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Forel (Hymenoptera : Formicidae)

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Ecological Studies on *Formica yessensis* Forel, with Special Reference to Its Effectiveness as a Biological Control Agent of the Pine Caterpillar Moth in Korea

I. Geographical and Ecological Distributions of *Formica yessensis* Forel (Hymenoptera: Formicidae)

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Formica yessensis occurs in southwestern Hokkaido, Honshu north of Hakone-Fuji Mountains, Korea (except Jeju-Do unsurveyed), Ussuri and northeastern China. In Hokkaido and Tohoku Province of Honshu it occurs from sea shore areas to mountains as high as 700 m, while in central Honshu at 700-1800 m in altitude. A record from northern Kyushu is very doubtful. The southern limit of its distribution is nearly 35°N both in Korea and Japan. However, the ant inhabits lower lands even at the southern limit in Korea, while only mountains as high as 1500 m at the southern limit in Japan. In Korea, favourable habitat of the ant is the red pine forest, whereas it is rather open land adjacent to forest margin in Japan.

INTRODUCTION

Formica (Formica) yessensis Forel has been noticed as a possibly important natural enemy of the pine caterpillar moth, *Dendrolimus spectabilis* Butler in Korea (Teranishi, 1916), and it has been generally believed that the injury by the moth is extremely low in the pine forests where the ant inhabits. However, the researches on the biology and ecology of the ant in Korea and on the role of the ant as a natural biological control agent were not undertaken before the senior author and his collaborators worked on the subject (Kim and Kim, 1973; Kim and Choi, 1976; Kim, 1977; Kim *et al.*, 1978).

Since 1972, the senior author has been engaged in the biological control study of the pine caterpillar moth by utilizing *F. yessensis* in red pine forests in Gyeongsang-Nam-Do, Korea. From 1978 to 1979, he carried out the investigation on the geographical and ecological distributions of the ant in Japan and Jeonlla-Nam-Do, Korea cooperated with the junior author. The present paper reports the results of their investigations on the geographical and ecological distributions of *F. yessensis*, especially in Korea and Japan.

PAST RECORDS AND SOME COMMENTS

F. yessensis has been recorded from Japan, Korea, Formosa, China, Ussuri

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Table 1. Geographical distribution records of *F. (F.) yessensis* in the world.

Province	Locality	Authority
Hokkaido	Sorachi	Forel (1901)
	Sapporo, Jozankei and Obihiro	Teranishi (1929)
	Fukushima and Matsumae	Morisita (1945b)
	Kutchan and Hakodate	Hayashida (1964)
	Ishikari Shore	Ito (1971)
Honshu	Mt. Apoi (500-700 m alt.)	Hayashida (1971)
	Niigata, Nagano and Fukushima Prefs.	Yano (1912)
	Iwate Pref.	Teranishi (1929)
	North of Chûbu-mountains	Teranishi (1934)
	Norikura (lower than 1700 m alt.)	Morisita (1940)
	Chûbu-mountains (700-1700 m alt.)	Morisita (1945a)
	Hakone (Mt. Kintoki)	Kondoh (1961)
	Hakkoda (500-600 m alt.)	Yasuno (1963)
	Shiga Heights (1400-1650 m alt.)	Kondoh (1967)
	Mt. Fuji (1500 m alt.)	Kubota (1970)
	Miyagi Pref. (Oshika Pen.)	Sonobe (1973)
	Norikura Heights (1200-1800 m alt.)	Kondoh (1976)
	Miyagi Pref. (Mt. Izumigatake, Mt Kitaizumigatake, Okunikkawa, Aobayama, Kitasendai, Kunimi and Mt. Taihakusan)	Sonobe (1977a)
Kyushu	Northern Kyushu (?)	Sonobe (1977b)
	Seoul	Teranishi (1916)
Korea	Suweon, Hwasan and Mt. Gungang	Teranishi (1929)
	Mt. Pakyon	Collingwood (1976)
Siberia	Tomsk and Tobolsk (?)	Emery (1909)
Ussuri	Possjet Bay	Karawajew (1929)
China	Luan-ping	Teranishi (1936)
Formosa	Mt. Nanhutashan (?)	Wheeler (1933)

and Siberia (Table 1).

In Japan it has been recorded from Hokkaido, Honshu and Kyushu. In Hokkaido the record is limited in the southwestern part. In the northeastern Hokkaido it is replaced by another closely related species, *Formica (Formica) truncorum* Fabricius (Sonobe, 1977b). Studies on the vertical distribution in Hokkaido revealed that it occurred from sea shore areas such as Cape Shirakami (Morisita, 1945b) and Ishikari Shore (Ito, 1971) to mountain areas such as Umanose (500-700 m), Mt. Apoi, southern part of the Hidaka Mountains (Hayashida, 1971).

In Tohoku Province of Honshu, it occurs also from sea shore areas such as Oshika Peninsula in Miyagi Prefecture (Sonobe, 1977a) to mountain areas such as Kayano grassland (510-540 m), Mt. Hakkoda, Aomori Prefecture (Yasuno, 1963). On the other hand, in central Honshu it occurs only north of Mt. Fuji (Kubota, 1970) and Mt. Kintoki, Hakone (Kondoh, 1961), and at 700-1800 m altitude; e.g., Shiga Heights at 1400-1650 m (Kondoh, 1967), Norikura Heights at 1200-1800 m (Kondoh, 1976) and Mt. Fuji at about 1500 m (Kubota, 1970). Morisita (1945a) recorded *F. yessensis* from the elevation of 700-1700 m in the Central Alpine Area in Honshu. It has not been recorded from southwestern parts of Honshu nor Shikoku (Okamoto, 1978).

There is, however, a peculiar record of *F. yessensis* in northern Kyushu (Sonobe, 1977). By the personal letter of Mr. R. Sonobe to the junior author it was revealed that the record was based on the specimen collected by Mr.

M. Goto in "Hiratani Spa, Kashima-shi, Saga Prefecture on June 9, 1974". In order to confirm the occurrence of the ant the authors surveyed intensively the area of Hiratani Spa and its vicinity on June 10, 1979, but they could not find any trace of nest nor worker ants. Since the locality in question is about 370 m in altitude and since it occurs in places higher than 700 m even in central Honshu, the authors concluded that the record from Kyushu was based on the specimen erroneously labelled (Murakami and Kim, in press).

Teranishi (1916) first recorded in Korea the occurrence of *F. yessensis* based on the specimen collected in Seoul by Mr. S. Yamamura, and afterwards from Mt. Reugi in Suweon, Hwasan and Mt. Gungang (Teranishi, 1929). D. Y. Kim (1968) recorded "*Formica rufa* (L.)" as a predator of the pine caterpillar moth in Jeonlla-Bug-Do, but since *F. rufa* occurs only in Europe it should be corrected as *F. yessensis*. Recently Collingwood (1976) recorded *F. yessensis* from Mt. Pakyon, Kaesong Province based on specimens collected in a deciduous forest.

On the other hand, Wheeler (1933) recorded it from Formosa based on the specimens collected by Mr. J. Sonan (=Minamikawa) on Mt. Nanhutashan ("Nankataigan" by Wheeler). As he stated that it was really intermediate between *approximans* Wheeler and *sinensis* Wheeler, i.e., the dorsal surface of the head and thorax being less hairy than in *approximans* and the typical *truncorum* Fabricius and the tibiae without oblique hairs as in *yessensis* and *sinensis*, it is doubtful whether the Formosan form is true *yessensis* or not. Although the altitude of the top of Mt. Nanhutashan is 3798 m, that of the point where the very specimens were collected is unknown.

Also, *F. yessensis* was recorded from Luan-ping, 130 km northeast from Peking in China (Teranishi, 1939). Emery (1909) recorded it from Tomsk and Tobolsk in Siberia, but according to Collingwood (1976) Siberian specimens named *F. yessensis* were synonymised as *Formica (Formica) lugubris* Zett. by Dlussky (1967). The specimens, however, recorded from Ussuri by Karawajew (1929) could be possibly real *yessensis* because the locality collected is rather closer to Chinese and Korean habitats.

SURVEY IN KOREA AND JAPAN

The authors recognized the occurrence of *F. yessensis* in following districts in Korea and Japan.

Korea: Gyeongsang-Nam-Do — Sancheung (460 m in altitude), Mt. Jiri (815 m), Euleung (420 m), Jinseung (300 m), Jinyang (350 m), Cheungkok Temple (410 m), Munsan (250 m), Gonyang (300 m), Sacheun (200 m), Guam (300 m), Hadong (350 m), Goseung (210 m), Namhae (50 m), Geujedo (70-200 m); Jeonlla-Nam-Do — Mt. Mudungsan (400 m).

Japan: Hokkaido — Ishikari Shore (0 m), Misumai (Sapporo) (100 m); Honshu — Norikura Heights (1300 m), Mt. Nyukasa (Takato, Nagano Pref.) (1300 m).

In addition, the junior author examined specimens of his own and those preserved in the Entomological Laboratory, Kyushu University, and found

more specimens of *F. yessensis* collected from following localities.

Korea: Hamgyeong-Bug-Do — 1 worker, Musan (labelled as “Enjômen, Mozangun, Kankyôhokudô, N. Korea, 8. vi. 1939, T. Hirao”). Hamgyeong-Nam-Do — 43 workers, Anbyeon (labelled as “Anpen-gun, Kankyônando, N. Korea, 29. x. 1939, S. Kumashiro”). Seoul — 31 workers, Namsan (labelled as “Nanzan, Keijo, Korea, 23.viii.1940, T. Shirôzu”). Chungcheung-Nam-Do — 2 workers, Kongju (labelled as “Seian-men, Kôshû-gun, Chûseinan-dô, C. Korea, viii.1939, K. S. Ryû”).

Japan: Hokkaido — 6 workers, Maruyama (labelled as “Maruyama, Sapporo, 11.vi.1956, K. Hayashida”); 20 workers, Tsukisappu (labelled as “Tsukisappu near Sapporo, 15.vii.1955, Y. Murakami”); 5 workers, Jozankei (labelled as “Jozankei near Sapporo, 30.vi.1958, Y. Murakami”); 1 worker, Jozankei (labelled as “Zyozankei, Ishikari, 10.vii.1960, S. Nakao”). Honshu — 10 workers, Mt. Aokiyama (Aizu-Wakamatsu) (labelled as “Mt. Odayama, Iwashiro, 19.v.1946, Y.

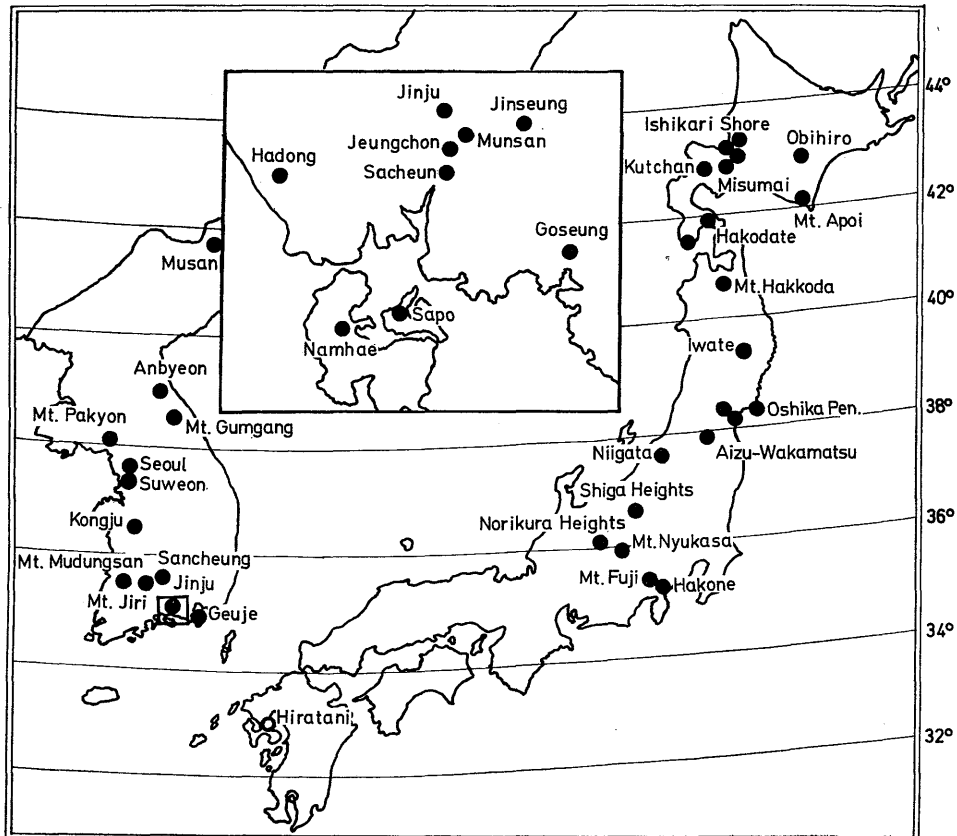


Fig. 1. Geographical distribution map of *F. (F.) yessensis* in Korea and Japan. Solid circles refer to the localities having been recorded and newly recorded, and open circle refers to the locality recorded but doubtful.

Kurosawa"); 1 worker, Sawa (Aizu-Wakamatsu) (labelled as "Sawa, Iwashiro, 24.v.1946, Y. Kurosawa").

Fig. 1 shows the distribution map of *F. yessensis* in Korea and Japan. According to this map, the ant distributes throughout Korea (except Jeju-Do uninvestigated), southern Hokkaido and Honshu north of Hakone-Fuji Mountains. Comparing the specimens collected from Korea and Japan, the authors concluded that there is no morphological difference between them. The southern limits of this ant both in Korea and Japan are approximately 35°N. However, at the southern limits of this ant, it occurs even in low lands such as Geujedo (70-200 m) and Namhae (50 m) in Korea, while it is found only on high mountains (at least about 1500 m) in Japan.

Ecologically, *F. yessensis* usually inhabits red pine forests in Korea, whereas it prefers grassland close to the forest margin in Japan. In Ishikari Shore the nests are mostly confined within the grassland occupied by eulalia, sweet brier and vines with moderately dense plant matrix, while absent both in sparse shore side vegetation and thick inland oak forest. Sufficient light intensity and presence of suitable nest cores are regarded as the factors principally responsible for their relative abundance as stated by Ito (1971). Hayashida (1957) also suggested *F. yessensis* preferred a certain degree of shade, and the best nest site was around the root of living trees with relatively shady and moist conditions (Hayashida, 1960). Sometimes the nests distribute in sparse secondary forests of the white birch and other deciduous trees (Morisita, 1945). Usually, the densities of trees in forests within the range of *F. yessensis* is observed too high for this ant to establish its nest in Japan, while in Korea the red pine trees are relatively sparse in forests, therefore sufficient light intensity provides a favourable condition for nesting.

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