Diversity and abundance of copepods on the north coast of Angola during hot season 2014–2016

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Abstract. The present work is aimed at discovering the diversity and abundance of copepods in the zooplankton community on the north coast of Angola, during the hot season 2014–2016. The samples were collected during the research cruise on board the Norwegian research ship “Dr. Fridtjof Nansen” in February – March on the Congo River and Luanda monitoring lines. Zooplankton sampling was performed using a multinet net in an oblique trawl (2014) and a WP2 net in a vertical trawl (2015 and 2016), both with 180 µm mesh. The samples were fixed in 4% formaldehyde and analyzed in the oceanography laboratory of the National Institute of Fisheries and Maritime Research in Angola. In the three years of sampling, copepods were present in the zooplankton community. The diversity of copepods on the northern Angolan coast, from 2014 to 2016 in the hot season, included 27 genera corresponding to 19 families. The Copepoda class was the most abundant group in the zooplankton community, corresponding to more than 80% of the abundance, having been represented by the orders Calanoida, Cyclopoida and Harpacticoida.

Keywords: zooplankton, north coast, Angola, copepods, zooplankton abundance, diversity

Introduction

Zooplankton corresponds to the set of heterotrophic planktonic organisms, belonging to several groups in the animal kingdom, thus comprising an immense variety of organisms of different shapes and dimensions, unicellular and multicellular [1]. In general, zooplankton occupies a key position in the aquatic food chain, as it is responsible for secondary productivity and for the transport and regeneration of nutrients through its high metabolism [2; 3]. The main zooplanktonic groups include ciliates, cnidarians, ctenophores, pteropods, crustaceans, pelagic tunicates (salps, doliolids, appendicularians), chaetognaths and fish larvae [3; 4].

Crustaceans are generally the dominant group in zooplankton communities [3–5], and among them copepods predominate. Copepoda is the most abun-
dant member of the marine plankton [1; 6; 7], and consequently the dominant holoplanktonic form corresponding to about 90–97% of zooplanktonic biomass. Most copepods are marine, however, there are many freshwater species and others in soil water films. There are also many parasitic species of various marine and freshwater animals, particularly fish [8]. As most copepods feed on phytoplankton, they are the main link between phytoplankton and the upper trophic levels of the marine food chain and an important part of the diet of many marine animals is composed of copepods [8; 9].

Knowing the diversity of copepods in zooplankton communities is relevant due to the ecological importance of copepods, added to the fact that they are identified as the most abundant components of zooplankton. The northern region of the Angolan coast is one of the two zones of high zooplankton concentration in Angolan sea waters [10], and our study on the diversity of the Copepoda class serves to complement this information.

The main purpose of the work was to study the composition of copepods within the zooplankton community on the north coast of Angola during the hot season (February – March) 2014–2016. The following specific objectives were defined: to describe the diversity of copepods in the zooplankton community and to determine dominance of orders; determine the abundance of copepods in the zooplankton community during the study period.

**Materials and methods**

The study area corresponds to the northern part of the Angolan coast (5°S–9°S) and includes the Congo River Monitoring Line (RCML) and the Luanda Monitoring Line (LDML) (Figure 1). The zooplankton samples were collected during the cruises exploring the marine resources of Angola, on board the Norwegian research ship “Dr. Fridtjof Nansen”, in the 3 periods of the hot season: February 3 to March 5, 2014; February 14 to March 23, 2015; February 25 to March 26, 2016.

**Figure 1.** Study area – northern coast of Angola. The dots indicate the sampling locations (stations):
RCML – Congo river monitoring line; LDML – Luanda monitoring line

*Source: data of the National Institute for Fisheries and Marine Research.*
In each monitoring line the stations were approximately 10–30 km apart. Zooplankton sampling was performed using a multinet net in an oblique trawl (2014) and a WP2 net in a vertical trawl (2015 and 2016), both with 180 µm mesh. The multinet contains 5 nets, and the samples were collected at five depth intervals (0–25, 25–50, 50–75, 75–100 and 100–200 m), in contrast, WP2 corresponds to a unique type of network sampling. In all, 83 samples were collected (Table 1).

Sample analysis included laboratory processing according to accepted methods [6], and quantitative and qualitative data analysis. Abundance (No. org./m³) was calculated using the formula [11]: \( N = \frac{n}{v} \), where \( n \) – number of organisms from each taxon in the sample, and \( v \) – volume of filtered water during drag. Dominance was calculated according to the formula [12]: \( Ar = \frac{N \times 100%}{Na} \), where \( N \) – number of organisms from each taxon in the sample, and \( Na \) – sum of the total number of organisms in the sample. The zooplankton biomass was determined using the gravimetric method of fresh weight [13].

### Table 1

<table>
<thead>
<tr>
<th>Line</th>
<th>Year</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stations</td>
<td>Samples</td>
<td>Stations</td>
<td>Samples</td>
</tr>
<tr>
<td>RCML</td>
<td>8</td>
<td>30</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>LDML</td>
<td>7</td>
<td>23</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>53</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

**Results and discussion**

Below, the diversity of copepods (systematic classification) of the zooplankton community in the period under study, according to Boltovskoy [7], and Ruppert and Barnes [8], as well as the analysis of the dominance of orders are represented. None of the registered organisms have been identified to their species. The symbols indicate the year in which the organization was registered, respectively: ⁕ – 2014; ● – 2015; ♦ – 2016.

Kingdom: Animalia Linnaeus, 1758
Phylum: Arthropoda
Subphylum: Crustacea
Class: Copepoda
Order: Calanoida Sars, 1903
Family: Calanidae Dana, 1849
  Genus: Calanoides  ●●●
  Genus: Calanus  ●●●
  Genus: Nannocalanus  ●●●
Family: Paracalanidae Giesbrecht, 1892
  Genus: Paracalanus  ●●
  Genus: Calocalanus  ●●
Family: Eucalanidae Giesbrecht, 1892
  Genus: Eucalanus  ●●●
  Genus: Pareucalanus  ●●●
The diversity of copepods included 27 genera corresponding to 19 families. Regarding the abundance, in three years sampling, both in the Congo monitoring line and in the Luanda line, copepods were the most abundant organisms, corresponding to more than 80% of the zooplankton community's abundance. Table 2 indicates the abundance of copepods within the zooplankton community in the period under study.

The results obtained by us agree with the previously described results by several authors about the great abundance of copepods in zooplanktonic sampling.
Ruby [14], and André [15] obtained the same results in the study area of Angolan coast. The Copepoda class was represented by the orders: Calanoida, Cyclopoida and Harpacticoida. Figure 2 illustrates the dominance of Copepoda class orders in the 2014–2016 period. The “NI” category corresponds to the larval stages (copepodites and nauplii).

Table 2

| Copepods abundance (No. org./m³) in zooplankton community on the north Angolan coast, 2014–2016 |
|----------------------------------|-----|-----|-----|
| Year                             | 2014 | 2015 | 2016 |
| RCML Zooplankton community       | 83 091 | 7917  | 8743 |
| Copepods                         | 68 608.4 | 6884  | 8214 |
| LDML Zooplankton community       | 60 757 | 22 843 | 17 856 |
| Copepods                         | 53 378 | 19 354 | 15 276 |
| Zooplankton community (both lines included) | 143 849 | 30 760 | 26 600 |

Source: data of the National Institute for Fisheries and Marine Research.

The order Calanoida was the dominant order on the north coast of Angola in the period 2015–2016. The order includes the genera *Calanus* (genus dominant on the Congo line in 2015 and Luanda line in 2016) and *Calanoides* (dominant genus on the Luanda line in 2015). Free-living and predominantly planktonic copepods [8], the order is the most successful of Copepoda's orders. Its success is due to the colonization of the entire pelagic environment, both in marine and freshwater ecosystems and saline lagoons [16]. They are rarely found in associations with other animals. Many species consume phytoplankton, others, predators, feed on a wide variety of prey [17].

![Figure 2](image_url)

*Figure 2. Dominance of orders in Copepoda class on the north coast of Angola, 2014–2016*

Source: data of the National Institute for Fisheries and Marine Research.
The order Cyclopoida was the second in terms of dominance. The order has planktonic and benthic, marine, and freshwater representatives. It includes some parasites [8]. Cyclopoida is the most abundant and successful order among copepods in freshwater ecosystems [17]. The Oncaeidae family is considered one of the most abundant in oceanic communities [17]. The genus Oncaea (dominant genus in 2014 in both monitoring lines and in the Congo river line in 2016) belongs to this order.

The order Harpacticoida had a low representativeness in the study area. Mainly constituted by benthic or epibentonic organisms with a pelagic minority [8; 9; 17], harpaticoides are adapted to marine, freshwater, and even semi-terrestrial habitats such as wet plants and decomposing leaves [18].

Conclusion

As previously described about the zooplankton community, the largest percentage of zooplankton abundance is attributed to copepods. In the northern part of the Angolan coast, Copepoda class was represented by the orders Calanoida, Cyclopoida and Harpacticoida.

References

Разнообразие и численность копепод на северном побережье Анголы в жаркий сезон 2014–2016 гг.

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Аннотация. Обсуждается разнообразие и численность копепод в сообществе зоопланктона у северного побережья Анголы в жаркий сезон 2014–2016 гг. Образцы зоопланктона были собраны во время рейсов на борту норвежского исследовательского судна Dr. Fridtjof Nansen в феврале – марте на линиях мониторинга Луанда и реки Конго.
Пробы зоопланктона отбирали с использованием мультисетевой системы – наклонный трал (2014) и сети WP2 – вертикальный трал (2015, 2016), обе с размером ячеи 180 мкм. Образцы закрепляли в 4%-м формальдегиде и анализировали в океанографической лаборатории Национального института рыбного хозяйства и морских исследований (INIPM) в Анголе. Копеподы присутствовали в сообществе зоопланктона все три года исследований. Всеночные и ракообразные у северного побережья Анголы в жаркий сезон 2014–2016 гг. были представлены 27 родами, относящимися к 19 семействам. Класс Copepoda оказался самой многочисленной группой зоопланктона, составляя более 80 % общей численности сообщества, и представлен тремя отрядами: Calanoida, Cyclopoida и Harpacticoida.

Ключевые слова: зоопланктон, северное побережье, Ангола, копеподы, численность зоопланктона, разнообразие

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