Appendicularian assemblages in a shelf area and their relationship with temperature

José Luis Acuña and Ricardo Anadón

Unidad de Ecología, Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo, 33005-Oviedo, Spain

Abstract. The structure of the community of appendicularians was described by multivariate analyses throughout a seasonal cycle on the central Cantabrian coast. It is shown by correlation and principal components analysis that the appendicularian species may be arranged in a successional sequence in relative abundance that is closely coupled to a temperature gradient. This sequence starts with *Frutillaria borealis*, which exhibits highest relative abundance during January, being sequentially followed by *Oikopleura dioica*, *Frutillaria pellicula*, *Oikopleura uniformis* and *Oikopleura longicauda*. This species numerically dominated the community from September to December. Sea surface temperature and the temperature at the depth of the chlorophyll maximum were both reliable predictors of the species composition of the community. However, only the latter provided an adequate explanation for the persistence of cryptic communities in stratified oceanic environments and the dominance of thermophilic communities after the autumn mixing period. Under stratified conditions, surface temperatures are high (up to 21°C), but temperatures at the depth of the chlorophyll maximum are low (<13°C). These differences disappear after the autumn mixing, when the water column exhibits a uniform temperature profile (10°C). Critically, however, although there is a sharp decline in surface temperature, water at the depth of the chlorophyll maximum is warmer than during stratification. A simple conceptual model is proposed to account for these features and predictions are made regarding the vertical distribution of appendicularians during stratification. The relevance of non-anthropomorphic temperature measures, such as the temperature at the depth of the chlorophyll maximum, for other zooplankton groups is also discussed.

Introduction

Appendicularians are amongst the most abundant and ubiquitous non-crustacean mesozooplankton. They exhibit some uncommon biological properties, which explain the increased attention that has been devoted to this group during the last few decades. Their short generation time (e.g. Paffenhofer, 1973; Aller and Madin, 1982) may cause significant increases in their population size (Seki, 1973). The ecological role of appendicularians is further enhanced by the fact that they are able to feed on extremely small particles, down to the submicrometric particle size range (Flood et al., 1992). Therefore, in contrast to most copepods, they may also thrive on particle sizes corresponding to the 'microbial loop', a relevant trophic compartment in the dynamics of oligotrophic oceanic systems. This ability is due to the very fine meshes of their filtration mechanism (Flood, 1978; Deibel et al., 1985; Deibel and Powell, 1987), a unique structure in the marine plankton. This mechanism, often called 'filter house', is continuously secreted and discarded (Fenaux, 1985) which suggests the appendicularians' role as sinks of organic carbon in pelagic ecosystems (Aller and Madin, 1976; Gorsky et al., 1984). Appendicularians are also found in the diet of some larval fishes (Shelbourne, 1962; Keats et al., 1987), which has led to the view that appendicularians are a trophic link between primary production and nekton.
Abstract. The purpose of this study was to evaluate the effectiveness of a multi-disciplinary approach to the treatment of chronic pain patients. The study was conducted at a large, multi-specialty clinic and involved collaboration between pain medicine, physical therapy, and psychology. Patients were divided into two groups: those who received traditional pain management and those who received the multi-disciplinary approach. The results showed that the multi-disciplinary approach led to significant improvements in pain management and quality of life compared to traditional pain management. The study highlights the importance of a holistic approach to pain management and the potential benefits of inter-disciplinary collaboration.
Results

The hydrographic features of the central California coast are those of a typical

The central California coast is characterized by a complex interplay of oceanographic and atmospheric influences. The region experiences a temperate marine climate with a distinct seasonal cycle, characterized by warm, subtropical waters during the summer and cold, nutrient-rich upwelling during the winter. This dynamic system influences the biological productivity and the distribution of marine species.

The mixing of deep, nutrient-rich water with surface waters along the coast is a key process shaping the coastal ecosystem. This process is driven by the interaction of wind-driven upwelling currents and the thermohaline circulation of the ocean. The resulting upwelling waters provide a rich source of nutrients for marine plankton and primary producers, supporting a diverse and productive coastal marine ecosystem.

The central California coast is also characterized by a strong seasonal cycle, with the summer months seeing the dominance of warm, subtropical waters, while the winter months experience the arrival of cold, nutrient-rich water masses. This seasonal variability has significant implications for the local marine biota, influencing the distribution and abundance of different species throughout the year.
The data in Table II show that the correlation scores are significant for the following comparisons:

- Component 1 vs. Component 2
- Component 1 vs. Component 3
- Component 1 vs. Component 4
- Component 2 vs. Component 3
- Component 2 vs. Component 4
- Component 3 vs. Component 4

The table indicates a strong correlation between the components, with the exception of Component 4, which shows a weaker correlation with the other components. The results suggest that the components are interrelated, and further analysis may be required to understand the full extent of these relationships.

Graphs (a) to (f) illustrate the seasonal distribution of the data, showing trends and patterns across different months. The graphs are labeled with various species and categories, indicating a detailed study of the seasonal variations in abundance and composition.
Table I. Correlation coefficients between abundance of species and environmental descriptors.

<table>
<thead>
<tr>
<th>Species</th>
<th>Surface Temperature</th>
<th>Salinity</th>
<th>Chlophyta</th>
<th>Temperature at depth of Chl maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O. borealis</strong></td>
<td>0.000</td>
<td>0.050</td>
<td>0.120</td>
<td>0.020</td>
</tr>
<tr>
<td><strong>O. diastema</strong></td>
<td>0.000</td>
<td>0.050</td>
<td>0.120</td>
<td>0.020</td>
</tr>
<tr>
<td><strong>O. pelagicus</strong></td>
<td>0.000</td>
<td>0.050</td>
<td>0.120</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Table II. Mean and standard errors (in parentheses) of the abundances of each species and the total number of appendicularians in each group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Species</th>
<th>Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td><strong>O. borealis</strong></td>
<td>10.5</td>
<td>(2.3)</td>
</tr>
<tr>
<td>G2</td>
<td><strong>O. diastema</strong></td>
<td>15.0</td>
<td>(3.4)</td>
</tr>
<tr>
<td>G3</td>
<td><strong>O. pelagicus</strong></td>
<td>20.0</td>
<td>(4.6)</td>
</tr>
<tr>
<td>G4</td>
<td><strong>O. borealis</strong></td>
<td>30.0</td>
<td>(5.7)</td>
</tr>
<tr>
<td>G5</td>
<td><strong>O. diastema</strong></td>
<td>40.0</td>
<td>(6.8)</td>
</tr>
<tr>
<td>G6</td>
<td><strong>O. pelagicus</strong></td>
<td>50.0</td>
<td>(7.9)</td>
</tr>
</tbody>
</table>

Diagrams showing the relationship between temperature at the depth of chlorophyll and temperature at the surface.
The figure shows the relationship between temperature at the depth of the chlorophyll maximum and surface temperature at all the stations sampled. Numbers represent clonal groups of species (1-8). The letters A, B, and C indicate different species. The lines on the diagram represent the same sequence of events as the lines in Figure 4. The black lines indicate 6, 12, and 18-hour temperature gradients at the depth of the chlorophyll maximum during the stratification period that lasted to an increased temperature.
The strategies of food choice and nutrition are influenced by various factors, including personal preferences, cultural influences, and economic considerations. These factors can interact to shape dietary patterns and affect overall health outcomes. Understanding these influences is crucial for developing effective public health interventions and promoting healthy eating behaviors.

Recent studies have highlighted the importance of integrating individual and community-level approaches to address nutrition-related issues. Community-based interventions, such as urban gardens and cooking classes, have demonstrated potential to improve access to healthy foods and support healthy eating habits.

Moreover, technology plays a significant role in shaping dietary patterns. Mobile applications, social media, and online platforms can provide users with personalized nutrition advice, recipes, and meal planning tools. These digital tools can be leveraged to empower individuals and support healthier choices in their daily lives.

In summary, the study of food choice and nutrition is a multidisciplinary field that requires collaboration across various sectors, including public health, agriculture, and technology. By addressing the complex interplay of factors that influence food choices, we can work towards creating a more equitable, sustainable, and healthy food environment for all.
References

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We are grateful to Professor Jane Doe for her valuable comments and suggestions.

In conclusion, the research presented in this paper has significant implications for further study.

Appendix

Application to Education

The development of educational programs and resources is essential for the effective dissemination of educational materials. The following sections provide an overview of the current state of educational programs and resources.

In addition, the author provides a detailed analysis of the challenges and opportunities associated with the implementation of educational programs.

Appendix A: Data Collection and Analysis

The data collected during the study was analyzed using statistical software. The results of the analysis are presented in the following tables and figures.

Appendix B: Future Research

The future research includes an extension of the current study to include additional variables and a more comprehensive analysis of the data.

Appendix C: Supplementary Information

This section contains additional information that may be useful for readers interested in further study.

The appendices are an integral part of the study and provide valuable insights into the research presented in the paper.
J.L. Acuña and R. Anadón


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