Biodiversity of fauna and flora in Korean paddy field

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Abstract: Biological diversity issues in rice paddies have also been critical concerns because rice paddies cover over 60% in the Korean agro-ecosystem. The major fauna of the paddy ecosystem is freshwater invertebrate, above ground insect and plant. Especially, freshwater invertebrate is the major important fauna to sustain the paddy ecosystem as predator of the lower trophic level and pray for birds on food-web dynamics as well. During last decade we surveyed the biodiversity of fauna and flora in paddy field and based on this survey we made the invertebrate and vegetation database. To be shown the map for public, we identified 222 species of 72 families at 199 spots throughout the country. This study will provide useful information about invertebrate and vegetation biodiversity around paddy field in Korea. Some species were chose as dominant species in the paddy field; Chironomidae, Clieon dipterum Linne, Sympetrum frequens (Sely) and Dixidae. On the other hand, the spider in paddy field was surveyed 22 orders, 77 families and 121 species. Spider group was covered with over 90% of the natural enemies in Korean paddy field. For vegetation database using the vegetation biotope type were classified by the Z-M school of phytosociology method. The paddy levee, 148 C3 plants and 18 C4 plants were recognized, and the average number of C3 and C4 plants at each quadrate was 12 and 3, respectively.
Keywords: biodiversity, paddy, invertebrate, fauna, flora

1. Introduction

Biodiversity is one of the most important issues worldwide nowadays, and each country has various policy measures to preserve its diversity. As long as the conservation of biodiversity and ecosystems is closely linked to human life and further our well-being, the efforts to preserve and improve our ecosystems has also been an important issue in agricultural sector. Especially, rice paddies are newly noted by peoples as one of wetland systems nationwide and worldwide from the fact that the last Ramsar convention. Rice paddies have formed a typical agricultural landscape for centuries in many areas including Asian regions.

Rice paddies that provide other animal and/or plant food sources and medicinal plants in addition to the production of staple food have already been listed as one type of artificial wetlands in the definition of the Ramsar Convention. This is from the fact that rice paddies support important wetland biodiversity, such as fish, amphibians and insects, and play a significant role in waterbird flyways and the conservation of waterbird populations in many parts of the world.

Recently, rice paddies are considered to be important ones in the conservation of wetland ecosystems. However, little attention has been paid to communities of organisms living in paddy field. This work aims to answer main questions: (1) how many fauna inhabit in paddy field in Korea? (2) how many flora inhabit in paddy field in Korea?

2. Materials and Methods

Study site and monitoring of invertebrates in Rice Paddy Field

The study site for the invertebrate diversity research for the agricultural ecosystem was conducted in rice paddy ecosystem from 1997 to 2006 across the country. The samples for the analysis of freshwater invertebrate fauna were collected 3 times by using 2l-beaker. After screening insects using by 150/㎛-sieve, the samples was transiently kept in the ice box with the moisture maintained. The samples were moved to our laboratory and stored in refrigerator for the classification and identification of insects afterwards. With the insects classified into each species simultaneously, insects were moved into separated vials containing 70% ethyl alcohol for the fixation and then each species was identified based on "Flooding biology in Japan"(川村, 1986), "An illustrated Japan freshwater invertebrate fauna book"(川合編, 1985), "An illustrated animal and plant book"(Il-Byeong Yun, 1988) and "An illustrated freshwater invertebrate fauna book"(Il-Byeong Youn, 1995). And, the number of each species identified was counted under the microscope. The insects above the ground were collected by swiping 10 times per plot and kept in the gauze pouch of 35cm× 60cm-size. The samples were rapidly frozen at -65^{o}C for 15 minutes in a de-freezer. The insects were classified into the functional group and the number of each of them was counted under the microscope. The species and their coverage of plant were investigated in 59 paddy levees by linear quadrat (10m×1m) using Bunce *et al.*(1999) and Karajina (1933). The classification of C3 and C4 plant was identified with papers of Jang & Lee (1983), and Okuda & Furukawa (1990).

3. Result and Discussion

The fauna of aquatic and terrestrial invertebrates in Korean paddy field

This study had conducted for 10 years from 1997 to 2006 at paddy field in Korea. Based on collected specimen, we identified 222 species of 72 families (Table 1). Most abundance species among the invertebrate was Arthropoda group as 194 species; Crustacea class is 22 species and Insecta class is 172 species. Species composition of the aquatic insect fauna in the rice paddy was described in Table 2. It was observed that total identified number of the freshwater insect fauna inhabited in the rice paddy was 5 orders, 42 families and 172 species. This table showed greater than the number of 7 orders, 12 families and 16 species identified by the previous observation for two paddy fields of an organic farming and a conventional control of pests by pesticides (Lee *et al*., 1997).

The others groups were composed of 28 species; 2 species of Platyeliminthes, 2 species of Nematoda, 1 species of Nematomorpha, 14 species of Mollusca, and 9 species of Annelida. But, it was hard to identify some species so as to clear identification was demanded of identification in species level. In this study we also confirmed some species never reported before in Korea. *Cyprinotus kimberleyensis* Mckenzie, *Stenocypris hislopi* Ferguson, *Stranadesia tuberculata* Hartmann, *Eodiaptomus japonicus* Burckhardt, *Aeolosoma japonica* YamaguchiNais variabilis Piguet, *Mesostoma lingua* Abildgard, *Mortonagrion hirosei* Asahina, *Sisyra nikkoana* Navas, *Copelatus minutissimus* Balfour-Browne, *Rhantus erraticus* Sharp, *Helophorus sibiricus* Motschulsky, *Helochares anchoralis* Sharp, *Berosus elongatulus* Jordan, *Anisops kuroiwae* Matsumura, *Ephydra riparia* Fallen. The number of terrestrial invertebrate in paddy field was 216 species (Table 3). The spider in paddy field was reported 22 orders, 77 families and 121 species and spider group was covered with over 90% of the natural enemies in paddy field. Based on the field survey , we made a database and serviced as the map for public (Fig 2 and 3).

Table 1. The number of invertebrate species identified in Korean paddy field

Phylum	Class	No. of species
Platyhelminthes	Turbellaria	2
Nematoda	Secernentea	1
	Adenophorea	1
Nematomorpha	Gordioida	1
Mollusca	Gastropoda	14
Annelida	Oligochaeta	4
	Hirudinea	5
Arthropoda	Crustacea	22
	Insecta	172

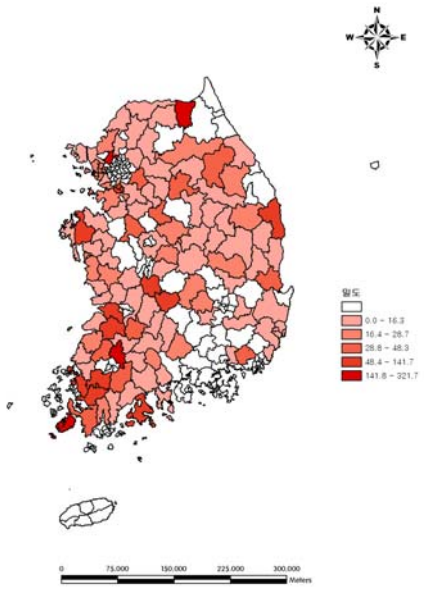

Fig. 2. *Austropeplea ollula*

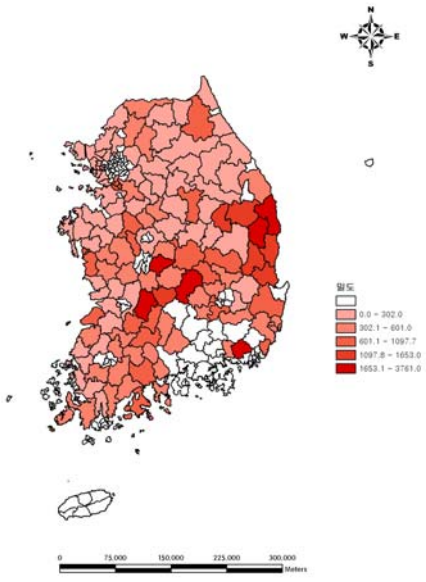

Fig. 3. Chironomidae

Table 2. Species composition of the aquatic insect fauna group in Korean paddy field

Order	Family	Species
Ephemeroptera	2	2
Hemiptera	13	35
Diptera	9	27
Odonata	8	48
Coleoptera	10	60
5 orders	42 families	172 species

Table 3. Species composition of the terrestrial invertebrate in Korean paddy field (including pest and natural enemy)

Family	No. of species
Chironomidae	62
Cicadellidae	48
Delphacidae	43
Veliidae	6
Ephydridae	5
Aphididae	5
Lycosidae	20
Tetragnathidae	3
Erigonidae	3
Others	21
Total	216

Seasonal changes of dominant aquatic invertebrates in paddy field

According to the seasons, the dominant species was changed. In the early rice growth stages from transplanting to June, Chironomidae was first dominant species. It was pointed that Chironimidae is important as food of natural enemy like a spider, so this is prevent outbreak of the pest. In July and August *Cloeon dipterum* Linne occupied 42.4% in aquatic insects and *Plea indistingueda* Matusmura appeared in paddy fields. In the late rice growth stages (Sept.), *Cloeon dipterum* Linne was still the first dominant species and *Ischnurum asiatica* (Brauer) was second dominant species (Fig. 4 and 5).

Fig. 4. Seasonal changes of dominant species in aquatic insects

Fig. 5. Major dominants species of the aquatic invertebrate in Korean paddy field

Survey of aquatic invertebrates in each province of Korean paddy field

Aquatic invertebrates were surveyed in rice paddy ecosystem from 2005 to 2007 in Korea. The surveying areas were: 1st year - Gangwon-do, Gyeonggi-do and Chungcheongbuk-do, 2nd year - Chungcheongnam-do, Jeollanam-do, and Jeollabuk-do, and 3rd year - Gyeongsangnam-do, Gyeongsangbuk-do, and Jeju-do. The number of species found in paddy fields varied from 106 to 201 by province and some extent of variation was also observed within each province, which ranged from 73 to 123 species. For the densities of aquatic invertebrates, their average population were in the range of 2,371～12,480 m^{-2} and the highest population density was observed in Namhae, 51,618 m^{-2}, averagely in Gyeongsangnam-do (Table 4).

The average density of aquatic insects in paddy field was 5,362 per m^2, 611 per m^2 for shellfish, 22,561 per m^2 for crustacean, and 27,500 per m^2 for aquatic invertebrates. Other indices for aquatic insects such as richness index, number of species, diversity index, evenness index, and dominance index were provided with 8.20, 9.1, 0.31, 0.13, and 0.86, respectively.

Table 4. The number of aquatic insects and freshwater invertebrates in paddy fields in each province

(unit: No./ m^2)

Division	Insects	Index	Annelida	Mollusca	Crustacea	Total
Gangwon	2,688	100	7	495	12,780	15,970
Gyeonggi	2,371	88	124	584	19,411	22,490
Chungbuk	7,052	262	8	359	16,822	24,241
Chungnam	3,372	126	49	918	16,800	21,139
Jeonbuk	6,311	235	27	871	17,984	25,193
Jeonnam	3,407	127	26	965	25,810	30,208
Gyeongbuk	8,830	329	56	369	54,983	64,238
Gyeongnam	12,840	478	41	552	32,740	46,173
Average	5,859	218	42	639	24,666	31,207

* Values are the average of the total sum of species numbers collected in a valley-in paddy and a common paddy field.

The change of C3/C4 vegetation on the Korean paddy levee

Temperature is not only known to influence plant growth in numerous ways, but is also an important determinant in the natural distribution of plants. The role of temperature in determining species distribution is currently receiving renewed attention, because it is important in prediction of vegetation response to global climate change. Therefore, in this study, the distribution and seasonal changes in the proportion of C3 and C4 type plants on the agricultural area of Korea were studied. The paddy levee, 148 C3 plants and 18 C4 plants were recognized, and the average number of C3 and C4 plants at each quadrate were 12 and 3, respectively (Table 5).

Table 5. Composition of C3/C4 vegetation in the paddy levee

Biotop types	Total No. Species		Species No./quadrat		Coverage/quadrat (%)	
	C_3	C_4	C_3	C_4	C_3	C_4
Paddy levee	148	18	11.6	2.9	55.3	35.9

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