Fish Distribution and Water Quality of Mountain Streams in the Jirisan National Park, Korea

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ABSTRACT : Fish fauna of mountain streams in the Jirisan National Park area of S. Korea (total area: 440.45 km^2, height: 1,915 m) was investigated at 33 sites from May 1997 to September 1999. A total of 4,670 individuals of fishes were collected and classified into 30 species and 12 families. *Zacco temmincki* (relative abundance (RA), 63.9%) was found to be the most abundant inhabitant. Subdominant species were *Pungtungia herzi* (RA 6.2%), *Zacco platypus* (RA 6.1%) and *Coreoleusiscus splendidus* (RA 4.8%). Among the total species, 13 species were identified as the Korean endemic species (7 families, 17.2% of 802 individuals). Dominant Korean endemic species was *C. splendidus* (relative abundance endemics (RAE), 27.8%). Superiors were *Coreoperca herzi* (RAE 21.8%) and *Liobagrus mediadiposalis* (RAE 19.8%). One exotic species (*Oncorhynchus mykiss*, a site and 5 ind.) and translated species (*Hypmesus niponensis*, two sites and 174 ind.) were collected in this survey. The proportion of Korean endemic species in the park (43.3%) was higher than the average of Korean Peninsular (25.9%). From this study, we conclude that the Jirisan National Park area in Korea would be very important for fish diversity and conservation, especially for the Korean endemic and endangered species.

Key words : Fish fauna, Jirisan National Park, Korean endemic species, Mountain streams

INTRODUCTION

National parks and protected areas possess a relatively rich ecological inventory data set, and are focal points for scientific research, allowing comparative analyses with surrounding areas, and can be used for long term monitoring programs, as well as protecting various elements of biodiversity (Zorn *et al*. 2001). The International Union for Conservation of Nature (IUCN) defines a national park as 'a large area wherein one or more ecosystem is preserved, unimpaired by human development or occupancy, or an area wherein the inhabitant species, the geological location, or the traditional customs are subjects of keen interest to the public in terms of scholarship, education, and leisure, or an area which displays a remarkable natural scenery'. South Korea has 20 national parks including four national parks in the sea, one ancient city national park (Gyeongju) and one mountain on an island (Mt. Halla in Jeju Island), and 11 natural ecosystem conservation areas. The total area of 14 national parks in mountain area (2,994 km^2) is about 3% of South Korea (99,434 km^2) and the Natural Ecosystem Conservation Area (100 km^2) covers about 0.1% of S. Korea (Jang *et al*. 2003).

Most mountain streams in South Korea are shallow with intermittence, and process obvious changes of discharge according to precipitation pattern. Water flows of most headwater streams have been limited due to cultivation and construction of small artificial pools for irrigation (Joo *et al*. 1997). Recently, numerous artificial disturbances, such as small dam, road construction, fires, and mining, triggered the physico-chemical alteration in mountain streams (Jang *et al*. 2003). The change of physical and chemical characteristics of mountain streams attributed by discharge, alteration of channel morphology, nutrient loading or wastewater from the basin would affect the biota of small stream ecosystems, especially fish fauna (Starrett 1951, Carander 1969, Schlosser 1982, Schlosser and Toth 1984, Pires *et al*. 1999).

Studies on fish fauna and community in South Korea have been relatively well conducted in major river systems (Choi and Kim 1972, Ju and Jeon 1977, Choi 1978, Ju *et al*. 1980, An *et al*. 1992, Yang and Chae, 1993), middle or lower part of rivers (>3 order stream; Choi 1972, Choi *et al*. 1973, Byeon *et al*. 1996, Choi *et*

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al. 1995, Song *et al*. 1995, Nam 1997a, b) and reservoirs (Choi 1969, 1973, Jeon 1980). However, there are only few studies on fish fauna in mountain streams due to difficulty of access and sampling. In the case of the Jirisan National Park, there are several reports and scientific papers (Ju *et al*. 1980, Choi and Jeon 1982, Lee 1991, Jeon and Hoang 1993). However, these papers deal with fish fauna in selected tributaries. Mountain streams in the Jirisan National Park were relatively undisturbed and protected. Therefore, in this study, fish fauna, water quality and conservation of fish fauna in the mountain stream of the Jirisan National Park were investigated.

MATERIALS AND METHODS

Study sites

Mt. Jiri (total area: 440.4 km^2, height: 1915 m) is located in the southern area of the Sobaek Mountains (Lat. 36˚~37˚N and Long. 127˚~128˚E), which was in the southern part of Korea (Fig. 1, Appendix). This mountain was designated as first national park in 1967. These headwater streams flow into Seomjin and Nakdong River. Stream substrata are composed mainly of granite bedrock and boulder. Most of sites are in the high gradient stream with riffle and pools. The study sites have clean water and its water temperature was low (< 20°C), showing the typical characteristics of Korea mountain streams. Most study sites had soft water, shaded by riparian vegetation.

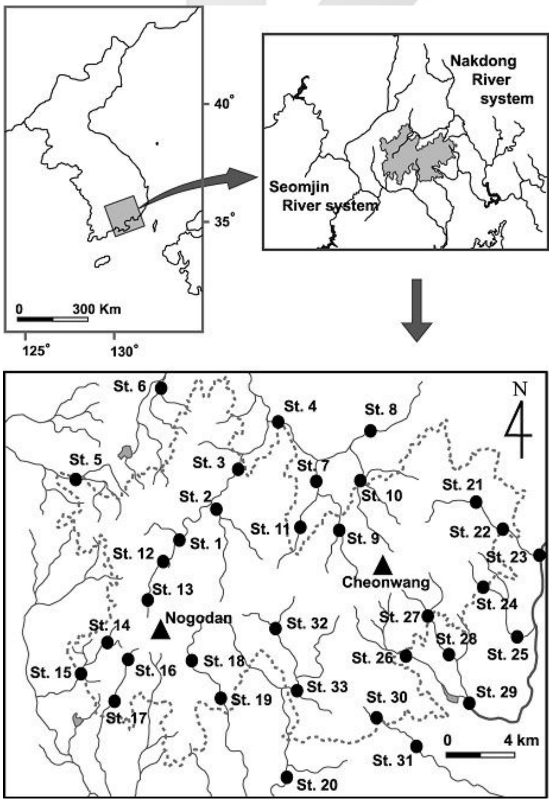

Fig. 1. Map showing sampling sites for ichthyofauna survey of the Jirisan National Park.

Sampling methods and analysis

Four sampling programs were conducted at 33 sites within the Jirisan National Park from May 1997 to September 1999 (Jun., Aug., Sept., 1997, Sept., Oct., Nov., 1998, Mar., Apr., Jun., Aug., 1999). Physio-chemical parameters (water temperature, dissolved oxygen, pH, alkalinity, conductivity, turbidity, COD, total nitrogen, and total phosphorus) were measured at the sampling sites. Water temperature and dissolved oxygen level were measured with an YSI DO meter (Model 58). Conductivity, pH and turbidity were measured using a Fisher conductivity meter (Model 152), Orion pH meter (407A) and a Shaban turbidity meter (Model 20052), respectively. Alkalinity, COD, total nitrogen, and total phosphorus were measured as described in APHA (1995).

Fishes were collected with scoop net (mesh 5 × 5 ㎜) and cast net (mesh 7 × 7 ㎜). The cast nets (4.5 $m^2 = \pi \times 1.2^2$ m) were cast 20 times at each time and site. Approximately 100 m of stream segment (both pool and shallow ripple areas) were sampled at each site. All specimens were identified using the keys of Kim and Kang (1992) and Kim and Park (2002), and followed classification system of Nelson (1994). Among collected specimens, necessaries for fixation and detailed identification were fixed with 10% formalin solution, counted, and then kept in 5% formalin solution. Species diversity index, dominance, richness, and species evenness of the collected specimen were calculated (Pielou 1969, 1975, McNaughton 1967, Margalef 1958).

RESULTS

Physico-chemical parameters

Similar physico-chemical characteristics were observed at most study sites (Table 1). Mean water temperature was 15.3 ± 2.2℃, showing the highest level (19.4℃) at Site 11, and the lowest (11.3℃) at Site 28. Mean level of dissolved oxygen was relatively high (9.97 ± 1.44 mg L^{-1}). The high DO could be attributed to lower water temperature and high water velocity. The maximum level was observed at 13.6 mg L^{-1} and minimum level 7.9 mg L^{-1}. The change in pH was similar to the changing pattern of DO. The relatively high pH level was observed during the study period. Conductivity and alkalinity at all sites were low (conductivity, 30.9 ± 6.2 $\mu S\ cm^{-1}$; alkalinity, 6.7 ± 1.9 mg L^{-1} $CaCO_3$). Stream in catchments have alkalinity near 7 mg L^{-1} (4~12 mg L^{-1}), and the pH averages were between 5.71 and 7.94 (6.88 ± 0.58). Mean turbidity was 0.53

Table 1. Physio-chemical environment of sampling sites in the Jirisan Naitonal Park during the sampling periods (May 1997~Sept. 1999; n=4)

Sites	WT (℃)	DO (mg L^{-1})	pH	Conductivity (μs cm^{-1})	Alkalinity (mg L^{-1} $CaCO_3$)	Turbidity (NTU)	COD (mg L^{-1})	TN (mg L^{-1})	TP (mg L^{-1})
1	15.2±0.2	9.1±1.4	6.85±0.47	17±1	8±6	3.9±1.7	1.4±0.1	0.24±0.05	0.06±0.00
2	15.0±0.2	9.4±1.6	6.81±0.35	16±2	6±3	3.6±1.9	1.6±1.1	0.05±0.02	0.11±0.00
3	16.0±1.1	8.4±1.0	6.90±0.36	18±1	6±16	4.0±2.5	2.4±3.7	0.15±0.03	0.16±0.03
4	16.3±2.3	8.4±0.8	7.02±0.56	34±2	4±13	6.3±1.4	1.8±5.2	0.79±0.07	0.19±0.00
5	16.0±1.5	9.0±0.7	6.93±0.63	30±12	8±6	5.4±1.2	1.4±0.2	0.90±0.15	0.10±0.01
6	17.9±4.8	8.1±0.6	6.91±0.55	68±1	6±0	9.4±1.2	6.4	1.61±0.11	0.24±0.00
7	15.3±0.4	8.5±0.3	5.82±0.49	17±11	6±3	3.4±2.1	0.4±1.6	0.15±0.03	0.08±0.01
8	17.0±1.5	8.6±0.2	6.35±0.01	30±1	4±8	4.9±0.9	1.0±1.1	0.53±0.04	0.12±0.00
9	14.4±0.1	9.0±0.8	6.67±0.29	13±6	4±4	2.8±1.8	0.4±0.6	0.01±0.03	0.18±0.01
10	15.7±1.4	8.5±0.9	5.62±0.96	17±11	8±5	4.7±1.9	9.4±1.2	0.58±0.07	0.30±0.00
11	15.1±2.2	8.7±0.8	6.30±0.03	16±7	4±1	3.9±2.6	1.4±1.6	0.23±0.02	0.07±0.02
12	12.2±3.4	9.3±1.2	7.22±0.08	ND	ND	1.6±0.4	0.8±0.9	0.13±0.13	ND
13	12.4±2.6	9.7±0.8	7.12±0.07	20±0	6±0	0.7±0.2	1.6±0.9	0.65±0.06	0.06±0.00
14	11.6±2.2	9.7±0.8	7.15±0.09	29±8	6±1	0.7±0.2	2.0±1.9	0.92±0.18	0.13±0.00
15	10.6±2.1	10.1±0.3	7.10±0.10	29±18	6±6	0.4±0.0	2.0±1.2	0.92±0.05	0.13±0.03
16	12.5±2.6	9.4±0.8	7.01±0.15	26±16	12±1	0.9±0.3	1.8±1.3	0.79±0.03	0.26±0.00
17	10.6±2.4	9.7±0.2	7.07±0.08	26±3	12±0	0.3±0.1	1.8±1.5	0.79±0.02	0.26±0.01
18	11.5±2.3	9.6±0.3	6.91±0.16	14	8	0.3±0.1	1.8	0.85	0.12
19	12.2±2.5	9.2±0.2	6.84±0.14	14	8	0.7±0.4	1.8	0.85	0.12
20	14.0±2.9	9.7±0.3	7.35±0.12	19	6	4.3±2.6	4.6	1.11	0.04
21	13.5±1.4	9.7±1.0	7.11±0.17	30	8	4.5±2.5	1.8	1.11	0.04
22	15.2±1.6	8.4±0.5	7.25±0.04	19	10	3.2±2.0	1.2	0.49	0.32
23	13.2±2.1	9.7±0.5	7.16±0.03	19	6	2.7±1.9	1.6	0.95	0.21
24	14.8±0.8	9.0±1.2	7.26±0.11	20	6	1.7±1.0	1.2	0.42	0.58
25	12.8±0.1	10.2±0.8	7.76±0.24	20	6	2.8±1.8	1.2	0.42	0.58
26	13.1±0.3	10.3±0.7	7.84±0.20	18	6	4.3±2.6	1.8	0.88	0.03
27	13.2±0.1	9.6±0.2	7.68±0.07	18	6	3.7±2.3	1.8	0.88	0.03
28	15.4±2.4	9.1±0.9	7.72±0.26	13	6	4.7±2.3	1.8	0.26	0.11
29	12.7±1.9	9.9±0.6	7.32±0.23	30	8	2.6±1.1	1.6	0.74	0.14
30	14.4±0.5	9.4±1.1	7.22±0.15	19	ND	1.6±0.3	ND	ND	ND
31	14.4±1.2	9.2±0.6	7.30±0.17	19	ND	1.6±0.4	ND	ND	ND
32	15.3±1.4	9.3±1.1	7.34±0.13	15	6	2.8±1.8	1.4	0.90	0.08
33	12.8±0.1	10.2±0.8	7.79±0.24	20	6	2.8±1.8	1.2	0.42	0.58

(WT, water temperature; DO, dissolved oxygen; TN, total nitrogen; TP, total phosphorus; ND, not determined)

± 0.41 (NTU), indicating a high transparency. However, a relatively high level (2.15 NTU) of turbidity was observed at site 17 where construction works were underway. In most sites, the levels of COD were low, but a high level (9.4 ± 1.2 mg L^{-1}) was detected at site 10. Average of concentration of total nitrogen was 0.65 ± 0.37 mg L^{-1}, and total phosphorus was 0.18 ± 0.16 mg L^{-1}. In the boundary area of the park, relatively higher levels of chemical parameters were observed.

Fish fauna

A total of 4,670 individuals of fish was collected and was classified into 30 species and 12 families. Of those 13 species were found to be endemic species of Korea (7 families, RA 17.2%, Table 2). In this study, *Zacco temmincki* (RA 63.9%) were confirmed to be abundant in the streams of the Jirisan National Park. The subdominant species were *Pungtungia herzi* (RA 6.2%), *Zacco platypus* (RA 6.1%), *Coreoleusiscus splendidus* (RA 4.8%) and *Coreoperca*

herzi (RA 3.7%). The constancy value (CV) of each site was 97.0% (*Z. temmincki*), 72.7% (*Liobagrus mediadiposalis*), 51.5% (*C. herzi*), and 48.5% (*Silurus microdorsalis*).

Among the Korean endemic species, *C. splendidus* (relative abundance of endemic species, RAE 27.8%) was dominant and the subdominant species were *C. herzi* (RAE 21.8%) and *L. mediadiposalis* (RAE 19.8%). *L. mediadiposalis*, one of the subdominant Korean endemic species, were distributed under conditions determined by substrate composting pebble, sufficient dissolved oxygen, clean water, and fast current velocity. These species are distributed either along headwater stream or valley stream. In this study, 17 species and 1,412 individuals were collected at the first and second

Table 3. The constancy values (%) of each fish species in each stream order of study sites

Species	Stream Order			Total	Species	Stream Order			Total
	1st	2nd	3rd			1st	2nd	3rd	
Anguillidae					* *Niwaella multifasciata*	6.7	8.3	33.3	12.1
Anguilla japonica	6.7			3	**Bagridae**				
Cyprinidae					* *Pseudobagrus koreanus*		8.3		3.0
Cyprinus carpio			16.7	3	* *Pseudobagrus brevicorpus*		8.3		3.0
Carassius auratus	6.7	8.3	33.3	12.1	**Siluridae**				
Pseudorasbora parva	6.7	8.3		6.1	* *Silurus microdorsalis*	40.0	58.3	50.0	48.5
Pungtungia herzi	20.0	58.3	66.7	42.4	**Amblycipitidae**				
* *Coroleuciscus splendidus*	33.3	25.0	66.7	36.4	* *Liobagrus mediadiposalis*	73.3	66.7	83.3	72.7
* *Squalidus gracilis majimae*	6.7	16.7	33.3	15.2	**Osmeridae**				
Pseudogobio esocinus		8.3	16.7	6.1	*Hypomesus niponensis*	6.7		16.7	6.1
* *Microphysogobio koreensis*		8.3	16.7	3.0	*Plecoglossus altivelis*		8.3		3
* *Microphysogobio yaluensis*			16.7	6.1	**Salmonidae**				
Rhynchocypris oxycephalu	6.7	8.3	16.7	9.1	# *Oncorhynchus mykiss*	6.7			3
Zacco temmincki	93.3	100.0	100.0	97.0	**Adrianichthyidae**				
Zacco platypus		16.7	50.0	15.2	*Oryzias latipes*		8.3		3
Cobitidae					**Centropomidae**				
Misgurnus anguillicaudatus	13.3	8.3		9.1	* *Coreoperca herzi*	40.0	58.3	66.7	51.5
Misgurnus mizolepis		8.3	16.7	6.1	**Odontobutidae**				
* *Koreocobitis naktongensis*			16.7	3.0	* *Odontobutis platycephala*	20.0	33.3	50.0	30.3
* *Iksookimia longicorpa*		25.0	33.3	15.2	**Gobiidae**				
Cobitis sinensis		8.3		3.0	*Rhinogobius brunneus*	6.7	8.3	16.7	9.1

(*, Korean endemic speices; #, exotic speices)

Table 4. The dominance, diversity, richness and evenness index of fish community in the Jirisan National Park (May 1997~Sept. 1999)

	1^{st} order (n=15)	2^{nd} order (n=12)	3^{rd} order (n=6)	Nakdong River (n=23)	Sumjin River (n=10)	Total
Dominance	0.78	0.64	0.61	0.71	0.76	0.70
Diversity	1.24	1.55	1.55	1.50	1.55	1.58
Richness	2.21	3.09	2.72	3.01	2.79	3.43
Evenness	1.01	1.12	1.17	1.06	1.21	1.07

order streams. At the third and fourth order streams, we collected 24 (1,711 ind.) and 21 species (1,547). *L. mediadiposalis* were collected at first and second (11 sites, constancy value 73.3%), third (8 sites, CV 66.7%), and fourth order stream (5 sites, CV 83.3%). *L. mediadiposalis* were distributed over headwater or valley stream. *C. splendidus, S. microdorsalis, C. herzi, P. herzi* and *Z. temmincki*, which are well known for fishes of headwater streams, were commonly observed (total ind.: 3,718). *Rhynchocypris oxycephalus* of *Rhynchocypris* sp., dominant species of headwater streams in S. Korea, were collected from 3 sites (25 ind.).

In all stream orders, *Z. temmincki* was observed high relative abundance and its constancy value was 100%. In the 1st order stream, constancy values of *L. mediadiposalis, C. herzi, S. microdorsalis* and *C. splendidus* were over 50%. These species were distributed over headwater stream and are endemics. In the 2nd order stream, *P. herzi* and *O. platycephala*, including these species, had high constancy values.

Comparison of ecological indices at stream order and river system is shown in Table 3. Dominance index shows the dominance of *Z. temmincki* and first order stream (0.78) and Seomjin River system (0.76) was higher than others. Richness index was at its highest when water reached second order stream (3.09) rather than other order streams. Evenness and diversity index was relatively high between third order streams (1.17 and 1.55) and that of Seomjin River system (1.55, 1.21) was higher than that of Nakdong River system. According to the results of clustering using the SPSS 11.0 (hierarchical cluster analysis), the sites were not significantly divided as each river systems, Seomjin and Nakdong River.

DISCUSSION

This survey suggests that mountain streams in Jirisan National Park area are very important for fish diversity and conservation, especially for the Korean endemic and endangered species. In the Nakdong River system of Mt. Jiri, endemism was also much higher in mountain streams (45.8%) than that of the middle and lower parts of the river (26.2%; Jang *et al.* 2001). The proportion of Korean endemic species in the Jirisan National Park area was highest at 3rd order stream (1st, 41.2%; 2nd, 33.3%; 3rd, 47.6%). In addition, the proportion of exotic species was very low in national park areas as compared with lowland rivers. Exotic fish, that are those species introduced to a country outside their natural range (Shafland and Lewis, 1984), were rarely observed at the Jirisan National Park. We collected 5 individuals of *Onchorynchus mykiss* at only one site in the Mt. Jiri. The *O. mykiss*, probably, had escaped from a fish farm near the site and was unhealthy compared to the cultured *O. mykiss*. *Hypomesus nipponensis*, a translated organism that are native species to a country but introduced to new areas outside their original distribution (Jang *et al.* 2003, transplanted: Shafland and Lewis, 1984), was collected from two sites.

Forty nine species (25.9% of total species) were endemic in S. Korea through an extensive literature review (Kim 1995). Fourteen endemic species of 7 families (35% of total collected species) were collected from present and previous surveys of Mt. Jiri area (40 species). Since our survey was conducted mainly in mountain or headwater streams, the numbers of collected endemic species were higher than average Korean endemism. This is partially due to habitat stability and lack of disturbances, such as introduction of exotic species and anthropogenic activities. Korean endemic species and species diversity of studied streams flowing into the West and the South Sea has a high proportion (Jang 2002). Since the length of these rivers is longer than that of streams flowing into the East Sea, species of these longer river systems have possibly more chance to evolve specialization. Many endemic species inhabit the Han River (to West Sea) and the Nakdong River system (to the South Sea) in S. Korea.

The selection of the protected area regarding stream characteristics, such as stream size and order, were more important than simple extension of protected area for conservation of fish diversity in national parks of S. Korea. However, there is a deficit of buffer zones for wild life in the national parks (Fig. 2). Moreover, four national parks (Deogyusan, Juwangsan, Bukhansan, and Sobaeksan National Park) lack buffer zones altogether. Most streams in Korean national parks are located in between the boundaries of the park and the exterior. In addition, stream size and order of the boundary area was generally bigger (high stream order) than that of

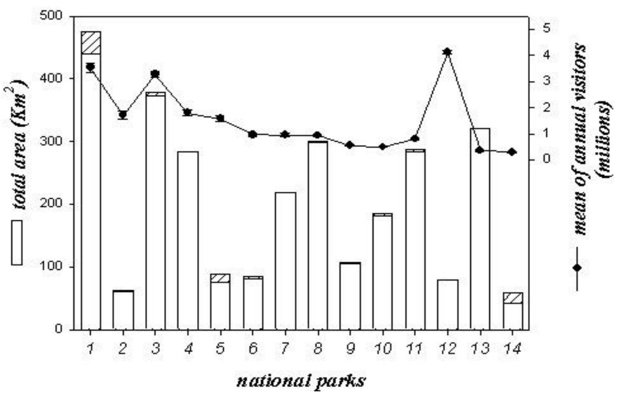

Fig. 2. Area of national park (□) and buffer zone (▨), and annual visitor number (-●-) in 14 Korean national parks (1, Jirisan; 2, Gyeryongsan; 3, Seoraksan; 4, Songnisan; 5, Naejangsan; 6, Gayasan; 7, Deogyusan; 8, Odaesan; 9, Juwangsan; 10, Chiaksan; 11, Woraksan; 12, Bukhansan; 13, Sobaeksan; 14, Wolchulsan National Parks).

national parks. Therefore, to maintain high species diversity and endemism, effective management of boundary area (especially, streams) may be more important than an extension of the buffer zone. The number of annual visitors in total national park area was over 21 millions people from 1992 to 2001 (Fig. 2). In the Jirisan National Park, although over 3.6 millions people visited every year since 1992, stream ecosystems have being rarely disturbed owing to the increased the public awareness during the last decades.

During the last several decades, streams and rivers in Korea have been drastically modified for agricultural usage and drinking water supplies with the construction of multi purpose dams, artificial reservoirs, levees, and weirs. These physical alterations and other human influences, such as road construction and deforestation, have caused dramatic changes in hydrologic regimes, and have accelerated eutrophication (Ha *et al*. 1999). In addition, large numbers of exotic fish have been introduced and these fish have been widely distributed in the large river ecosystems of Korea since the 1980's (Jang *et al*. 2001). Although introduced species can impact native ecosystems through: (1) habitat alterations; (2) introduction of diseases or parasites; (3) hybridization with native forms; (4) trophic alterations; and (5) spatial alterations (Ross, 1991), there is limited comparative information regarding the status of exotic and introduced fish in S. Korea. Most of the streams in East Asia have been also altered by human activities, and the resultant degradation of aquatic habitats for fish is of great concern (Inoue and Nakano 2001). Most small and fast flowing streams in mountains have often changed to large and low flowing streams with the construction of small weirs for irrigation and flood control. This would cause organisms adapted to rapid streams to move into more mountainous areas, and would result in their replacement by organisms adapted to slowly flowing streams (Yuma *et al*. 1998). Harrel *et al*. (1967) proposed a hypothesis that the increase in species diversity with stream order might be attributed to an increase in available habitat and a decrease in environmental fluctuations. This hypothesis could be applied to high order mountain streams in Korea. At present, the flora and fauna of Korean national parks are legally protected from human intervention. However, national park boundary areas are not large enough to encompass an entire ecosystem, and many stresses as affecting the ecosystem originate beyond park boundaries. Streams within the parks are major conduits for the exchanges of organisms, matter, and energy. In the case of fish, physical and chemical disturbances of the streams outside the protected areas are also the cause of decreasing species diversity. Until now, the importance of streams in national park boundary areas has been insufficiently recognized in S. Korea. Therefore, the protection of streams in buffer zones from human disturbance is the key to the preservation of fish diversity in national parks. For the long term management and conservation of fish fauna of the national parks and protected areas in Korea, good bench mark sites for long term monitoring, and buffer zones including boundary areas of national parks and management of catchment areas needed for conservation of fish diversity must be determined.

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Appendix

Site 1: Dalgung, Dalgung valley, Deokdong-ri, Sannae-myeon, Namwon City, Jeollabuk-do

Site 2: Seoksil, Baemsagol, Deokdong-ri, Sannae-myeon, Namwon City, Jeollabuk-do

Site 3: Eoksuteo, Deokdong-ri, Sannae-myeon, Namwon City, Jeollabuk-do

Site 4: Sannae, Sannae-myeon, Namwon City, Jeollabuk-do

Site 5: Yukmojeong, Jangan-ri, Jucheon-myeon, Namwon City, Jeollabuk-do

Site 6: Industrial area, Inwol-ri, Dong-ri, Namwon City, Jeollabuk-do

Site 7: Sildeok, Samjeong-ri, Macheon-myeon, Haman-gun, Gyeongsangnam-do

Site 8: Yongyudam, Songjeong-ri, Macheon-myeon, Haman-gun, Gyeongsangnam-do

Site 9: Chungbaekmu, Macheon-myon, Haman-gun, Gyeongsangnam-do

Site 10: Chilseon valley, Juseong-dong, Yetan-ri, Macheon-myeon, Haman-gun, Gyeongsangnam-do

Site 11: Gwangdae valley, Eumjeong-dong, Samjeong-ri, Macheon-myeon, Haman-gun, Gyeongsangnam-do

Site 12: Ansimso, Simwon, Gwasa-ri, Gwangye-myeon, Gurye-gun, Jeollanam-do

Site 13: Simwon velley, Simwon, Sandong-myeon, Gurye-gun, Jeollanam-do

Site 14: Up region of Cheonunsa, Banggwang-ri, Gwangye-myeon, Gurye-gun, Jeollanam-do

Site 15: Down region of Chonunsa, Banggwang-ri, Gwangye-myeon, Gurye-gun, Jeollanam-do

Site 16: Up region of Hwaeomsa, Masan-myeon, Gurye-gun, Jeollanam-do

Site 17: Down region of Hwaeomsa, Masan-myeon, Gurye-gun, Jeollanam-do

Site 18: Up region of Yeongoksa, Naeseo-ri, Toji-myeon, Gurye-gun, Jeollanam-do

Site 19: Down region of Yeongoksa, Naeseo-ri, Toji-myeon, Gurye-gun, Jeollanam-do

Site 20: Ssanggaesa, Unsoo-ri, Hwagae-myeon, Gurye-gun, Jeollanam-do

Site 21: Yupyong-ri, Samjang-myeon, Sancheong-gun, Gyeongsangnam-do

Site 22: Daewonsan Bridge, Yupyong-ri, Samjang-myeon, Sancheong-gun, Gyeongsangnam-do

Site 23: Pyeongchon Bridge, Pyeongchon-ri, Samjang-myeon, Sancheong-gun, Gyeongsangnam-do

Site 24: Annaewol, Namwon-ri, Samjang-dong, Sancheong-gun, Gyeongsangnam-do

Site 25: Naewonsa, Namwon-ri, Samjang-dong, Sancheong-gun, Gyeongsangnam-do

Site 26: Beopgae Bridge, Jungsan-ri, Sicheon-myeon, Sancheong-gun, Gyeongsangnam-do

Site 27: Jungsan, Jungsan-ri, Sicheon-myeon, Sancheong-gun, Gyeongsangnam-do

Site 28: Box office, Namdae-ri, Sicheon-myeon, Sancheong-gun, Gyeongsangnam-do

Site 29: Jungsan valley, Sicheon-ri, Sicheon-myeon, Sancheong-gun, Gyeongsangnam-do

Site 30: Junghak Bridge, Mukgae-ri, Cheongam-myeon, Hadong-gun, Gyeongsangnam-do

Site 31: Reservoir, Mukgae-ri, Cheongam-myeon, Hadong-gun, Gyeongsangnam-do

Site 32: Yesin, Wangseong elementary school, Daeseong-ri, Hwagae-myeon, Hadong-gun, Gyeongsangnam-do

Site 33: Wangseong elementary school, Daeseong-ri, Hwagae-myeon, Hadong-gun, Gyeongsangnam-do