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SCAVENGING AMPHIPODS OF THE ANGOLAN DEEP-SEA HABITAT, WITH A FOCUS ON ABYSSORCHOMENE DISTINCTUS (BIRSTEIN & VINOGRADOV, 1955)

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ABSTRACT

Owing to its vast natural resources and the influence of the Congo River and associated submarine canyon, the Angolan continental margin is of both socioeconomic and ecological interest. The deep-sea ecosystems of the region are, however, understudied, and much of the deep-sea fauna remains undescribed. Here, we document the scavenging amphipods of the the Angolan deep-sea habitat, which provides valuable new insight into the ecology of Angolan deep-sea scavengers. This can be used as an ecological baseline, against which resource-extraction impacts can be measured. 7 996 scavenging amphipods, representing 10 species, were identified. At least four species were new to science. The relatively low scavenger diversity of the region, combined with the large sample sizes, may be indicative of abundant food-falls in the region due to the presence of the submarine canyon system.

The dominant species across all samples, *Abyssorchomene distinctus* (Birstein & Vinogradov, 1955), was the focus of a population-level study, which was used to describe the population structure of this species and identify species traits. Of the 826 *A. distinctus* dissected and measured, 533 were unsexed juveniles, 149 were male, and 144 were female. Females were significantly larger than males, which is indicative of non-mate-guarding pre-copulatory behaviour, but had significantly shorter antennae, which may indicate that males use chemical cues during mate-searching. Two, three, and five discrete size-based cohorts were identified for juveniles, males, and females respectively. No ovigerous females were caught but brood size of *A. distinctus* was estimated to be 10 – 38 offspring based on ovary contents.

Keywords: Amphipoda, Angola, Congo Submarine Canyon, continental margin, necrophage, population ecology

INTRODUCTION

In general, the continental margin environment is of great ecological importance owing to its role in connecting terrestrial and shallow-water habitats to deep-sea ocean basins. The continental margin region off the coast of Angola is of particular socioeconomic and ecological interest due to its abundant natural resources and large, deeply incised, submarine canyon (Heezen et al., 1964), which is directly linked to the second largest river system in the world, the Congo (Eisma & Van Bennekom, 1978; Savoye et al., 2009). The deep-sea ecosystems of the Angolan continental margin are, however, relatively understudied. Chemosynthetic systems have received some attention but bathyal habitats on the margin are underrepresented, though unpublished environmental assessments by industry scientists do exist (Jones et al., 2014). Therefore, study of the bathyal habitat of the Angolan continental margin presents the opportunity to identify and describe novel deep-sea assemblages and species that are new to science. Furthermore, ecological assessments can be used as a baseline against which the potential impacts of expanding resource extraction activities in the region can be measured.

Previous assessments of the deep-sea fauna of the Angola continental margin and basin have identified a large number of species that are new to science. Of the 682 Harpacticoida copepod species recently identified by George et al. (2014) only five were formally described with the remainder new to science. This is despite past research programmes (e.g. BIOZAIRE, Sibuet & Vangriesheim, 2009) and expeditions to the region that resulted in first description of many peracarid species (Brandt et al., 2005, and references therein). Other, previously undescribed, crustaceans (e.g. isopods, Brix et al., 2014; amphipods, Horton, 2004; Horton & Thurston, 2014) and loriciferans (Gad, 2005) have also been recently described from the region. While these advances have no doubt furthered our understanding of Angolan deep-sea communities, the scavenging fauna of the region remains understudied, especially in comparison to studies on legacy study areas in the North Atlantic (e.g. the Porcupine Abyssal Plain and Seabight, Billett et al., 2001; Hartman et al., 2012). Records of invertebrate scavengers in the Angolan continental margin region are particularly lacking.

Scavenging organisms play an integral role in deep-sea communities, dispersing and reintegrating organic carbon from food-falls into the wider ecosystem (Stockton & DeLaca, 1982; Britton & Morton, 1994; Payne & Moore, 2006; Higgs et al., 2014). These food-falls provide a localised and concentrated input of nutrients into the generally nutrient poor deep-sea habitat and their assimilation by scavengers forms the foundation of deep-sea food chains driven by secondary production (Payne & Moore, 2006). The Angola basin has been identified as a region with frequent large food-falls (Higgs et al., 2014), possibly due to the presence of the Congo Submarine Canyon, one of the largest submarine canyons in the world (Heezen et al., 1964; Shepard & Emery 1973). Traces from the plume produced by the Congo River and its interaction with the canyon system can be detected up to 800 km from the river mouth, where nutrient-rich effluent enhances the primary productivity of surface waters (Van Bennekom & Berger, 1984). Nutrient-rich waters are also found in deep marine environments owing to the active canyon system (Van Bennekom & Berger, 1984; Khripounoff et al., 2003; Vangriesheim et al., 2009). The effects of the nutrient-rich environments generated by the Congo River plume are reflected in high-density assemblages of sipunculans and echiurans in the Angola basin (Saiz-Salinas, 2007). Nutrient-rich areas are also expected to have scavenging assemblages dominated by a few specialist scavenger species (Stefanescu et al., 1994; King et al., 2008; Duffy et al., 2012).

This study aims to document the scavenging amphipods (Crustacea: Lysianassoidea) that attend large food-falls in the Angolan deep-sea habitat and provide new insight into the life history and population structure of the dominant scavenging amphipod species in the region.

MATERIALS & METHODS

Sample collection and processing

Samples were collected as part of baseline benthic surveys on behalf of the oil company BP Exploration (Angola) Limited. Five samples of scavenging amphipods were collected in 2005, with a further five samples collected in 2014 (Table 1; Figure 1). All samples were collected using simple traps (a Perspex tube with single funnel opening) baited with bigeye tuna (*Thunnus obesus* (Lowe, 1839)) and attached to the frame of the RObust BIOdiversity lander (ROBIO; OceanLab, Aberdeen, UK), a free-fall lander equipped with two acoustic releases, current meter, digital stills camera, flashgun, and battery pack (Jamieson & Bagley, 2005). The ROBIO lander was deployed in ‘tripod mode’ off the coast of Angola from the Gardline operated *Ocean Endeavour* in water 482 - 2073 m deep. On retrieval, amphipod samples were fixed in 100 % ethanol and returned to the laboratory where they were sorted, identified to species level, and counted. A non-metric multidimensional scaling plot was used to visualise Bray-Curtis dissimilarity amongst deep-water sites after species counts were converted to proportions. Sample B19-ROBIO was excluded from this analysis as the only sample taken from < 500 m water depth. A PERMANOVA test with 999 permutations was used to compare the composition variance of samples collected in 2005 and 2014.

[FIGURE 1 / TABLE 1]

The most abundant species was selected for a detailed population-level analysis. A random number generator was used to select a random subset of 826 individuals identified as *Abyssorchomene distinctus* (Birstein & Vinogradov, 1960) from sample

56761#1. Selected *A. distinctus* individuals were dissected and measured under a stereo-dissecting microscope. Organisms were sexed using primary and secondary sexual characteristics and diagonal length of coxal plate 4 (C4L; as described in Duffy et al., 2015) was measured for all individuals using a stage graticule. Oostegite and gill length were also measured for all females. Prior to dissection, the total body length (TBL; distance along the dorsal margin between the anterior margin of the head and the tip of the telson) of 50 randomly selected individuals was measured using a digital graphics tablet and HTML-assisted Measuring System (HaMS; Duffy et al., 2013). A linear model was used to correlate total body length to coxal plate 4 measurements so that the latter could be used a proxy for the former in all individuals. This reduces error that may arise from the variable posture of specimens and allows damaged specimens to be included in analyses.

Population characterisation

Characterisation analyses can be performed on either the total body length measured for all individuals or a correlated proxy (Duffy et al., 2013; Duffy et al., 2015). Therefore, the diagonal length of coxal plate 4 was used for this analysis as a proxy for total body length. Growth stages, or cohorts, of the *A. distinctus* population were identified from the length-frequency distribution of all measured specimens, with each discrete Gaussian component representing a successive moult. Oostegite stages were identified from a frequency distribution of the oostegite length:gill length ratio, where each discrete Gaussian component represented an oostegite stage.

Probability density histograms of coxal plate 4 measurements were plotted by sex (male, female, unsexed juveniles). Oostegite:gill ratios for all females were also plotted as probability density histograms. Gaussian components were identified from these plots initially by eye and then confirmed using the probability paper method (Cassie, 1954; Harding, 2009). The ‘mixdist’ package (Macdonald & Pitcher, 1979; Macdonald & Du, 2011) in R statistical software (R Development Core Team 2015) was used to confirm and refine the parameters of each identified component. The ANOVA function of this package was used to test if the identified Gaussian components differed significantly from the original data.

RESULTS

A total of 7 996 lysianassoid amphipods were identified from the 10 sampling sites. Ten species were identified, representing seven genera (Table 1). Of these, at least four species were new to science at the time of collection, though *Cyclocaris franki* Horton & Thurston, 2014, has now been described. *Abyssorchomene distinctus* or *Paracallisoma* sp. 6 were the dominant species in all but one (B19-ROBIO) sample (5.0 - 94.7 %, 5.0 - 87.5 % relative abundance respectively). *Podoprion ruffoi* Lowry & Stoddart, 1996 was the only species found in sample B19-ROBIO, which was the shallowest trap deployment (482 m), and was represented by only three individuals. Species richness of each sample was low and ranged from one (B19-ROBIO) to six (B18-ROR1). A multidimensional scaling plot visualising Bray-Curtis dissimilarity amongst sites > 1000 m water depth (Figure 2), in combination with a PERMANOVA test (n = 9, F_1 = 1.5258, R^2 = 0.1790, p = 0.0550), indicated that the compositions of samples taken in 2005 and 2014 were not significantly different.

[FIGURE 2]

Of the 826 *A. distinctus* specimens from sample 56761#1 that were dissected and measured for population analyses 149 males, 144 females, and 533 unsexed juveniles of varying size were identified. No ovigerous females were identified. There was a positive correlation between total body length and coxal plate 4 length (n = 50, TBL = 6.8743 C4L + 2.0486, R^2 = 0.8878). This allowed for coxal plate 4 measurements to be used as a proxy to estimate total body length. Estimated total body length for *A. distinctus* studied ranged from 5.46 to 19.12 mm (9.04 - 13.91 mm and 9.49 - 19.12 mm for specimens identified as males and females respectively).

Sexual dimorphism

The size distributions of males and females were significantly different from each other (Figure 3A; Mann-Whitney U-test: $U = 3911.5$, $p < 0.001$). Coxal plate 4 measurements of females were on average larger than males and had greater maximum size (males, Q1 = 0.900, Q2 = 1.200, Q3 = 1.300; females, Q1 = 1.300, Q2 = 1.500, Q3 = 2.000). Males had significantly longer antennae relative to total body length (Figure 3B; MWU: $U = 1\,733$, $p = 0.003$; males, Q1 = 1.363, Q2 = 1.775, Q3 = 2.000; females, Q1 = 1.613, Q2 = 1.900 Q3 = 2.387).

[FIGURE 3]

Sexual development

Oostegites were visible in females as small as 5.46 mm body length. It should be noted that *A. distinctus* possesses an accessory gill that may be mistaken for an oostegite, however it is present in both males and females and close examination confirms it is part of the primary gill structure. An oostegite:gill ratio frequency histogram and 'mixdist' model (ANOVA: *d.f.* = 12, $\chi 2 = 12.26$, $p = 0.4250$) identified three distinct oostegite stages (OS). All but one of the females with OS3 oostegites possessed setose oostegites, which indicates sexual maturity. Only one individual with OS2 oostegites had setae and no OS1 oostegites were setose. Ovaries were recoverable from 11 individuals and oocytes were arranged linearly. The total number of oocytes within recovered ovaries ranged from 5 to 19 with a median of 15 oocytes per ovary. Author observations, coupled with knowledge of a congener species (Duffy et al., 2013), indicate that both ovaries contain approximately equal numbers of oocytes and therefore brood size estimates lie between 10 and 38 individuals. Penal papillae in this species were pronounced and easily identified on examination of section 7 of the carapace.

Population characterisation

Gaussian components, each representing a cohort or growth stage, were identified for juveniles, males, and females (Table 2). Individuals that could not be sexed were assigned to one of two juvenile stages (Figure 4). There was minimal overlap between the distribution of the largest juveniles (J2) and the smallest sexed individuals (M3, F3; Figure 4). Males fitted into three distinct cohorts (M3, M4, and M5; Figure 4A). The presence and number of these was confirmed using the probability paper method and the parameters were further refined using the 'mixdist' package. The fitted model did not differ significantly from the data (ANOVA: *d.f.* = 5, $\chi 2$ = 4.10, p = 0.5348).

Five cohorts were identified for females (F3 – F7; Figure 4B). The parameters of these cohorts were confirmed using the probability paper method combined with a 'mixdist' model fitted to the data (ANOVA: *d.f.* = 2, $\chi 2$ = 0.2728, p = 0.8725). Linear growth factors between cohorts ranged from 1.18 to 1.36 with juvenile growth factors at the higher end of this range. These growth factors are comparable to those previously reported for *Abyssorchomene abyssorum* (Stebbing, 1888) (Duffy et al., 2013).

[FIGURE 4 / TABLE 2]

DISCUSSION

Two of the species identified, *Abyssorchomene distinctus* and *Paracallisoma* sp. 6, featured in all but the shallowest sample, frequently in high relative abundances. *Abyssorchomene distinctus* has been previously found at depths ranging from 2635–5173 m (Barnard & Ingram, 1990; Jamieson et al., 2011). Sampled at 1157 m deep, the four *A. distinctus* in sample B18-ROR2 represent the shallowest confirmed record of this species to date (though it should be noted that the species was described by Birstein & Vinogradov, 1960, from a specimen taken in a non-closing net operating between 2000 m deep and the surface, thus the actual depth of capture of the original record cannot be confirmed). The low abundance, relative to deeper samples, in this sample and sample B18-ROR1 (1461 m depth) suggests that this represents the uppermost limits of the depth-range of this species. *Abyssorchomene distinctus* is reported from the type locality in the Pacific Ocean, Near Palau (Birstein & Vinogradov, 1960), the East Pacific vent region (Barnard & Ingram, 1990), the Loyalty Islands (Lowry & Stoddart, 1994), the Kermadec Trench (Jamieson et al., 2011), the Cape Verde Plain, North Atlantic (Thurston, 1990), and Mid-Atlantic Ridge (Horton et al., 2013). The finding of this species in both the Pacific and Atlantic Oceans warrants further investigation to determine whether or not the populations are conspecific.

Paracallisoma sp. 7 is similar in appearance to a species of *Paracallisoma* Chevreux, 1903, yet to be described from the Faroe-Shetland Channel (*Paracallisoma* sp. 2; Horton, 2006), but individuals are outside the known size range for that species and it is therefore likely to be new to science. Only 34 individuals were found from six samples (Table 1). All new species of *Paracallisoma* are being described elsewhere as part of a series of revisions of the family Scopelocheiridae (first revision, Horton & Thurston, 2015).

Cyclocaris franki Horton & Thurston, 2014, was described in a recent revision of the genus *Cyclocaris*, from the material reported herein. The species is only known from the Atlantic Ocean, from the Angolan continental margin, 1850–2059 m, the Sierra Leone Rise, 1203 m, and the Cape Verde Islands, 1477 m (Chevreux, 1903; 1935). All known material of *C. franki* has been obtained from baited benthic traps (Horton & Thurston, 2014).

The entity reported here as *Valettiopsis macrodactyla* Chevreux, 1909 and as redescribed in Horton (2004) is likely also a new species. *Valettiopsis macrodactyla* was first described by Chevreux (1909) and the description repeated with different illustrations and further material in 1935 (Chevreux, 1935). A further specimen was attributed to *V. macrodactyla* by Lincoln & Thurston (1983). This entity is now recognised as *V. lincolni* Horton, 2004. The key to *Valettiopsis* provided by Hendrycks (2007) indicates that the description of the palm of Gnathopod 2 for *V. macrodactyla sensu strictu* does not match that of the illustrations of *V. macrodactyla sensu* Horton 2004. The type of *V. macrodactyla* Chevreux, 1909 thus warrants a full redescription to distinguish it from the Angolan species and to prevent further errors in identification.

The species *Valettiopsis longidactyla* Horton, 2004, was originally described from material collected off the coast of Angola from two male type specimens. This study adds a further four specimens to those known and extends the known depth of occurrence of this species from 1252 m to 1850 m (Horton, 2004). *Valettiopsis lincolni* Horton, 2004 was described from material taken from the Bay of Biscay

Abyssal Plain, at 4300 m and has also been recorded from the Gulf of Mexico at 1326 m. This study adds a further four specimens from 1850 m off the Angolan coast.

Podoprion ruffoi is the sole species collected from the shallowest sample at 482 m. There is only one other specimen known, described from the stomach of a fish taken off the coast of Namibia in 410–460m depth (Lowry & Stoddart, 1996). The samples collected as part of this study add three specimens and provide a significant range extension, indicating that members of the genus *Podoprion* appear to be specialist scavengers occurring shallower than 1200m. This second finding of *P. ruffoi* in the 400–500m depth range off the coast of West Africa suggests the species is constrained to this depth-range but may have a broad geographic distribution along the African continental slope.

The absence of species of the genus *Eurythenes* Smith in Scudder, 1882 from all samples described here is notable. *Eurythenes* is a ubiquitous genus of scavenging amphipod with a pan-oceanic distribution (Stoddart & Lowry, 2004; Brandt et al., 2012). With the recent resolution of the *E. gryllus* (Lichtenstein in Mandt, 1822) species-complex, it is now understood that the genus is comprised of at least seven species. (D'Udekem D'Acoz & Havermans, 2015). Members of the genus are almost always recovered from baited traps deployed at bathyal, abyssal, and hadal depths (e.g. Thurston, 1990; Duffy et al., 2012; Horton et al., 2013). There are two potential explanations for its apparent absence from samples from the Angolan slope, either sampling bias or true absence of *Eurythenes*. Although the former cannot be wholly ruled out, 10 localised samples across a 1500 m depth range represents relatively good sampling effort for deep-sea scavenging amphipods and one would expect to catch at least one *Eurythenes* specimen if they are present in the environment (e.g. Horton et al., 2013 described the contents of 12 baited trap deployments on the Mid-

Atlantic Ridge and all contained *Eurythenes*; of the eight trap deployments on the Iberian margin described by Duffy et al., 2012, all but two contained *Eurythenes*). The diameter of the trap opening may have prevented large individuals from entering, but an identical trap has previously caught multiple *Eurythenes* specimens (Cousins et al., 2013). It is, therefore, likely that the genus is absent from the Angolan continental margin at the studied depths. The distribution of *E. gryllus sensu lato* suggests that the upper thermal tolerance of *Eurythenes* is ~ 4 °C (Thurston, 1990, and references therein) and, as the water temperature recorded at all sites is near to or in excess of this temperature (Table 1), the environment of the Angolan deep sea may be inhospitable to this species.

Angolan scavenging amphipod assemblages

The identification of four species not previously described, and unexpected absence of *Eurythenes*, highlights how little is currently known of deep-sea scavenging guilds in the Angola region. Despite multiple sample sites, a broad depth-range of sampling (482 – 2073 m deep), and the large number of individuals collected in this study, only ten in species in total were found. A regional species richness (γ-diversity) of ten is similar to the regional diversity reported for the bathyal depths of the Bay of Biscay (22 deployments, 2080 – 2225 m water depth, $\gamma = 8$; Thurston, 1990), although the sampling depth-range and sample-size of these samples was much smaller. The richness of the Angolan continental margin scavenging amphipod community is lower than the lysianassoid richness reported from large catches from bathyal depths at the Mid-Atlantic Ridge (12 deployments, 2340 – 2628 m water depth, $\gamma = 31$; Horton et al., 2013) despite sampling efforts at the Mid-Atlantic Ridge covering a narrow depth-range of 288 m compared to the 1591 m depth-range of this study. The Mid-Atlantic ridge may, however, be acting as a biogeographic boundary in this region (Alt et al., 2013; Horton et al., 2013) meaning that the high regional diversity is an artefact of sampling across multiple biogeographic regions. Regardless, the species richness values reported by Horton et al. (2013) for each of the discrete sampling areas around the Mid-Atlantic ridge (NW = 15, NE = 18, SE = 23, SW = 18) were all higher than the total richness of the Angolan continental margin.

The relatively low diversity and large sample sizes reported here are comparable to scavenging amphipod assemblages described from submarine canyons on the Iberian Peninsula (Duffy et al., 2012). The finding of high numbers of only a few amphipod species in samples between 6.0 and 6.5 ° S (Figure 1) is particularly interesting. The large sample sizes suggest that there is a large background scavenging population in the sampling area (Blankenship et al., 2006) and this may be indicative of a high nutrient deep-sea habitat in the region, a result of the Congo submarine canyon system (Figure 1). Submarine canyons, especially large canyons like Congo that deeply incise the continental shelf (Heezen et al., 1964), capture sediments and channel them into the deep sea (van Weering et al., 2002; Cúrdia et al., 2004). This makes submarine canyons hotspots of secondary production (Soliman & Rowe, 2008; De Leo et al., 2010; van Oevelen et al., 2011), with active canyon systems enriching surrounding deep-sea environments (Van Bennekom & Berger, 1984; Khripounoff et al., 2003; Vangriesheim et al., 2009). Cúrdia et al. (2004) identified estuarine input as a primary source of the large quantities of terrigenous organic matter that enter canyon systems. As Congo Submarine Canyon is directly linked to the second largest river system in the world (Eisma & Van Bennekom, 1978; Savoye et al., 2009), the terrigenous input is expected to be sizeable. Nutrient-rich river effluent also enhances primary productivity of surface waters up to 800 km from the coast (Van Bennekom & Berger, 1984). Surface productivity is closely linked to deep-sea nutrient availability via particulate organic carbon flux and bentho-pelagic coupling processes (Lutz et al., 2002; Drazen et al., 2012).

The combination of enhanced primary production of surface waters, terrigenous and shelf-material input, and enhanced secondary production that is driven by the Congo submarine canyon and river systems results in deep-sea habitats that are relatively rich in nutrients. These nutrient-rich environments have been shown to support dense sipunculan and echiuran assemblages in the Angola Basin (Saiz-Salinas, 2007). The effects of the river and canyon systems on the frequency of large food-falls for scavenging organisms are difficult to accurately ascertain. However, increased primary and secondary productivity are expected to increase overall ecosystem biomass including the number of larger organisms that become food-falls when they die. This theory is supported by the finding of three large food-falls in the vicinity of the Congo Canyon (Higgs et al., 2014), a remarkably high number given the infrequent occurrence of naturally occurring deep-sea food-falls recorded globally (Stockton & DeLaca, 1982; Smith et al., 2015), though this may be reflective of sampling effort. Turbidity currents in the canyon system may also increase food-fall occurrence through direct mortality of megafauna (Angel & Rice, 1996).

Potential impacts of oil-extraction

Generally, scavenging species are thought to benefit from disturbances as mortality of less motile organisms (Jones et al., 2006) would increase food-fall availability. Scavenging amphipods are relatively motile (Laver et al., 1985; Bluhm, 2001) and are therefore able to quickly respond to disturbance events. The pervasiveness of scavenging amphipods in disturbed environments may mean that physical disturbance from oil-extraction activity will benefit scavenging communities as a result of increased food-fall availability. Coupled with the findings of Neff & Durell, (2012) that concentrations of contaminants associated with deep-sea oil extraction (polycyclic aromatic hydrocarbons, saturated hydrocarbons, sterane triterpane petroleum biomarkers) were not significantly different in amphipods found near extraction sites before and after well commission, it is unlikely that the short-term effects of oil-extraction activities will be detrimental to deep-sea scavenging amphipods. Regardless, this study of the deep-sea scavenging amphipod community in the early stages of extraction activity provides a valuable baseline for studying any long-term effects that may occur.

Population ecology of *Abyssyorchomene distinctus*

The large number of *A. distinctus* recovered in this study provided the opportunity of a population-level study of this poorly understood deep-sea amphipod. This provides further population-level baseline data for any future studies examining the effect of prospecting and extraction activity. The sexual dimorphism observed in *A. distinctus* is very similar to that documented for its congener *A. abyssorum* (Duffy et al., 2013). Lysianassoid females are often larger than males (Sainte-Marie, 1991), which may reflect the non-mate-guarding pre-copulatory behaviour (Bousfield & Shih, 1994; Bousfield 2001) that is characteristic of lysianssoid amphipods (Conlan, 1991). The significantly longer antennae possessed by male *A. distinctus* is another sexual dimorphic trait also observed in *A. abyssorum* (Duffy et al., 2013). Elongated antennae are hypothesised to enhance tactile detection (Steele, 1995) and chemosensing ability (Kaufmann, 1994) during mate searching activity.

Five female cohorts were identified with larger, sexually mature females, possessing large setose oostegites (OS3), indicating their ability to form a brood-pouch and carry a brood (Steele, 1991). The estimated brood size of *A. distinctus* (10-38 eggs) is much lower than that reported for *A. abyssorum* (36-78 eggs; Duffy et al., 2013). Sainte-Marie (1991) identified a generally positive correlation between brood size and female body length in other lysianassoid species but noted that this relationship is variable. As such, the brood size relative to female body size is within expectations for lysianassoid amphipods.

No ovigerous female *A. distinctus* were identified from individuals examined in this study. Brooding deep-sea scavenging amphipods are rarely observed at food-falls (Duffy et al., 2015), although there are a handful of exceptions (e.g. Blankenship et al., 2006; Horton & Thurston, 2011; Horton et al., 2013). The rarity of brooding females at food-falls is attributed to reduced mobility when carrying a brood, vulnerability owing to a softened cuticle (Ingram & Hessler, 1987; Thurston & Bett, 1995), and general increase in predation risk at food-falls (Lampitt et al., 1985; Jamieson et al., 2011). Due to the sampling methods used in this study, a bias in population structure is unavoidable. Openings of all traps used were wide enough so as to not prohibit entry of any *A. distinctus* regardless of their size. The possibility that local hydrographic conditions influence the population structure (e.g. strong currents prevent smaller individuals with reduced mobility reaching the trap) should also be noted.

Owing to its position, linking coastal waters to abyssal basins, the deep-sea ecosystem on the Angolan continental margin houses a unique, interesting, and newly described scavenging amphipod community. The presence and influence of the Congo Submarine Canyon further adds to the complexity and connectivity of the margin region, providing a pathway for the estuarine system to affect deep-sea organisms. The study of this region will allow for comparisons to be made with other deep-sea scavenging assemblages and populations around the world and provide an important ecological baseline to monitor the effects of resource extraction activities.

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Figure 1: Bathymetric map of the continental margin off the coasts of the Republic of Angola and the Democratic Republic of the Congo (DRC). Contours indicate depth in metres. Sampling sites used in this study indicated by stars.

Figure 2: Non-metric multidimensional scaling plot of Bray-Curtis similarity amongst deep (> 1000 m water depth) sites used in this study. Triangles and circles represent samples taken in 2005 and 2014 respectively, stress = 4.1144. See Table 1 for site specific environmental data and location.

Figure 3: Estimated body-size (A) and corrected antennal length relative to body size (B) of antenna 1 (grey) and antenna 2 (white) of male and female *Abyssorchomene distinctus*. Median and interquartile ranges shown.

Figure 4: Probability density histogram for coxal plate 4 measurements for juveniles (A, B; grey), males (A; white), and females (B; white). Normal distributions, identified using ‘mixdist’ package of R statistical software, indicated.

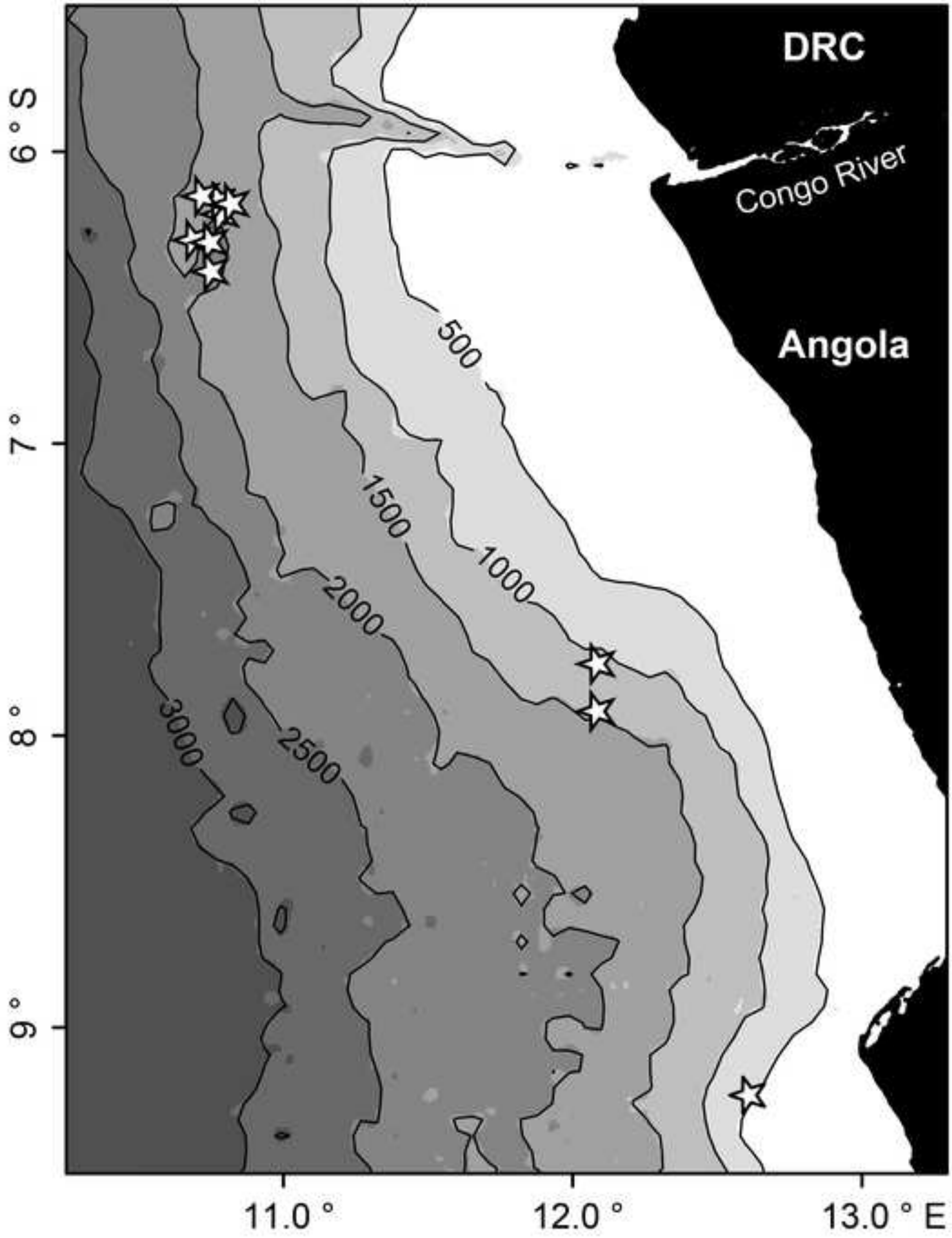
Table 1: Sampling site location and environmental data, and scavenging amphipod composition of each baited-trap analysed from deployments on the Angolan continental margin in 2005 and 2014. Samples ordered by depth. Four species were new to science at the time of collection, and *Cyclocaris franki* has since been described.

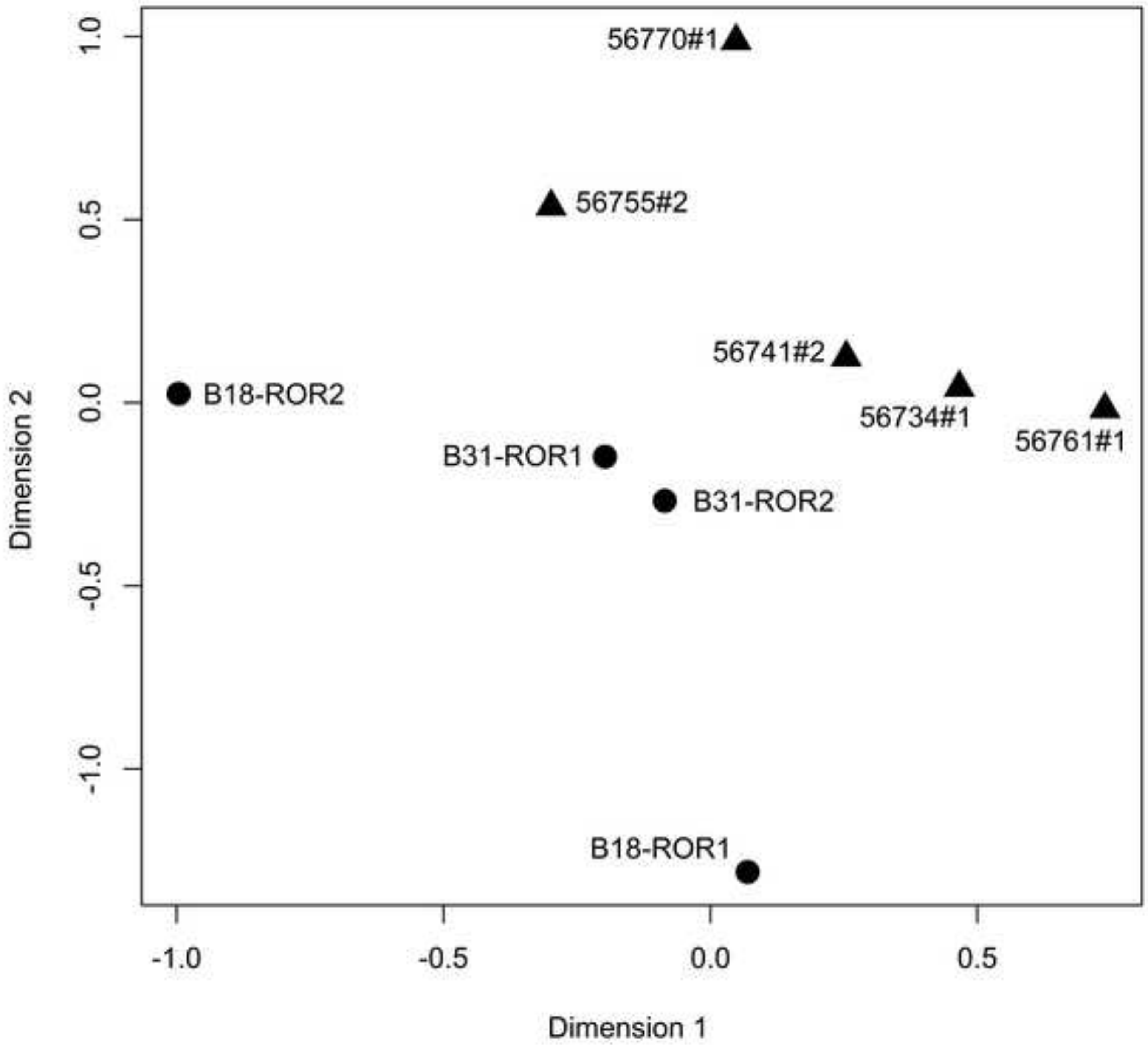
	B19-ROBIO	**B18-ROR2**	**B18-ROR1**	**B31-ROR2**	**56770#1**	**56734#1**	**56741#2**	**56755#2**	**56761#1**	**B31-ROR1**
Latitude (°)	-9.2320	-7.7550	-7.9170	-6.1790	-6.2147	-6.1690	-6.1529	-6.3034	-6.3113	-6.4110
Longitude (°)	12.6090	12.0850	12.0840	10.821	10.7857	10.7770	10.7179	10.6877	10.7476	10.7500
Depth (m)	482	1157	1461	1760	1850	1859	1965	2002	2059	2073
Date (dd/mm/yy)	02/09/14	26/08/14	27/08/14	23/08/14	01/11/05	26/10/05	27/10/05	02/10/05	30/10/05	18/08/14
Soak time (hh:mm)	18:58	20:50	12:23	13:03	27:47	22:14	15:14	15:00	23:15	20:55
Temperature (° C)	7.94	4.29	4.10	3.88	3.87	4.08	3.72	3.81	3.69	3.33
Current velocity (cm s-1)	2.9	1.8	2.7	1.9	1.90	4.80	2.50	2.70	3.30	2.6
Abyssorchomene distinctus (Birstein & Vinogradov, 1960)	0	4	3	17	160	86	162	147	2991	738
Cyclocaris franki Horton & Thurston, 2014	0	0	0	2	1	6	0	1	41	0
Cyphocaris bouvieri Chevreux, 1916	0	0	1	0	0	0	0	0	0	0
Hirondellea sp. 1	0	0	41	5	0	0	0	0	0	1
Paracallisoma sp. 6	0	28	13	94	125	223	395	67	2562	39
Paracallisoma sp. 7	0	0	1	1	0	10	6	0	15	1
Podoprion ruffoi Lowry & Stoddart, 1996	3	0	0	0	0	0	0	0	0	0
Valettiopsis lincolni Horton, 2004	0	0	0	0	4	0	0	1	0	0
Valettiopsis longidactyla Horton, 2004	0	0	0	0	4	0	0	0	0	0
Valettiopsis macrodactyla Chevreux, 1909	0	0	1	0	0	0	0	0	0	0
Combined abundance	**3**	**32**	**60**	**119**	**290**	**325**	**563**	**216**	**5609**	**779**
Species richness	**1**	**2**	**6**	**5**	**4**	**4**	**3**	**3**	**4**	**4**

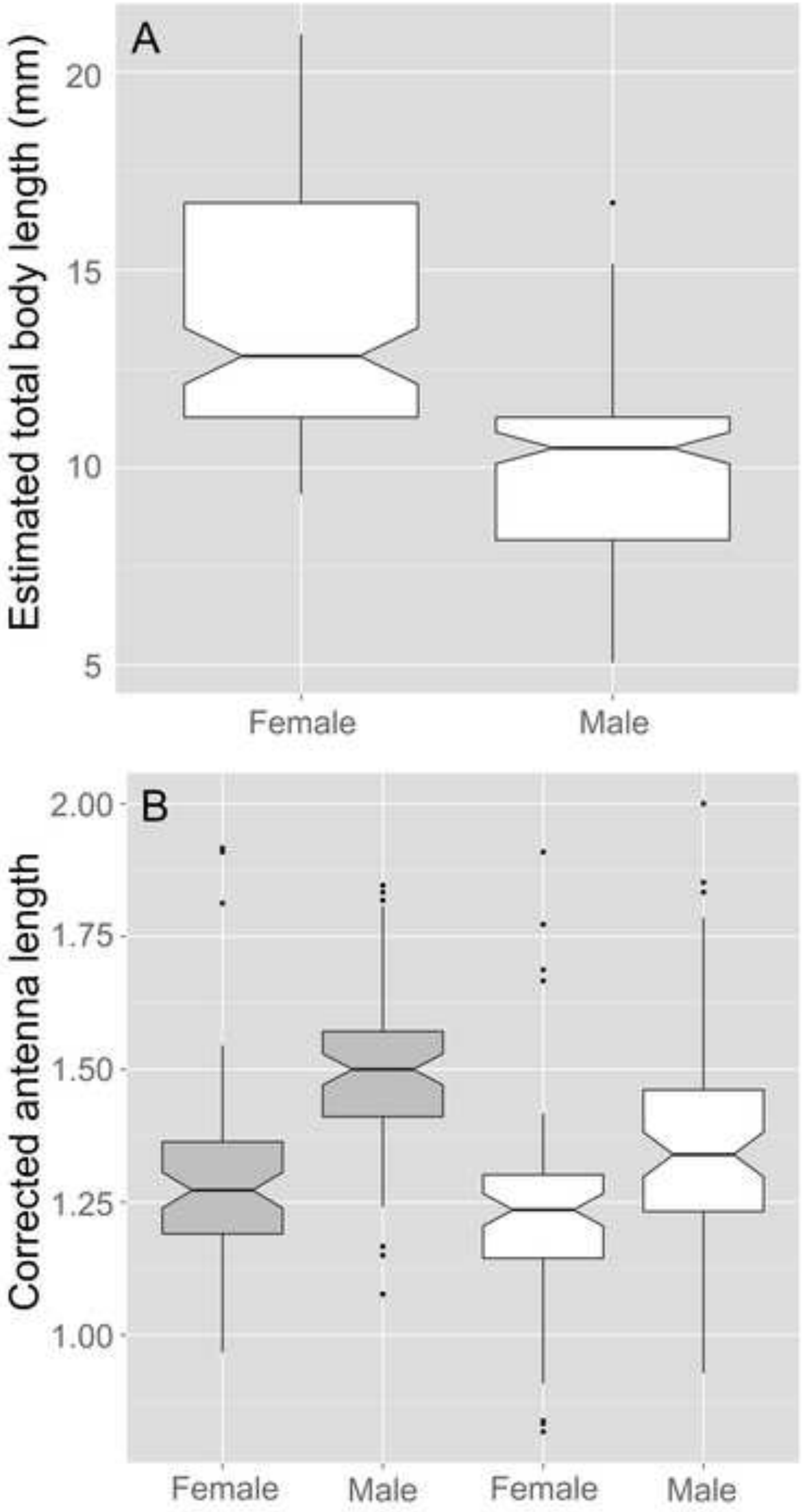
Table 2: Mean coxal plate 4 measurement (C4L) and estimated total body length (TBL) for all *Abyssorchomene distinctus* cohorts identified in this study. Linear growth factor between successive cohorts in parentheses.

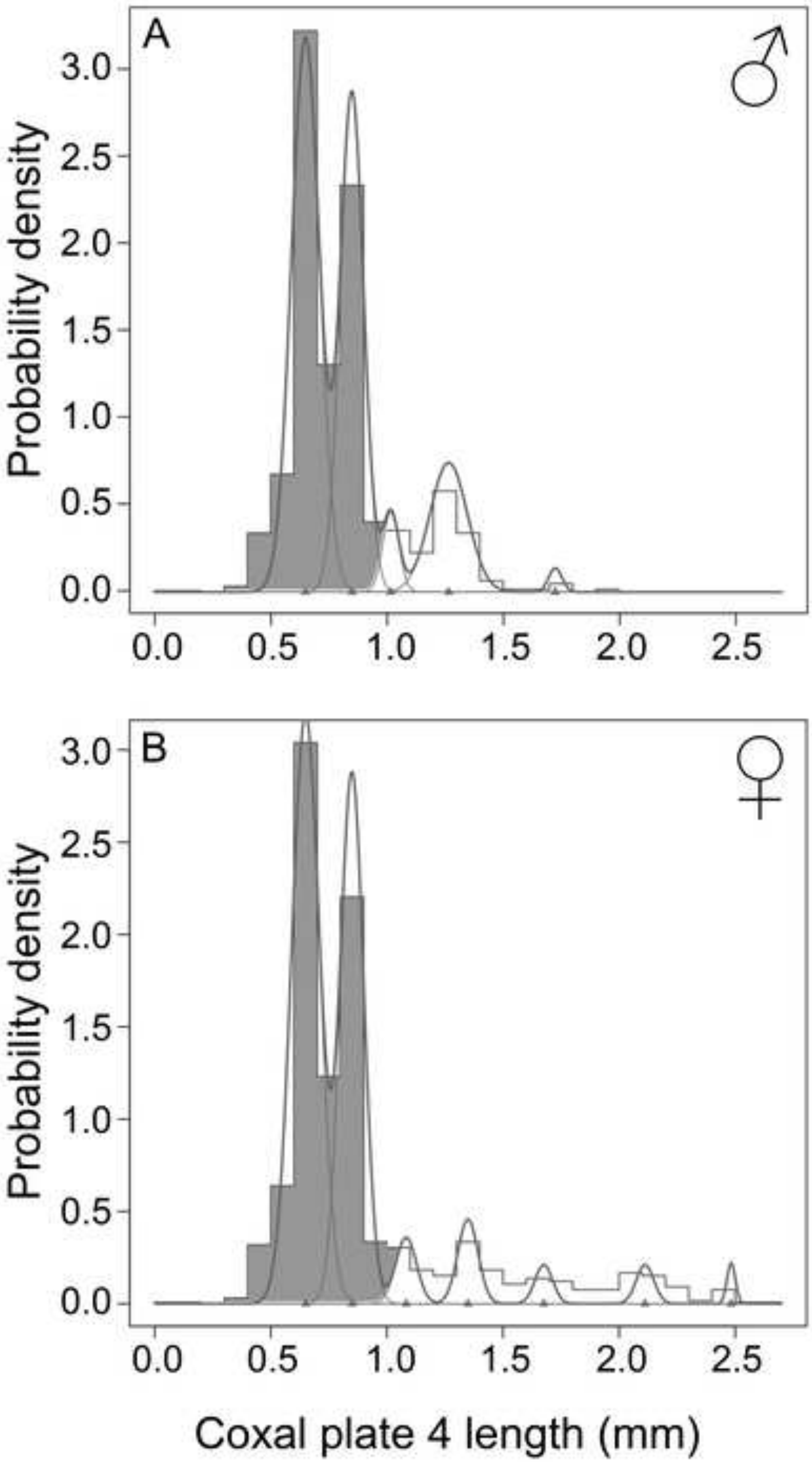
Juvenile	**C4L**	**TBL**		**Male**	**C4L**	**TBL**		**Female**	**C4L**	**TBL**	
J1	0.65	6.52									
			(1.31)								
J2	0.85	7.89									
				M3	1.02	9.04		F3	1.08	9.49	
							(1.25)				(1.25)
				M4	1.27	10.75		F4	1.35	11.32	
							(1.36)				(1.25)
				M5	1.73	13.91		F5	1.68	13.57	
											(1.26)
								F6	2.11	16.57	
											(1.17)
								F7	2.48	19.12	

Figure 1


DRC
Congo River
Angola
500
1000
1500
2000
2500
3000
6 ° S
7 °
8 °
9 °
11.0 °
12.0 °
13.0 ° E


56770#1
56755#2
56741#2
56734#1
56761#1
B18-ROR2
B31-ROR1
B31-ROR2
B18-ROR1
1.0
0.5
0.0
-0.5
-1.0
Dimension 2
-1.0
-0.5
0.0
0.5
Dimension 1


A
Estimated total body length (mm)
20
15
10
5
Female
Male
B
Corrected antenna length
2.00
1.75
1.50
1.25
1.00
Female
Male
Female
Male


A
♂
B
♀
Probability density
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
Coxal plate 4 length (mm)