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Comparative Studies of Ant Faunas of Korea and Japan
II. Faunal Comparison between Mainland of Korea and That of Japan

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Abstract. The faunal characteristics of ants in the Korean Peninsula and the Japanese main islands were investigated. Jaccard's coefficient values showed that the Korean fauna is most similar to that of Honshu. The highest faunal similarity is marked in Honshu and Shikoku + Kyushu. Two hypotheses on the faunal cluster formation in these areas are considered: 1) the effect of geographical barrier such as the Korea Strait; 2) climatic differences between Korea and southwestern Honshu, Shikoku and Kyushu.

Key words: faunal similarity, ants, Japan, Korea.

Introduction

The purpose of this study is to summarize the biogeographic characteristic of ant fauna of Korea and Japan by using quantitative methods. We discussed the ant fauna of small islands between the Korean Peninsula and the Japanese mainland in the part I (Choi *et al.*, 1992). In this paper (part II), we execute a faunal comparison between the Korean and the Japanese main islands by using the following two data sets: 1) species records from the Korean Peninsula and the Japanese main islands (Hokkaido, Honshu, Shikoku, and Kyushu); 2) those from eleven prefectures (Korean "Do", and Japaneses "Ken" or "Fu" in administrative districts).

In Japan, there were many poorly investigated prefectures in ant fauna. However, our recent collecting efforts reduced such prefectures. The distributional records of ants of each prefecture were compiled in 1994 by Terayama *et al.* (1994). On the other hand, Choi *et al.* (1993) reviewed the distribution of ants of Korea in prefectural level.

This paper deals with the faunal similarities of ants between Korea and Japan in relatively large scale level such as mainlands and prefectures.

Materials and Methods

The data treated in this paper are those from 4 Korean and 7 Japanese prefectures which have been well investigated (Terayama *et al.*, 1994; Choi *et al.*, 1993). The geographical position of these prefectures is shown in Fig. 1, and these size and species number are shown in Table 1. As for the data of the Korean Peninsula and the Japanese main islands, Terayama *et al.* (1992), Choi *et al* (1993), and the Myrmecological Society of Japan (1989, 1991, 1992) are consulted. In these data, we omitted doubtful records and taxonomically problematic species.

The faunal similarity is examined by using the

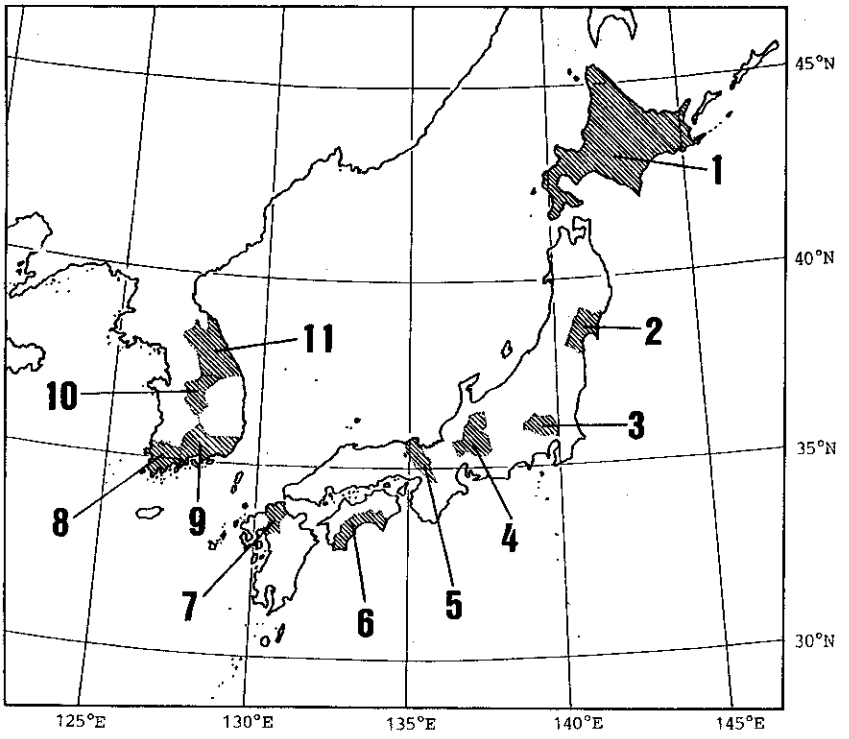

Fig. 1. Map of study areas. 1-7, Japan; 1, Hokkaido; 2, Miyagi-ken; 3, Saitama-ken; 4, Kyoto-fu; 6, Kochi-ken; 7, Fukuoka-ken. 8-11, Korea: 8, Jeonlanam-do; 9, Gyeongsangnam-do; 10, Chungcheongbuk-do; 11, Gangweon-do.

Table 1. Size of study areas and number of species.

Area code	Area	No. of species	Size (km²)
	Japanese main islands*	158	366,000
1	Hokkaido	63	84,000
	Honshu	139	227,000
2	Miyagi-ken	73	7,300
3	Saitama-ken	81	3,800
4	Gifu-ken	103	9,900
5	Kyoto-fu	72	4,600
	Shikoku + Kyushu	134	55,000
6	Kochi-ken	95	7,100
7	Fukuoka-ken	85	4,900
	Korea	118	219,000
8	Jeonlanam-do	54	12,300
9	Gyeongsangnam-do	60	8,800
10	Chungcheongbuk-do	60	7,400
11	Gangweon-do	42	16,900

*: Hokkaido, Honshu, Shikoku and Kyushu, excluding the island parts.

Jaccard's Coefficient (CC) which is defined by the following equation:

$$CC = c / (a + b - c) \quad (0 \leqq CC \leqq 1)$$

Where a and b are the total number of species found in the 1st and 2nd areas respectively, and c is the number of species found in both areas. This index has no serious drawback and works well to resemblance measurement (Hubálek, 1982). The obtained CC-value matrices were examined by cluster analysis using the UPGMA method.

Results

Comparison between the Korean Peninsula and the Japanese main islands

Figure 2 shows the number of species in each area and the number of common species with two areas. The number of species in an area ranges from 63 to 139, and the lowest species number is marked in

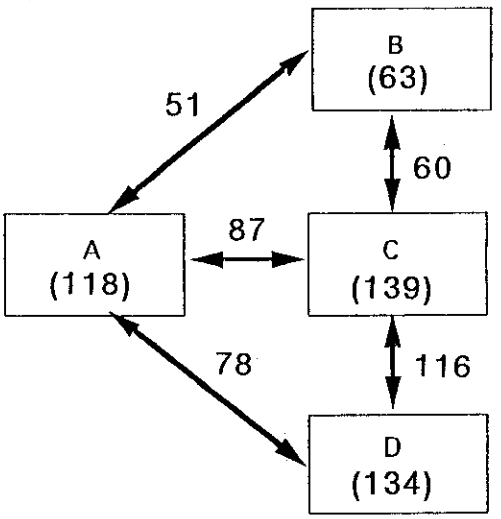

Fig. 2. Number of species in the each area and the number of common species. A, Korea; B, Hokkaido; C, Honshu; D, Kyushu + Shikoku.

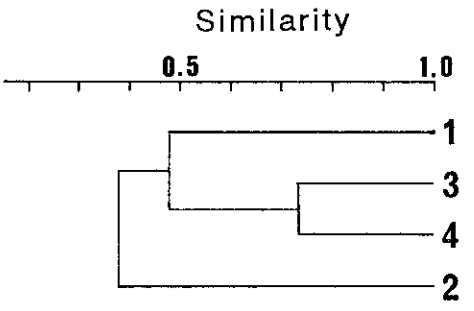

Fig. 3. Dendrogram showing the similarity among ant species compositions of the Korean Peninsula and the Japanese main islands. 1, Korea; 2, Hokkaido; 3, Honshu; 4, Shikoku + Kyushu.

Hokkaido, second lowest in Korea, and the highest in Honshu. To consider the differences of areal size, it is said that the species diversity of Kyushu + Shikoku is higher than that of Honshu.

Table 2 and Fig. 3 show the CC-values and the results of cluster analysis of CC, respectively. To compare with CC-values between Korea and the Japanese main islands, Korea and Honshu have the highest value of 0.512, next highest 0.448 (Shikoku + Kyushu), and the lowest 0.392 (Hokkaido). The highest value among all study areas is marked in Honshu and (Shikoku + Kyushu) (0.739). These aspects are clearly shown in a cluster analysis (Fig. 3). Honshu and Shikoku + Kyushu are formed in a most compact cluster at the similarity level 0.739, and Hokkaido is most independent. Korea is added in the cluster (Honshu and Shikoku + Kyushu) at the similarity level 0.480.

Table 2. Number of common species (upper triangular matrix) and Jaccard's values (lower triangular matrix). 1. Korea; 2, Hokkaido; 3, Honshu; 4, Shikoku + Kyushu.

	1	2	3	4
1	-----	51	87	78
2	0.392	----	60	47
3	0.512	0.423	----	116
4	0.448	0.313	0.739	----

Comparison among prefectures

Table 3 shows the number of common species and the CC-values between two prefectures. The CC-values from 0.283 (Fukuoka-ken - Jeonlanam-do) to 0.739 (Gyoengsangnam-do - Chungcheongbuk-do). High similarity more than 0.700 is found in the following 4 combination of areas: Saitama-ken - Gifu-ken (0.720), Kochi-ken - Fukuoka-ken (0.714), Gyeongsangnam-do - Chungcheongbuk-do (0.739), and Gyeongsangnam-do - Gangweon-do (0.701).

Figure 4 shows the result of a cluster analysis of CC-values. The area is classified into 2 major faunal groups at the similarity level 0.48, that is, Korean 4 prefectures and Japanese 7 prefectures including Hokkaido. In the latter cluster, it is further divided into 3 subgroups at the similarity level 0.57: Hokkaido, Miyagi to Kyoto, and Kochi + Fukuoka. The Korean prefectures formed a rather compact cluster at the similarity level more than 0.60 in this data set.

Table 3. Number of common species (upper triangular matrix) and Jaccard's values (lower triangular matrix). 1, Hokkaido; 2, Miyagi-ken; 3, Saitama-ken; 4, Gifu-ken; 5, Kyoto-fu; 6, Kochi-ken; 7, Fukuoka-ken; 8, Jeonlanam-do; 9, Gyeongsangnam-do; 10, Chungcheongbuk-do; 11, Gangweon-do.

	1	2	3	4	5	6	7	8	9	10	11
1	---	51	47	56	43	45	35	25	39	39	33
2	0.600	----	59	67	54	56	51	27	42	45	36
3	0.485	0.621	----	77	59	65	56	33	45	46	38
4	0.509	0.625	0.720	----	64	74	68	36	52	53	45
5	0.467	0.593	0.628	0.509	----	62	55	29	42	41	36
6	0.398	0.500	0.586	0.489	0.590	----	75	31	45	46	37
7	0.310	0.477	0.509	0.424	0.539	0.714	----	28	34	41	34
8	0.313	0.307	0.367	0.295	0.341	0.292	0.283	----	36	35	36
9	0.464	0.462	0.469	0.381	0.467	0.409	0.306	0.545	----	51	47
10	0.464	0.511	0.484	0.393	0.451	0.422	0.394	0.522	0.739	----	43
11	0.293	0.396	0.392	0.402	0.400	0.330	0.324	0.600	0.701	0.606	---

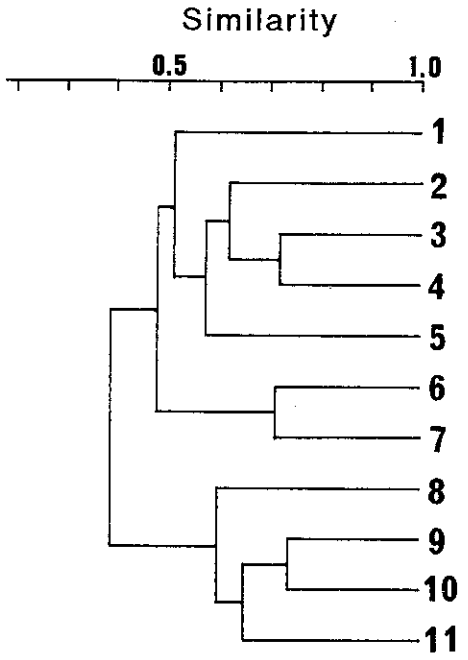

Fig. 4. Dendrogram showing the similarity among ant species compositions of study areas. 1, Hokkaido; 2, Miyagi-ken; 3, Saitama-ken; 4, Gifu-ken; 5, Kyoto-fu; 6, Kochi-ken; 7, Fukuoka-ken; 8, Jeonlanam-do; 9, Gyeongsangnam-do; 10, Chungcheongbuk-do; 11, Gangweon-do.

We also performed the statistical test among the means of CC-values within Japanese areas, within Korean areas, and between Korean and Japanese areas. The analysis of variance (ANOVA) showed significant difference at the level of 1% ($F = 29.8310$, $df = 2$, $p < 0.01$). The means of CC-values within Korean areas and those within Japanese areas were significantly higher than between Korean and Japanese areas by the Tukey-Kramer method (Sokal & Rohlf, 1981) of statistical analyses at the significance level of 5%.

Table 4. Results of the statistical test (ANOVA) among the means of CC-values within Japanese areas, within Korean areas, and between Korean and Japanese areas.

Source of variation	df	SS	MS	F
Sb	2	0.42651	0.21325	29.8310*
Sw	53	0.37888	0.00715	
S	55	0.80539		

* $p < 0.01$

Discussion

The differences of the number of species, in a large scale, would strongly affect the altitude or

climatic factor rather than areal size in this survey area. The high latitude area contains fewer number of ant species than that of the low latitude area.

As for the similarity of species composition, the Korean Peninsula indicated the highest similarity in CC-value to Honshu which lies almost the same latitude to Korea. It is possible that the high similarity is accounted for by the resemblance of climate or vegetations between them. The highest faunal similarity is marked in that between Honshu and Shikoku + Kyushu. Similarity between Korea and Shikoku + Kyushu showed lower than that of these areas.

Two possible explanations are considered: 1) the existence of the geographical barrier; 2) the differences of climatic factor. The lower similarity between Korea and Shikoku + Kyushu would be affected by the Japan Sea and the Korean Strait in the former explanation. These geographical barriers will course a different faunal formation. As for the latter explanation, 120 °C. month isothermal line of Kira's warmth index (1945, 1947) runs from Kyushu through Shikoku to southeastern Honshu, while it is not extended to the mainland of Korea. This line almost agrees with southern limit of distribution of some subtropical species. So the ratio of these species in the species composition would be high in Shikoku, Kyushu, and southern Honshu, and low in Korea and northern Honshu.

In the prefectural level analysis, four Korean study areas formed a compact cluster which shows high similarity of faunas among them. The heterogeneity of the species compositions in Korea is small. Combination of prefectures of Korea and Japan which lies almost the same latitude, e.g., Kyoto-fu - Jeonlanam-do and Miyagi-ken - Gangweon-do, showed low similarities between them. Therefore, faunal similarities in prefecture level don't seem simply affected by the factor of latitude. Hokkaido formed a cluster with the areas north of Kyoto. The faunas of these prefectures include the Palaearctic species which are mostly distributed in the mountainous regions. The high faunal similarities to Hokkaido would be the presence of these species in these area. While, the high similarity between Fukuoka and Kochi would explain the coexistance of the some subtropical species.

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（要約）

韓国および日本のアリ相の比較研究
Ⅱ．韓半島および日本本土間の比較

寺山　守・崔　炳文・緒方一夫

韓半島と日本本土のアリ相を計量的に比較し，生物地理学的属性を論議した．

大規模地域間での比較では，アリの種数そのものは面積よりも緯度に強く影響を受けると考えられた．Jaccardの共通係数で比較すると，ほぼ同緯度にある韓半島と本州は種組成の点で総体的に類似性が高かった．また四国と九州を込みにしたアリ相が韓半島より本州に類似していることについては2つの理由が考えられた．一つは朝鮮海峡という地理的な障壁あるいは地史的なギャップによることで，もう一つは，環境要因で本州太平洋岸から四国，九州では温量指数が120以上であるのに対して，韓半島では120より低いという温度の影響である．

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