

**Taxonomic Status of *Silpha perforata*
(Coleoptera: Silphidae) from Jeju Is., Korea**

**Young Bok Cho^{*}, Sei-Woong Choi¹, Masaaki Nishikawa²
and Yong Jung Kwon³**

(Natural History Museum, Hannam University, Daejeon 306-791, Korea;

¹Department of Environmental Education, Mokpo National University,
Mokpo 534-729, Korea; ²Kashiwagaya 1112-16, Ebina, 243-0402, Japan;

³Department of Agricultural Biology, Kyungpook National University,
Daegu 702-701, Korea)

ABSTRACT

The clustering analysis and comparison of male genitalia of *Silpha perforata* complex were carried out to decide the taxonomic status of the population from Jeju Is., Korea. One hundred and five individuals from Korea, Japan, and China were examined for the present study. Based on the result, the population of Jeju Is. was treated as intraspecies of *Silpha perforata* with a morphological variation.

Key words: taxonomy, *Silpha perforata*, Silphidae, Coleoptera, Korea

INTRODUCTION

The members of *Silpha perforata* complex have been known to distribute widely in North-eastern Asia including Mongolia, East Siberia, Far East of Russia, China, Korea, and Japan (Růžička et al., 2002). The loss of the flying ability by degeneration of hind wings resulted in division of populations at species and subspecies-level depending on where it occurs. For example, members of *Carabus* species (Carabidae) were divided into different species or subspecies depending on the

* To whom correspondence should be addressed

Tel: 82-42-629-7699, Fax: 82-42-629-8245, E-mail: youngcho@mail.hannam.ac.kr

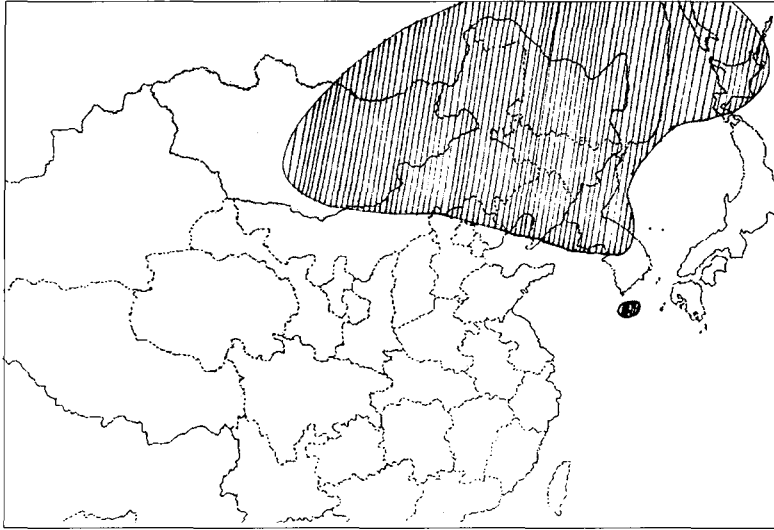


Fig. 1. The distribution of *Silpha perforata* complex in North-eastern Asia.

localities due to the degeneration of hind wings (Kown and Lee, 1984).

Since Gebler (1832), who first described a new species from Siberia, there has been several new species or subspecies from East Asia: *Silpha perforata* Gebler 1832 (type locality: Siberia), *Silpha mongolica* Faldermann, 1835 (type locality: Mongolia), *Silpha sculptipennis* Faldermann, 1835 (type locality: Mongolia), *Silpha venatoria* Harold, 1877 (type locality: Hokkaido, Japan), *Silpha perforata* var. *lateralis* Potevin, 1926 (no formal type series; see Růžička et al., 2002), *Silpha mandli* Potevin, 1932 (type locality: Russia), and *Silpha perforata elongata* Potevin, 1943 [type locality: Korea (Soul = Seoul)].

However, they were treated as the members of *S. perforata* with geographical variations by several workers (Kraatz, 1876; Hatch, 1928; Emetz, 1975; Růžička et al., 2002).

In the Korean peninsula, this species is distributed mainly in the northern parts around relatively high altitudes and shows the most southern distributional limitation in Mt. Sobaeksan, Gyeongsangbuk-do, but the members of this species are also found in Mt. Hallasan, Jejuo Is., particularly (Fig. 1).

The present study is aimed to solve the following question: why this species is absent in southern area of Korean peninsula except in Jejuo Is. The population of Jejuo Is. shows different body shape from the Korean peninsula and other countries. Although Nomura and Lee (1992) tried to treat the specimens from Mt. Hallasan (Jejuo Is.) as a subspecies, they could not determine the status due to the only one female collection and bad condition of specimen. Here we reassess the taxonomic status of the members from Jejuo Is. comparing with those of mainland and its neighboring countries.

To examine the taxonomic level of *S. perforata* from Jejuo Is., we used the clustering analysis by the quantitative variables of morphological characters and compared the male genitalia of the specimens from the Korean mainland, China, and Japan (Table 1).

Table 1. The list of 17 localities of *Silpha perforata* complex investigated for clustering analysis.

No. of Locality	Countries	Localities	No. of Individuals examined
1	North Korea	Mt. Myohyangsan, Pyeonganbuk-do	8
2		Mt. Cheonmasan, Pyeonganbuk-do	7
3	South Korea	Mt. Seolaksan, Gangwon-do	1
4		Osaekyaksu, Gangwon-do	5
5		Mt. Odaesan, Gangwon-do	9
6		Mt. Balwangsan, Gangwon-do	1
7		Mt. Baekunsan, Gangwon-do	2
8		Mt. Hambaeksan, Gangwon-do	6
9		Mt. Taebaeksan, Gangwon-do	4
10		Mt. Sobaeksan, Gyeongsangbuk-do	17
11		Mt. Hallasan, Jejudo Is.	12
12	China	Mt. Jangbaeksan (= Mt. Baekdusan)	5
13		Longgang, Jilin	2
14	Japan	Shiwonuma, Hokkaido	3
15		Hidaka, Hokkaido	2
16		Shiribeshi, Hokkaido	5
17		Chisenupuri, Hokkaido	16

MATERIALS AND METHODS

A total of 105 adult specimens of *Silpha perforata* complex from 17 localities in Korea, China, and Japan, were examined (Table 1). The specimens used in this study were obtained from the following institutions: Natural History Museum, Hannam University, Daejeon, Korea (HUNHM); Natural History Laboratory, National Science Museum, Daejeon, Korea (NCM); Department of Agricultural Biology, Kyungpook University, Daegu, Korea (KNUAB).

A total of nine variables were selected from raw measurements including three combinations of quantitative characters: PL-Pronotum length, PW-Pronotum width, APW-Anterior margin width of pronotum, EL-Elytra length, EW-Elytra width, and CW-Compound eyes width. Three combinations of the measured value (PL/PW, EL/EW and PW/EW) were calculated respectively. We attempted a clustering analysis by average linkage method between groups using 105 adult specimens in SPSS/PC+ program packages (SPSS Inc, 2001). We dissected the male adult specimens to compare the genitalic characteristics from eight localities including Jejudo Is., Korean mainland, Japan, and China, considering their morphological differences and distributions.

RESULTS

1. Morphological variabilities

In Korea, *Silpha perforata* has been reported to be distributed in the northern area and Jejudo

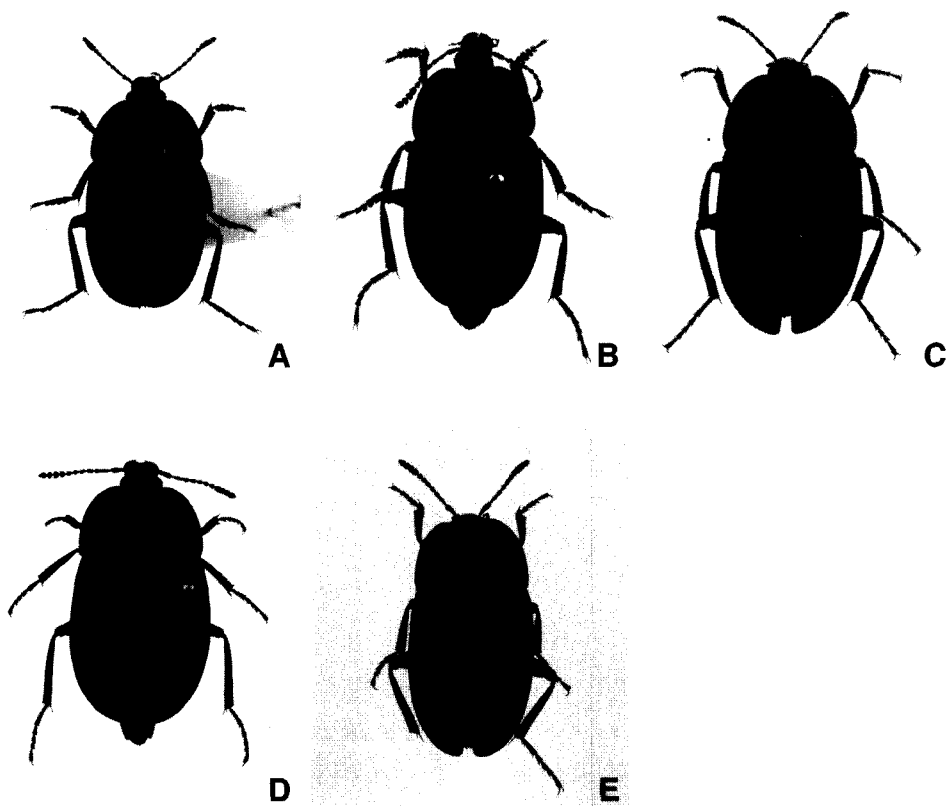


Fig. 2. Habitus of *Silpha perforata* complex collected in the five localities. A, Mt. Jangbaeksan (= Mt. Baekdusan), China; B, Mt. Myohyangsan, Pyoengانبuk-do, northern Korea; C, Mt. Taebaeksan, Gangwon-do, southern Korea; D, Mt. Sobaeksan, Gyeongsangbuk-do, southern Korea; E, Mt. Hallasan, Jejudo Is., southern Korea.

Is. with no data from southern area (Fig. 1). The members of this species show high morphological variations according to the localities, representing five types (Fig. 2). Type I is of Mt. Jangbaeksan (= Mt. Baekdusan; 2,100-2,300 m altitudes) and has the smallest body size such as the ones from Siberia (Fig. 2A). Type II with larger body size can be found in northern part of Korea (Fig. 2B). Types III-IV with the smaller body size than type II are found in middle part of Korea (Fig. 2C-D). Type V with elongated body form is shown from Jejudo Is. (Fig. 2E).

In spite of severe variations of body forms among the local populations, no variations were observed in the male genital structures from eight localities (Fig. 3).

2. Clustering analysis

We conducted the clustering analysis using nine quantitative variables from 105 individuals to clarify whether the population of Jejudo Is. are separated from the other localities in morphological characteristics. Six variables are normally distributed (Kolmogorov-Smirnov tests, $P > 0.1$) except

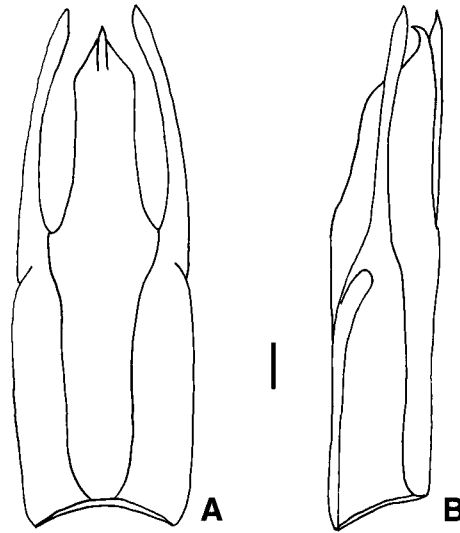


Fig. 3. The aedeagus of *Silpha perforata* from Jeju Is., Korea. A, dorsal view; B, lateral view. Scale bar = 0.38 mm

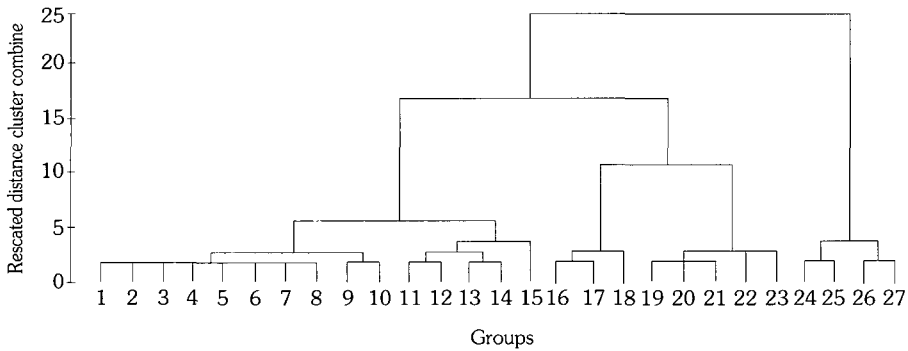


Fig. 4. Dendrogram of the clustering analysis using average linkage (between groups) from 27 groups in table 2.

three variables (APW, EW, and CW). The result shows that 105 individuals are clustered into 27 groups (Fig. 4). Table 2 shows the localities of 105 individuals clustered into 27 groups with the same coefficient value according to the clustering analysis. Two main clusters are firstly divided by 90% phenon line. One cluster (24-27 groups), consisting mainly of the specimens of northern part of Korea, is separated with the other cluster by the larger body size relatively. But the localities belonging the former cluster are also appeared in 4, 8, 13, and 14 groups of the latter cluster. It is shown the morphological variations among the specimens even in the same locality. The population of Jeju Is. were placed into 6 different groups: 1, 6, 7, 19, 20, and 22 (Table 2). Therefore there was no evidence to separate the populations of Jeju Is. from the other members of *S. perforata* complex.

Table 2. The cluster grouping of 105 individuals according to similarity by average linkage method (between groups).

Group	Country	Locality	No. of Individuals	Entry No.	
1	Japan	Chisenupuris, Hokkaido	6	95, 102, 99,	
	Korea (S.)	Mt. Hallasan, Jejudo Is.	3	176, 35, 31,	
		Osaekyaksu, Gangwon-do	2	43, 55, 71,	
		Mt. Odaesan, Gangwon-do	1	91, 66, 103,	
		Mt. Sobaeksan, Gyeongsangbuk-do	1	105	
2	Korea (S.)	Mt. Odaesan, Gangwon-do	1	46	
3	Japan	Shiribeshi, Hokkaido	3	86, 89, 52,	
	Korea (S.)	Chisenupuris, Hokkaido	4	58, 54, 78,	
		Mt. Sobaeksan, Gyeongsangbuk-do	7	3, 9, 59,	
		Mt. Seolaksan, Gangwon-do	1	4, 94, 101,	
		Mt. Balwangsang, Gangwon-do	1	40, 53, 87,	
		Mt. Odaesan, Gangwon-do	2	104, 98, 47,	
		China	Mt. Longgang, Jilin	1	49, 60
4	Japan	Hidaka, Hokkaido	2	83, 100, 64, 93, 32, 48, 34, 51, 84, 61, 90, 92, 15	
	Korea (S.)	Chisenupuris, Hokkaido	4		
		Mt. Sobaeksan, Gyeongsangbuk-do	3		
		Osaekyaksu, Gangwon-do	2		
		Mt. Odaesan, Gangwon-do	1		
		Korea (N.)	Mt. Myohyangsan, Pyeonganbuk-do		1
5	Korea (N.)	Mt. Cheonmasan, Pyeonganbuk-do	1	24	
6	Korea (S.)	Mt. Hallasan, Jejudo Is.	1	72	
7	Korea (S.)	Osaekyaksu, Gangwon-do	1	33, 96, 69	
	Japan	Chisenupuris, Hokkaido	1		
8	Korea (S.)	Mt. Hambaeksan, Gangwon-do	2	25, 39, 23, 29	
	Korea (S.)	Mt. Taebaeksan, Gangwon-do	1		
		Korea (N.)	Mt. Cheonmasan, Pyeonganbuk-do		1
9	Korea (S.)	Mt. Sobaeksan, Gyeongsangbuk-do	4	62, 85, 41, 56, 63, 97, 45, 50	
	Korea (S.)	Mt. Odaesan, Gangwon-do	2		
		Japan	Shiribeshi, Hokkaido		1
		Chisenupuris, Hokkaido	1		
10	Korea (S.)	Mt. Hambaeksan, Gangwon-do	1	26	
11	Korea (S.)	Mt. Baekunsan, Gangwon-do	1	1	
12	Korea (S.)	Mt. Baekunsan, Gangwon-do	1	2	
13	Korea (N.)	Mt. Myohyangsan, Pyeonganbuk-do	1	13, 28	
	Korea (S.)	Mt. Hambaeksan, Gangwon-do	1		

Table 2. Continued.

Group	Country	Locality	No. of Individuals	Entry No.
14	Korea (N.)	Mt. Cheonmasan, Pyeonganbuk-do	5	19, 36, 22, 12, 20, 37, 18, 30, 79, 21
		Mt. Myohyangsan, Pyeonganbuk-do	1	
	Korea (S.)	Mt. Taebaeksan, Gangwon-do	2	
		Mt. Hambaeksan, Gangwon-do	1	
	China	Mt. Longgang, Jilin	1	
15	Korea (S.)	Mt. Hambaeksan, Gangwon-do	1	27
16	China	Mt. Jangbaeksan	2	6, 7
17	China	Mt. Jangbaeksan	1	8
18	Japan	Shiwonuma. Hokkaido	1	82
19	Korea (S.)	Mt. Hallasan, Jejudo Is.	4	70, 75, 80, 74, 68
	Japan	Shiwonuma. Hokkaido	1	
20	Korea (S.)	Mt. Sobaeksan, Gyeongsangbuk-do	2	57, 65, 77, 44, 67
		Mt. Hallasan, Jejudo Is.	2	
		Mt. Odaesan, Gangwon-do	1	
21	Japan	Shiribeshi, Hokkaido	1	88
22	China	Mt. Jangbaeksan	2	9, 42, 73, 5
	Korea (S.)	Mt. Odaesan, Gangwon-do	1	
		Mt. Hallasan, Jejudo Is.	1	
23	Japan	Shiwonuma. Hokkaido	1	81
24	Korea (N.)	Mt. Myohyangsan, Pyeonganbuk-do	1	14
25	Korea (N.)	Mt. Myohyangsan, Pyeonganbuk-do	1	17
26	Korea (N.)	Mt. Myohyangsan, Pyeonganbuk-do	2	10, 38, 16
	Korea (S.)	Mt. Taebaeksan, Gangwon-do	1	
27	Korea (N.)	Mt. Myohyangsan, Pyeonganbuk-do	1	11

DISCUSSIONS

We conducted the clustering analysis and compared the male genital structures to clarify the taxonomic status of the members of Jejudo Is. with 105 individuals in 17 localities of Korea, Japan, and China. But we could not find the evidence that the members of Jejudo Is. are clearly separated from the others of *S. perforata* complex, even they have elongate body form.

We need more biogeographical information about the faunal members of Jejudo Is., which are distributed in low latitudes of northeastern Asia. The special distribution of the species can be found in other geometrid species [e.g. *Thera variata* (Denis and Schiffermuller), *Eulithis prunata*

(Linnaeus), *E. testata* (Linnaeus): Choi, 2002]. We can presume simply that this population moved towards northern area in the Korean peninsula, but some of them migrated to the high altitude of Mt. Hallasan according the climatic change from the last glacier.

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제주도산 넓적송장벌레 (딱정벌레목: 송장벌레과)에 대한 분류학적 검토

조 영 복* · 최 세 웅¹ · Massaki Nishikawa² · 권 용 정³

(한남대학교 자연사박물관: ¹목포대학교 환경교육과;

²일본 Ebina: ³경북대학교 농생물학과)

요 약

제주도산 넓적송장벌레의 개체군에 대한 분류학적 위치를 검토하기 위해 한국, 일본 및 중국지역의 105개체의 성충을 대상으로 수리분석과 수컷 생식기 비교를 실시하였다. 그 결과, 제주도산 송장벌레 개체군은 지역적 특성의 형태적 차이를 보여주는 넓적송장벌레 (*Silpha perforata*) Gebler의 종내 변이로 나타났다.