒介与病原生物研究室,云南 大理 671000;
2) 大理学院检验医学系,云南大理 671000;
3) 汕头大学医学院细胞生物与遗传学教研室,广东汕头 515031

太平洋甲胁虱是寄生于黄胸鼠体表的一种主要吸虱昆虫,在云南广泛分布。应用 Iwao 直线回归方法及其随机偏离度检验对太平洋甲胁虱在黄胸鼠不同个体间的空间分布格局进行了研究。根据 Iwao 直线回归方法,建立了 $M^* = 12.10 + 4.76M$ ($r = 0.75$, $P < 0.01$)的回归方程,所得到的 α 与 β 值($\alpha = 12.10$, $\beta = 4.76$)均明显高于判定界线值 0 和 1。对 α 与 β 值进行随机偏离度检验, $F = 6.07$ ($P < 0.05$),由此判定太平洋甲胁虱在黄胸鼠不同个体间的空间分布格局为聚集型分布,这说明太平洋甲胁虱对黄胸鼠的寄生是不均匀的,存在聚集并有形成大小不一的吸虱个体群的趋势。

关键词 虱目 甲胁虱科 太平洋甲胁虱 吸虱 空间格局

致谢:本项目得到国家自然科学基金(项目批准号:30060078)及云南省教育厅科学基金(项目批准号:02zy132)联合资助。