**R E S E A R C H   A R T I C L E**

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# SHORT TERM ESTIMATION OF THE BENTHIC ENERGY IN TWO ARID TROPICAL SANDY BEACHES AT SOUTH EASTERN RED SEA, SAUDI ARABIA USING BIOMETRIC CONVERSION

## ABSTRACT:

The energy content of benthic invertebrates was estimated of two arid tropical sandy beaches, namely AlBirk and AlHorida, on the south eastern coast of the Red Sea, Saudi Arabia in the summer of 2007. This is the first study to deal with the benthic energy of such arid tropical beaches, using the relationship between body dimensions and wet weight to estimate biomass (and from this, ash free dry weight) as well energy content independently of species identifications. The energy values were generally lower than those in Temperate or Arctic zones. The average energy content at AlBirk and AlHorida beaches was 4 and 1.4 Kcal.m$^{-2}$, respectively. AlBirk was dominated by Amphipoda, Bivalvia, Polychaeta, and Ostracoda, with energy values of 1.3, 1, 1, and 0.5 Kcal.m$^{-2}$, respectively, while AlHorida was dominated by Polychaeta with a value of 0.9 Kcal.m$^{-2}$. The differences between the two sites in terms of average wet biomass, ash free dry weight and energy per m$^2$ were attributable to differences in wave energy, grain size and organic matter that led to the differences in abundance and dominance.

## KEY WORDS:

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## INTRODUCTION:

Sandy beaches have generally been considered as nonproductive habitats as their inhabitants pursue a burrowing mode of life and are mostly hidden (Bally, 1994). Studies of such beaches have examined the responses of the inhabitants to wave energy (Short and Wright, 1983), the effects of climate change and sea-level rise on the intertidal benthic macrofauna (Fujii, 2012), and the influence of environmental factors on intertidal Nematoda (Venekey *et al.*, 2014). However, estimation of aquatic macro invertebrates energy is a necessary pillar stone for the evaluation of energy flow, budgets, and allocations in the ecosystem (Paxton and Miller, 2013). Relatively few studies dealt with the benthic macrofaunal energy of soft sediments. Among such studies, Company and Sarda (1998) who focused on a specific group of organisms (decapods) in terms of metabolic rates and energy content of deep sea (Western Mediterranean Sea).

Slobodkin and Richman (1961) evaluated the energy content of a wide range of animal species using a miniature bomb calorimeter. Norrbin and Bamstedt (1984) compared the energetics of benthic and planktonic invertebrates. While, Wacasey and Atkinson (1987) and Dauvin and Joncourt (1989) evaluated the benthic energy contents in the Canadian Arctic and the Western English Channel, respectively.

Recently, Blanchard and Knowlton (2013) studied the caloric content of macrobenthic communities in the Arctic Northeast Chukchi Sea. Relatively few studies have been employed wet weight (biomass) conversion factors to ash-free dry weight and energy to compare differences among regions. In terms of the northern global hemisphere (Temperate and Arctic Regions), studies are limited to Lie (1968) for the Pacific North America invertebrate taxa, Ellis (1960) for the Arctic North America taxa, Rumohr *et al.* (1987) for the Baltic invertebrate taxa, Gilat (1969) for the benthic invertebrates of the Ligurian Sea and Ricciardi and Bourget (1998) who assembled a compilation of weight-to-weight conversion

factors for marine and estuarine macro invertebrate taxa, using data from many species and geographic regions. Others have dealt with benthic invertebrate energy content in southern hemisphere temperate regions. For example, Bally (1994) examined the benthic energy values and ash content of macrofauna on sandy beaches at the west coast of South Africa. All of these studies were restricted to temperate and arctic regions, reflecting a scarcity of studies dealing with the energy content and ash-free dry weight of the benthic macrofauna on the sandy beaches at arid tropical regions such as those examined in the current study.

## MATERIAL AND METHODS:

### Study Sites Description and Physico-chemistry:

The study sites, namely AlBirk and AlHorida, are about 56 kilometres apart along the south eastern coast of the Red Sea (Fig. 1). AlBirk site is situated northern to the AlHorida site. Wave average and tide range was 0.25 m and 0.2 m in AlBirk and 1 m and 0.6 m in AlHorida, respectively. Sediment grain size was not the same in the two sites. It was relatively coarser in AlHorida than in AlBirk. The physical nature of the two study sites was influenced by these differences. AlBirk is characterized by relatively small bays while AlHorida is an open beach with relatively more wave energy. Table 1 shows the characteristics of the study sites.
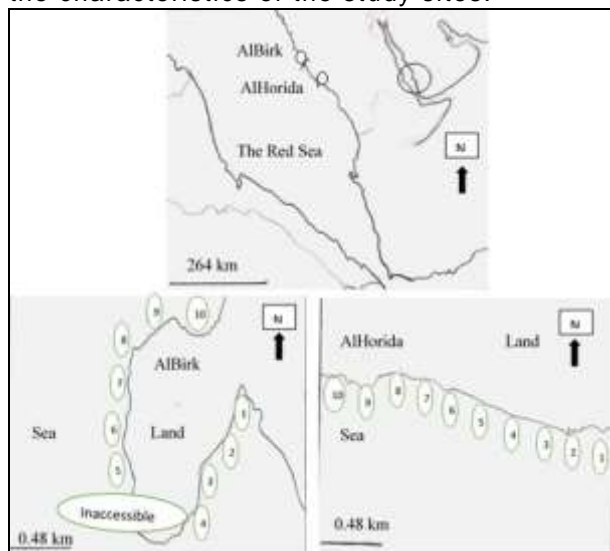


Fig. 1. The two study sites AlBirk and AlHorida at Southeastern Red Sea, Saudi Arabia.

Table 1. characteristics of the study sites.

|  | AlBirk | AlHorida |
| --- | --- | --- |
| Position | 18°12'47.08"N 41°31'31.56"E | 17°48'24.92"N 41°51'34.47"E |
| Median grain size (Phi) | 3.7 ± 0.57 | 2.0 ± 0.26 |
| Organic matter % | 0.80% ± 0.08 | 0.20% ± 0.06 |
| Temperature °C | 37 | 36 |
| Salinity | 40.7 | 41.0 |

### Environmental Variables Measurements:

### Abiotic Field Measurements:

Sea water temperature and salinity were measured using a waterproof pen-type digital salinity meter model 837-1. Ten sediment samples were taken from each site using an 8.8 cm diameter corer to measure organic matter content, and median grain size _. Samples were maintained in acid-washed bottles and immediately frozen on return to the laboratory.

In the laboratory sediment median grain size was determined for each replicate per site, by washing sediment samples of known weight through a series of stacked sieves (1000, 500, 250, 125, and 63 µm) on top of a pre-calibrated volume bucket to collect smaller grain sizes. The percentage weight contribution of each sediment portion was then calculated. For smaller size fractions (16 & 31 µm) a known portion of the suspension was collected, dried, then weighed; its percentage relative to the original sediment sample was calculated. This method is modified from Buchanan (1984) as suggested by Palmer and Strayer (1996).

Organic matter was measured by the loss-on-Ignition (LoI) method (using Muffle furnace), which is a modification of a method described by Ben-Dor and Banin (1989).

LoI % = (weight105 – weight400)/weight105 X 100

Where weight105 is the sediment weight at 105°C, and weight400 is the sediment weight at 400°C.

### Biotic Fieldwork Measurements:

Three replicate cylindrical corer samples at ten stations in each study site (diameter 20 cm, depth 10 cm) were sampled in the summer of 2007 from soft sediment at AlBirk and AlHorida sites. Sediment samples were placed in polythene bags and fixed with 10% buffered formalin.

In the laboratory sediment samples were sieved using 500 µm mesh size. The collected organisms were preserved in 70% alcohol, enumerated and identified to major taxa for each replicate.

Biomass was calculated only for organisms for which published relationships existed between body dimension and wet weight according to Ramsay *et al.* (1997) and Abada (2000). Similarly, energy content was calculated only for cases for which there were published data converting biomass wet weight to ash free dry weight and to energy (Rumohr *et al.*, 1987). The percentage of the considered organisms in AlBirk and AlHorida was 97% and 95%, respectively.

The author is aware that conversion factors from ash free dry weight to energy for some species have been published (Ricciardi and Bourget, 1998). However, the

methodology used in the current study has the advantage of reducing time-consuming detailed taxonomy, leading to an easy and quick estimation of biomass as wet weight (Ramsay *et al.* 1997; and Abada 2000) that depends on organismal body shape regardless of taxonomic position and conversion of this into ash free dry weight, and finally to energy values, using published data (Rumohr *et al.*, 1987), without reliance on bomb calorimetry, which has been used in all other methods of energy estimations. Accordingly, this method allows an efficient evaluation of energy that yields estimates for the whole community quickly and inexpensively.

Organism body dimensions (length and width) were measured using a binocular microscope (National Optical and Scientific Instruments Inc. stereoscopic zoom microscope with digital camera model DC3-420TH). The image magnification was calibrated for each lens used. Organism images were projected onto a computer screen. In case of long curved animals such as Polychaeta, successive straight lines were drawn around the periphery of the organism's image. Lengths measured could be summed to obtain the total organismal body length or width. For short, straight organisms like Ostracoda, lines were drawn to capture length and width. Biomasses as wet weight values were derived according to Ramsey *et al.* (1997) and Abada (2000). The wet weight biomasses were then converted to ash-free dry weights, which were then translated to energy values as Joules according to Rumohr *et al.* (1987), and Ricciardi and Bourget (1998). Finally, energy values were expressed as calories.

### Statistical Analysis:

Multifactor analysis of variance as well as one way ANOVA were used to test differences between the two sites as well as the major taxa in terms of abundance, energy content, and their interactions. To show the distinctions of the major taxa caloric content between the present study and some other studies all over the world, Geospatial model was used.

### RESULTS:

The environmental variables measured reflected the arid equatorial conditions of the study sites. Temperature were 36°C and 37°C at AlHorida and AlBirk, respectively. Salinity was relatively consistent between 40.7‰ and 41.0‰ at the study sites. However, the median grain size and the percentage of organic matter content were relatively different between the two sites. Although both sites are sandy beaches, the sediment at AlBirk was finer than that at AlHorida. The percentage of organic matter content was generally higher at AlBirk than AlHorida (Table 1).

Multifactor ANOVA of square root transformed abundance data showed that AlBirk was significantly higher than AlHorida ($P=0.0000$). Moreover, the taxa individual abundances and their interaction with sites abundances were significantly higher in AlBirk except for Polychaeta ($P = 0.0000$, $P = 0.0000$, respectively). The sequence of dominance at AlBirk was different from that at AlHorida. For example, at AlBirk, Gastropoda, Polychaeta and Ostracoda were the highest followed by Bivalvia, Amphipoda, Nematode, Cyclops, Foraminifera, and Hirudinea. Whereas the sequence at AlHorida, was Polychaeta as the highest followed by Cumacea, Ostracoda, Bivalvia, Amphipoda, Isopoda, Decapoda, Gastropoda, Nemertea, and Pycnogonida (Fig. 2). According to Engelmann, 1978, the relative contribution of individual taxa in both sites can be summarized as in table 2.
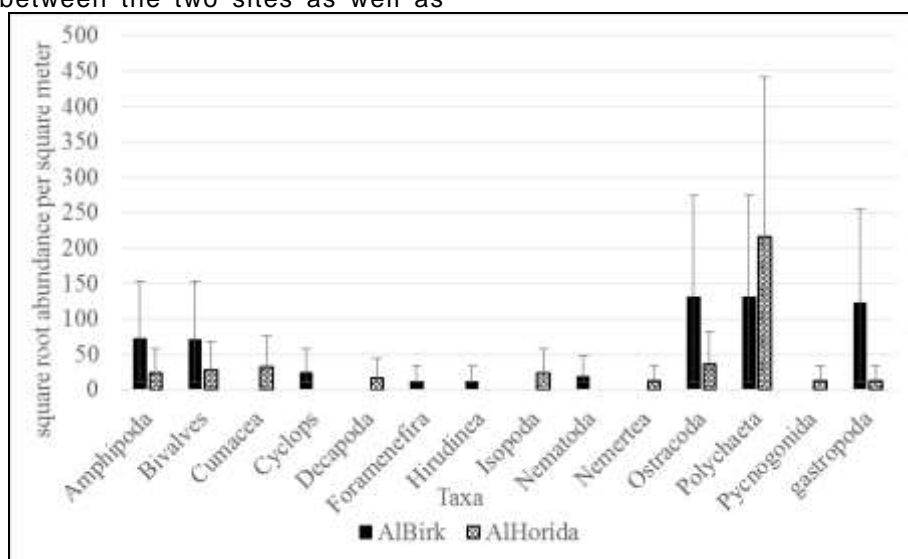


Fig. 2. Interaction plot of the overall abundance with the individual taxa abundances at the two study sites.

Table 2. List of the major taxa square root transformed abundance data per square meter and their relative contribution in the study sites. r.c.: relative contribution, eudominant (A) over 30% of individuals, dominant (B) 10 – 30% of individuals, subdominant (C) 5 – 10% of individuals, minor (D) 1-5% of individuals and rare (E) under 1% of individuals, g = grouping (Engelmann, 1978).

| Taxa | AlBirk | | | AlHorida | | |
|---|---|---|---|---|---|---|
| | Square root mean abundance | r.c. % | g | Square root mean abundance | r.c. % | g |
| Amphipoda | 76 | 7% | C | 39 | 1% | D |
| Bivalvia | 76 | 7% | C | 35 | 2% | D |
| Cyclops | 29 | 1% | D | 0 | 0% | |
| Cumacea | 0 | 0% | | 41 | 3% | D |
| Decapoda | 0 | 0% | | 29 | 1% | D |
| Foraminifera | 21 | 1% | D | 0 | 0% | |
| Gastropoda | 170 | 36% | A | 21 | 1% | D |
| Hirudinea | 21 | 1% | D | 0 | 0% | |
| Isopoda | 0 | 0% | | 29 | 1% | D |
| Nematode | 32 | 1% | D | 0 | 0% | |
| Nemertea | 0 | 0% | | 21 | 1% | D |
| Ostracoda | 132 | 22% | B | 35 | 2% | D |
| Polychaeta | 140 | 24% | B | 221 | 86% | A |
| Pycnogonida | 0 | 0% | | 21 | 1% | D |
| Total | 284 | | | 238 | | |

The mean taxon wet biomass at AlBirk took the pattern of decreasing from Bivalvia, Amphipoda, Polychaeta, Ostracoda, Cyclops, and Gastropoda. However, this pattern has modified in case of mean taxon ash free dry weight and energy content, where Amphipoda dominated the other taxa and followed by Bivalvia, Polychaeta, Ostracoda, Cyclops, and Gastropoda. Similarly, at AlHorida, the pattern of mean taxon biomass differed from those of ash free and energy. Mean taxon biomass decreased in the following order: Bivalvia, Decapoda, Amphipoda, Gastropoda, Ostracoda, Polychaeta, and Isopoda, whereas both ash free dry weight and energy took the following sequence, decreasing from Decapoda, Amphipoda, Bivalvia, Gastropoda, Ostracoda, Polychaeta, and finally Isopoda. However, the mean taxon biomass, ash free dry weight, and energy values for the same taxa were generally higher at AlBirk than those at AlHorida except for the means of Ostracoda and Gastropoda at AlHorida, which were higher than those at AlBirk (Table 3).

Table 3. Mean taxon biomass (mg), ash free dry weight (mg), and energy (K.cal./g) values of the study sites. (±SD) standard deviation.

| Site | Major taxa | Mean taxon biomass (mg) | ± SD | Mean taxon ash free (mg) | ± SD | Mean taxon energy (K.cal./g) | ± SD |
|---|---|---|---|---|---|---|---|
| AlBirk | Amphipoda | 0.929 | 1.2 | 0.135 | 0.18 | 0.723 | 0.93 |
| | Bivalvia | 1.435 | 1.99 | 0.099 | 0.13 | 0.539 | 0.74 |
| | Cyclops | 0.052 | 0.058 | 0.008 | 0.009 | 0.061 | 0.074 |
| | Ostracoda | 0.113 | 0.045 | 0.016 | 0.007 | 0.088 | 0.035 |
| | Polychaeta | 0.227 | 0.35 | 0.030 | 0.05 | 0.167 | 0.26 |
| | Gastropoda | 0.030 | 0.069 | 0.003 | 0.006 | 0.014 | 0.032 |
| AlHorida | Amphipoda | 0.570 | 0.4 | 0.083 | 0.06 | 0.443 | 0.33 |
| | Bivalvia | 1.086 | 1.00 | 0.075 | 0.06 | 0.408 | 0.34 |
| | Ostracoda | 0.163 | 0.031 | 0.024 | 0.004 | 0.127 | 0.026 |
| | Polychaeta | 0.081 | 0.29 | 0.011 | 0.04 | 0.060 | 0.22 |
| | Gastropoda | 0.291 | 0.019 | 0.025 | 0.001 | 0.134 | 0.006 |
| | Isopoda | 0.005 | 0.0002 | 0.001 | 0.0001 | 0.004 | 0.0003 |
| | Decapoda | 0.700 | 0.05 | 0.101 | 0.015 | 0.545 | 0.049 |

Generally, the overall energy values in the current study were relatively lower than those of the temperate or arctic regions ( Fig. 3 & Table 4).
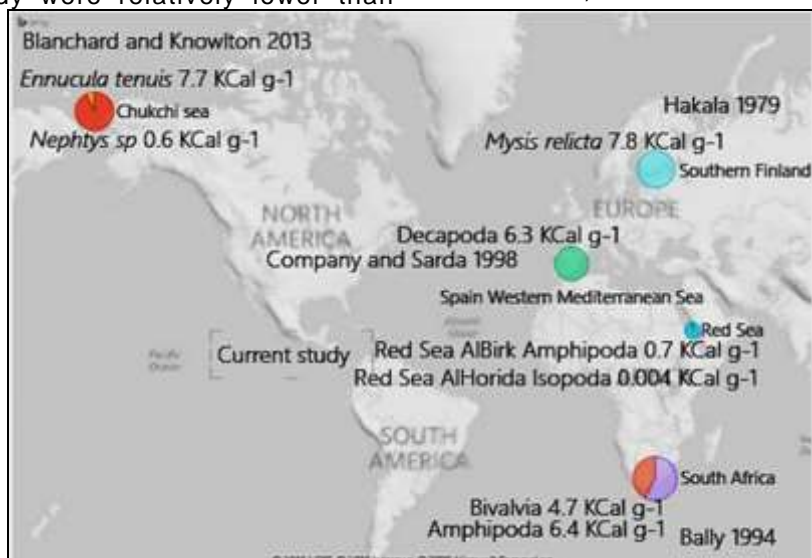


Fig. 3. Low energy content (Kcal g-1) of the dominant taxa in the current study relative to those in Temperate and Arctic Regions.

Table 4. Comparison of the energy content (Kcal g-1) of the dominant taxa for some other studies with that of the current study.

| Studied area | taxon | energy content | | reference |
|---|---|---|---|---|
| | | Maximum | Minimum | |
| South Africa | Amphipoda | 6.4 | | Bally 1994 |
| | Bivalvia | | 4.7 | |
| Southern Finland | *Mysis relicta* | 7.8 | 5.5 | Hakala 1979 |
| Western Mediterranean Sea | Decapod | 6.3 | 4.3 | Company and Sarda 1998 |
| Northeastern Chukchi Sea | *Ennucula tenuis* | 7.7 | | Blanchard and Knowlton  (2013) |
| | *Nephtys sp* | | 0.6 | |
| Southern Eastern Red Sea | Amphipoda | 0.7 | | Current study |
| | Isopoda | | 0.004 | |

One-way ANOVA of square root transformed mean taxon biomass, ash free dry weight and energy for the different taxa in both sites revealed that they were not significantly different, with *P* values 0.1464, 0.1698, and 0.1924, respectively.

**Mean Taxon Energy and Its Abundance Relationship:**

The taxon energy content is a sensitive scale to two important factors. The first is the taxon abundance and the second is its mean energy. In case of abundance, its elevated level results in elevated total energy despite of the low mean taxon energy. For example, polychaeta represented about 26% of total energy, which is nearly the same percentage of its abundance at AlBirk (Fig. 4). Whereas Polychaeta abundance percentage at AlHorida was about 93% considering only the five major taxa, its energy share was about 73%. (Figs 2 & 4). On the other hand, high mean taxon energy results in high taxon energy despite of its low abundance. The energy values of Amphipoda and Bivalvia were higher than that of the Ostracoda despite of their low abundances relative to that of Ostracoda in both sites, (Figs 2 & 4).
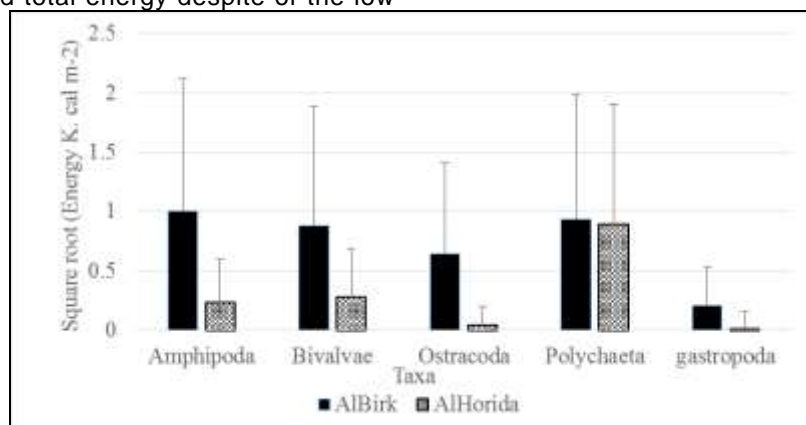


Fig. 4. interaction plot of the square root transformed energy of the five major taxa present in both AlBirk and AlHorida.

## DISCUSSION:

Nearly all the previous energy determination studies (Bally, 1994, Company and Sarda, 1998) used a micro bomb calorimeter to measure the energy values. This restricts the animals for only this estimation. Therefore, I introduced a new methodology for estimating benthic energy without using the micro bomb calorimeter, which depended on organismal body dimensions. The methodology of Ramsey *et al.* (1997) and Abada (2000), which translates organismal body dimensions (length and width) to wet weight is an easy straight forward taxonomy-free method. It avoids destruction of the animals, permitting further studies, and also avoids direct weighing, which is difficult for small delicate organisms, prone to under-estimation due to desiccation, in addition to the organismal weight loss due to preservation (Wetzel *et al.*, 2005; Paxton and Miller, 2013). On the other hand, biomass determination depending on the organism body dimensions has been urged due to its more perspicacity and preciseness than other methods (Benke *et al.*, 1999; Miserendino, 2001; Põllupüü, 2007). Moreover, following Rumohr *et al.* (1987) or Ricciardi and Bourget (1998), it is easy to use conversion factors to get the ash free dry weight and, consequently, the energy content.

Some studies have evaluated energy flow and production values using weight to energy conversions (Brey *et al.*, 1988) to determine total caloric content of organisms (Villanueva *et al.* 2004, Brey and Gerdes, 1998). However, Brawn *et al.* (1968) and Blanchard and Knowlton (2013) have argued that caloric content can covary with the environmental characteristics. In fact, caloric content can vary not only with the environmental variables but also with many other factors such as metabolic rates (Company and Sarda, 1998), differences in age, sex, and season (Blanchard and Knowlton, 2013), (Bagatini *et al.*, 2007), seasonality (Hakala, 1979), and body size (Griffiths, 1977). Therefore, environmental characteristics should not alone prevent the use of conversion factors, where variability can exist within the same taxon in the same environment. Moreover, using the conversion factors in the current study has yielded energy values that are equivalent to values derived from measurements obtained using a bomb calorimeter in other studies, such as Bally (1994), Blanchard and Knowlton (2013), and Company and Sarda (1998). Simply, it is an introduction to a new concept of estimating the benthic energy, depending on the organismal body dimensions without direct measures of weight or energy.

The energy contents (Kcal g$^{-1}$) of the dominant taxa in the Temperate and Arctic Regions were higher than those in the current study (Lie, 1968; Hakala, 1979; Bally, 1994; Company and Sarda 1998; Blanchard and Knowlton, 2013). This can be attributed to two main reasons. First, according to the presumption of Dunbar (1968) and Cushing (1976), it is broadly trusted that food unpredictability increases towards the polar environments, supporting the evolutionary trend towards higher energy levels in species that inhabit regions with fluctuating food availability as compared to species that inhabit regions of greater environmental predictability. Therefore, it is not strange to find that the organisms at the higher latitudes will tend to store more energy and have higher energy values (Griffiths, 1977); and (Slobodkin and Richman, 1961). Second, the stresses imposed by the environmental variables like extreme salinity (about 41$_0$%) and high temperature (37°C) in such arid equatorial sites, may exert physiological stress because of the energetic cost of osmoregulation (McLachlan and Brown, 2006). Company and Sarda (1998) reported that the benthic-endobenthic decapod energy content increases with a lowering of metabolic rates. Moreover, the energy cost of osmoregulation frequently increases with increasing temperature and is compounded by decreasing oxygen tensions (McLachlan and Brown, 2006). Accordingly, the energy content of the current study may have been low due to (predicted) increased metabolic rate due to high salinity and temperature in this arid area. This occurs not only for animals but also for mangrove plants in a shallow arid embayment in the Arabian Gulf (Al-Maslamani *et al.*, 2012).

It is worth mentioning that at the level of specific taxa, energy content varies due to differences in energy quota appropriated for various biological and ecological functions. Moreover, energy content covaries with age, sex, and season. Therefore, energy content is much more predictable at the community level (Blanchard and Knowlton, 2013). Furthermore, food quality and quantity contribute to the variability of the organismal caloric content (Villanueva *et al.*, 2004). This probably contributed strongly to the variability of the mean biomass, ash free dry weight and energy value within taxa at each study site (reflected in high standard deviations). Similarly, Blanchard and Knowlton (2013) had a wide range of energy content (kcal/g) in the same taxa in different stations. For example, *Nephtys* spp. (0.6-6.2), *Ennucula tenuis* (1.9-7.7), Ampeliscidae (2.8-7.2) and Maldanidae (2.5-6.8).

The generally elevated energy level at AlBirk (4 Kcal m$^{-2}$) relative to that at AlHorida (1.4 Kcal m$^{-2}$), can be attributed indirectly to the wave energy effect (visual observation), which was relatively higher at AlHorida than AlBirk.

Menn (2002) in his study in the Eastern North Sea, showed that high wave energy is a limiting factor of macrofauna, whereas, low wave energy shore favored macrofauna. Furthermore, organic materials may accumulate on low wave energy shores and, indeed, values of organic content were higher at AlBirk. Additionally, McLachlan (1996) supported the hypothesis that an increase in sand particle size results in a change in beach state and a decrease in species richness and abundance, which is in an agreement with the AlHorida results. Brawn *et al.* (1968) revealed an indirect relationship between the caloric content and sediment grain size through its influence on the organismal biomass and consequently its energy content. Hagen *et al.* (2012), Blanchard and Knowlton (2013), and Carcedo *et al.* (2015) pointed out that organic matter promotes macrofaunal density and biomass. Therefore, this conclusion confirms the results of the current study, where the noticeable high wave energy, coarser sediment grain size, and low organic matter at AlHorida site relative to low wave energy, finer sediment grain size, and high organic matter at AlBirk, are responsible for the differential taxa abundances and finally the energy content. Additionally, the variability in mean taxon energy and abundance strongly influenced energy contributions in the community. Interestingly, mean Polychaeta energy at AlHorida was nearly a fourth of that at AlBirk,

resulting in an overall Polychaeta energy reduction at AlHorida relative to that at AlBirk.

The current study, on its own, is considered as a pioneer study from two points of view. The first is its scouting methodology, in terms of using the concept of the body dimension-biomass relationships for estimating the wet weight of macrofauna, then using conversion factors instead of bomb calorimetry. Second, it is the first energetic study in such arid equatorial sandy beaches that can be compared with analogues conducted in temperate and arctic regions. Therefore, it explored new information in a new manner. However, the current study has its advantages and disadvantages. First, its advantages can be summarized in the fact that the studied organisms can be kept for further studies, and it improves estimations for small delicate organisms. Second, its disadvantages lie in the scarcity of the published data of the animals' body dimensions and their weights as well as the relationship of the ash free dry weight with energy content of the aquatic organisms. This information is available only for certain taxa at particular locations.

## ACKNOWLEDGEMENTS

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## تقدير الطاقة القاعية في مدى زمني قصير في المناطق المدارية القاحلة في اثنين من الشواطئ الرملية بجنوب شرقي البحر الأحمر، المملكة العربية السعودية باستخدام تحويل القياسات الحيوية

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تـم تقـدير محتـوى الطاقـة للحيوانـات اللافقاريـة القاعية في اثنين مـن الشواطئ الرمليـة في المنطقة الاستوائية القاحلة (منطقتا البرك والحريضة) واللتان تقعان على الساحل الجنوبي الشرقي للبحر الأحمر بالمملكة العربية السعودية في صيف عـام 2007. وهـذه هـي أول دراسة للتعامل مع الطاقة القاعيـة في منطقة اسـتوائية وذلك باستخدام العلاقة بـين أبعاد الجسـم والـوزن الرطب لتقدير الكتلة الحيوية (ومنها تقدير الوزن الجاف الخالي مـن الرماد) ثم محتوى الطاقة بدون اللجوء لتصنيف نوع الحيوان. وكانت قيم الطاقة بشكل عـام أقل مـن تلـك الموجـودة فـي المناطق المعتدلة أو القطبية. فقـد كـان متوسـط محتـوى الطاقة في منطقة البرك والحريضة (4) و (1.4) كيلو كالوري

للمتر المربـع علـى التوالي. وقـد كانـت السـيادة بمنطقة البـرك لمزدوجـات الأرجـل Amphipoda وللمحـار ثنائيـات الصـدفة Bivalvia وللديـدان الحلقيـة عديـدة الأشـواك Polychaeta والصدفيات القشرية Ostracoda، حيـث كانت قيـم الطاقة 1.3 و 1 و 0.5 كيلو كـالوري للمتر المربع علـى التوالي فـي حـين سـادت الديـدان الحلقيـة عديدة الأشـواك Polychaeta منطقة الحريضة بقيمة طاقة قـدرها 0.9 كيلـو كـالوري للمتر المربع. وترجع الاختلافـات بـين الموقعين مـن حيـث متوسـط الـوزن الرطـب والـوزن الجـاف الخالي من الرماد والطاقة لكل متر مربع إلى الاختلافات في طاقة الأمواج وحجـم حبيبـات التربـة والمـواد العضوية مؤدية إلى التباين في أعداد وهيمنة الحيوانات.