Data Analysis in Fisheries Science: Relationship Between Predator and Prey Lengths

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Abstract

In this project I will investigate the relationship between marine predators and their prey and try to find trends, specifically between their lengths. Using a large data set produced by Barnes et al [1], I will use R to identify these relationships using various techniques and plots. Looking at the relationship between predator and prey lengths has important applications in the fishing industry. The research in this paper could give reasons for a minimum length of fish that fisherman are allowed to catch, as the smaller fish could be part of the diet of more predators, and therefore a lack of fish under that minimum length could cause more fish to starve, reducing biodiversity.

Contents

1 Introduction

1.1 The Barnes Data Set

Throughout this project I will be using a data set produced by Barnes et al in 2008 called "Predator and Prey Body Sizes in Marine Food Webs" [1]. This data set has 34929 observations of 62 variables, but I will be focussing on just six of these; predator scientific name, predator length, predator length unit, prey scientific name, prey length and prey length unit.

1.2 What other studies have found and how they have influenced my project

1.2.1 Costa's Research

Costa found that mean, minimum, maximum and variance of prey size were all positively associated with body size. This suggests that larger predators consume a variety of different sized prey types, increasing both the maximum and minimum size they eat. A similar result can be found in previous studies looking at terrestrial predators conducted by Vézina (1985) [5] and Costa et al. (2008) [2], who found that larger predators tend to consume a wider range of prey sizes. In a similar study which looks at predacious lizards, Costa actually found a negative relationship, concluding that larger predators were actually consuming a narrow diversity of prey categories.

In my project I will investigate this relationship further, looking at the length of each species rather than their mass to see if this follows the same patterns that Costa and Vézina found. Taking inspiration from Costa's calculations and figures, I will calculate the trophic-niche breadth of predators and plot this against their lengths in millimetres.

1.2.2 Scharf's Research

Scharf et al used regression analysis to look at ratio-based trophic niche breadths and found that they generally did not expand with predator ontogeny [1] and tended to narrow for the largest predators [4]. They also found that "the range of prey sizes eaten expanded with increasing predator body size for each of the marine predators examined, leading to asymmetric predator size - prey size distributions".

In my project I will investigate whether these results can be replicated using the Barnes data set [1]. I feel this will be important as the Scharf study uses a relatively narrow data set of only 18 species, all off the northeast US coast, so it will be interesting to see whether these results can be found across the 27 locations, 93 predator types and 174 prey types that were observed by Barnes et al. Taking inspiration from figure 4 in the Scharf paper, I will produce a plot showing the ratio of prey length/predator length, the relative frequencies and the cumulative frequencies.

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[1]"The entire sequence of events involved in the development of an individual organism" - Collins English Dictionary [3]

1.3   Explanation of Mathematics Required

1.3.1   Ratio-Based Trophic-Niche Breadth

1.3.2   Regression Techniques

2   Preparing the Data

In order to use this data, I first had to ensure it was usable and suitable for my area of research. On initial inspection of the data set, by plotting the log of the predator lengths against the log of the prey lengths, I could see anomalies where the smaller predators were consuming much larger prey.
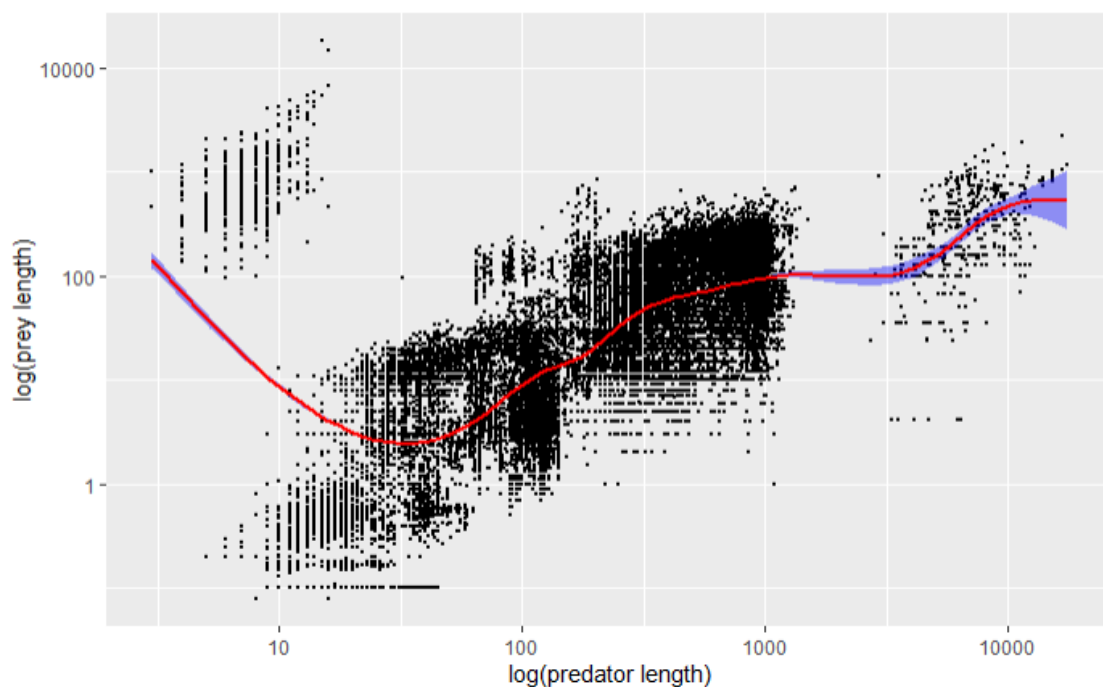

Figure 1: Graph showing the relationship between the log of predator length and the log of the length of their prey

Upon further inspection of the data set itself, I found that there were three different measurement units used for the lengths of the marine animals; these were micrometres (µm), millimetres (mm) and centimetres (cm). With a view to create accurate plots from this data set, I converted all length data into millimetres by multiplying the centimetre data by ten, and dividing the micrometre data by a thousand. The length data was then ready to be presented. As can be seen below, the anomalies are no longer present and a positive correlation between predator and prey lengths can be seen.
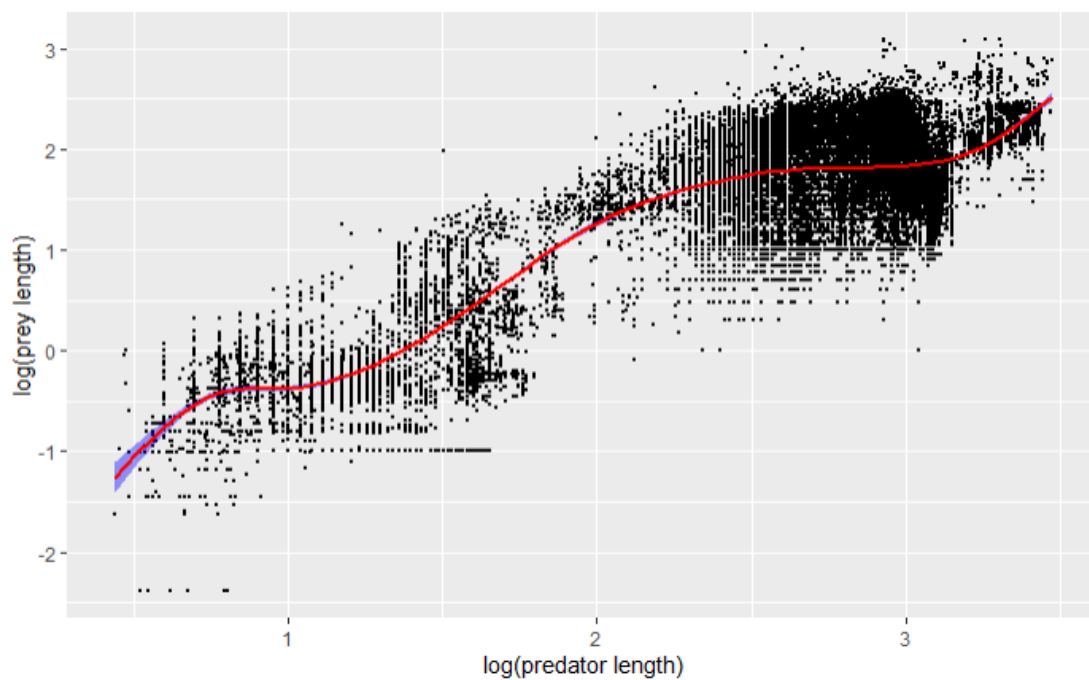
Figure 2: Corrected graph showing the relationship between the log of predator length and the log of the length of their prey

3 Results

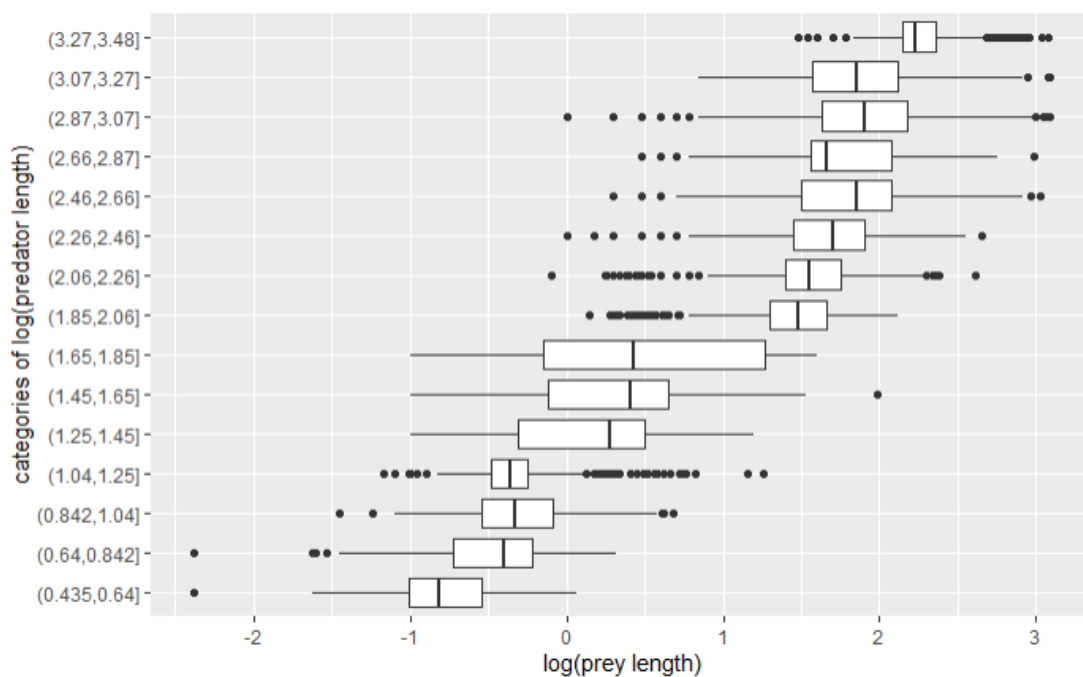## 3.1 Predator Length - Prey Length Patterns

Figure 3: Box plot, using a log scale, showing the range of prey lengths eaten by different categories of predator lengths
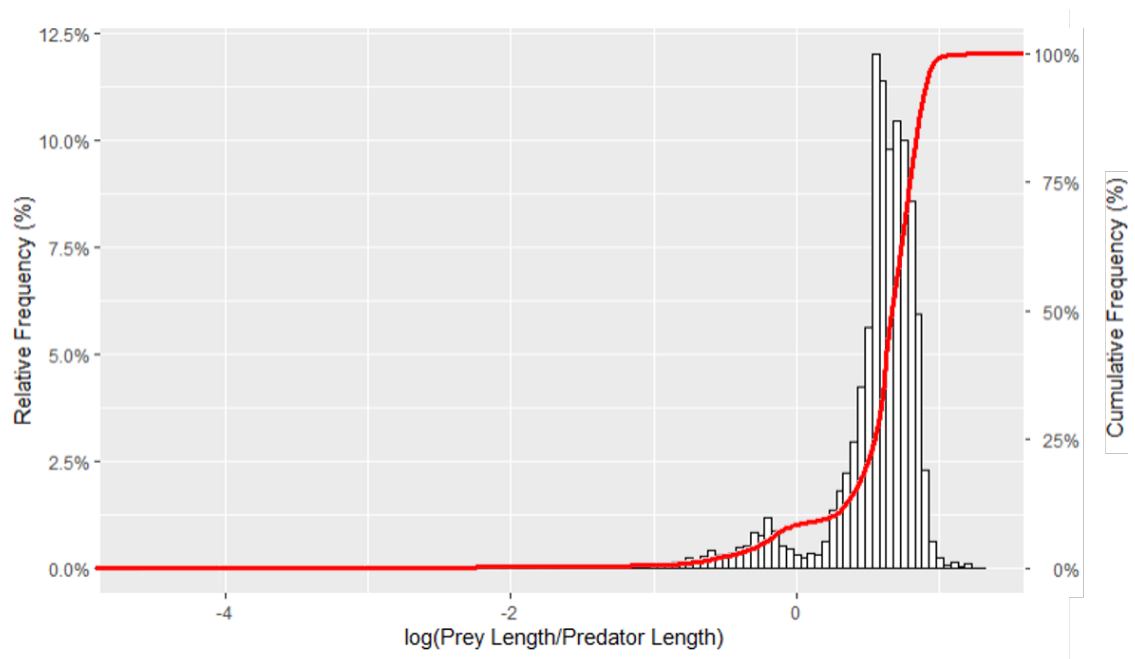
3.2   Ratio-Based Trophic-Niche Breadth

Figure 4: Box plot showing relative frequency distributions of prey size/predator size ratios consumed by marine fish predators and empirical cumulative distribution function shown in red

4   Conclusions

References

[1] C. Barnes, D. Bethea, R. Brodeur, J. Spitz, V. Ridoux, C. Pusineri, B. Chase, M. Hunsicker, F. Juanes, A. Kellermann, et al. Predator and prey body sizes in marine food webs: Ecological archives e089-051. *Ecology*, 89(3):881–881, 2008.

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[4] F. S. Scharf, F. Juanes, and R. A. Rountree. Predator size-prey size relationships of marine fish predators: interspecific variation and effects of ontogeny and body size on trophic-niche breadth. *Marine Ecology Progress Series*, 208:229–248, 2000.

[5] A. F. Vézina. Empirical relationships between predator and prey size among terrestrial vertebrate predators. *Oecologia*, 67(4):555–565, 1985.