Community structure of fish in Jinan Region, China

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Abstract. To understand the community structure characteristics of fish, in spring (May) and in autumn (October) 2015, 25 sampling sites of Jinan Region was investigated. Result showed that 34 and 24 species of fish of spring and autumn were identified. TP, SS and TN is important environmental factors affecting of fish community structure of Jinan Region respectively in spring, TP and TN were important environmental factors affecting of fish community structure of Jinan Region respectively in autumn.

1. Introduction
In recent years, fish community has been one of hotspots and focuses in the existing researches of river ecology all the time [1, 2]. Fish community is one of species most widely distributed in river ecosystem [3, 4] and plays an indispensable role in ecological functions, such as material circulation and information transfer in river ecosystem [5, 6]. In recent years, as an indicator species for evaluating environmental health, fish community has been widely used for monitoring river ecology and plays a role of guiding and monitoring protection and management for rivers [7, 8].

Jinan region (Shandong province) is famous for spring water in China. In recent years, owing to decreasing rainfall and constantly exploitation of spring water in Jinan region, underground water level in the region has reduced and spring water stopped, so that spring culture in Jinan region reduces greatly. In the meanwhile, the increase of human activities results in that water bodies, like Daming Lake in Jinan city lack of fresh water for supplement, causing more serious water pollution. Moreover, due to absence of governance, most rivers in city have become sewage outfalls for industrial waste water and sanitary sewage, so ecological protection of rivers in Jinan region is imperative.

2. Materials and methods
2.1. Collection of fish samples
In accordance with the field conditions in Jinan region, 25 sampling points were set in total (Fig.1). Two persons collected fishes in the range 400 meters in the upstream and downstream of each sampling point. In 30 minutes, one was responsible for collecting fishes by using an electric shock instrument, while the other one held a brail and a bucket to collect fish using the braid and putting the fish in the bucket. After collection, the fishes were identified and treated in the field. The species of all fish samples were identified. At sampling points with water depth exceeding two meters, the fish
samples were collected by using the hanging net method. In these regions, the hanging nets were hung in different regions of sampling points and then taken back after 30 minutes.

2.2. Determination of water environmental factors
When determining water environmental factors in different seasons and sampling points in Jinan region, these, including water temperature (Temp), conductivity (Cond) and dissolved oxygen (DO) were determined by using a water quality analyzer in the field. The pH value was determined by utilizing a portable acidity meter. The collected parallel water samples were taken back to the laboratory for determination. Based on relevant standards \cite{16}, the following indexes, including suspended solid (SS), alkalinity (Alk), ammonia nitrogen (NH$_4^+$), total nitrogen (TN), nitrite nitrogen (NO$_2^-$), total phosphorus (TP), calcium ions (Ca$^{2+}$), hardness (TD) and permanganate index (COD$_{ Mn }$) were determined \cite{9}.

2.3. Data analysis and processing

2.3.1. Structural characteristics of fish community and analysis of water environmental factors.
The relevant data, such as species of fishes, density, biomasses and Shannon-Weiner indexes at each sampling point were calculated. The principal component analysis (PCA) was firstly carried out on water environmental parameters at each sampling point and then the canonical correspondence analysis (CCA) was conducted on water environmental parameters and fish community \cite{9}.

2.3.2. Data analysis. SPSS 18.0 was used for correlation analysis of data and box diagram was analyzed through Origin Pro 7.0. Histogram was analyzed by using WPS 2013, while PCA and CCA were conducted through Canoco 4.5. Moreover, map of sampling points was drawn on Arc Map 10.0.

3. Results

3.1. Structural characteristics of fish community and correlation with environmental factors
There are 34 species of fishes in five orders identified in two seasons in Jinan region, mainly belonging to Cypriniformes. Moreover, 34 and 24 species of fishes are mainly found in spring and
In spring, species belonging to Cypriniformes has the largest number (23), followed by those in Perciformes (six species), while other fish species are less. In autumn, there are 16 species belonging to Cypriniformes, involving most species, followed by Perciformes (four species). Moreover, there are only small numbers of other species belonging to Siluriformes and Synbranchiformes. In terms of density, the species belonging to Cypriniformes are dominant in the two seasons. In spring, the density of species in Cypriniformes accounts for 90.67% in the total density, while that of species in Perciformes accounts for 8.12% in the total density. In autumn, the densities of species in Cypriniformes and Perciformes separately account for 89.61% and 7.89% in the total density. In these two seasons, the densities of other species belonging to Cyprinodontiformes, Siluriformes and Synbranchiformes are less (Tables 1 and 2).

### Table 1. Species number and percentage of fishes in Jinan Region in spring

| Family            | Number of species | Ratio of the density |
|-------------------|-------------------|----------------------|
| Cypriniformes     | 23                | 90.67%               |
| Perciformes       | 6                 | 8.12%                |
| Siluriformes      | 3                 | 1.04%                |
| Synbranchiformes  | 1                 | 0.13%                |
| Cyprinodontiformes| 1                 | 0.04%                |

### Table 2. Species number and percentage of fishes in Jinan Region in autumn

| Family            | Number of species | Ratio of the density |
|-------------------|-------------------|----------------------|
| Cypriniformes     | 16                | 89.61%               |
| Perciformes       | 6                 | 7.89%                |
| Siluriformes      | 1                 | 1.53%                |
| Synbranchiformes  | 1                 | 0.97%                |

From the perspective of seasons, fish species in spring in Jinan region are more than those in autumn at most sampling points. The average number of fish species in the whole region in spring is 5.56 and the largest number at a single point is 15, locating at point J1. In autumn, the average number of fish species in the whole region is 4.60 and the largest number at a single point is 10, also locating in point J1. At this point, the fish species mainly include *Sarcocheilichthys nigripinnis*, *Pseudorasbora parva* and *Opsariichthys bidens*. The density of fish is low in the region and the density in autumn is obviously higher than that in spring. The average density of fish in spring in the whole region is 33.16 and the largest density at a single point is 176.00, found at point J25. This point is mainly dominated by *Huigobio chinssuensis*. In autumn, the average density of fish in the whole region is 44.68 and the density at a single point reaches the highest of 152.00, also locating at point J25 that mainly shows *Rhodeus lighti*. The biomass of fish in spring is obviously higher than that in autumn. The average biomass of fish in spring is 433.79 g and the highest biomass at a single point is found at J16 and reaches 2,786.00 g. In autumn, the average biomass of fish is 336.28 g. The highest biomass at a single point is 1,653.00 g (point J3). In Jinan region, the diversity of fish community in spring is generally higher than that in autumn. The average Shannon-Weiner index of fishes in spring is 1.68 and the highest diversity at a single point is found at J1 located in southern mountain area, presenting the highest Shannon-Weiner index of 3.58. In autumn, the average Shannon-Weiner index of fishes is 1.42. The highest diversity at a single point is also found at J1 in southern mountain area where the largest Shannon-Weiner index is 2.75 (Fig. 2).
Fig. 2 Community structure of fish in spring and autumn in Jinan Region
Box diagram analysis demonstrates that in Jinan region, the number of species, density and Shannon-Weiner index of fishes in spring are significantly higher than those in autumn, while the biomass of fishes in spring is lower than that in autumn (Fig. 3). Statistical analysis results show that the number of species (R=0.554, P<0.01), density (R=0.429, P<0.05) and Shannon-Weiner index (R=0.458, P<0.05) of fish communities in spring and autumn in the region are significantly different, while the differences of biomasses (R=0.124, P>0.05) of fish communities in the two seasons are unobvious. Therefore, this supports the results of box diagram analysis.

![Fig.3 The community structure of fish in spring and autumn](image)

The values of water environmental factors in spring and autumn in Jinan region are shown in Table 3. The results demonstrate that the average water temperature in spring is 20.72 °C, while that in autumn is 13.38 °C. The average pH values in the two seasons are separately 8.09 and 8.14, so the water is alkaline. Cond and the contents of Ca$^{2+}$, ALK, TD, NH$_4^+$, NO$_2^-$ and TP in water in spring are higher than those in autumn, while the contents of SS, DO, TN and COD$_{Mn}$ are lower than those in autumn. In spring and autumn, pH, NH$_4^+$ and COD$_{Mn}$ are significantly correlated (P<0.05), while Cond, Ca$^{2+}$, TD and NO$_2^-$ show extremely significant correlation.

| Environment factors | Spring | Autumn |
|---------------------|--------|--------|
| T(°C)               | 20.72±1.92 | 13.38±1.93 |
| pH                  | 8.09±0.28 | 8.14±0.36 |
| Cond(ms/m)          | 999.04±532.92 | 990.33±561.87 |
| SS(mg/L)            | 72.29±196.63 | 73.17±188.00 |
| Ca$^{2+}$(mg/L)     | 66.40±27.44 | 66.22±26.96 |
| ALK(mg/L)           | 180.77±64.51 | 151.96±47.73 |
| TD(mg/L)            | 308.84±105.95 | 290.37±95.95 |

| Environment factors | Spring | Autumn |
|---------------------|--------|--------|
| DO(mg/L)            | 8.53±1.34 | 8.72±1.37 |
| TN(mg/L)            | 3.22±2.18 | 3.58±1.93 |
| NH$_4^+$(mg/L)      | 0.81±1.56 | 0.64±0.43 |
| NO$_2^-$ (mg/L)     | 0.14±0.22 | 0.10±0.15 |
| COD$_{Mn}$ (mg/L)   | 4.48±2.35 | 4.84±2.04 |
| TP(mg/L)            | 0.21±0.41 | 0.18±2.04 |

| P                   | 0.69    | 0.69    |
|                     | 0.00**  | 0.00**  |
| P                   | 0.05    | 0.05    |
|                     | 0.00**  | 0.00**  |

| P                   | 0.13    | 0.13    |
|                     | 0.08    | 0.01*   |
| P                   | 0.01*   | 0.00**  |
|                     | 0.01*   | 0.32    |

* $P < 0.05$, ** $P < 0.01$
PCA results in spring and autumn in Jinan region show that two principal axes of PCA in the two seasons separately explain 61.91% and 69.41% of data-carrying capacities. The changes of two principal axes in spring are mainly affected by water environmental factors, such as TP, TN, total alkalinity (TA), SS and pH, while water environmental factors including TP, TN, SS, Cond and Ca\(^{2+}\) mainly influence the changes of two principal axes in autumn (Fig. 3). The common driving factors of water environment in the two seasons are TP, TN and SS (Fig. 4).

The CCA results of fishes in spring and autumn in Jinan region (Fig. 5) present that the correspondences between structures of fish communities and water ecological factors are different in spring and autumn in the region. In spring, there are a large number of fish, rich species and complex structure. TP (\(P=0.01\)), TN (\(P=0.02\)) and SS (\(P=0.04\)) are main environmental factors influencing fish community in spring. Of them, TP greatly affects the second principal axis and shows a positive correlation, while TN significantly influences and is positively correlated with the first principal axis. SS mainly greatly affects the second principal axis and has a positive correlation. In autumn, the number of fish species reduces and structure of community changes greatly. Moreover, response of fish community to driving factors decreases. For the above reasons, TP (\(P=0.03\)) and TN (\(P=0.04\)) are main environmental factors affecting fish community in spring and they greatly affect and have a positive correlation with the second principal axis.

### 4. Discussion

Based on the survey results, it can be seen that 34 fish species in five orders are identified in Jinan region. All of these species, that is, the largest number of species, appear in spring, while there are only 24 species in autumn. In these two seasons, species in Cypriniformes are dominant, while other fish species are relatively less. With regard to the average densities, there are 33.16 and 44.68 fish in the two seasons separately, and the average biomasses of fish communities are 433.79 g and 336.28 g. This may be because food (Chironomidae larva) of fishes in water in autumn is in the fertile period, so that the total density of fish in autumn is higher than that in spring. A lot of researches demonstrate that Shannon-Weiner index of fish community can be used to evaluate water conditions to some extent [6, 21, 22]. The averages Shannon-Weiner index of fishes in spring and autumn in Jinan region are relatively lower and reach 1.68 and 1.42, respectively. While evaluating the water-quality standard only according to Shannon-Weiner index [6, 10], as the value of the index ranges from 1 to 2, water in Jinan region shows moderate pollution in the two seasons.

The correlation between fish communities and water environmental factors in spring and autumn in Jinan region was analyzed through CCA. The results show that fish communities in the two seasons have certain differences. TP, TN and SS exert certain influences on fish communities in the two seasons. Of them, the contents of nitrogen and phosphorus in water are important indexes for measuring pollution degree of water all the time and play an important role for survival and breeding of fishes in the long term [4, 6]. The increase of contents of nitrogen and phosphorus in water can raise degree of eutrophication of water, so that structure of fish community in water becomes simpler and species and density of fish community decrease correspondingly [11, 12]. TP and TN, as main water environmental factors affecting fish communities in spring and autumn in Jinan region, have a positive correlation with structure of fish community in spring, while they are negatively correlated with the structure in autumn. SS has certain influences on and a positive correlation with the structure of fish community in spring [13].

### 5. Conclusion

In this survey, 34 and 24 floating fishes were separately indentified, and there are 33.16 and 44.68 fish in terms of average species densities, in spring and autumn. Moreover, the average biomasses are 433.79 g and 336.28 g and the average Shannon-Weiner indexes are 1.68 and 1.42. By evaluating water body in Jinan region by using Shannon-Weiner index, it is found that the water is moderately polluted.
In the survey of water environmental factors, TP and TN are environmental factors affecting fish communities in spring and autumn. TP, TN and SS are main environmental factors influencing structure of fish community in spring, while TN and TP are main influencing factors in autumn.

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