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Wildlife trade study based on the ANOVA method

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Abstract. Today, 78% of new human infectious diseases originate from wild animals. A complete ban on wildlife trade would be effective in stopping the occurrence and spread of infectious diseases, but it is estimated that a ban on wild meat consumption could cost China's economy 50 billion RMB ($7.1 billion) and put millions of people out of work. Therefore, it is worth considering whether the wildlife trade should be banned in the long term. In this paper, we first collected data on wildlife trade for 20 years and performed steps such as integrating and classifying the data, testing statistics, data pre-processing, and eliminating outliers. The most traded species was the macaque. Then, a principal component analysis was conducted to analyze the contribution of each purpose of wildlife trade, and a multiple regression analysis was used to obtain the most important purposes of commercial, zoo, and circus or traveling exhibitions. Finally, through one-way ANOVA, it was found that wildlife trade import and export data did not vary much in different years, but in 2019, the number of imports decreased sharply and the number of exports surged.

Keywords: Wildlife trade; Principal component analysis; Analysis of variance; COVID-19.

1. Introduction

Wildlife markets have been questioned as the source of the New Crown epidemic and the 2002 SARS outbreak, and wildlife trading regulations were permanently tightened by China's top legislature after the New Crown virus outbreak. Direct contact between human and animal species due to wildlife trade and increased human-livestock-wildlife interactions due to the rapid fragmentation of wildlife habitats are two major factors contributing to the spread of zoonotic diseases [4]. How should trade in wildlife products be regulated from a long-term perspective? To this end, this paper provides the following analysis of the wildlife trade.

This paper uses the CITES trade database as a data source. This database contains more than 20 million trade records and is publicly accessible. First, we collected data on wildlife trade from 1990-2022 and processed the data to obtain the most traded wildlife groups and species. Then, we analyzed the purpose of trade and counted the main purposes of wildlife trade. Finally, we used one-way ANOVA to obtain the changes in wildlife import and export data over years.

2. Analysis of trade data based on principal component analysis

First, for statistical methods, continuous data were processed using paired samples t-test with the following statistics.

$$t = \frac{\overline{d}-\mu_0}{s_d/\sqrt{n}}. \tag{1}$$

Where $i = 1 \ldots n, \overline{d} = \frac{\sum_{i=1}^{n} d_i}{n}$ is the mean of the paired sample differences, $s_d = \sqrt{\frac{\sum_{i=1}^{n}(d_i-\overline{d})^2}{n-1}}$ is the standard deviation of the paired sample differences, and n is the number of paired samples. The statistic t obeys a t-distribution with degrees of freedom of $n = 1$ under the condition that the null hypothesis: $\mu = \mu_0$ is true.

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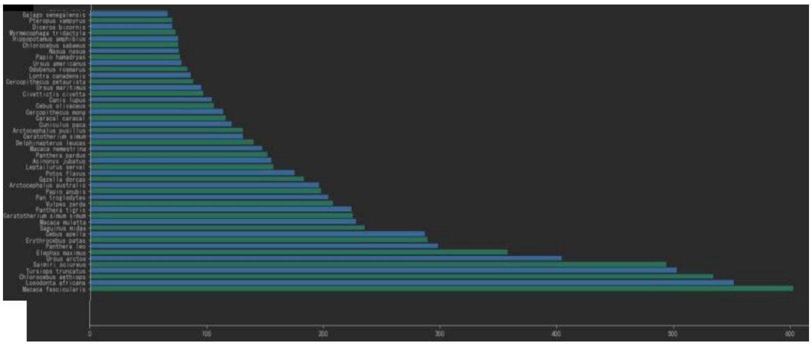
Then, the discrete data were processed using the chi-square independence test to create statistical data on the distribution of wildlife trade based on the classification of different families, genera, and species.

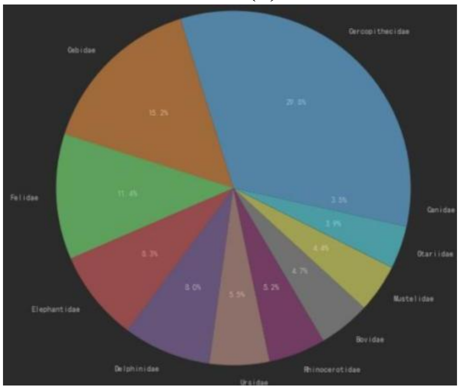
$$X = \sum_{i=1}^{n} \frac{(o_i - e_i)^2}{e_i}. \tag{2}$$

Where o_i is the observed value and e_i is the expected value, i.e., the expected value under the assumption that the variables are independent.

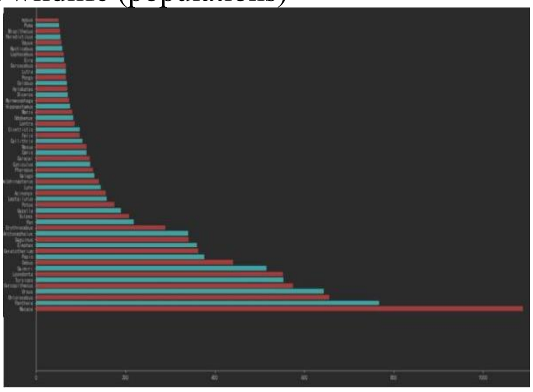
Finally, the following graphs are then drawn from the statistical data, which can visualize the maximum trade of wildlife groups and species. Among them, Macaca fascicularis is the most abundant and is the main traded species.



(a) Trade distribution of wildlife (populations)



(b) Trade distribution of wildlife (family)



(c) Trade distribution of wildlife (genus)

Fig. 1 Statistical map of the distribution of wildlife trade

To find out the main purposes of wildlife trade, we used the principal component analysis method.

It can be found from the data that there are eleven main purposes of wildlife involved in the trade, T (commercial), Z (zoo), Q (circus or traveling exhibition), P (personal purpose), S (scientific use), B (captive breeding or artificial breeding), E (educational purpose), G (botanical garden), H (hunting), L (law enforcement/judicial/forensic), and M (biological introduction or elicitation). Considering these eleven purposes as eleven random variables, denoted as $X_1, X_2, \ldots, X_p$, principal component analysis is to transform the problem of these p indicators into a problem of discussing linear combinations of p indicators, and these new indicators $F_1, F_2, \ldots, F_k \ (k \leq p)$, fully reflecting the original according to the principle of retaining the main amount of information indicators and are independent of each other.

That is, the dimensionality reduction process is carried out to seek the linear combination of the original indicators F_i.

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$$\begin{cases} F_1 = a_{11}ZX_1 + a_{21}ZX_2 + \dots + a_{p1}ZX_p \\ F_2 = a_{12}ZX_1 + a_{22}ZX_2 + \dots + a_{p2}ZX_p \\ \dots\dots \\ F_m = a_{1m}ZX_1 + a_{2m}ZX_2 + \dots + a_{pm}ZX_p \end{cases}. \tag{3}$$

Where $a_{1i}, a_{2i}, \dots\dots a_{pi} (i = 1, \dots\dots, m)$ is the eigenvalue of the covariance array of X with multiple corresponding eigenvectors, and $ZX_1, ZX_2, \dots\dots, ZX_p$ is the value of the original variables normalized.

The final visualization results are as follows.

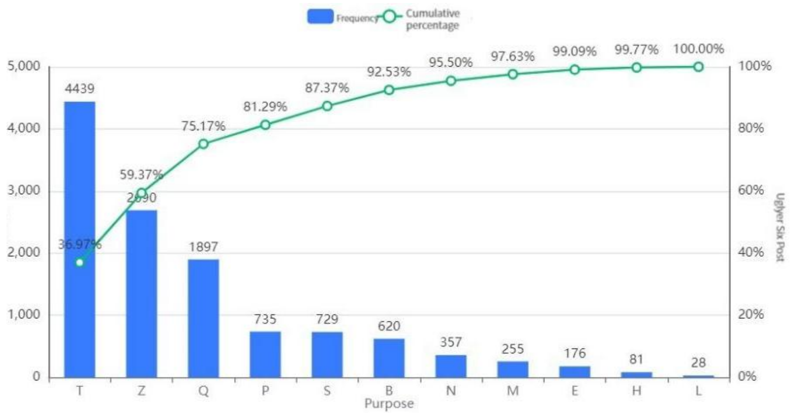

Fig. 2 Wildlife Trade Purpose Analysis Chart

As can be seen from the graph, commercial use accounts for the largest share. The main purposes are T (commercial), Z (zoo), and Q (circus or traveling exhibition).

3. Analysis of trade fluctuations based on ANOVA

To discuss whether the effect of time is significant for wildlife trade activities, this paper uses a one-way analysis of variance [1] to see how import and export data change over the years.

Step1. Establishing hypotheses

H_0: $\mu_1 = \mu_2 = \ldots = \mu_c$; That is, the means of the groups are not significantly different and time is not related to the change in trade.

H_1: $\mu_1, \mu_2, \ldots, \mu_c$ are not all equal.

Step2. Calculate the sample mean and sample variance

$$\overline{x_j} = \frac{\sum_{i=1}^{n_j} x_{ij}}{n_j}. \tag{4}$$

$\overline{x_j}$ is the sample mean at the j level, x_{ij} is the i value at the j level, and n_j is the sample capacity at the j level.

$$S_j^2 = \frac{\sum_{i=1}^{n_j} (x_{ij} - \overline{x_j})^2}{n_j - 1}. \tag{5}$$

S_j^2 is the sample variance at the j level.

Step3. Calculate the MSB of the variance between groups

$$MSB = \frac{\sum_{j=1}^{c} n_j (\overline{x_j} - \overline{\overline{x}})^2}{c - 1}. \tag{6}$$

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$\sum_{j=1}^{c} n_j(\overline{x_j} - \overline{\overline{x}})^2$ is the sum of squared horizontal terms, denoted as SSB; $c-1$ is the degree of freedom of SSB. $\overline{\overline{x}} = \frac{\sum_{j=1}^{c}\sum_{i=1}^{n_j} x_{ij}}{n_T}$, where $\overline{\overline{x}}$ denotes the overall sample mean and n_T denotes the sum of each sample capacity.

Step4. Calculate the intra-group variance MSE

$$MSE = \frac{\sum_{j=1}^{c}\sum_{i=1}^{n_j}(x_{ij}-\overline{x_j})^2}{n_T-c}. \tag{7}$$

$\sum_{j=1}^{c}\sum_{i=1}^{n_j}(x_{ij} - \overline{x_j})^2$ is the sum of squared error terms, denoted as SSE, and $n_T - c$ is the degree of freedom of SSE.

Step5. Calculate the F-statistic

$$F = \frac{MSB}{MSE}. \tag{8}$$

The calculation yields $F = 1.119 < 3.47 = F0.05(2,21)$, which falls in the acceptance domain. Therefore, H_0 is accepted and H_1 is rejected, i.e., the import and export data do not differ much in different years.

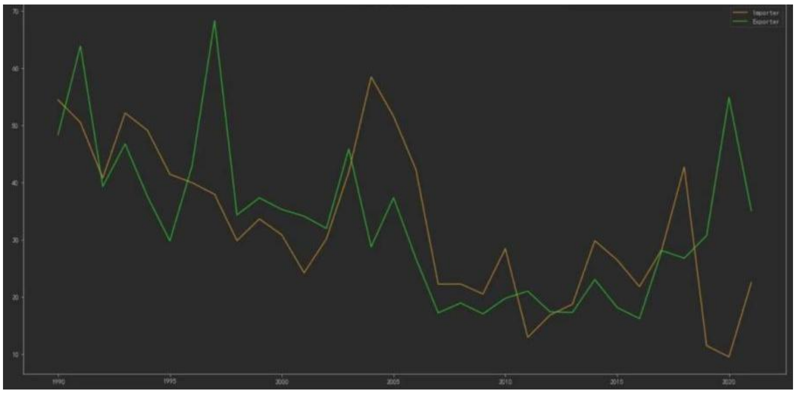

Fig. 3 2003-2022 Wildlife trade import and export volume changes

Among them, the yellow line represents the number of imports and the green line represents the number of exports. From figure 3, it is found that wildlife import and export are more active in 2003-2006, import is more stable in 2007-2021; export is more stable in 2007-2019, and export is more active in 2020. Since the beginning of monitoring, wildlife trade has increased in most industries, and the total number of wildlife import trade permits in China reached 20,379 with rapid annual growth, but the growth rate has slowed down in recent years and shows a downward trend in fluctuations [2].

For example, between 1996 and 2018, the global fish market increased from $40 billion to $180 billion, timber from $65 billion to $137 billion, and reptile leather for the fashion trade from $140 million to $600 million. At the same time, the number of annual transactions legally traded through CITES has increased, from less than 5,000 transactions in 1977 to a peak of more than 1.3 million in 2015, with simultaneous increases in shipments and similar trends in seizures of illegally traded species. Balancing people's needs for livelihoods, particularly with access and benefit-sharing rights, along with the impact on species survival remains difficult. Finding ways to enable the long-term survival of species that are equitable and do not destroy livelihoods is an ongoing challenge.

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4. Summary

Most of the new human pathogens that have had a significant impact on human health or the economy in the last three decades have originated in the wild. Although China is now fully liberalized, these short-term successes should not be touted given the far-reaching negative environmental, social, and economic impacts of the COVID-19 pandemic. We call for urgent action to regulate wildlife trade, expand the protection of native ecosystems, and reduce consumer demand for wildlife parts and products to reduce the risk and severity of future zoonotic diseases [3].

In this paper, we visualize wildlife trade data for nearly 20 years in graphical form and analyze that Macaca fascicularis is by far the most traded species, and most of all traded wildlife is used for commercial aspects. Moreover, since the outbreak of the new crown epidemic in 2019, the number of wildlife imports has decreased significantly and the number of exports has increased, reaching a minimum and a peak in 2020, respectively, and since then both numbers have gradually approached.

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