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Diversity of Insect Fauna in Junam Wetland of Korea

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주남 습지대의 곤충다양성

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ABSTRACT: A sampling survey was conducted at three reservoirs of Junam wetland (6.02 km^2) in Korea to identify the wetland insect fauna along with their dominance, diversity, richness and evenness. Methods of monitoring were visual inspection and sweeping in 2010, Malaise trapping in 2011, light trapping and pitfall trapping in 2012. In total, 9,269 individuals (36.3% coleopterans, 21.3% lepidopterans and 13.9% odonates) were collected, belonging to 574 species, 141 families and 14 orders. For the number of species, lepidopterans shared the highest (31.2%), followed by coleopterans (28.0%) and hemipterans (12.9%). Dominant species were *Enochrus simulans* (Coleoptera) (7.9% of total individuals) followed by *Hydaticus grammicus* (Coleoptera) (4.3%), *Galerucella nipponensis* (Coleoptera) (4.1%), *Elophila interruptalis* (Lepidoptera) (3.1%) and *Apis mellifera* (Hymenoptera) (2.2%). Total counts of coleopterans, lepidopterans and odonates in the three reservoirs were quite high, but the counts were not significantly different among the reservoirs. Insect diversity index (H') and richness index (RI) of the Junam wetland were 5.04 and 59.10, respectively.

Key words: Sampling survey, Insect fauna, Diversity, Wetlands, Community analyses

초 록: 주남 습지대(6.02 km^2) 곤충상의 다양도, 우점도, 풍부도 등을 습지대 내 3곳의 습지에서 조사하였다. 조사방법으로는 육안조사와 쓸어잡기는 2010년, 말레이즈 트랩 조사는 2011년, 유아등 조사와 함정트랩 조사는 2012년에 실시하였다. 총 14目 141科 574種의 9,269 개체 (딱정벌레목 36.3%, 나비목 21.3%, 잠자리목 13.9%)가 조사되었다. 種數로 비교해 보면, 나비목이 31.2%로 가장 높았고, 그 다음이 딱정벌레목(28.0%) 노린재목(12.9%) 순이었다. 우점종(총 조사개체에 대한 각 종의 개체수 비율)은 애넓적물땡땡이(*Enochrus simulans*, 7.9%), 꼬마줄물방개(*Hydaticus grammicus*, 4.3%), 일본잎벌레(*Galerucella nipponensis*, 4.1%), 연물명나방(*Elophila interruptalis*, 3.1%), 양봉꿀벌(*Apis mellifera*, 2.2%) 순이었다. 세 곳의 습지에서 조사된 딱정벌레목, 나비목, 잠자리목 곤충의 수는 매우 많았지만 세 습지 간에 차이는 없었다. 주남 습지대의 곤충다양도(H'), 풍부도(RI)는 각각 5.04, 59.10이었다.

검색어: 곤충조사, 곤충상, 다양도, 습지, 군집분석

Diversities of insects are making this earth ecosystem always the suitable habitat for all (Samways, 1992). Rapid urbanization is narrowing down the level of insect fauna and their diversities (Tchakonte et al., 2015). In every ecosystem, insect diversities are among the least explored ones. In wetland ecosystem also, due to its complicated set up, insect diversities are less explored than that of terrestrial ecosystems. Obviously some efforts are made in recent years revealing a high scope of wetland insect fauna.

In particular, wetlands are transitional zones between aquatic and terrestrial environments and provide habitats for aquatic insects (Yoon et al., 2010) and are highly diverse and complex

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ecosystem that includes a wide spectrum of other aquatic habitats (Gopal et al., 2008). Wetlands are habitats for many organisms and helpful in maintaining ecosystem by mitigating floods, water pollution and global warming as well as by restoring the reactive nitrogen (Hey et al., 2012). Wetlands provide many important services to human society, but are at the same time, ecologically sensitive and adaptive systems (Turner et al., 2000). Estimates of global wetland area range from 5.3 to 12.8 million km^2. About half of the global wetland area has been lost and remaining wetlands occupy less than 9% of the earth's land area (Joy and Kercher, 2005).

In this study, we have tried to understand the diversity and the density level of terrestrial and aquatic insect species of Junam wetland which is the biodiversity hotspot of South Korea with similar characteristics of seasonal lakes or ponds (Skeffington et al., 2006; Regan et al., 2007). Junam wetland is composed of three sub-wetlands; Junam, Dongpan, and Sannam reservoirs which got its shape by the flooding of Nakdong river in the due course of time. Its manipulated structure (3 m of mean depth, 8,980 km^2 of storage area) is due to embankment for agricultural water supply system in 1920 (Cho et al., 2003). This wetland received much more attention only after 1980s as it became a popular bird sanctuary. Now, it inhabits many endangered wild flora and fauna.

For this wetland, migratory birds (Hahm et al., 1999, 2001), physical and chemical water quality (Lee and An, 2009), vascular flora (Lee et al., 2013), and terrestrial insect fauna (Ahn and Park, 2012) have been investigated. However, studies on the diversity of insect species are sparse. So, this type of study is quite relevant in those wet land ecosystems where in dry seasons, we can cross the wet land areas closer towards the arena making it possible to record and observe more wetland inset species which becomes an aquarium during rainy season. These are certainly enriched with aquatic insect fauna. Not only are these, the wetland is also popular habitat for some endangered as well as rare primitive insect species which could be the study spot for evolutionary process too.

Materials and methods

Study sites

This study was carried out in three reservoirs of Junam wetland (6.02 km^2), Changwon city, Gyeongsangnam-do (35° 18'46"N and 128°39'55"E), South Korea which is composed of three small interconnected reservoirs; Junam, Dongpan, and Sannam, for three consecutive years, 2010-2012 (Fig. 1). Explanations on the wetland and survey points were well described by Ahn and Park (2012) who studied the terrestrial insect fauna of the wetland.

Junam reservoir (JR) is the largest one (2.85 km^2) among the three. The migratory birds (white-necked crane, whooper swan, various ducks etc.) inhabit the reservoir from late October to November. Its shallow wetland flourishes plenty of aquatic plants (*Zizania latifolia*, *Nelumbo nucifera*, *Trapa japonica*, *Hydrocharis dubia* and *Nymphoides indica*), aiding beauty to the wetland. Three points, J1 (35°18'33"N and 128°40'44"E), J2 (35°19'45"N and 128°40'30" E) and J3 (35°18'47"N and 128°39'55"E) were marked as survey sub-sites.

Dongpan reservoir (DR) is the second one (2.42 km^2) with several marshlands and grasslands and is famous for its

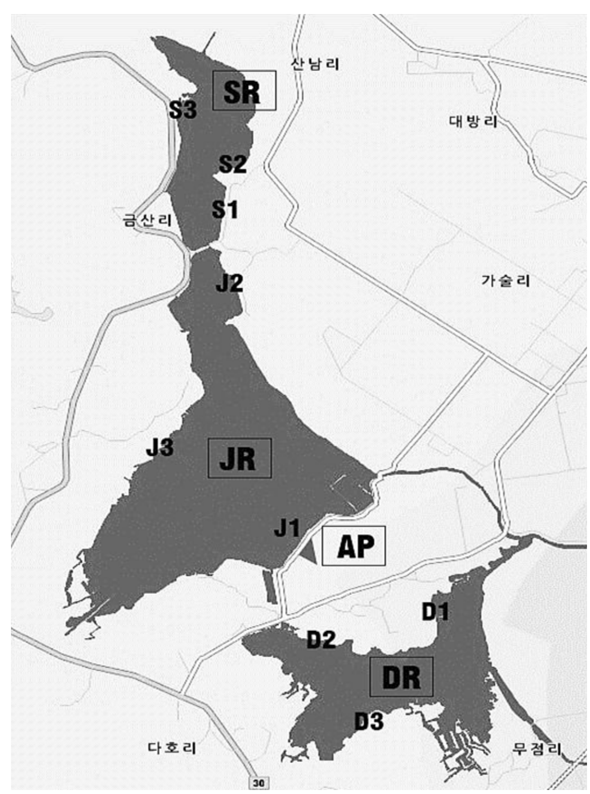

Fig. 1. Survey sites in the Junam wetland, Korea. Three sites at each reservoir were selected for this study; J1, J2 and J3 at Junam reservoir (JR); D1, D2, and D3 at Dongpan reservoir (DR); S1, S2 and S3 at Sannam reservoir (SR). Explanations on the reservoirs and survey points were well described by Ahn and Park (2012).

intactness. It is rest spot for many migratory birds. Water body is covered with aquatic plants (*N. indica*, *Nymphoides peltata*, *T. japonica*, *H. dubia* etc.). Three points, D1 (35°18'10"N and 128°40'30"E), D2 (35°18'12"N and 128°41'23"E) and D3 (35°18'09"N and 128°41'37"E) were identified as the survey sub-points.

Sannam reservoir (SR) is the smallest one (0.75 km^2) which is the only reservoir allowed for fishing, and its inner core is marshy land making it more attractive to the naturalists. *N. indica* and *T. japonica* are the main aquatic floras of this reservoir. Three survey sub-points, S1 (35°19'58"N and 128°40'26"E), S2 (35°20'09"N and 128° 40'29"E) and S3 (35°20'13"N and 128°40'12"E) were selected for this survey.

Survey time and methods

Visual monitoring and sweeping, light trapping, pitfall trapping, and Malaise trapping were carried out for 3 consecutive years from 2010 to 2012. For aquatic insects, circular net trapping and skimming net trapping were used.

Visual monitoring and sweeping

In total, nine points (three points in each reservoir, each measuring 3 m wide and 100 m long) (Fig. 1) were marked and surveyed during May 19 to 21, June 22 to 24, July 20 to22, August 22 to 24, September 27 to 29 and October 19 to 21 in 2010. The naked eye survey was complemented with a digital camera (Nikon 300D, Tokyo, Japan) and sweep netting (mouth diameter=50 cm). Results from visual monitoring and sweeping (Ahn and Park, 2012) were re-analyzed in this study to be incorporated into the results from the following survey methods.

Light trapping

Light traps (net length 55 cm and 5 watt black light bulb; Solar trap, Eco SolaTec Inc., Jinju, South Korea) were installed at the most insect-abundant survey sites (J3, D1, S1) after evaluating and confirming by visual monitoring and sweep netting. Light trapping was carried out for six days per month from May to September in 2012 except for August, as it was the month of heavy rainfall.

Pitfall trapping

Six pitfall traps were also installed at a distance of 3 m from the light traps. Three traps were baited with rice wine and other three with mackerel heads. Rice wine was filled one third of the 200 ml container (8 cm high with 7 cm mouth diameter and 5 cm bottom diameter) and the container was installed in level with the ground and covered with grass trashes on the top. Three time investigations (observations and re-installation of traps in the interval of two days) were made during May 20 to 22, June 23 to 25 and September 24 to 26 in 2012.

Malaise trapping

Malaise traps were installed at hill site adjoining to the reservoirs to collect migratory insects as depicted by Lachat et al. (2006) except using 80% alcohol here. Catches were collected on May 15 and September 25 in 2011.

Net trapping for aquatic insects

Nine survey points (3 in each reservoir) which were rich in aquatic plant species, and covered with a lot of fallen leaves were selected for aquatic insect survey. Observations were recorded on May 21, June 22, September 19 and October 10, 2010. Circular nets (Ø=20 cm and 0.5 mm mesh size) and skimming nets (Ø=50 cm, and 1 mm mesh size) (Hardy et al., 1987) were used to collect the aquatic insects. The collection was carried out for thirty times in 20 minutes at each point. Only one of the authors performed all-time collection to reduce the human ability errors.

Specimen preservation, photography and identification of insect species

The insect species which were observed by naked eyes and collected with sweep net were photographed for identification. The insects which were collected with light traps, pit fall traps and Malaise traps were converted into specimen for further classification. For identification of the photographed insects and insect specimens, we referred to the Korea Biodiversity Information System (Korea National Arboretum, 2012) and

Illustrated Color Guide Books to Insects (Ahn, 2010; Baek, 2012; Huh, 2012; Jung, 2007; Kim, 2003; Park et al., 2006; Son, 2009). Insects which could not be identified from those sources were subjected to the experts.

Wet specimens of aquatic insects, Malaise trapped and pitfall trapped insects were preserved in 80% alcohol. Light trapped and sweep net trapped insects were dry-preserved. Key of classifications by Pennak (1989), McCafferty (1981), Wiederholm (1983), Kawai (1985), Yoon (1988) and Cummins and Merritt (1996) were used to identify the catches. The identified specimens are now kept in the Erang Bio-Environment Research System (Jinju Bio-industry Promotion Foundation, Jinju, Gyeongnam, Korea). All photographs of insects taken during transect walk were posted on the Internet site 'Gonchung Nara Sikmul Nara - Insect and Plant Kingdom' (http://cafe.naver.com/lovessym).

Statistical analyses

Indices of dominance, diversity, richness, evenness, and similarity were calculated using corresponding formulae to each index. Dominance index (DI) given by McNaughton (1967) was used as an index comparing the degree of dominance which range from 0 to 1 with the higher value suggesting greater dominance. Diversity index (H') is based on the species richness (the number of species present) and species abundance (the number of individuals per species) (Pielou, 1966). A higher value means a higher diversity index within populations (Margalef, 1958; Lloyd and Ghelardi, 1964). Richness index (RI) shows the state of the community by using the total population and number of species (Margalef, 1958). Evenness index (EI) is a value indicating the degree of uniform species in community. Values range from 0 to 1 with the higher value suggesting greater evenness (Pielou, 1975). Similarity index (SI) quantifies the degree of homogeneity among the survey area, values ranging from 0 to 1 with the higher value suggesting greater similarity (Sørensen, 1948). Formulae for these indices were recently described by Ahn and Park (2012) who analyzed the terrestrial insect fauna of Junam wetlands.

Results and discussion

Insect fauna of Junam wetland

In total, 9,269 individuals representing 574 species, 141 families and 14 orders were collected from the Junam wetland (sum of Junam, Dongpan and Sannam reservoirs) (Table 1).

Table 1. Number of families, species (with percent share) and individual insects of different orders surveyed at the Junam wetland for three years from 2010 to 2012

Order	No. of families	No. of species (%)	No. of individuals (%)
Ephemeroptera	1	2 (0.35)	134 (1.45)
Odonata	5	26 (4.53)	1,286 (13.87)
Blattaria	1	1 (0.17)	23 (0.25)
Dermaptera	2	4 (0.70)	53 (0.57)
Orthoptera	8	33 (5.75)	795 (8.58)
Mantodea	1	3 (0.52)	44 (0.47)
Hemiptera	25	74 (12.89)	657 (7.09)
Neuroptera	3	6 (1.05)	16 (0.17)
Raphidioptera	1	1 (0.17)	1 (0.01)
Coleoptera	38	161 (28.05)	3,369 (36.35)
Hymenoptera	9	37 (6.45)	554 (5.98)
Diptera	14	41 (7.14)	318 (3.48)
Trichoptera	5	6 (1.05)	42 (0.45)
Lepidoptera	28	179 (31.18)	1,977 (21.33)
Total	141	574 (100.0)	9,269 (100.0)

The highest numbers of species collected were Lepidopterans (31.2%), followed by Coleopterans (28.1%) and Hemipterans (12.9%). However, the highest number of individuals belonged to Coleoptera (36.3%), followed by Lepidoptera (21.3%) and Odonata (13.9%). With the close diversity with this, Junam wetland showed quite higher diversity than the wetland Mulyoungahri oreum where 136 species from 39 families were reported (Cho et al., 2011) and the lake Daechung where 143 species from 57 families were recorded (Cho et al., 2008). From the well preserved Gotjawal wetland, only 217 species has been reported (except lepidopterans) (Yang et al., 2006).

The most dominant species of Junam wetland was *E. simulans* followed by *Hydaticus grammicus*, *Galerucella nipponensis* and *Elophila interruptalis* (Table 2). *E. simulans* and *H. grammicus* were mostly collected in the light traps. *G. nipponensis* was collected in secondly higher numbers in both Dongpan and Sananm reservoirs. The reason for dominance of *G. nipponensis* might be the abundance of its host plant *T. japonica* in these two reservoirs.

The most dominant coleopteran species was *E. simulans* (21.3%) followed by *H. grammicus* (11.7%) and *G. nipponensis* (11.4%). *Harmonia axyridis*, a predator of aphids ranked fourth. Among the lepidopterans, *E. interruptalis* was the most dominating one accounting for 279 (14.1%) of the survey. This is possibly because *E. interruptalis* feeds on its aquatic host plants like *N. indica* and *H. dubia* which were abundantly found in the Junam wetland. In addition, *Polygonia c-aureum* and *Grapholita delineana* that feed on *Humulus japonicus* of

Table 2. The dominant species belonging to a few major orders surveyed at three reservoirs of Junam wetland in 2010-2012

Scientific name	Reservoir				% of total
	JR	DR	SR	Total	
Coleoptera					
Enochrus simulans	220	323	176	719	21.3
Hydaticus grammicus	136	158	100	394	11.7
Galerucella nipponensis	81	170	134	385	11.4
Harmonia axyridis	79	56	30	165	4.9
Ophraella communa	48	59	18	125	3.7
Other 152 species	649	587	375	1581	46.9
Total individuals	1,213	1,323	833	3,369	100.0
Lepidoptera					
Elophila interruptalis	90	145	44	279	14.1
Polygonia c-aureum	71	26	25	122	6.2
Chilo suppressalis	48	33	28	109	5.5
Paraponyx vittalis	31	56	12	99	5.0
Grapholita delineana	20	51	21	92	4.7
Other 174 species	486	526	264	1276	64.5
Total individuals	746	837	394	1,977	100.0
Odonata					
Crocothemis servilia mariannae	70	46	55	171	13.3
Ischnura asiatica	65	45	20	130	10.1
I. senegalensis	37	54	34	125	9.7
Deielia phaon	66	36	24	126	9.8
Orthetrum albistylum	68	34	16	92	7.2
Other 21 species	274	227	115	642	49.9
Total individuals	580	442	264	1,286	100.0

JR: Junam reservoir, DR: Dongpan reservoir, SR: Sannam reservoir.

Junam wetland were other dominating species. *Chilo suppressalis* and *Paraponyx vittalis* were also collected in plenty due to the availability of paddy plantation, the host plant around the reservoirs. *Crocothemis servilia mariannae* was the most dominant among odonates, accounting for 171 (13.3%) of total individuals followed by *Ischnura asiatica*, *Deielia phaon*, *Ischnura senegalensis* and *Orthetrum albistylum*.

Insect species identified from each reservoir of Junam wetland

The lowest number of species (283) and individuals (2,228) were found in Sannam reservoir compared with Junam (362 species and 3,667 individuals) and Dongpan reservoirs (394 species and 3,364 individuals) (Table 3). Sannam had smaller populations and fewer species of insects than the other two reservoirs. This is possibly due to the higher seasonal variation of water level of Sannam reservoir than the other two (Ahn and Park, 2012). Imoobe and Ohiozebau (2010) found that the aquatic insect composition in Okhuo River declined during rainy season and increased during the dry season. So, freshwater environment is considered to be influential in insect distribution. In other words, insects in Sannam reservoir were expected to be sensitive to changes in the environment, due to water filled reservoir during rainy season. On the other hand, insect diversity was very less towards bird sanctuary of Junam reservoir, compared to its rear side. It is because the composition of communities is strongly altered by anthropogenic manipulations (Hillebrand et al., 2008).

On an average, all those three reservoirs followed a similar pattern in insect fauna (Table 3). Number of families was highest from Coleoptera in all the reservoirs, followed by Lepidoptera. The highest number of species was recorded in Lepidoptera, and was followed by Coleoptera and Hemiptera in all the three reservoirs. But, for individuals, coleopterans were the highest followed by lepidopterans and odonates. Total individuals from Coleoptera, Lepidoptera, and Odonata of Junam, Dongpan and Sannam reservoirs were very high (69.2%, 77.3%, and 66.9%, respectively) in their abundance followed by Orthoptera and Hemiptera.

Number of common species among the three reservoirs is shown in Fig. 2. The species of which more than 10 individuals were collected are used in this graph. Among the 157 species, 111 species were common in all reservoirs. Three species were

Table 3. Number of insect families, species and individuals surveyed at three reservoirs of Junam wetland in 2010 to 2012

Order	No. of families*			No. of species*			No. of individuals*		
	JR	DR	SR	JR	DR	SR	JR	DR	SR
Ephemeroptera	1	1	1	1	1	1	68	45	21
Odonata	5	5	4	23	23	20	580	442	264
Blattaria	1	1	1	1	1	1	7	4	12
Dermaptera	2	1	2	4	3	3	24	12	17
Orthoptera	8	6	5	27	17	22	356	179	260
Mantodea	1	1	1	3	3	3	18	1	15
Hemiptera	19	23	17	49	63	43	228	261	168
Neuroptera	1	3	2	2	6	3	2	9	5
Raphidioptera	0	1	0	0	1	0	0	1	0
Coleoptera	27	28	24	84	99	70	1,213	1,323	833
Hymenoptera	6	8	7	18	21	15	282	120	152
Diptera	9	11	11	30	29	26	130	108	80
Trichoptera	3	5	2	3	6	2	13	22	7
Lepidoptera	23	26	20	117	121	74	746	837	394
Total	106	120	97	362	394	283	3,667	3,364	2,228

*JR: Junam reservoir, DR: Dongpan reservoir, SR: Sannam reservoir found only in Junam reservoir, five only in Dongpan and two only in Sannam reservoir. Higher number of common insect species among the three reservoirs (111 species) is mainly due to the similar limnological environment of the reservoirs. Comparing the common species between two reservoirs, Junam and Dongpan reservoirs were more similar (with 17 common species) with each other than Dongpan and Sannam reservoirs (9 common species).

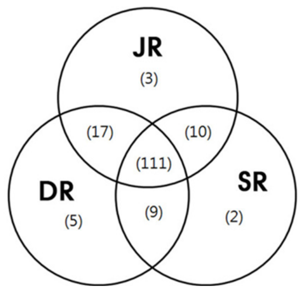

Fig. 2. The common species in three reservoirs of Junam wetland. The species which more than 10 individuals were collected are considered. JR: Junam reservoir, DR: Dongpan reservoir, SR: Sannam reservoir.

Aquatic insect species are listed in Table 4. The insects were classified as aquatic, even if one of their developmental stages was found in water. Fifty-one aquatic insect species were surveyed in the Junam wetland belonging to18 families and 6 orders. The most frequently collected species were odonates (39.2%), followed by coleopterans (29.4%) and hemipterans (21.6%).This result is quite different from Park et al. (2012)

Table 4. A list of aquatic insect species collected at Junam (JR), Dongpan (DR), and Sannam (SR) reservoirs in Junam wetland from 2010 to 2012. The insect were classified as aquatic, even if one of their developmental stages was found in water

Order	Family	Scientific name	JR	DR	SR
Ephemeroptera	Baetidae	*Cloeon dipterum* (Linnaeus)	●	●	
		Baetidae gen. et sp.			●
Odonata	Coenagrionidae	*Ischnura asiatica* (Brauer)	○	○	○
		Paracercion calamorum (Ris)	○	○	○
		P. hieroglyphicum (Brauer)	○	○	○
		P. v-nigrum (Needham)	○	○	
	Platycnemididae	*Platycnemis phyllopoda* Djakonov	○	○	○
	Aeshnidae	*Aeschnophlebia longistigma* Selys	○		
		Anax nigrofasciatus Oguma		○	○
		A. parthenope Julius Brauer	○	○	○
	Libellulidae	*Crocothemis servilia mariannae* (Kiauta)	○	○	○
		Deielia phaon (Selys)	○	○	○
		Orthetrum albistylum Selys		○	○
		Pantala flavescens (Fabricius)	○		
		Pseudothemis zonata Burmeister		○	○
		Sympetrum infuscatum (Selys)	○	○	○
		S. darwinianum (Selys)	○	○	
		S. eroticum (Selys)		○	○
		S. frequens (Selys)	○	○	○
		S. kunckeli (Selys)		○	
		S. parvulum (Bartenef)	○	○	
		S. pedemontanum elatum (Selys)		○	
Hemiptera	Nepidae	*Laccotrephes japonensis* Scott	●	●	
		Nepa hoffinanni Easki	●	●	
		Ranatra chinensis Mayr	●	●	●
		R. unicolor Scott		●	

Table 4. Continued

Order	Family	Scientific Name	JR	DR	SR
Hemiptera	Belostomatidae	*Diplonychus esakii* Miyamoto et Lee	●	●	●
	Corixidae	*Sigara substriata* (Uhler)	●	●	
	Notonectidae	*Notonecta triguttata* Motschulsky		●	●
	Gerridae	*Aquarius paludum* (Fabricius)	●	●	●
		Gerris gracilicornis (Horváth)		●	●
		G. latiabdominis Miyamoto	●	●	●
		G. nepalensis Distant		●	
Coleoptera	Haliplidae	*Peltodytes intermedius* (Sharp)	●	●	
		P. sinensis (Hope)		○	○
	Dytiscidae	Dytiscidae gen. et sp.	○	○	○
		Hydaticus grammicus Germar	○	○	○
		Laccophilius lewisius Sharp		●	●
		L. difficilis Sharp	●	●	●
		L. kobensis Sharp		●	
		Rhantus erraticus (Sharp)	●	●	
		R. pulverosus (Stephens)			○
	Hydrophilidae	*Berosus pulchellus* MacLeay		○	
		Enochrus simulans (Sharp)	○	○	○
		Hydrochara affinis (Sharp)	○	○	○
		Sternolophus rutipes Fabricius	○	○	○
	Chrysomelidae	*Galerucella nipponensis* (Laboissiere)	○	○	○
	Curculionidae	*Lissorhoptrus oryzophilus* Kuschel	○	○	○
Diptera	Tipulidae	*Tipula taikun* Alexander	○		○
	Statiomyidae	*Odontomyia garatas* Walker	○	○	
Lepidoptera	Pyralidae	*Elophila interruptalis* (Pryer)	○	○	○
Total			36	46	33

The insect species marked with '●' were collected only by net trapping for aquatic insects, and the species marked with '○' were by net trapping as well as one of the methods used for terrestrial insect collecting.
Supplementary data are available at Korean Journal of Applied Entomology online.

where they reported 29 species of benthic macro-invertebrates in Junam wetlands. Lee et al. (2009b) reported 80 species from Upo wetland having similar benthic environment. Bae et al. (2004) also reported 103 species from Upo wetland and nearby Topyeong river. Among the aquatic insect species surveyed here by different methods, only 18 species were newly recorded (not overlapping) (Table 4, ● mark).

Community analyses

The community analyses on the survey sites of Junam wetland (Table 5) revealed that the diversity index (H') and richness index (RI) were 5.04 and 59.10, respectively. Even though it is not reasonable to compare the diversity of a place with others in which different survey methods were adopted, the indices of insect diversity of other wetlands in Korea were reported as follows; Mulyeongari-Oreum wetland in Jeju 3.49-3.42 (Cho et al., 2011), Sinbulsan wetland in Ulsan metropolitan city 2.26-3.17 (Lee et al., 2009a) and Daechung Lake wetland 1.56-3.93 (Cho et al., 2008). While the richness indices (RI) were 4.90-7.47 in Sinbulsan wetland (Lee et al., 2009a), 1.92-17.38 in Daechung Lake wetland of Chungbuk province (Cho et al., 2008) and 5.34-9.64 in the riversides of DMZ area of Korea (Park et al., 2012). The dominance index

Table 5. Community analyses of insect fauna of each reservoir of Junam wetland in 2010 to 2012

Reservoir*	DI	H'	EI	RI
JR	0.12	4.96	0.85	42.20
DR	0.16	4.74	0.81	44.05
SR	0.15	4.66	0.84	33.64
Three reservoirs	0.12	5.04	0.80	59.10

* JR: Junam reservoir, DR: Dongpan reservoir, SR: Sannam reservoir; DI: dominance index, H': diversity index, RI: richness index, EI: evenness index.

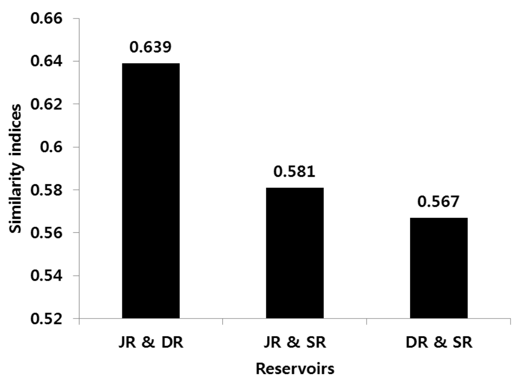

Fig. 3. Comparison of the similarity indices (SI) in respect to insect fauna among three reservoirs of Junam wetland, 2010-2012. JR: Junam reservoir, DR: Dongpan reservoir, SR: Sannam reservoir.

(DI) of Junam wetland (0.12) was same with that of Mulyeongari-Oreum wetland (Cho et al., 2011), but lower than 0.27-0.53 of Sinbulsan wetland (Lee et al., 2009a).

Comparing the indices among reservoirs, Junam reservoir showed slightly higher diversity (H') (4.96) than Dongpan (4.74) and Sannam reservoirs (4.66). The RI was similar in Dongpan (44.05) and Junam (42.20) reservoirs and was lower in Sannam reservoir (33.64). The DI and evenness index (EI) did not show big gaps among reservoirs, showing variations of 0.12-0.16 and 0.81-0.85, respectively (Table 5).

Junam and Dongpan reservoirs were similar to each other by 0.639 of SI (Fig. 3). The indices between Sannam and Junam reservoirs (0.581), and Sannam and Dongpan reservoirs (0.567) were slightly lower than the similarity of Junam and Dongpan reservoirs. Population is said to be heterogeneous when SI is less than 20% and homogenous when it is greater than 80% (Whittaker, 1956). Thus, the three reservoirs in Junam wetland are quite similar but not homogenous in their insect fauna.

In summary, this study was conducted to examine the insect diversity of Junam wetland in Korea, employing visual inspection and sweeping, light trapping, malaise trapping and pitfall trapping as the modes of sampling survey for three consecutive years during 2010 to 2012. This study proved Junam wetland as the insect diversity hotspot of Korea. In total, 9,269 insect individuals were collected, representing 574 species, 151 families and 14 orders with high degree of diversity index (5.04) and richness index (59.10). The Junam wetland is already famous for its flora and is also the popular bird sanctuary. Moreover, the wetland could be the insect sanctuary for naturalists, ecologists, biologists, entomologists, wet land activists and also for eco-tourists, too. Certainly, this study added some basic figure on the whole biodiversity status of Junam wetland.

Supplementary information

The supplementary information (a list of insect species except aquatic insects surveyed at Junam wetland) is available free of charge on the website of Korean Journal of Applied Entomology at http://www.entomology2.or.kr

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