Ichthyofauna distribution in downstream region of Opak River, Yogyakarta

[Persebaran iktiofauna di bagian hilir Sungai Opak, Yogyakarta]

Djumanto✉, Maria Intan P. Devi, Eko Setyobudi

Fisheries Department, Faculty of Agriculture, Gadjah Mada University
✉ Surel: lely4192@yahoo.com

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Abstract

Opak River, a river upstream on the slopes of Merapi Mount and empties into Indian Ocean, has a diverse aquatic biotic such as fishes. The aim of this study was to determine the species, abundance, and distribution of fishes in the downstream region of Opak River in Yogyakarta. The length of Opak River was approximately 60 km, the length in upper and downstream region around 30 km each. There were five sampling stations, and the station 1 was located in 5 km away from the river mouth, then followed by station 2 until 5, with the distance between stations around of 4-6 km. Fish sampling was conducted every week from May to June 2012 with six replicates, using electrofishing operated by local fishermen. The result showed that there were 2295 individuals of fishes comprising of 7 orders, 23 families, 30 genera, and 35 species. Of them, there were 26 freshwater species, 5 estuarine species, 3 marine species, and 1 catadromous species. Estuarine and marine species could penetrate into freshwater as far as about 10 km and 5 km from the river mouth, respectively. The most abundant family was Cyprinidae, and the highest individual abundance was *Barbonymus* sp., followed by *Puntius binotatus* and *Rasbora argyrotaenia*. The length distribution among fishes ranged between 2.2 and 36.0 cm, with an average of 9.12 cm. The shortest fish was *Sicyopterus longifilis*, while the longest was *Anguilla marmorata.* The weight distribution among fishes ranged from 0.07 to 505.0 g, with an average of 14.9 g.

Keywords: abundance, biodiversity, fishes, freshwater, Java.

Abstrak

Sungai Opak yang berhulu di lereng Gunung Merapi dan bermuara di Samudera Hindia, memiliki biota air yang beragam jenis, misalnya ikan. Tujuan penelitian ini adalah untuk menyajikan informasi spesies, kelimpahan, dan distribusi ikan di wilayah hilir Sungai Opak di Yogyakarta. Panjang Sungai Opak sekitar 60 km, panjang di wilayah hulu dan hilir masing-masing sekitar 30 km. Pengambilan contoh ditetapkan sebanyak lima stasiun yang dimulai dari muara, yaitu stasiun 1 terletak 5 km dari muara sungai, kemudian diikuti oleh stasiun 2 sampai 5, dengan jarak antar stasiun sekitar 4-6 km . Pengambilan contoh ikan dilakukan setiap minggu dari Mei hingga Juni 2012 dengan enam ulangan, menggunakan alat kejut yang dioperasikan oleh nelayan setempat. Hasil penelitian menunjukkan bahwa jumlah ikan hasil tangkapan diperoleh sebanyak 2295 individu yang berasal dari 7 ordo, 23 famili, 30 genera, dan 35 spesies. Berdasarkan habitatnya, ada sebanyak 26 spesies air tawar, 5 spesies air payau, 3 spesies air asin , dan 1 spesies katadromus. Spesies ikan air payau mampu bergerak masuk ke sungai yang tawar sejauh 10 km dari muara, sedangkan spesies ikan air asin bergerak sejauh 5 km dari muara. Famili yang memiliki kelimpahan spesies paling banyak adalah Cyprinidae dan kelimpahan individu tertinggi adalah *Barbonymus* sp. kemudian diikuti oleh *Puntius binotatus* dan *Rasbora argyrotaenia*. Distribusi panjang ikan berkisar antara 2,2 dan 36,0 cm, dengan rata-rata 9,12 cm. Ikan terpendek adalah *Sicyopterus longifilis*, sedangkan terpanjang adalah *Anguilla marmorata*. Distribusi bobot individu ikan berkisar 0,7-505,0 g , dengan rata-rata 14,9 g.

Kata penting: kelimpahan, keanekaragaman hayati, ikan, air tawar, Jawa.

Introduction

Freshwater resources are essential for human existence, people have settled preferentially near rivers and other water source for millennia. Consequently, freshwater ecosystems and species have suffered from ongoing stresses caused by human use since the beginning of human history. Freshwater organism are, in general, at higher risk of extinction than those in terrestrial ecosystems such as forests and grasslands (Allan *et al.* 1997, Dudgeon *et al*. 2005), and freshwater biodiversity has declined faster than either in terrestrial or marine biodiversity over the past 30 years (Xenopoulos *et al*. 2005). In Yogyakarta Special Region, there is no data about the rate of species loss in freshwater ecosystems; however it must be greater than that for terrestrial fauna (Saunders *et al*. 2002, Trijoko & Pranoto 2006).

The major factors responsible for this rapid decline in freshwater species are physical alteration, habitat loss, water withdrawal, pollution, over-exploitation, and the introduction of non-native species (Revenga *et al*. 2005). Habitat alteration is cited as a leading cause of extinction in general, and has contributed to 73% (Miller *et al*. 1989) of the fish extinctions in North America during the twentieth century.

Over the last century, freshwater ecosystems have suffered from intense human activities (Cowx 2004) resulting in habitat loss and degradation (Maitland 1995, Poff *et al*. 1997). Some activities on watershed or in river bodies can cause water biotic habitat change or degradation. Habitat alterations (e.g. pollution, dams, water diversion, changes in land use), and introduction of exotic species are the most damaging factors for native fish populations. Negative effects of pollution associated with habitat degradation, changes in fish reproductive environments, are well known and have resulted in large-scale population and species decline (Phillips & Johnston 2004). As a consequence, many native fish species have become extinct or are highly endangered, in particular in rivers of Yogyakarta Special Region where heavy demand is placed upon freshwater resources.

Fishes are a conspicuous part of riverine ecosystems, and have been exploited for aesthetic, religious, recreational, and economic reasons. However, an assessment of fish population in downstream region of Opak River is still very limited or no proper research conducted as yet. Information on the fish species composition and their distributions are frequently needed to resolve biological questions associated fisheries management, juvenile and adult population changes and research programs. The aim of this study was to investigate the diversity of fishes and their distribution inhabit in downstream region of Opak River.

Materials and methods

Study area

Opak River is situated in the eastern part of Yogyakarta Special Region extending from upstream region in Cangkringan sub-district to Pleret sub-district, and water source comes from Merapi slopes then flow downstream into the Indian Ocean. The length of Opak River was approximately 60 km and divided into two regions, namely upstream and downstream where the length in upstream and downstream was around 30 km each. The upstream morphologically is narrower (2.0-7.0 m), steeper and shallower (40-80 cm) than in the downstream that is wider (7.0-142 m), less sloping and deeper (80-160 cm). The downstream is approximately 30 km long (Figure 1) and receives effluent from the vicinity in the form of solid and liquid waste. Along the riverside is a residential area, paddy fields and home industries (traditional food, leather craft, batik). Waste that goes into the river originates from predominantly organic domestic source.

The river receives untreated sewage from household, home industry, and agricultural practice (main contributor) along the river. In the rainy season the water is abundant and the quality is good, but during the dry season the water is limited and drought occurs in some parts of the river. Along river shoreline the predominant habitat are woody riparian vegetation, various types of shrubs, food crops, and vacant land resulting in less bank erosion.

Sampling technique

The river is relatively narrow at about 7 m in upstream region and 142 m wide in downstream region, but about 8-12 m in the middle of

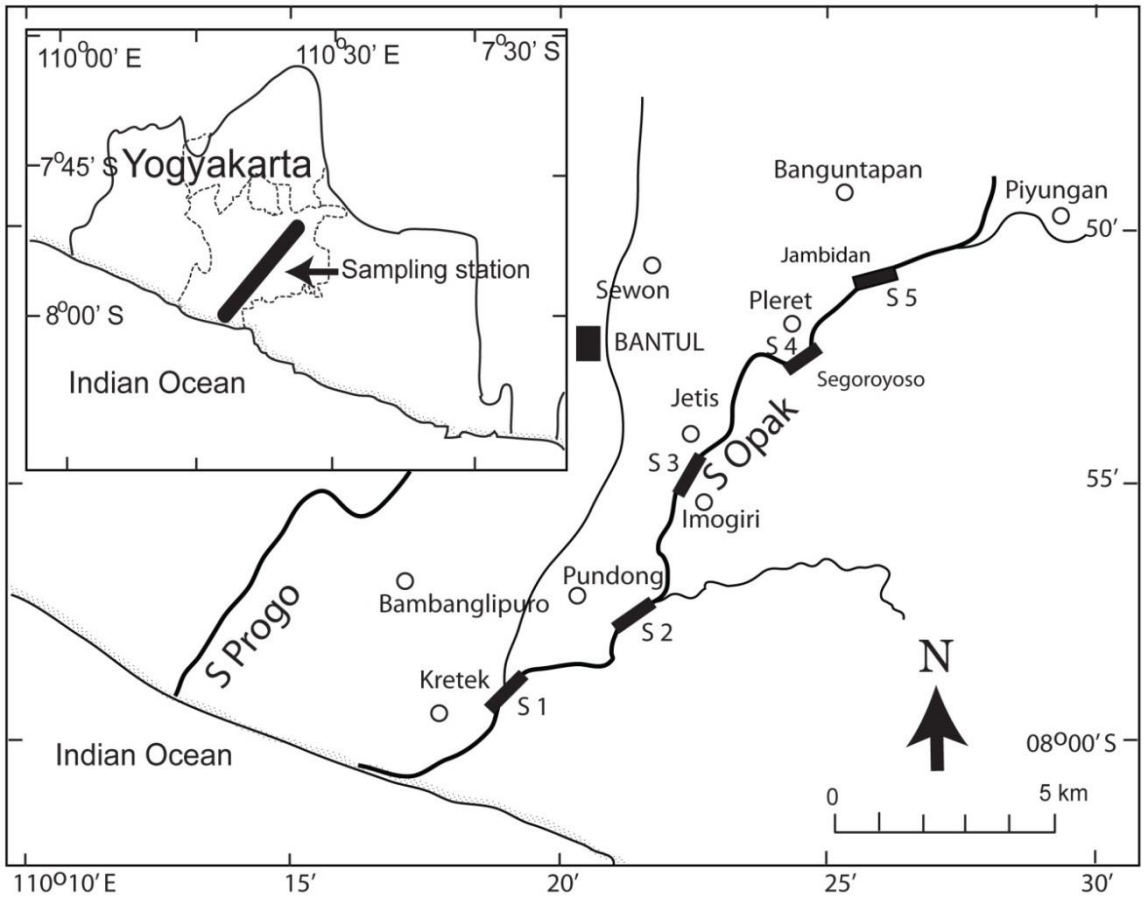

Fig 1. Map showing sampling station (S 1 to S 5) in downstream region of Opak River

river. There were five sampling stations, and the station 1 was located in 5 km away from the river mouth, then followed by station 2 until 5, the distance between stations were around of 4-6 km. Sampling operations was conducted for all wetted perimeter channel habitats, the distance between station was 4-6 km (Figure 1). Fishing was conducted weekly intervals from May to June 2012, using a set electrofishing system (Hughes *et al.* 2002) as unselective fishing gear belong to and operated by fishermen at five sampling stations. Fishing was carried out by pulled the fishing gear and moved across river body from one side to other side extending 1 km upstream direction. Fish sampling was conducted every week from May to June 2012 with six replicates.

All fish samples were collected then transported to the laboratory for identification and measurement of total length and individual weight. Fishes were identified to the species level based on Kottelat *et al*. (1993) and Nakabo (2002). The lengths were performed using measuring board to the nearest 0.1 cm. Individual fresh weight was measured to the nearest 0.1 g with an electric balance after removing residual water from the body surface.

At each sampling station, the following quantitative and qualitative microhabitat variables were recorded three replicates: water depth, current velocity, temperature, water clarity, pH, substrate and presence of submerged vegetation. Water temperature was measured to the nearest 0.1°C, and current velocity measured with drift

time of a floating ball to the nearest 1 cm s^{-1}. Water clarity was measured by immersion of a Secchi disc, pH measured with pH meter, substrate identified by substrate grabbling, vegetation type was counted as visually.

Result

River characteristic

The physical characteristics of the river were relatively similar along the river, as would be expected given the invariant gradient, land use and flow. There were no consistent longitudinal variations in width, temperature, and pH among sampling sites. There were differences between the most downstream and upstream sites, the downstream site (station 1) being more confined with muddy substratum than the upstream site (station 5) at high flows and with gravel at the bottom (Table 1). The river width tends to decrease toward upstream direction. The width in the downstream was very wide around 142 m, while in the upper stream was very narrow around 6.7 m. The depth was relatively similar towards upstream, except in the station 2 located upstream of a dam so that station was deeper than other stations. The flow rate was variable from 0.12 to 1.13 m s^{-1} with the slowest being located in station 2 which was almost stagnant, while the highest flow rate was located in the station 5 with the speed about twice than that of other stations. Water acidity was in the range of neutral between pH 7.0 and 7.3. Riparian vegetation along the river consists of perennial crops (*Bambusa arundinacea*, *Gigantochloa apus, Samanea saman*, *Musa paradisiaca, Mangifera indica*), food crops (*Oryza sativa, Manihot esculenta*), seasonal crops (*Carica papaya, Musa* spp.), wild plants (*Marantha arundacea, Ricinus communis, Colocasia esculenta, Ceratoptaris thalictroides*), shrubs (*Penisetum purpureum, Physalis minima, Saccharum officinarum*), and grass (*Cymbopogon nardus, Imperata cylindrica*).

Species composition

A total of 2295 individual fishes were collected, representing 35 species, 30 genera, 24 families, and 7 orders (Table 2) during May-June 2012. Individual number of fish in each station was tend to increase in upstream direction, except in the station 2 that was located near a dam which was the highest. The highest abundance of species was recorded in *Barbonymus* sp. (N=21.96%), followed by *Puntius binotatus* (N=16.64), *Rasbora argyrotaenia* (N=15.56), *Osteochilus vittatus* (N=6.10), and *Barbonymus schwanenfeldii* (N=5.80). The number of those species was counted for 60.26% of the total fish samples. The other 30 species contributed less than 40% of the total number of fish individuals.

Cyprinidae was comprised of seven species namely *Barbonymus schwanenfeldii, Barbonymus* sp.*, Hampala macrolepidota, Puntius binotatus, Puntius orphoides, Osteochilus vittatus,* and *Rasbora argyrotaenia.* Four families were

Table 1. Physical parameters of the sampling stations in downstream region of Opak River

Station	Width (m)	Depth (m)	Velocity (m s^{-1})	Water clarity (m)	Temperature (^oC)	pH	Substrate	Riparian vegetation
S1	142.0	0.70	0.52	0.20	29.6	7.0	muddy	elephant grass, taro, lemon grass
S2	93.0	1.60	0.12	0.90	28.8	7.0	sand muddy	ferns, bananas, grass,
S3	49.4	0.60	0.65	0.60	28.6	7.1	Sand muddy	bamboo, mango, coconut, bananas, ferns, grass,
S4	10.1	0.60	0.49	0.60	29.2	7.3	rocky sand	bananas, bamboo, ferns, and grasses
S5	6.7	0.80	1.13	0.20	29.2	7.0	stone sand	grasses, bamboo, banana

represented by two species namely Channidae (*Channa striata, Channa gachua),* Cichlidae (*Oreochromis niloticus, Oreochromis* sp.), Gobiidae (*Glossogobius circumspectus, Sicyopterus longifilis*), and Bagridae (*Hemibagrus nemurus, Hemibagrus planiceps*). Nineteen families were represented by one species, namely Anabantidae (*Anabas testudineus*), Osphronemidae (*Trichopodus trichopterus*), Carangidae (*Caranx sexfasciatus),* Ambassidae (*Ambassis vachellii*), Eleotrididae (*Eleotris melanosoma*), Lutjanidae (*Lutjanus argentimaculatus*), Mastacembelidae (*Macrognathus aculeatus*), Mugilidae (*Mugil cephalus*), Osphronemidae (*Osphronemus goramy*), Rhyacichthyidae (*Rhyacichthys aspro*), Nemacheilidae (*Nemacheilus fasciatus*), Cobitidae (*Lepidocephalichthys hasseltii*), Clariidae (*Clarias batrachus*), Loricariidae (*Pterygoplichthys pardalis*), Synbranchidae (*Monopterus albus*), Hemiramphidae (*Dermogenys pusilla*), Poeciliidae (*Poecilia* sp.), Anguillidae (*Anguilla marmorata)* and Syngnathidae (*Microphis argulus).*

Species distribution

Among the 35 species, only eleven species were found in all five sampling stations (Figure 2), two herbivorous cyprinids (*Barbonymus* sp*., R. argyrotaenia*), three carnivorous fishes (*B. schwanenfeldii, H. nemurus, H. planiceps*), one omnivorous cyprinids (*P. binotatus*), and two other omnivorous fishes (*T. trichopterus*, *O. niloticus*), and the rest made up of three carnivorous fishes (*C. striata, C. batrachus, D. pusilla*). There were five species found only in station 1 that located is in 5 km away from the river mouth (*A. vachellii, M. cephalus, M. argulus, C. sexfasciatus, L. argentimaculatus*). There were four species found only in station 2 that is the deepest station (*C. gachua, L. hasseltii, O. goramy, E. melanosoma*). Two species, namely *M. albus* and *Oreochromis* sp., was found in station 4 that narrowest and shallowest than other station.

The distribution of fishes was varied between stations. The small size (total length < 15 cm) for instance planktivorous *N. fasciatus,* found to be abundant in station 4 and 5 where the water was very shallow (0.6-0.8 m) and width of stream narrow (6.7-10.1 m). The big size (total length > 15 cm) for example herbivorous *O. goramy*, carnivorous *H. macrolepidota,* and *C. striata* were found to be abundant in station 2 where the water was deep (1.6 m) and water body wide (93.0 m). The abundance of fish species in the station 5 was primarily dominated by *Barbonymus* sp. (%N=9.1%)*,* while the station four and five were primarily dominated by *R. argyrotaenia* and *C. sexfasciatus* (%N=11.85% and 2.57%).

Based on the habitat preferences, there were 26 fishes identified as fresh water species, five fishes as brackish water species, three fishes as marine species and one fish as catadromous species (Figure 2). Brackish water species could be found from station 1 until station 2 where the distance was about 5 to 10 km away from the sea. Interestingly, marine species such as *L. argentimaculatus*, *C. sexfasciatus*, and *M. argulus*, could be found in station 1 even though it was nearly freshwater. Station 1 was located close to the river mouth with a distance approximately 5 km away from coastal line, and it can be considered as a tidal influenced habitat.

Size distribution

The length distribution of fish showed a range between 2.2 and 36.0 cm with standard deviation value was between 0.1 and 7.4 cm (Figure 3). The smallest species was *S. longifilis* (Gobiidae), while the largest was *A. marmorata* (Anguillidae)*,* and an average length ranged bet-

ween 6.3 and 16.6 cm. There were five species (14.3%) namely *D. pusilla, Poecilia* sp.*, M. cephalus, L. hasseltii,* and *S. longifilis*, less than 5 cm, and some 18 species (51.4%) was less than 10 cm, and the rest (34.2%) more than 10 cm. The widest range between the longest to the shortest was *C. striata* (28.5 cm), while the smallest range was *Poecilia* sp. (1.2 cm).

Table 2. List and abundance of fishes caught during May-June 2012 sampling in station S1-S5 downstream region of Opak River

No	Scientific name	English Name	S1	S2	S3	S4	S5	Total	(%)
1	*Ambassis vachellii* **	vachelli's glass perchlet	3					3	0.13
2	*Anabas testudineus*	climbing perch	1	2	1		1	5	0.22
3	*Anguilla marmorata* ****	giant mottled eel	1	1				2	0.09
4	*Barbonymus schwanenfeldii*	tinfoil barb	20	40	20	16	37	133	5.80
5	*Barbonymus* sp.	-	3	43	154	95	209	504	21.96
6	*Caranx sexfasciatus* ***	bigeye trevally	59					59	2.57
7	*Channa gachua*	-		7				7	0.31
8	*Channa striata*	striped snakehead	7	14	2	8	3	34	1.48
9	*Clarias batrachus*	walking catcfish	1	1	3	19	3	27	1.18
10	*Dermogenys pusilla*	wrestling halfbeak	8	10	3	40	17	78	3.40
11	*Eleotris melanosoma* **	broadhead sleeper		2				2	0.09
12	*Glossogobius circumspectus* **	circumspect goby	8	5				13	0.57
13	*Hampala macrolepidota*	hampala barb	17	58	9		4	88	3.83
14	*Lepidocephalichthys hasseltii*	-		1				1	0.04
15	*Lutjanus argentimaculatus* ***	snapper	1					1	0.04
16	*Macrognathus aculeatus*	frecklefin eel			1	1		2	0.09
17	*Microphis argulus***	flat nose pipefish	1					1	0.04
18	*Monopterus albus*	asian swamp eel				1		1	0.04
19	*Mugil cephalus* **	flathead grey mullet	3					3	0.13
20	*Hemibagrus nemurus* **	asian redtail catfish	4	6	22	16	34	82	3.57
21	*Hemibagrus planiceps* **	-	3	3	27	1	6	40	1.74
22	*Nemacheilus fasciatus*	barred loach				43	48	91	3.97
23	*Oreochromis niloticus* *	nile tilapia	1	7	11	4	33	56	2.44
24	*Oreochromis* sp.*	red tilapia				1		1	0.04
25	*Osphronemus goramy* *	giant goramy		1				1	0.04
26	*Osteochilus vittatus*	bonylip barb		17	8	54	61	140	6.10
27	*Osteochilus melanopleura*	-		10		4		14	0.61
28	*Poecilia* sp.	guppy	2		3	5	8	18	0.78
29	*Pterygoplichthys pardalis*	suckermouth catfish	4		8	6	4	22	0.96
30	*Puntius binotatus*	silver barb	46	201	49	46	40	382	16.64
31	*Puntius orphoides*	javaen barb		13	5	15	15	48	2.09
32	*Rasbora argyrotaenia*	silver rasbora	21	272	13	45	6	357	15.56
33	*Rhyacichthys aspro* **	loach goby	3	3				6	0.26
34	*Sicyopterus longifilis*	threadfin goby	5	15				20	0.87
35	*Trichopodus trichopterus*	three spot goramy	12	23	6	9	3	53	2.31
	Total (individual)		234	755	345	429	532	2295	
	Percentage (%)		10.2	32.9	15.0	18.7	23.2		

*Non native fishes ** brackish water fishes ***marine fishes **** Catadromous fishes

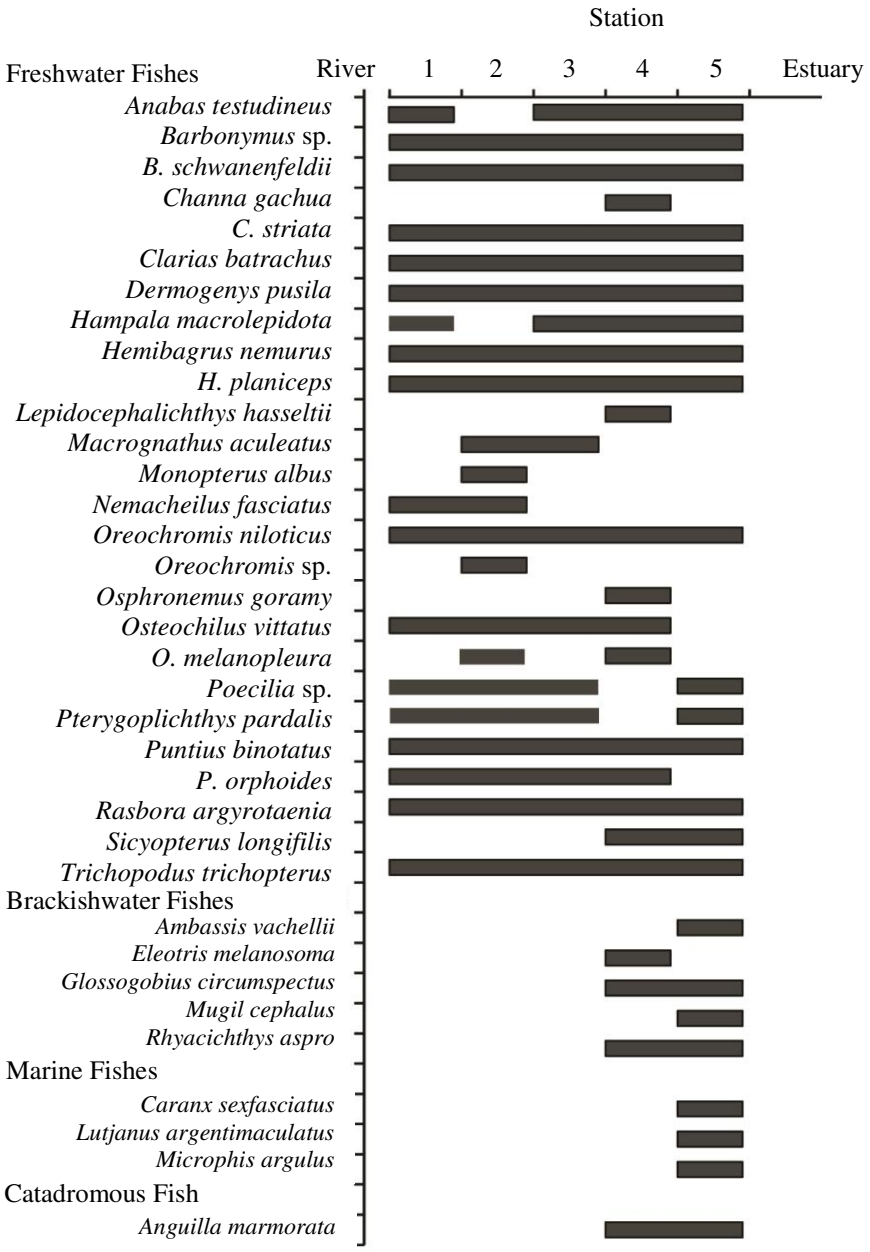

Figure 2. The fishes found (indicated by bar) during May-June 2012 sampling survey along the downstream region of Opak River

The weight distribution of fish showed a range between 0.13 and 505 g (Figure 3). The smallest fish weight was *D. pusilla*, while the largest weight of fish was *B. schwanenfeldii*. Average weight ranged between 0.5 and 71.0 g. The average weight of six species, namely *A. vachellii, D. pusilla, Poecilia* sp.*, L. hasseltii, M. argulus,* and *N. fasciatus* was less than 1 g, thirteen species was between 1 and 10 g, while the rest (16 species) was more than 10 g.

Discussion

The number of fishes found in this research was 35 species, which was relatively higher than those found by Trijoko & Pranoto (2006) that found as many as 22 species. It was also higher than those found by Djumanto & Probosunu (2011) that found as many as 12 species. Djumanto & Probosunu (2011) conducted research using similar method in Gendol River as tributaries of Opak River upstream region. Mean-

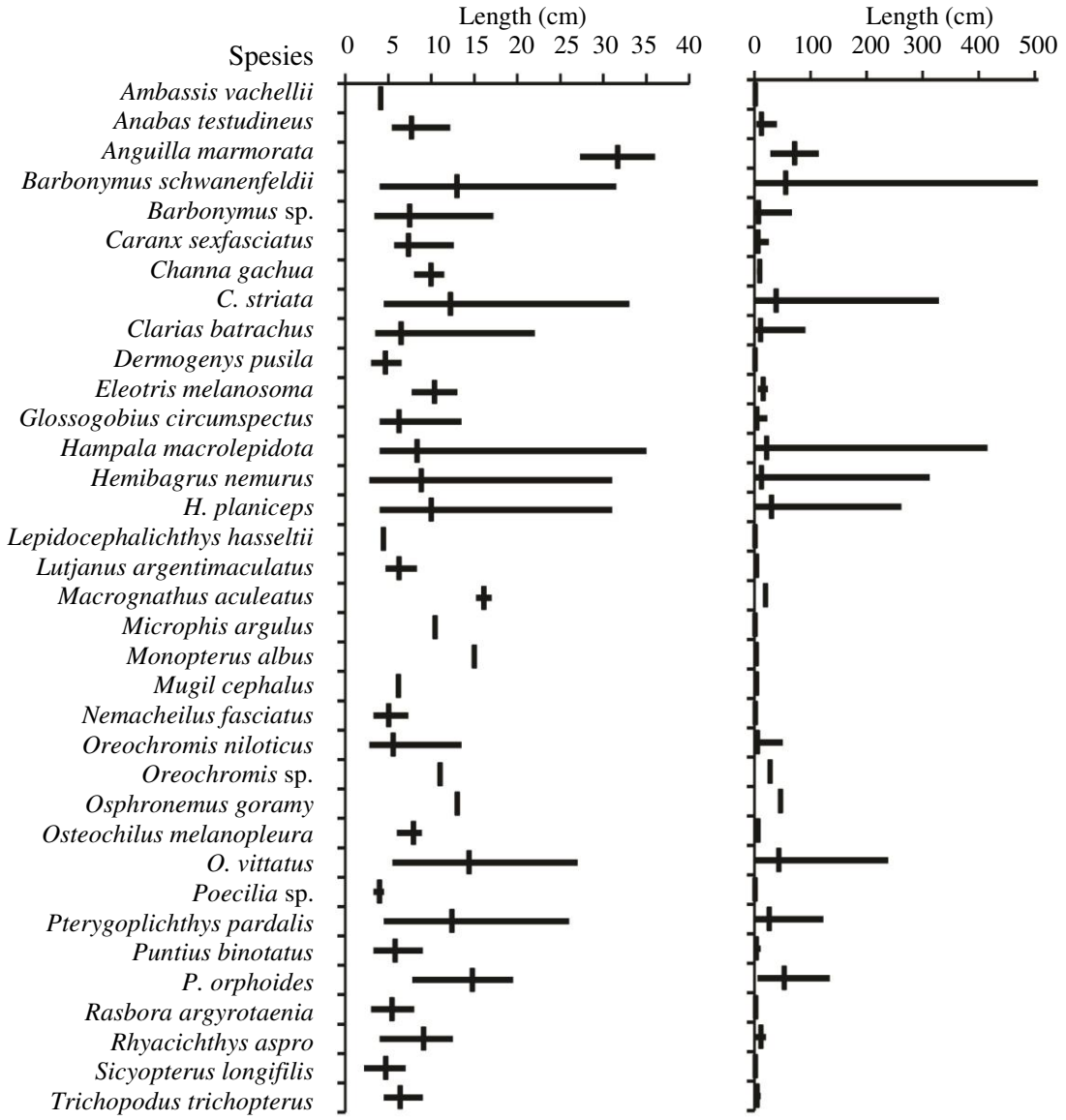

Figure 3. Horizontal bars showing from minimum to maximum distribution of length (left) and weight (right) of fishes collected from downstream region of Opak River, vertical bars as average

while, Trijoko & Pranoto (2006) conducted research in Opak River by electrofishing at 20 stations using swept area sampling of 100 m with three replicates during March and April. The differences of fishes was possibly caused by covering area of sampling was broader, and fishingwas conducted more frequently, and sampling time was conducted in the middle of the dry season. Although cyprinids dominated among sampling station, but the composition and species was different. Cyprinids species namely *Barbonymus* sp.*, P. binotatus,* and *R. argyrotaenia* was the most abundant in this research, while Trijoko & Pranoto (2006) found *P. binotatus* and *N. fasciatus* was the most predominant. On the other hand, the most abundant species in tributaries was *N. fascuatus*, *P. binotatus*, and *P. reticulata* (Djumanto & Probosunu 2011).

The high individual dominance of some fish species in downstream region of Opak River was related to seasonal disturbances, such as large and unpredictable variations in water level

and river discharge (Silvano *et al.* 2000), flow regime and gravel river bed (Jowett *et al*. 2005) which favor some species better adapted to such conditions. Floods and droughts were the key elements of the flow regime that affected fish abundances. The floods in rainy season allowed recruitment of riverine species and had no detrimental effect on adult fishes, whereas droughts during dry season reduced habitat for species with a preference for high water velocities and had detrimental effects on fish abundances that were proportional to the magnitude and duration of low flows. Most tropical riverine fishes prefer to spawn in the mid rainy season (Stickney 2005, Kottelat *et al*. 1993), while some species prefer to spawn at the end of the rainy season, such as *R. lateristriata* in Ngrancah River that spawn in the end of rainy season (Djumanto *et al*. 2008). The occurrence of spawning in fish is influenced by both internal and external factors of the fish (Stickney 2005). External factors such as availability of suitable spawning site, adequate water, availability of mate and food supply are very crucial for fish spawning success. Some species of cyprinid need good water quality, such as high water clarity and oxygen concentrations, and suitable habitat that fulfill in the end of rainy season (Djumanto *et al*. 2008). The combination of rainy recruitment and dry low flows resulted in variations in fish abundances, with higher abundances in lower area of river. At the downstream region of Opak River, seasonal changes of water level probably occur usually as flood pulses. These flood pulses are predictable in time, enabling a great number of fish species to cope with these fluctuations.

Many studies have demonstrated that only a few species from several representative families can adapt well to the highly variable abiotic, such as temperature, silt, oxygen, drought, flow regime (Jowett *et al*. 2005) and biotic (predation and competition) conditions in river habitats (Quan *et al.* 2009). The common species that utilize gravel river bed as nursery habitat are cyprinid taxa such as *Barbonymus* sp*., P. binotatus*, and *R. argyrotaenia*. These taxa have been identified as riverine specialists in many regions (Nelson 2006). For example, Trijoko & Pranoto (2006) found that, of the total fish abundance sampled along upstream region of Opak River, *P. binotatus* accounted for more than 54% followed by *N. fasciatus* accounted more than 16%. Cyprinid species dominated in number both in upstream and downstream region of Opak River.

Fish community found close to the estuary usually comprise of true freshwater fishes, brackish water fishes, marine fishes, catadromous species, and visitor species. Among those fishes were found in the varied stage of their life cycle inhabited in the downstream region of Opak River. Based on the habitat preferences, there are four categories found in the downstream region of Opak River, these are:

a) True fresh water fish was the biggest fish that inhabit the river ecosystem from upstream to downstream. In this species found young fish and adult phases that most of the family Cyprinidae (*Barbonymus* sp*., B. schwanenfeldi, P. binotatus, R. argyrotaenia*), Bagridae (*H. nemurus, H. planiceps*), Channidae (*C. striata*), Clariidae (*C. batrachus*), and Osphronemidae (*T. trichopterus*).
b) True brackish water fishes, which species complete their life cycle in ecosystem of estuary. This group was found to inhabit the station 1 and 2, which the distance of station 2 to the river mouth is about 10 km. The species consist of family Ambassidae,

Eleotrididae, Mugilidae, and Rhyacichthyidae. Numbers of individual was found to be few and of small size or juvenile stage, so the river ecosystem was used as nursery and feeding ground.

c) The marine species is a species of fish that move up into the upstream region in search of food, so river ecosystem as temporary habitat. These groups were *C. sexfasciatus, L. argentimaculatus,* and *M. argulus.* Those fishes were found only in station 1 which the distance to the river mouth about 5 km, and very few numbers and small size.

d) Catadromous species is a species that life in fresh water and migrate to sea for reproduction. This group was represented by Anguillidae (*Anguila marmorata*), found in station 1 and 2 as a habitat for living.

The presence of mangrove ecosystems in estuary and water quality in good condition could play an important role in influencing the abundance of fish in the area. Ecosystem of the downstream regions of Opak River plays an important role as habitat for shelter from predators attack. This occurs due to the high diversity of habitats such as river basins, the rapids zone, the shallow and deep water so that it becomes a comfortable place to shelter for young fish. In addition, these ecosystems have high productivity to provide food for the young fish. As a result, the abundance and diversity of fish in estuary ecosystem is very high (Zahid *et al.* 2011).

Management and conservation of public resource

The fishing activities in public waters, such as lower part of Opak River, in Yogyakarta are very intensive by using various types of fishing gear. The mean catches ranged from 0.5 to 2.5 kg per hour with a selling price between Rp 5,000 to Rp 25,000 or US$ 0.50 to US$ 2.50. The high fishing activity is shown by the estimated number of fisherman using electric stunner or electrofishing in Bantul Regency of about 200 people. It is estimated they do fishing with frequency about 5-10 per month and duration of 3-5 hours a day. Although not available yet an accurate official data, but this shows that river fishing activity is very important and have not gotten yet the attention of relevant agencies.

Fish populations in river waters are particularly vulnerable to the entry of domestic waste disposal, home industry, agriculture and industrial wastes. Waste is often a major source of environmental pollution. High fishing activity and environmental pollution causes fish populations to decline drastically. Effect of contaminants on fish populations were varies depending on the type and concentration of contaminants, fish species, fish age, duration of pollutants exposure and environmental conditions. For instance, cadmium at a concentration of 2 µg Cd^{+2} l^{-1} ppm may cause impaired on sensory systems and affect to habitat selection in *Galaxias fasciatus*, which ultimately affect the distribution of populations (Baker & Montgomery 2001). If this condition continues, it can cause the extinction of fish species in the river waters. Some fish species are difficult to catch, such as frecklefin eel (*M. aculeatus*), asian redtail catfish (*H. nemurus*) and others, which was originally found in many rivers in Java, now is very difficult to catch.

An action should be taken to increase the fish population of the river waters. Some actions that can be done in several areas such as reintroduction of fish in the area that population has decreased, establishment of reserves around spawning sites, setting of fishing zones and fishing activity monitoring. These activities must involve all relevant stakeholders such as department of fish-

eries, government, community and other interested parties. Despite some local successes, these efforts have not been successful basin-wide, with regard to either conservation or improving the sustainability of fisheries. Reasons for failure include: (1) insufficient knowledge of the managed systems, (2); lack of clear objectives, (3) use of inadequate management protocols and (4) lack of monitoring.

Conclusion

The ecosystem of downstream region of Opak River contains rich fish resources. There were 35 species of fish consisting of 26 species freshwater fish, 5 species of estuarine fish, and 3 species of marine fish, and 1 species of catadromous species. Freshwater species were distributed among the various sampling stations. Marine and estuarine species penetrated until 5 km and 10 km, respectively, away from the river mouth. The most dominant family was Cyprinidae, and the most abundant species was *Barbonymus* sp. followed by *P. binotatus* and *R. argyrotaenia*. The smallest species was *S. longifilis*), while the largest was *A. marmorata*), and an average length ranged between 6.3 and 16.6 cm. There were five species less than 5 cm, and some 18 species was less than 10 cm, and 12 species more than 10 cm.

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