Application of Species Cumulative Curve in the Investigation of Swimming Organisms in the Fishway of Cao'e River

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Abstract: Using the species cumulative curve (EstimateS) to analyze the monitored swimming biological data in the Cao'e River gate fishway, the results showed that as the number of sampling increased, the number of species gradually increased, and the cumulative curve rose sharply and then became smooth asymptote, indicating that the swimming organisms in the fishway were fully sampled; there were estimated to be 30 species of swimming organisms in the fishway, and 27 species were found in the actual sample survey, and the survey discovery rate reached 90%, and the sampling survey effect was good.

1. Introduction
In the survey of biological populations and communities, due to objective reasons, most surveys can only take the form of sampling, and whether the sampling amount is sufficient determines the accuracy of the survey data to a large extent. Species accumulation curves are used to describe the increase of species with the increase in sampling amount. They are an effective tool to understand the species composition of survey plots and predict species abundance. They are widely used in biodiversity and community surveys. It is used to judge the adequacy of the sampling amount and estimate the species richness[1-2]. In the current international related research, the species accumulation curve is generally used to judge whether the sampling amount is sufficient. Under the premise of sufficient sampling amount, the species accumulation curve is used to predict species richness[3-7].

In order to study the fish crossing effect of the fish pass of the Cao'e River, it is necessary to monitor the fish population and quantity in the fish pass. Since the statistics are based on sampling survey methods, is the amount of sample surveys sufficient? What is the population richness of the fishway biome in the Cao'e River? And what proportion of the fish species found in the survey accounted for the actual fish species? It is necessary to use scientific and reasonable methods for judgment and estimation.

In this study, the statistical software EstimateS was used to analyze the accumulation curve of fish species passing by the Cao'e River fishway.

2. Methodology
In Excel, the number of individual fish caught in the 14 times of monitoring is statistically summarized by type (Table 1), and EstimateS was used to process the data to calculate the number of samples in the results (Samples, the number of monitoring captures in this example), Individuals (Individuals, the total number of fish in this example) and the number of species [S, the number of fish populations in this...
example], 3 sets of data, to plot the number of sampling times and the number of individual fish species accumulation curve Excel smooth line scattered points Figure, and determine whether the sampling is sufficient according to the upward trend of the species accumulation curve. On the premise of sufficient sampling, ACE (Abundance-base Coverage Estimator), ICE (Incidence-based Coverage Estimator), Chao1, Chao2, Jackknife1, Jackknife2, Bootstrap, MM (Michaelis-Menten) in the calculation results of the summary data are used as Cao’e River. There are different estimates of fish population abundance in fish passages, among which the non-parametric first-order knife-cut method (Jackknife1) and the bootstrap method (Bootstrap) are relatively accurate estimates [8-9].

Table 1: Summary table of individual fish population statistics

| Month         | 5 | 6   | 7   | 8   | 9 | 10  | 11  |
|---------------|---|-----|-----|-----|---|-----|-----|
| Batch         |   | 1   | 2   | 3   | 4 | 5   | 6   |
| Macrobrachium superbum | 5 | 20 | 8 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eriocheir sinensis | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ilyoplax tansuiensis | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coilia ectenes | 280 | 352 | 163 | 0 | 614 | 40 | 0 | 0 | 0 | 4 | 6 | 3 | 1 | 2 |
| Grass carp    | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Black carp    | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Megalobrama amblycephala | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 1 |
| Erythroculter dabryi | 0 | 0 | 0 | 0 | 7 | 2 | 3 | 4 | 0 | 4 | 3 | 5 | 0 |
| Erythroculter ilishaelformis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Culter mongolicus | 1 | 0 | 0 | 0 | 19 | 3 | 6 | 7 | 4 | 5 | 4 | 2 | 0 | 0 |
| Minnow        | 311 | 263 | 107 | 0 | 211 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Xenocypris davidi | 0 | 0 | 0 | 11 | 24 | 9 | 0 | 8 | 0 | 0 | 3 | 1 | 0 | 0 |
| Silver carp   | 0 | 0 | 0 | 0 | 0 | 6 | 9 | 7 | 9 | 9 | 9 | 3 | 0 | 0 |
| Bighead carp  | 0 | 0 | 0 | 0 | 9 | 5 | 5 | 5 | 8 | 10 | 5 | 7 | 8 | 0 |
| Carp          | 0 | 0 | 0 | 2 | 1 | 2 | 2 | 3 | 0 | 0 | 0 | 1 | 0 | 1 |
| Crucian carp  | 9 | 11 | 5 | 6 | 25 | 4 | 8 | 4 | 0 | 6 | 5 | 4 | 6 | 6 |
| Yellow-head catfish | 0 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Eel           | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Liza haematocheila | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 |
| Lateolabrax maculatus | 3 | 8 | 3 | 2 | 11 | 3 | 4 | 0 | 0 | 4 | 2 | 4 | 1 | 4 |
| Odontobutis obscurus | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Baby croaker  | 19 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Snakehead     | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
3. Data analysis

According to the Estimate software operation process\(^6\), the original data as imported into the software to calculate and output the results (Table 2).

Table 2 Summary of some calculation results output by EstimateS

| Samples | Individuals (computed) | S(est) | S Mean (runs) | ACE Mean | ICE Mean | Chao 1 Mean | Chao 2 Mean | Jack 1 Mean | Jack 2 Mean | Bootstrap Mean | MMRuns Mean | MMMeans (1 run) |
|---------|------------------------|-------|---------------|----------|----------|-------------|-------------|-------------|-------------|----------------|-------------|----------------|
| 0       | 0                      | 0     | 0             | 0        | 0        | 0           | 0           | 0           | 0           | 0              | 0           | 0              |
| 1       | 209.93                 | 8.33  | 8.59          | 9.49     | 8.59     | 8.59        | 8.59        | 0           | 8.59        | 0              | 0           | 0              |
| 2       | 419.86                 | 12.43 | 12.24         | 13.49    | 48.52    | 12.79       | 17.25       | 16.51       | 14.37       | 32.62         | 24.49       |
| 3       | 629.79                 | 15.11 | 14.54         | 16.24    | 30.12    | 15.31       | 21.49       | 19.77       | 21.71       | 17.01         | 31.76       | 25.31          |
| 4       | 839.71                 | 17.03 | 16.68         | 18.43    | 28.23    | 17.77       | 22.62       | 22.7        | 25.48       | 19.46         | 31.77       | 25.9           |
| 5       | 1049.64                | 18.52 | 18.22         | 20.14    | 26.47    | 19.29       | 23.07       | 24.17       | 26.64       | 21.03         | 29.01       | 26.38          |
| 6       | 1259.57                | 19.73 | 19.4          | 21.66    | 25.93    | 20.91       | 25.28       | 25.14       | 27.35       | 22.15         | 28.61       | 26.79          |
| 7       | 1469.5                 | 20.74 | 20.48         | 22.61    | 26.58    | 22.04       | 24.69       | 26.3        | 28.45       | 23.28         | 28.5        | 27.15          |
| 8       | 1679.43                | 21.6  | 21.19         | 23.39    | 27       | 22.98       | 25.69       | 27.05       | 29.47       | 23.97         | 28.35       | 27.48          |
| 9       | 1889.36                | 22.34 | 21.76         | 24.41    | 27.2     | 23.72       | 26.1        | 27.47       | 29.64       | 24.49         | 28.24       | 27.77          |
| 10      | 2099.29                | 23    | 22.7          | 25.57    | 28.03    | 24.93       | 27.34       | 28.43       | 30.59       | 25.45         | 28.31       | 28.03          |
| 11      | 2309.21                | 23.58 | 23.39         | 26.55    | 28.57    | 25.98       | 27.14       | 29.1        | 31.34       | 26.13         | 28.46       | 28.27          |
| 12      | 2519.14                | 24.1  | 24.04         | 27.98    | 29.16    | 27.08       | 27.74       | 29.85       | 32.31       | 26.81         | 28.65       | 28.49          |
| 13      | 2729.07                | 24.57 | 24.69         | 28.96    | 29.65    | 27.73       | 28.12       | 30.49       | 32.74       | 27.47         | 28.87       | 28.69          |
| 14      | 2939                   | 25    | 25            | 29.49    | 29.62    | 28          | 27.79       | 30.57       | 32.55       | 27.69         | 29.03       | 28.88          |

3.1. Sufficiency of sampling size

Using the species accumulation curve to judge whether the sampling amount is sufficient is based on the characteristics of the curve: if the curve has been rising sharply, almost a straight line, it indicates that the sampling amount is insufficient and the sampling amount needs to be increased; if the curve becomes an asymptotic line after a sharp rise and then increases slowly, it indicates that the sampling is sufficient and data analysis can be carried out\(^{1-2,10}\).

Using the Samples, Individuals, and S values in Table 2, plot the number of sampling fishing times, the number of fish populations, and the species accumulation curve of the number of fish individuals and populations, respectively (Fig.1 and Fig.2). The two curves show that with the increase in sampling times, although the number of fish species and individuals gradually increased, they did not rise in a straight line. The characteristics of the two growth curves both showed a smooth asymptote after a smooth rise. This morphology indicates that the research conducted a sufficient survey of fish sampling in the Cao’e River fishway.
3.2 Species richness estimation
Species richness is usually regarded as one of the most important criteria for determining conservation value. Obtaining reliable estimates of species richness is an important goal of diversity conservation. The EstimateS software provides commonly used estimation methods ACE (Abundance-base Coverage), ICE (Incidence-based Coverage Estimator), Chao1, Chao2, MM (MichaelisMenten), Jackknife1, etc.[1-2,11]. Table 2 lists eight different methods, including ACE, ICE, Chao1, Chao2, Jackknife1, Jackknife2, Bootstrap, and MM, to estimate the abundance of fish communities in the Cao'e River gate fishway. The different results are 30 species, 30 species, 28 species, 28 species, 31 species, 33 species, 28 species and 29 species, respectively. The actual monitoring survey found 27 species, accounting for 81.82% to 96.43% of the estimated number of true species. Most of the swimming creature species in the fishway on the right bank of the Cao'e River have been collected and the effect is good.

4. Discussions
Currently, we are facing a severe situation of biodiversity protection, and the relatively backward level of biodiversity research methods forces us to carry out relevant research on the basis of scientific methodology. The adequacy of sampling amount is a concern in current biodiversity and community surveys[2,12]. Some studies directly express the species abundance status of the community by using the sample number S value instead of the estimated species richness. It may lead to an underestimation of the actual number of species [2]. Therefore, the popularization and application of species accumulation curves are particularly important.

Before using EstimateS to estimate species richness, it is necessary to judge the adequacy of sampling. It is only meaningful to analyze the data on the basis of sufficient sampling. In addition, the software provides a variety of methods for estimating the abundance of species. Which method is used to get the estimated value closer to the actual situation remains to be further studied.

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