Sampling Red Sea copepods for long-term ecotoxicology Culture

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Abstract

In aquatic ecosystems, copepods play a significant role in connecting lower and higher trophic levels. Their abundance, variety, and community composition react quickly to changes in water quality, nutrient enrichment, pollution, and climate driven environmental stress, making them very promising bioindicators for evaluating water sustainability. Therefore, the Red Sea's high warmth, salinity, fast evaporation, and low freshwater input make it an ideal place to research copepods, however there are still few controlled cultures of locally collected copepods. Establishing laboratory cultures of particular copepods that were collected from the Red Sea under regulated environmental circumstances was the goal of this effort. In addition to facilitating the observation of copepod survival, activity, development, and reproduction, the cultures were created to offer a reliable biological model for upcoming experimental investigations. In addition to advancing knowledge of Red Sea planktonic ecosystems, the establishment of locally derived copepod cultures can enable studies on environmental stresses, pollution responses, and climate-related changes. These cultures may also be used in aquaculture as a dependable source of live feed. In conclusion, creating controlled cultures of Red Sea copepods offers a crucial basis for upcoming studies in aquaculture, ecology, and ecotoxicology.

Key word: Copepods, Laboratory Culture, Red Sea, environmental stress, ecotoxicology

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1 Introduction

Marine biodiversity is strongly influenced by planktonic organisms, including phytoplankton and zooplankton, which form the foundation of aquatic food webs. Among zooplankton, copepods are one of the most abundant and ecologically important groups of multicellular organisms in aquatic ecosystems. They are crustaceans that inhabit a wide range of environments, including marine and freshwater systems, and occupy diverse ecological niches as free-living planktonic organisms, benthic forms, and parasites (Figure 1) (1,2). Copepods can constitute a substantial proportion of medium-sized zooplankton biomass and therefore play an important role in maintaining marine ecosystem structure and function.

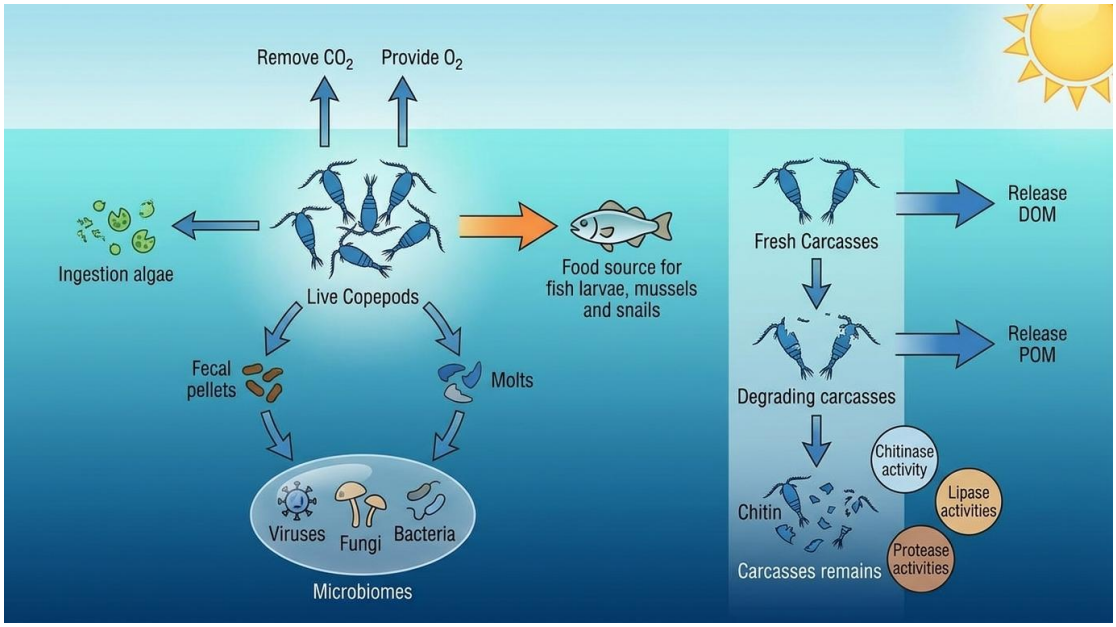


Figure 1 Ecological role of copepods in the marine environment

Copepods are favored in aquaculture as a live feed due to their nutritional advantages over conventional options like Artemia and rotifers. They enhance the nutritional quality and digestibility of food, leading to improved growth, survival rates, and health of fish larvae. Copepods also boost larval performance by increasing stress tolerance and reducing deformities. Their associated microbiome positively influences larval outcomes by mitigating harmful bacteria and providing probiotic effects. Additionally, their abundance in marine ecosystems positions copepods as a crucial and effective feed source in fish rearing, reinforcing their global preference in aquaculture. Through their feeding activity, metabolism, and excretion, copepods also contribute to nutrient cycling and the transfer of carbon within aquatic ecosystems. Consequently, changes in copepod abundance, distribution, and community composition can influence ecosystem productivity and trophic interactions (3,4). Their ecological importance makes them valuable organisms for investigating changes in marine environmental conditions.

In addition to their ecological importance, copepods are highly responsive to environmental factors such as temperature, salinity, food availability, and nutrient conditions. Variations in these factors can affect their survival, reproduction, development, and population dynamics. Therefore, copepods can provide useful biological information about environmental and climatic changes, particularly those associated with increasing ocean temperatures and changes in marine ecosystem conditions (5). Their sensitivity to environmental stressors also makes them suitable organisms for controlled laboratory experiments and ecotoxicological investigations.

The Red Sea represents a particularly important environment for studying copepods because of its distinctive physical and environmental characteristics. It is characterized by high temperatures, high salinity, strong evaporation, and an arid surrounding climate. Unlike many coastal marine environments, the Red Sea receives very limited riverine freshwater input because of the region's arid conditions. Consequently, atmospheric transport, coastal activities, urbanization, and other anthropogenic sources can contribute to the introduction and distribution of pollutants within the marine environment (6). These environmental characteristics can influence planktonic communities and may affect the distribution, abundance, and physiological condition of copepods.

Despite the ecological importance of copepods in the Red Sea, there is a need for controlled laboratory cultures of locally collected species to support experimental studies. Establishing cultures under controlled environmental conditions provides an opportunity to investigate copepod survival, development, feeding, and responses to environmental stressors while reducing the variability associated with field conditions. Such cultures can also provide a consistent biological model for future ecotoxicological studies examining the effects of pollutants and other environmental stressors on marine organisms (2). Therefore, this project aimed to establish laboratory cultures of selected copepods collected from the Red Sea under controlled environmental conditions. The cultures were developed as a foundation for monitoring copepod survival, activity, and development and for supporting future ecological and ecotoxicological assessments of environmental stressors relevant to the Red Sea ecosystem.

2 Methodology

Copepod Sampling and Laboratory Processing

Copepods were collected from the KAUST shore using a plankton net (Figure 2) and transferred into clean containers containing seawater collected from the sampling site. The samples were taken to the lab for further processing and analysis. Before being used in the culture system, Red Sea seawater was filtered to remove undesirable organisms and particle materials. During preparation, the culture medium was kept at a temperature of 27°C and a salinity of about 41 ppt (Figure 3). Selected copepods were carefully transferred to separate culture vessels containing filtered Red Sea seawater. The cultures were then kept in an incubator at a constant temperature of 24°C with a photoperiod of 12 hours light and 12 hours dark. These conditions were maintained throughout the culture period to ensure a consistent environment for copepod growthand development (Figure 4). To ensure proper water quality, the culture

medium was refreshed twice a week with newly filtered Red Sea seawater. Copepods were fed three times each weewith the chosen microalgal diet (Figure 5). Throughout the trial, the cultures were checked for survival, swimming activity, developmental growth, and overall health. Any changes in copepod abundance, behavior, or physical condition were documented to determine the appropriateness of the existing culture conditions (6).



Figure 2 Copepods collected from the KAUST Red Sea shore using a plankton net.



Figure 3 Filtered Red Sea water maintained at 41 ppt salinity and around 27°C

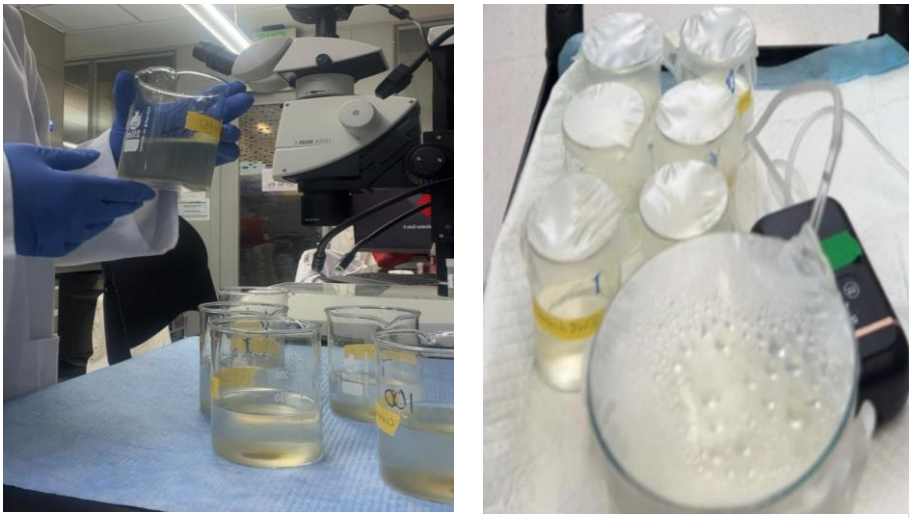


Figure 4 Individual copepods isolated under a stereomicroscope and maintained at 24°C under a 12hr light and 12hr dark photoperiod.

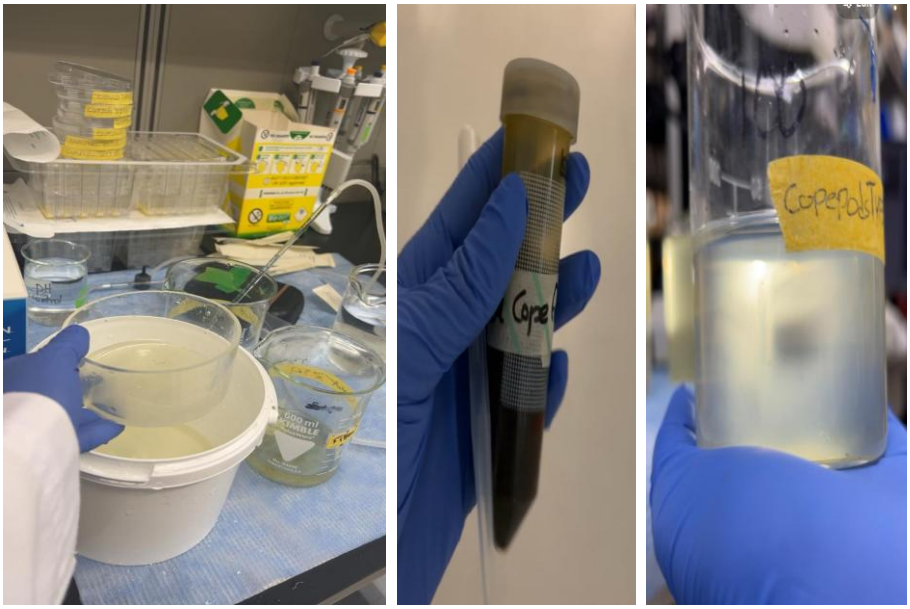


Figure 5 Culture medium renewed twice weekly and copepods fed three times weekly. Cultures were monitored for survival and development

3 Results and Observation

Microscopic observations were conducted to examine the morphological diversity of copepods collected from the Red Sea. The samples revealed a variety of copepod forms with different body shapes, sizes, and appendage structures, allowing for the preliminary identification of diverse species such as Acartia, Calanus, Cyclopoida, and Oithona. These findings illustrate the variety of copepod communities seen in Red Sea waters (Figure 6).

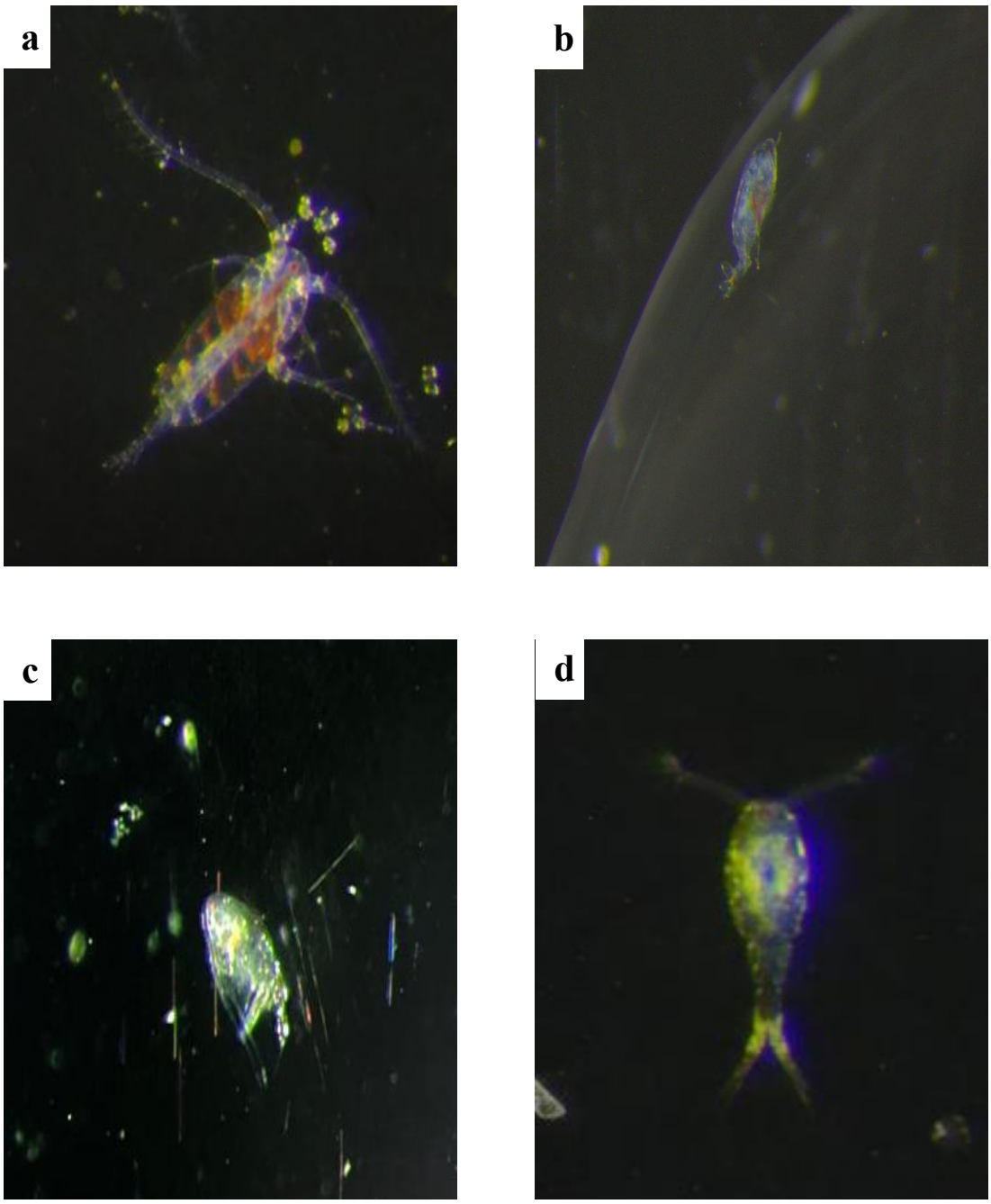


Figure 6 Microscopic pictures of selected copepods from Red Sea a- (Acartiura) *clausi*, b- (Acartiura) *clausi, c*- Cyclopoida and d- Oithona sp.

A new copepod culture was produced using Red Sea samples to keep live copepods in a controlled laboratory environment (Figure 7). The culture allows for long-term observation of copepod survival, development, and reproduction, as well as support for future research into their growth and life-cycle stages (Figure 9). Establishing a steady culture is therefore a critical step toward using Red Sea copepods as a viable source for future ecological and aquaculture research.

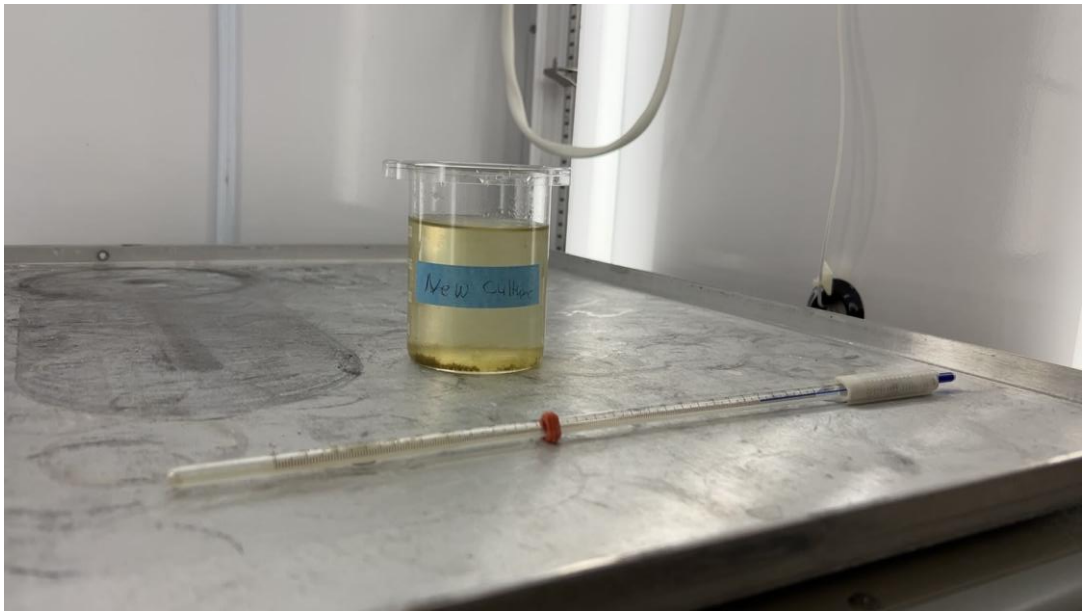


Figure 7 Laboratory Culture of Copepods

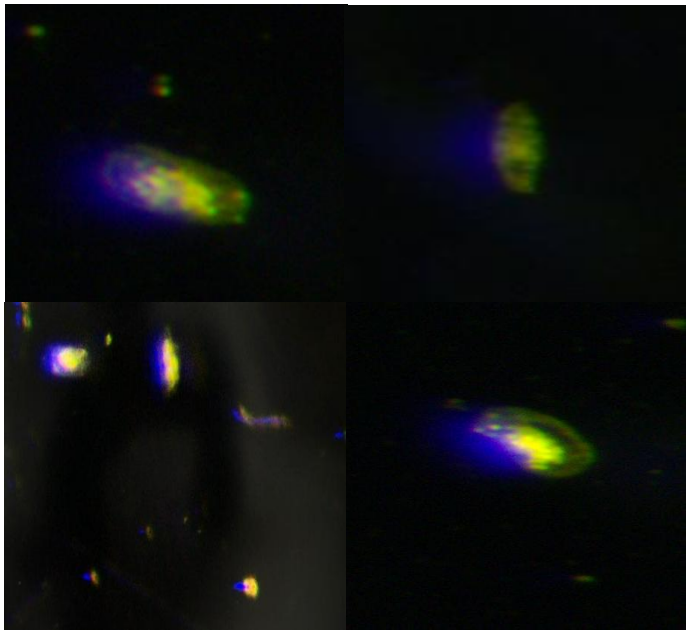


Figure 8 Microscopic pictures of Nauplius stages

4 Future Work

Copepods are essential in marine ecosystems and contribute to biodiversity. Recent findings underscore the need for comprehensive taxonomic knowledge to support ecological research. Future studies should prioritize assessing copepod sensitivity to marine pollutants, including heavy metals and microplastics, to understand their vulnerability and its implications for ecosystem health. Additionally, the identification of biomarkers in copepods may facilitate early detection of environmental stress. Research should also focus on the bioaccumulation of contaminants in marine food webs, considering the role of copepods as prey for higher trophic levels, thus linking ecotoxicology with food web dynamics (6).

Copepods are vital to marine ecosystems and possess considerable commercial value, especially in aquaculture, fisheries management, and environmental monitoring. Their ecological roles and nutritional benefits make them essential as live feed in aquaculture, where they support the growth and survival of fish and crustacean larvae. This dependence on copepods enhances hatchery success and aquaculture production, ultimately leading to higher yields and improved quality. Copepods are crucial not only as a food source but also as indicators in fisheries management and environmental monitoring. Their abundance and species composition affect fish recruitment and growth, helping fisheries managers predict changes in commercial fish populations for sustainable harvesting. Additionally, copepods respond sensitively to environmental shifts, making them reliable bioindicators of ecosystem health. Monitoring copepod communities aids in detecting pollution and climate change impacts, supporting the long-term sustainability of marine ecosystems essential for fishery and aquaculture operations (5).

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