LAPORAN PENELITIAN
PENELITIAN DASAR UNGGULAN PERGURUAN TINGGI (PDUPT) TAHUN 1

Eksplorasi Ekosistem Bentik sebagai Bioindikator Kualitas Perairan dibidang Marine Bioprospecting Sumber Pangan Alternatif pada Kawasan Strategis Pesisir Sumatera Selatan (Musi Ecosystem Project / Musi Eco Pro) (Tahun 1)

TIM PENGUSUL

Ketua Tim:
Dr. Rozirwan, S.Pi., M.Sc / NIDN 0021057908

Anggota:
Dr. Fauziyah, S.Pi. NIDN 0031127501
Dr. Wike Ayu Eka Putri, S.Pi., M.Si / NIDN 0012057905

Dibiayai oleh:
Dana BOPTN DRTPM
Universitas Sriwijaya Tahun Anggaran 2022
0214.01/UN9.3.1/PL/2022
Sesuai dengan Nomor Kontrak Induk
Nomor 245/E5/PG.02.00.PT/2022

Universitas Sriwijaya
Desember 2022

HALAMAN PENGESAHAN LAPORAN AKHIR
SKEMA PENELITIAN DASAR UNGGULAN PERGURUAN TINGGI (PDUPT)

1. Judul Penelitian	: Eksplorasi Ekosistem Bentik sebagai Bioindikator Kualitas Perairan dibidang Marine Bioprospecting Sumber Pangan Alternatif pada Kawasan Strategis Pesisir Sumatera Selatan (Musi Ecosystem Project / Musi Eco Pro)
2. Bidang Penelitian	: Kemaritiman
3. Ketua Peneliti	
a. Nama Lengkap	: Dr. Rozirwan, S.Pi., M.Sc.
b. NIDN	: 0021057908
c. Pangkat dan Golongan	: Pembina/ IV.A
d. Fakultas/Jurusan/Prodi	: MIPA/ Ilmu Kelautan
e. Telepon/HP/E-mail	: 081371711885/ rozirwan@unsri.ac.id
4 Jumlah Anggota Peneliti	: 2 orang
a.Nama Anggota I	: Dr. Fauziyah, S.Pi.
NIDN/NIDK	: 0031127501
b.Nama Anggota II	: Dr. Wike Ayu Eka Putri, S.Pi., M.Si.
NIDN/NIDK	: 0012057905
6 Jangka Waktu Penelitian	: 1 Tahun (*Tahun Pertama*)
7.Jumlah Dana yang Disetujui	: Rp. 122,000,000

Mengetahui
Dekan Fakultas MIPA,

Prof. Hermansyah, S.Si., M.S.i., Ph.D
NIP. 197111191997021001

Indralaya, 2 Desember 2022
Ketua,

Dr. Rozirwan, S.Pi., M.Sc.
NIP. 197905212008011009

Menyetujui,
Ketua LPPM,

Samsuryadi, S.Si., M.Kom., Ph.D.
NIP. 197102041997021003

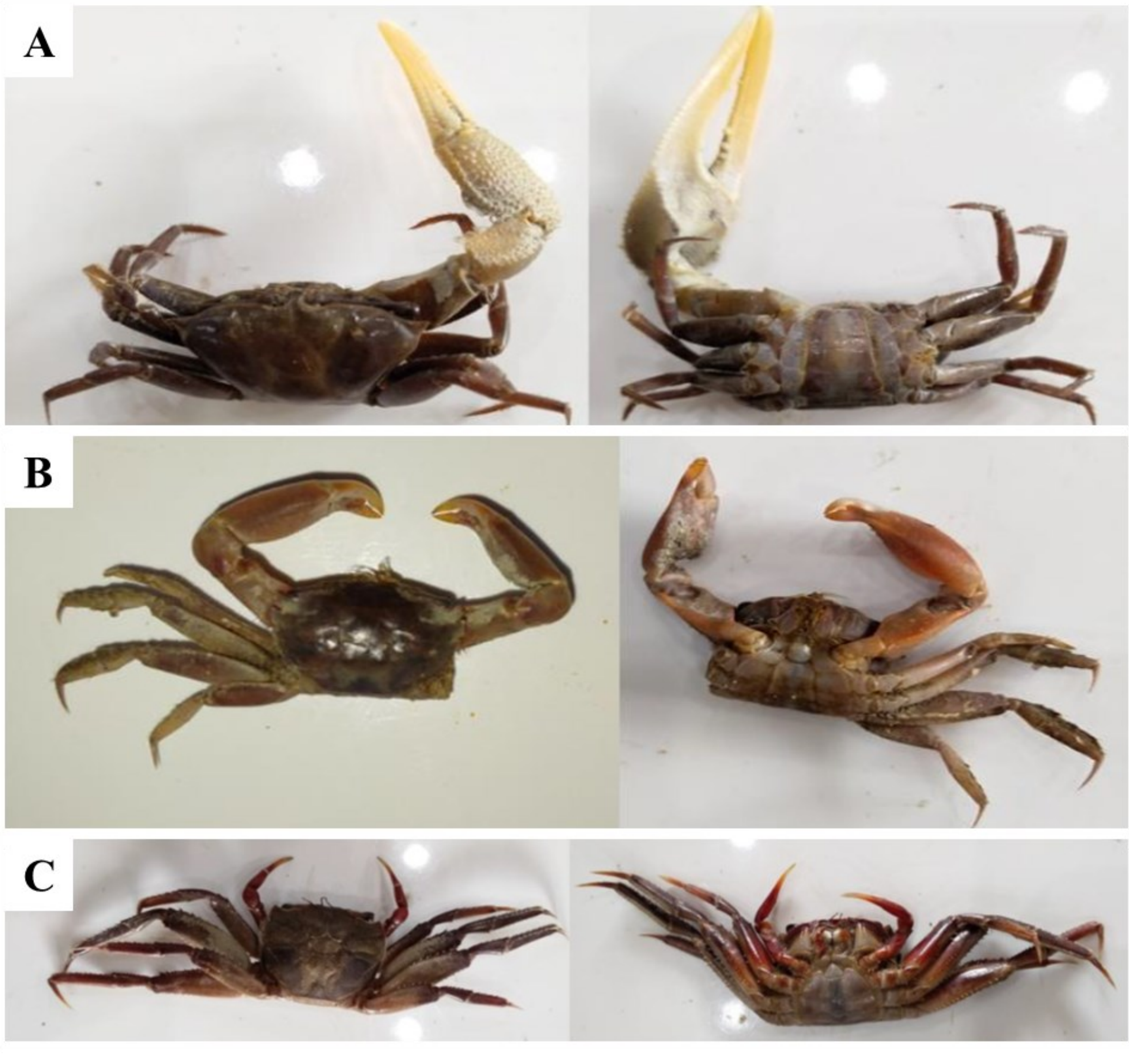
Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. **HASIL PELAKSANAAN PENELITIAN:** Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian meliputi data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

A. Status Keanekaragaman Komunitas Bentik di Pesisir Sumatera Selatan

Krustasea

Keanekaragaman spesies kepiting yang ditemukan di pesisir Sumatera Selatan (Gambar 1), yaitu *Uca dussumieri* (Edwards, 1852), *Metaplax longipes* (Stimpson, 1858), *Metaplax distinct* (Edwards, 1852). Selama pengambilan sampel, kualitas pengukuran perairan diambil secara in situ. Pada substrat ditemukan lumpur hitam halus dengan kedalaman 60 sampai 100 cm. Hasil parameter lingkungan yang diukur salinitas 27-29 psu, suhu 29-30°C, pH 6,08-6,2, nitrat 6,69 mg/L, dan fosfat 0,197 mg/L.



Gambar 1. Keanekaragaman spesies kepiting di pesisir Sumatera Selatan, A) *Uca dussumieri* (Edwards, 1852); B) *Metaplax longipes* (Stimpson, 1858); C) *Metaplax distinct* (Edwards, 1852)

Kepiting *Uca dussumieri* (Edwards, 1852) memiliki keunikan pada capitnya. Ketika capit besar rusak atau patah, ia akan tumbuh kembali atau capit lainnya akan membesar. Berwarna cerah kekuningan, dan ruam atau bergerigi pada permukaan dactylus, propodus dan carpus. Karapas menyerupai trapesium dengan sisi anterior yang lebih lebar dan ujung yang runcing, hal itu disebut karapas trapesium. Berwarna hitam kecoklatan, coklat tua dan jingga kehitaman (1). Bola mata berwarna hitam dan bulat dengan batang mata panjang mendekati ujung anterior karapas. Kepiting ini memiliki lima pasang kaki, terdiri dari satu pasang di bagian depan capit, dan empat pasang kaki berjalan. Perutnya berwarna kebiruan berbentuk segitiga memanjang. Berdasarkan ciri morfologinya, spesies ini tergolong *fiddler crab*, memiliki kemiripan dengan beberapa spesies lain seperti *Uca demani* dan *Uca urvillei* (2,3). Hal ini dapat ditemukan di daerah berlumpur daerah mangrove (4,5).

Kepiting *Metaplax longipes* (Stimpson, 1858) memiliki karapas coklat tua (Gambar 1.B). Karapas berbentuk bujur sangkar dengan bagian bawah yang lebih pendek atau disebut karapas persegi atau subkuadrat. Spesies ini memiliki sepasang capit yang berukuran sama dan lebih panjang dari empat pasang kaki berjalan. Capitnya berwarna oranye-coklat, sedangkan ciri lainnya adalah bagian propodus yang sangat panjang, daktil yang pendek, dan permukaan cheliped yang cukup halus (2). Bola matanya berwarna hitam dengan panjang batang mata memanjang ke ujung anterior karapas. Kepiting ini memiliki lima pasang kaki yang terdiri dari satu pasang capit dan empat kaki berjalan. Kaki kedua dan ketiga berjalan lebih panjang dari kaki pertama dan keempat. Perut berwarna coklat muda, dan memiliki bentuk segitiga memanjang. Genus spesies ini adalah *Metaplax* spp. dari famili Varunidae. Berdasarkan morfologi dan pohon filogenetik, spesies ini memiliki kemiripan dengan *Metaplax takahashii*, *Cyclograpsus granulosus*, *Helice wuana*, dan *Eriocheir japonica* (2,6). Hampir semua spesies dari genus ini ditemukan di habitat berlumpur di dekat ekosistem mangrove, juga ditemukan di substrat berpasir yang didominasi oleh air laut (6–8).

Kepiting *Metaplax distinct* (Edwards, 1852) memiliki karapas berbentuk persegi panjang dengan sisi agak membulat dan sisi bawah yang lebih pendek dari bagian atas yang disebut subkuadrat atau bujur sangkar. Karapas didominasi warna coklat tua, dengan kedua sisi anterior meruncing. Capit dari spesies ini pendek dan kecil dibandingkan dengan kaki berjalan, hal ini menunjukkan jenis kelamin betina, karena spesies betina ini memiliki sepasang capit yang lebih pendek dan lebih kecil dari pada spesies jantan (9,10). Capitnya didominasi merah kehitaman dengan dactyl oranye. Kedua bola mata berbentuk bulat hitam dengan batang yang memanjang hampir ke sisi luar anterior. Ada lima pasang kaki, satu pasang capit dan empat pasang kaki berjalan. Ukuran kaki jalan kedua dan ketiga lebih panjang dari kaki jalan pertama dan keempat. Spesies ini betina, dengan perut segitiga yang lebar dan bulat (11). Spesies ini memiliki kemiripan dengan *Metaplax gocongensis* dan *Metaplax indica* (12). Diklasifikasikan dalam famili Varunidae, disebut juga kepiting dengan habitat muara berlumpur, banyak ditemukan di kawasan mangrove dan pantai berpasir (8,13).

Spesies C1 merupakan spesies kepiting yang unik. Keunikannya ada pada bagian capit jantannya, sepasang capitnya memiliki ukuran berbeda. Di beberapa kondisi, capit terbesar spesies ini terdapat di sebelah kanan dan di beberapa individu ditemukan di sebelah kiri. Terkait hal ini, bentuk dan corak capit kedua spesies sama namun yang membedakannya hanya pada posisi capit terbesar dan terkecilnya saja. Beberapa penelitian terdahulu telah melaporkan keunikan spesies kepiting *Uca dussumieri*. Spesies *Uca dussumieri* ini memiliki keunikan pada capitnya, jika capit besarnya patah atau hilang maka capit besar itu akan tumbuh kembali pada keadaan semula. Namun proses capit besarnya tumbuh ada dua kemungkingan yang terjadi, kemungkinan pertama bisa tumbuh di capit terbesar yang mengalami kepatahan atau di tempat awalnya dan kemungkinan kedua bisa tumbuh dari posisi capit terkecilnya lalu capit kecil akan tumbuh lagi di tempat capit yang hilang (14–18). Keunikan spesies *Uca dussumieri* telah menjadi ciri khas sendiri untuk spesies fiddler crab ini yang berasal dari family Ocypodidae (3,19–21).

Spesies C1 ini sangat diduga sebagai spesies *Uca dussumieri*. Bentuk karapasnya yaitu trapezoidal dengan ujung anterior karapas yang melancip lalu coraknya memiliki kemiripan yakni berwarna coklat kehitaman. Corak capitnya juga sama karena berwarna putih kekuningan (19). Spesies *Uca dussumieri* termasuk ke dalam kepiting yang berhabitat di lumpur. Hal ini juga sesuai pernyataan (22) dan (23), bahwa secara umum spesies *Uca dussumieri* dapat ditemukan di daerah mangrove yang berlumpur. Spesies C1 yang diambil dari migratory birds ground at Sembilang National Park Indonesia juga berhabitat di substrat lumpur. Berdasarkan beberapa analisa ini didapatkan bahwa spesies C1 memiliki kemiripan yang sangat jelas dengan spesies *Uca dussumieri*.

Spesies C2 memiliki karapas yang berbentuk squarish atau subquadrate (2). Sepasang capitnya memiliki ukuran yang sama, cheliped spesies ini sangat panjang terutama bagian propodusnya, namun bagian dactyl memiliki ukuran tergolong pendek dan berwarna coklat kejinggaan. Warna karapasnya coklat kehitaman dengan bagian ujung anterior karapas terdapat dua gerigi yang melancip. Melalui identifikasi morfologinya, spesies C2 cukup membingungkan untuk diidentifikasi namun diduga sebagai spesies *Metaplax longipes***.** Spesies ini termasuk ke dalam family Varunidae yang dikenal sebagai family Thoracotrematan crabs (24,25). *Metaplax longipes* sebelumnya termasuk golongan Sesarminae dari family Grapsidae karena secara morfologi sangat mirip, namun berdasarkan hasil filogenetik termasuk ke Varunidae (6,7) dan oleh sebab itu *Metaplax longipes* sudah keluar dari golongan Grapsidae. *Metaplax longipes* mudah ditemukan di wilayah intertidal berlumpur kawasan mangrove (2,6,8). Berdasarkan habitat hidupnya ini dia termasuk golongan kepiting deposit feeder (26,27).

Berdasarkan identifikasi morfologi, spesies C3 diduga sebagai spesies *Metaplax disdincta*. Spesies ini memiliki bentuk karapas subquadrate (2,28). Jenis ini dikenal dengan karapas yang berbentuk kotak dan bagian posterior karapas cenderung membulat. Secara sekilas karapasnya sama dengan spesies dari kelompok Varunidae namun memiliki perbedaan pada bentuk capitnya. Hal ini disebabkan oleh spesies yang ditemukan ini berjenis kelamin betina. Ini dibuktikan dari bentuk abdomennya yaitu segitiga yang melebar. Jenis kelamin betina dari kelompok Varunidae memiliki sepasang capit yang sangat kecil dibandingkan spesies jantan (10,29,30). Berdasarkan (31) dan (32), bahwa ukuran capit kepiting betina berukuran lebih kecil dibandingkan kepiting jantan. Warna karapas spesies C3 berwarna coklat tua kehitaman dan warna capitnya berwarna hitam kemerahan dengan bagian chela berwarna keoranyean. Spesies ini berhabitat di pantai belumpur hingga berpasir (13). Spesies ini jugga termasuk kepiting yang ditemukan di kawasan mangrove (33,34). Pada beberapa kasus, spesies ini ditemukan dengan warna karapas yang lebih cerah, ini disebabkan oleh lingkungan tempat hidupnya (35,36). Karapas yang lebih gelap akan ditemukan pada daerah berlumpur sedangkan karapas yang lebih cerah akan ditemukan pada daerah susbrat cenderung berpasir (37,38).

Secara keseluruhan kepiting yang ditemukan pada penelitian ini diduga tergolong ke dalam kepiting–kepiting kecil dari family Ocypodidae dan Varunidae. Dua family juga memiliki kesamaan, sesuai yang dilaporkan oleh (39), bahwa Metaplax yang berasal dari Varunidae terkadang memiliki karakteristik perilaku yang sama dengan Ocypodidae. Secara morfologi dan cara hidupnya juga memiliki kemiripan dengan genus Macrophtalmus dari Ocypodidae. Semua spesies yang ditemukan memiliki habitat di ekosistem mangrove yang berlumpur. Kepiting memiliki peran sebagai sumber makanan bagi beberapa predator seperti burung pantai dan ikan (40–42), sedangkan di kawasan Taman Nasional Berbak-Sembilang sebagai sumber makanan bagi burung migran (43).

Scylla serrata

S. serrata termasuk dalam famili Portunidae dan kelas Krustasea dari filum Arthropoda. *S. serrata* memiliki warna karapas hijau kehitaman. Terdapat 3 pasang kaki yaitu sepasang cheliped yang digunakan untuk mencari mangsa, 3 pasang kaki jalan, dan sepasang kaki renang yang berbentuk pipih (Gambar 2).

Gambar 2. Kepiting bakau (*S. serrata*)

Taksonomi

Kingdom	: Animalia
Filum	: Arthropoda
Kelas	: Malacostraca
Ordo	: Decapoda
Family	: Portunidae
Genus	: Scylla
Spesies	: *Scylla serrata* (Forskal, 1775)

Anadara granosa

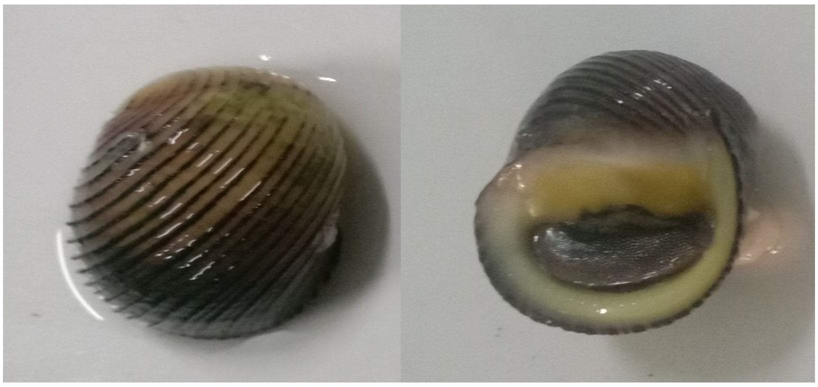
Kerang darah (*Anadara granosa*) merupakan salah satu hewan yang tergolong moluska dan termasuk ke dalam kelas bivalvia. Bivalvia merupakan kelompok hewan dengan karakteristik memiliki tubuh pipih lateral dan seluruh tubuhnya tertutup dua buah cangkang dan ukuran panjang *A. granosa* dari setiap stasiun berkisar 2-3 cm. *A. granosa* dewasa berukuran panjang 5-6 cm dan lebar 4 cm.

Gambar 3. Kerang darah (*Anadara granosa*)

Taksonomi
Kingdom : Animalia
Filum : Mollusca
Kelas : Bivalvia
Subkelas : Pteriomorpha
Order : Arcoida
Famili : Arcidae
Genus : Anadara
Spesies : *Anadara granosa*

Nerita balteata

Nerita balteata termasuk dalam family Neritidea dan kelas Gastropoda dari filum Moluska. *N. balteata* ditemukan pada stasiun 6 hingga 15 di kawasan mangrove yakni pada akar dan batang mangrove. *N. balteata* memiliki ciri morfologi yaitu memiliki cangkang berwarna coklat kekuningan berbentuk oval dan memiliki garis *cord* spiral berwarna hitam. Selain itu gastropoda ini memiliki cangkang yang berukuran panjang berkisar 2-3 cm dan lebar berkisar 2 cm



Gambar 4. *Nerita balteata*

Taksonomi
Kingdom : Animalia
Filum : Moluska
Kelas : Gastropoda
Famili : Neritidea
Genus : Nerita
Spesies : *Nerita balteata*

Cerithidea obtuse

Ciri-ciri morfologi untuk gastropoda jenis *Cerithidae obtuse* termasuk dalam famili Potamididae dan kelas Gastropoda dari filum moluska. *C. obtuse* ditemukan pada stasiun 6 hingga 10 di kawasan mangrove yakni pada akar dan batang mangrove. Ciri-ciri morfologi untuk gastropoda jenis *C. obtusa* yaitu dilihat dari cangkang yang memiliki warna coklat keputihan dan berbentuk kerucut tebal yang memiliki putaran dekstral (berputar ke arah kanan). Ukuran panjang cangkang berkisar antara 3-4,4 cm dan lebar cangkang 2-2,3 cm.

Gambar 5. *Cerithidea obtusa*

Taksonomi
Kingdom : Animalia
Filum : Moluska
Kelas : Gastropoda
Ordo : Sorbeoconcha
Famili : Potamididae
Genus : Cerithidea
Spesies : *Cerithidea obtusa*

Cerithidea cingulata

Cerithidae cingulata termasuk dalam famili Potamididae dan kelas Gastropoda dari filum Moluska. *C. cingulata* ditemukan pada stasiun 11 hingga 15 di kawasan mangrove yakni pada akar dan batang mangrove. Ciri-ciri morfologinya memiliki bentuk kerucut dan *apex* meruncing, warna cangkang coklat kekuningan atau coklat gelap, inner lip berwarna putih mengkilap.

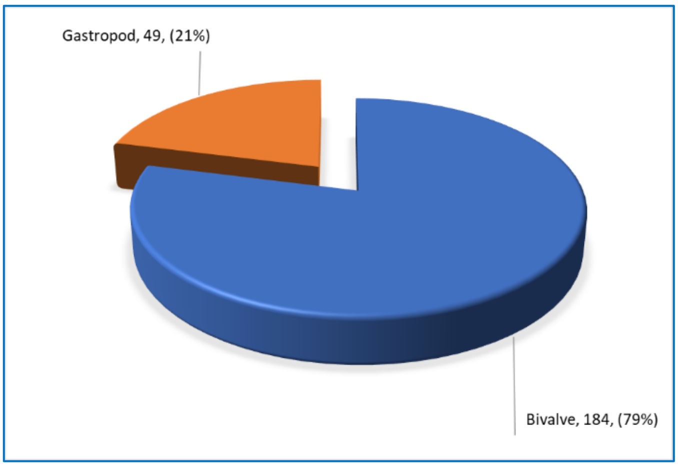
Gambar 6. *Cerithidea cingulata*

Taksonomi
Kingdom : Animalia
Filum : Moluska
Kelas : Gastropoda
Ordo : Sorbeoconcha
Famili : Potamididae
Genus : Cerithidea
Spesies : *Cerithidea cingulata*

B. Status Ekologi Moluska di Pesisir Sumatera Selatan

Hasil pengukuran kualitas perairan di kawasan pesisir Taman Nasional Berbak-Sembilang menunjukkan kondisi yang relatif stabil atau normal untuk pertumbuhan moluska. Rata-rata nilai pH perairan diperoleh pada kondisi normal 7,29 ± 0,59, serta salinitas 30,38 ± 1,30 psu. Oksigen terlarut (DO) dan suhu di semua stasiun pengamatan dikategorikan dalam kondisi baik dengan nilai rata-rata 7,78 ± 0,78 mg/L dan 29,49 ± 0,14 °C, namun kecerahan menunjukkan nilai rata-rata rendah yaitu 15,45 ± 6,18% terutama di muara. Kecepatan aliran ditemukan menurun di daerah teluk atau muara dengan nilai rata-rata 0,18 ± 0,12 m/s, sedangkan sebaran konsentrasi nitrat dan fosfat ditunjukkan relatif merata dengan rata-rata 6,08 ± 0,48 mg/L, dan 0,18 ± 0,01 mg/L.

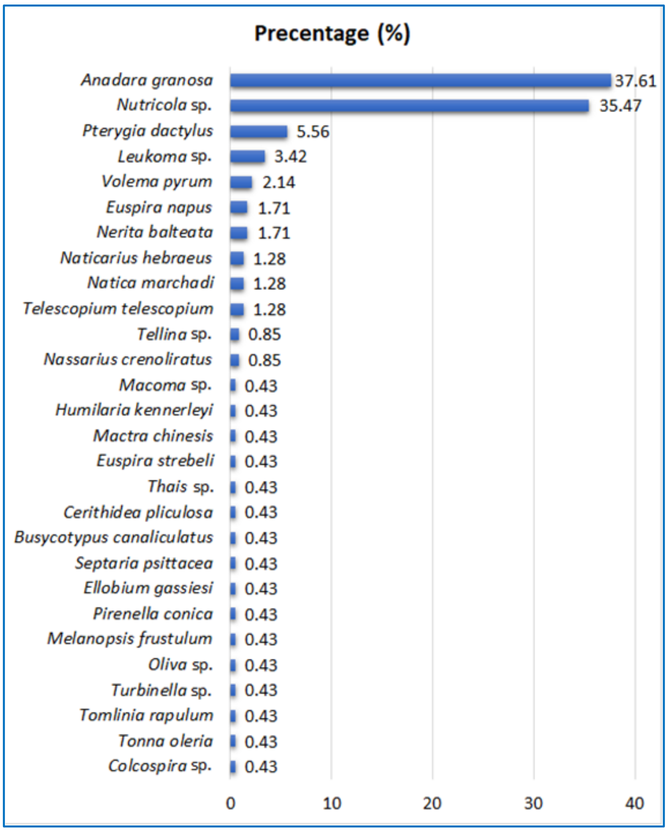
Komposisi moluska di semua stasiun pengamatan ditemukan hanya dua kelas, didominasi oleh Bivalvia 79% dan Gastropoda 21%. Sebaran kedua kelas ini tidak merata, dimana hanya terdapat pada stasiun-stasiun tertentu.



Gambar 7. Struktur komunitas Moluska di lokasi pengamatan

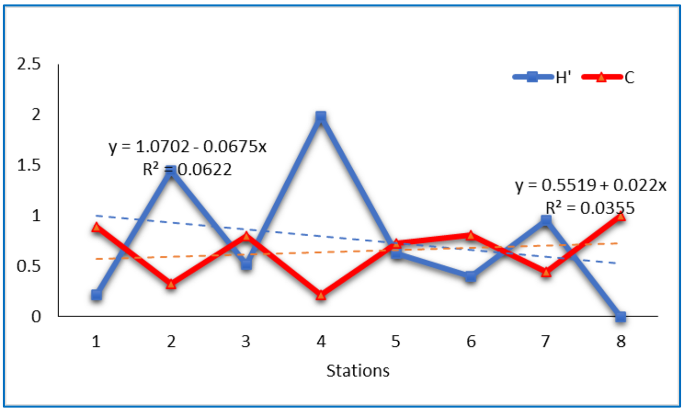
Sebanyak 28 spesies moluska yang teridentifikasi yang dinominasi oleh kelas Gastropoda dengan 21 spesies, sedangkan kelas Bivalve dengan 7 spesies. Namun, kelimpahan Bivalvia ditemukan lebih banyak daripada Gastropoda. Distribusi kelimpahan dan keanekaragaman jenis ditemukan tidak merata, seperti *Anadara granosa* yang ditemukan di hampir semua stasiun pengamatan, tetapi lebih banyak ditemukan hanya pada satu atau dua stasiun.

Nilai rata-rata keseluruhan individu moluska di lokasi pengamatan adalah 263,25 ind/m^2. Kelimpahan tertinggi terdapat pada stasiun 4 sebesar 531 ind/m^2, stasiun 3 sebesar 495 ind/m^2, stasiun 6 sebesar 333 ind/m^2, dan stasiun 5 sebesar 297 ind/m^2, sedangkan yang lainnya diambil sebagai rata-rata ditemukan. Dua jenis moluska yang ditemukan mendominasi, yaitu: *Anadara granosa* 37,61% dan *Nutricola* sp. 35,47%, keduanya berasal dari kelas Bivalvia, berbeda dengan kelimpahan kelas Gastropoda yang didominasi oleh *Pterygia dactylus* 5,56% dan *Volema pyrum* 2,14%. Selain itu, sebaran kelas Bivalvia ternyata lebih merata dibandingkan Gastropoda.



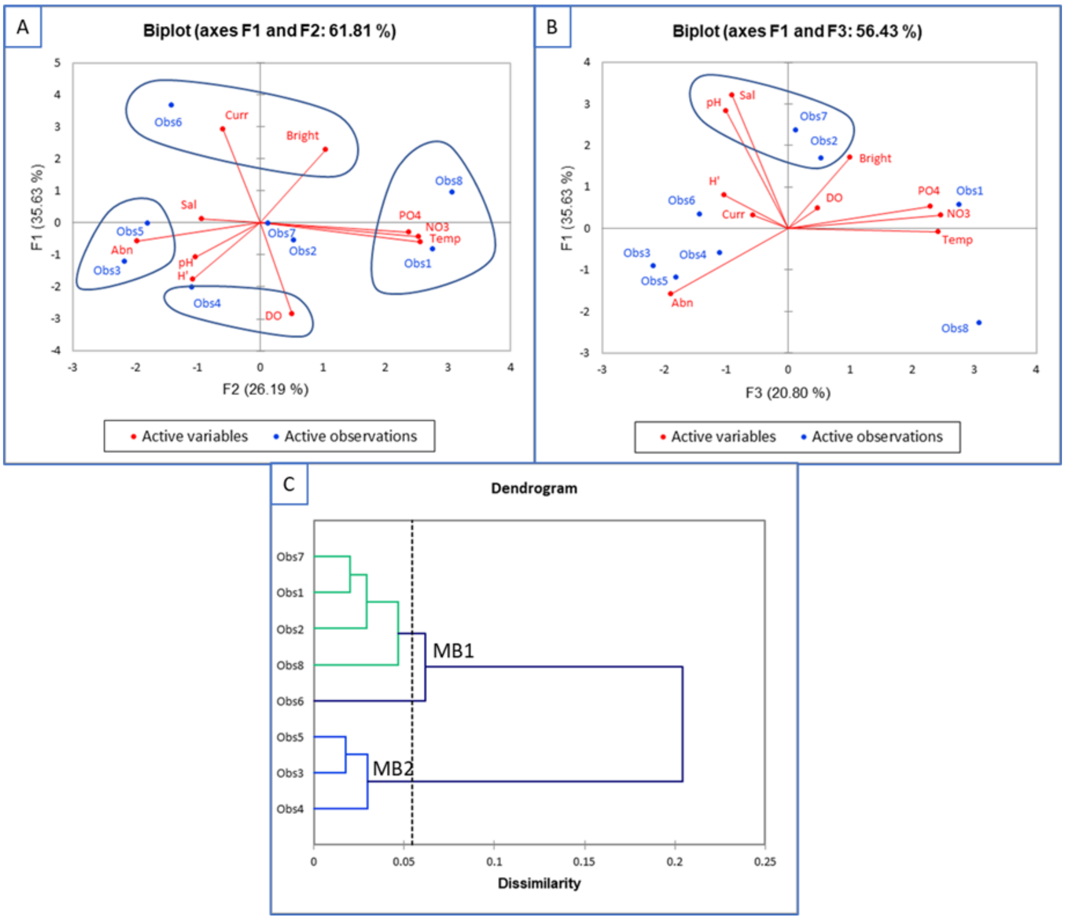
Gambar 8. Persentase spesies moluska

Mengingat keragaman spesies, indeks Shannon-Wiener (H') semuanya menurun secara signifikan di hampir semua stasiun pengamatan kategori rendah (Stasiun 1, 3, 5, 6, 7, dan 8), kecuali ada dua stasiun dalam kondisi sedang. kategori (Stasiun 2 dan 4). Hal ini juga didukung oleh nilai indeks Simpson (C), dimana dominasi spesies terjadi hampir di semua lokasi.



Gambar 9. Indeks Keanekaragaman Moluska di Taman Nasional Berbak-Sembilang

Hasil hubungan parameter kualitas air dengan kelimpahan dan keanekaragaman moluska di lokasi penelitian diperoleh Eigenvalues Kumulatif 82,61%, terbentuk lima kelompok yaitu: empat kelompok terbentuk pada sumbu F1 dan F2, sedangkan yang lainnya terbentuk pada sumbu F3 . Selain itu, kemiripan antar stasiun pengamatan dibentuk oleh dua cluster berkode MB1 dan MB2.



Gambar 10. Hubungan antara parameter kualitas air dengan kelimpahan dan keanekaragaman moluska, (a) sumbu F1 dan F2; (b) sumbu F3; (c) *Dendrogram dissimilarity*

Hasil analisis kemiripan yang dihitung dengan indeks dissimilaritas Bray-Curtis (Gambar 10c) menunjukkan bahwa sebaran kelimpahan dan keragaman moluska hampir sama, membentuk dua cluster (MB1 dan MB2). Nilai kesamaan rata-rata sebesar 83,74%. Klaster MB1 terbentuk pada stasiun 1, 2, 6, 7, dan 8 yang berada di pantai terbuka. Cluster ini dicirikan oleh suhu, salinitas, pH, kecerahan nutrisi, dan arus air yang lebih tinggi. Hal ini diduga karena pengaruh kuat wilayah massa air laut Selat Melaka dan Laut Cina Selatan. Klaster MB2 dibentuk oleh stasiun 3, 4, dan 5 yang terletak di muara muara sungai, ditandai dengan oksigen terlarut dan kelimpahan moluska yang lebih tinggi dibandingkan lokasi lain. Fluktuasi parameter kualitas air yang terus menerus diduga berdampak pada dominasi beberapa spesies di setiap stasiun. Kedua klaster tersebut menggambarkan bahwa kelimpahan dan keanekaragaman moluska di garis pantai lindung TNBS sangat dipengaruhi oleh perubahan parameter kualitas air.

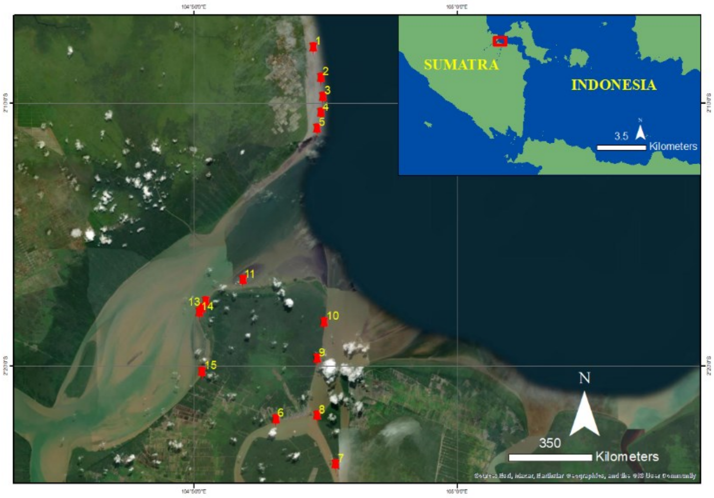
Terdapat 28 spesies moluska yang ditemukan di garis pantai lindung TNBS, yang dikelompokkan menjadi dua kelas, yaitu Bivalve 79% dengan 7 spesies, dan Gastropoda 21% dengan 27 spesies. Komposisi individu kelas Bivalvia lebih dominan dibandingkan dengan Gastropoda, meskipun jumlah spesiesnya lebih sedikit. Bivalvia memiliki kemampuan toleransi yang tinggi terhadap perubahan parameter lingkungan (44). Komposisi ini juga telah dilaporkan di pantai barat India (45), di estuari dari Sungai Gharehsou (46), di perkebunan bakau dan dua asosiasi alami Khanh Hoa, Vietnam (47). Berbeda dengan yang diberitakan bahwa Polychaeta lebih dominan di Muara Sungai Yangtze dan Pulau Batam, Indonesia (48), Gastropoda ditemukan dominan di Muara Musi (49), Gastropoda juga dominan di telaga parut kecamatan Pasuruan Jawa Timur (50), Gastropoda mendominasi Mumbai, pantai barat India (51). Hal ini menunjukkan bahwa persebaran individu kedua kelas moluska tersebut sangat bergantung pada habitatnya.

Kelimpahan moluska ditemukan cukup tinggi, yang meningkat secara signifikan di daerah estuari dibandingkan dengan daerah pesisir terbuka. Hal ini diduga dipengaruhi oleh keluarnya massa air dari tanah yang membawa lebih banyak bahan tersuspensi dan unsur hara. Selain itu pertemuan massa air menimbulkan daerah percampuran yang berdampak pada peningkatan kesuburan perairan. Kondisi ini sangat cocok untuk pertumbuhan dan reproduksi komunitas moluska sebagai biota sessile akuatik. Kelimpahan total ini lebih tinggi dari yang dilaporkan oleh (52–62).

C. Bioakumulasi Logam Berat Pada Biota Bentik Dari Pesisir Sumatera Selatan

Akumulasi Logam Berat pada Komunitas Bentik

Pengambilan sampel biota bentik untuk menganalisa kandungan logam berat disajikan pada Gambar 11.



Gambar 11. Lokasi *sampling*

Kandungan logam berat berdasarkan hasil pengukuran menggunakan AAS (*Atomic Absorption Spectroscopy*) Tipe AA 7000 pada tiga variabel disajikan pada Tabel 1.

Tabel 1. Kandungan logam berat

Sampel	**Stasiun**	**Logam Berat**			
		Pb	**Baku Mutu Pb**	**Cu**	**Baku Mutu Cu**
	1	0,400		TTD	
	2	0,429		TTD	
	3	0,434		TTD	
	4	0,333		TTD	
	5	0,302		TTD	
	6	0,008		TTD	
	7	TTD		TTD	
Air (mg/l)	8	TTD	0,008*	TTD	0,008*
	9	TTD		TTD	
	10	TTD		TTD	
	11	0,053		TTD	
	12	0,105		TTD	
	13	0,112		TTD	
	14	0,625		TTD	
	15	0,085		TTD	
	1	8,680		2,738	
	2	8,458		2,039	
	3	8,730		2,189	
	4	5,083		3,463	
	5	6,716		1,930	
	6	4,329		3,296	
	7	3,523		2, 357	
Sedimen (mg/kg)	8	3,989	50**	2,822	65**
	9	3,921		2,451	
	10	1,261		0,193	
	11	9,312		12,614	
	12	11,070		10,510	
	13	9,656		12,496	
	14	7,440		19,300	
	15	9,454		17,070	

Sampel	Stasiun	Logam Berat			
		Pb	Baku Mutu Pb	Cu	Baku Mutu Cu
	1	0,0026		0,0014	
	2	0,0041		0,0024	
	3	0,0042		0,0021	
	4	0,0029		0,0022	
	5	0,0044		0,0021	
	6	0,0010		0,0010	
***Neoleanira tetragona* (mg/kg)**	7	0,0004		0,0004	
	8	0,0005	0,12***	0,0021	3,28***
	9	0,0008		0,0008	
	10	0,0020		0,0016	
	11	0,0013		0,0003	
	12	0,0001		0,0009	
	13	0,0037		0,0022	
	14	TTD		0,0006	
	15	0,0008		0,0014	
	1	0,003		0,004	
	2	0,001		0,011	
	3	0		0,004	
	4	0,003		0,013	
	5	0,002		0,009	
	6	-		-	
***Anadara granosa* (mg/kg)**	7	-		-	
	8	-	0,12***	-	3,28***
	9	-		-	
	10	-		-	
	11	-		-	
	12	-		-	
	13	-		-	
	14	-		-	
	15	-		-	
	1	-		-	
	2	-		-	
	3	-		-	
	4	-		-	
	5	-		-	
	6	0,004		0,005	
***Nerita balteata* (mg/kg)**	7	0,004		0,005	
	8	0,003	0,12***	0,004	3,28***
	9	0,002		0,024	
	10	0,002		0,023	
	11	0,002		0,004	
	12	0,002		0,003	
	13	0,004		0,018	
	14	0,003		0,02	
	15	0,002		0,02	
	1	-		-	
	2	-		-	
	3	-		-	
	4	-		-	
	5	-		-	
***Cerithidea obtusa* (mg/kg)**	6	0,002		0,005	
	7	0,002	0,12***	0,005	3,28***
	8	0,003		0,016	
	9	0,003		0,012	
	10	0,003		0,009	
	11	-		-	
	12	-		-	
	13	-		-	

Sampel	Stasiun	Logam Berat			
		Pb	Baku Mutu Pb	Cu	Baku Mutu Cu
	14	-		-	
	15	-		-	
Cerithidea cingulata (mg/kg)	1	-		-	
	2	-		-	
	3	-		-	
	4	-		-	
	5	-		-	
	6	-		-	
	7	-		-	
	8	-	0,12***	-	3,28***
	9	-		-	
	10	-		-	
	11	0,001		0,021	
	12	0,001		0,026	
	13	0,001		0,018	
	14	0,004		0,026	
	15	0,004		0,022	
***Scylla serrata* (mg/kg)**	1	-		-	
	2	-		-	
	3	-		-	
	4	-		-	
	5	-		-	
	6	-		-	
	7	-		-	
	8	-	0,12***	-	3,28***
	9	-		-	
	10	-		-	
	11	0,0002		0,031	
	12	0,0001		0,055	
	13	TTD		0,080	
	14	0,0021		0,030	
	15	0,0008		0,062	

Keterangan, TTD : Tidak terdeteksi alat AAS

* : Kepmen LH. No.51 Tahun 2004

** : ANZECC, 2013

Konsentrasi logam berat Pb di air dari hasil pengukuran di laboratorium berkisar TTD – 0,625 mg/L. Konsentrasi terendah pada stasiun 7, 8, 9 dan 10 dan tertinggi pada stasiun 14. Sedangkan Nilai konsentrasi logam berat Cu yang didapatkan tidak terdeteksi oleh AAS. Konsentrasi logam berat Pb pada sedimen berdasarkan hasil pengukuran didapatkan berkisar 1,261 – 11,070 mg/kg . Konsentrasi terendah terdapat pada stasiun 10 dan stasiun 12. Adapun nilai konsentrasi logam berat Cu di sedimen didapatkan berkisar antara 1,930 - 19,30 mg/kg. Konsentrasi logam berat Pb dalam polychaeta memiliki kisaran TTD - 0,0044 mg/kg sedangkan nilai konsentrasi logam berat Cu adalah berkisar antara 0,0003 -0,0024 mg/kg.

Konsentrasi logam berat Pb dan Cu pada *A. granosa* yang ditemukan di stasiun 1 sampai 5 secara berurutan berkisar 0 - 0,003 mg/kg (Pb) dan 0,004-0,013 mg/kg (Cu). Konsentrasi logam berat Pb dan Cu pada *N. balteata* yang ditemukan di stasiun 6 sampai 15 secara berurutan berkisar 0,002 – 0,004 mg/kg (Pb) dan 0,003 – 0,024 mg/kg (Cu). Konsentrasi logam berat Pb dan Cu pada *C. obtusa* yang ditemukan di stasiun 6 sampai 10 secara berurutan berkisar 0,002 – 0,003 mg/kg (Pb) dan 0,005 – 0,016 mg/kg (Cu). Konsentrasi logam berat Pb dan Cu pada *C. cingulata* yang ditemukan di stasiun 11 sampai 15 secara berurutan berkisar 0,001 – 0,004 mg/kg (Pb) dan 0,018 – 0,026 mg/kg (Cu).

Konsentrasi logam berat Pb dan Cu dalam polychaeta yang didapatkan tidak melebihi baku mutu yang ditetapkan *International Atomic Energy Agency* Tahun 2003, dimana baku mutu logam berat Pb bernilai 0,12 mg/kg dan untuk Cu bernilai 3,28 mg/kg. Konsentrasi logam berat dapat bertambah tergantung dengan kondisi lingkungan perairan (63). Logam berat dapat berpindah ke dalam tubuh organisme melalui rantai makanan (64). Selain melalui rantai makanan, logam berat bisa masuk ke dalam tubuh polychaeta melalui kebiasaan dan pola makan dari polychaeta itu sendiri.

Konsentrasi logam Cu dan Pb pada *A. granosa* yang ditemukan di lokasi penelitian tergolong lebih rendah dibandingkan beberapa penelitian lain seperti pada penelitian (65) dan (66) yang mana juga meneliti kandungan logam berat yang terdapat pada jaringan bivalvia yakni berkisar 1,34 ± 0,59 mg/kg dan 2,45 mg/kg untuk Cu serta 0,04 ± 0,01 mg/kg dan 2,97 mg/kg untuk Pb. Kandungan logam berat akan terus meningkat seiring dengan lamanya kerang hidup di lingkungan sedimen karena sifatnya yaitu *filter feeder*. Menurut (67) juga konsentrasi logam berat pada sedimen juga mempengaruhi tinggi rendahnya konsentrasi logam berat pada kerang darah.

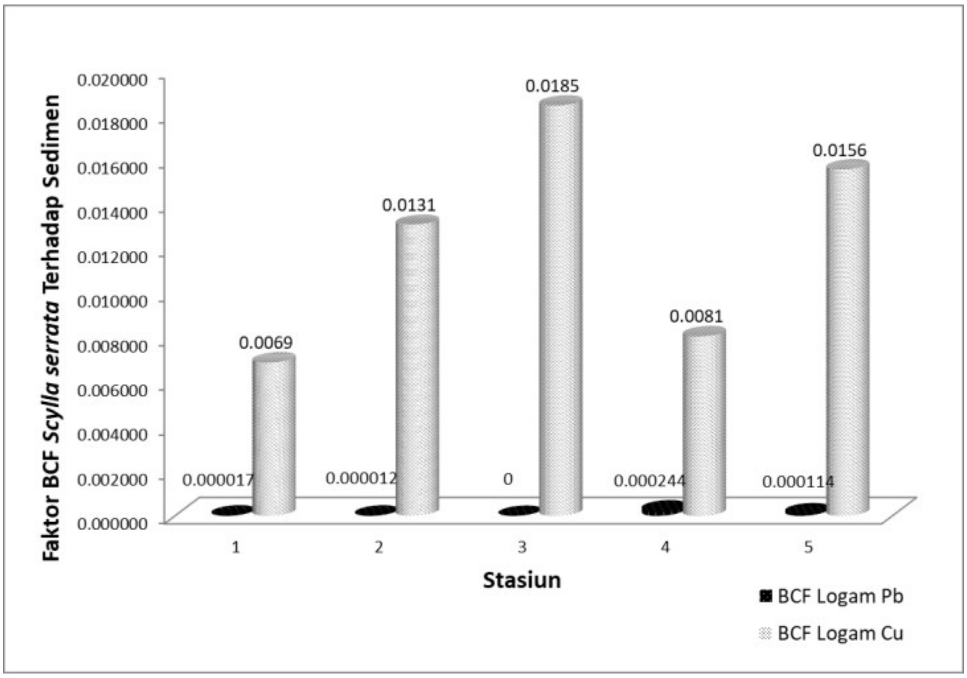
N. balteata, C. cingulata dan *C. obtuse* ditemukan di kawasan mangrove yakni pada akar dan batang mangrove. Kemampuan setiap masing-masing spesies gastropoda dalam mengatur dan mengakumulasi logam berat dikaitkan dengan fisiologi pencernaan pada spesies dan laju penyerapan logam berat oleh organisme itu sendiri. Perbedaan konsentrasi logam berat juga dipengaruhi oleh tingkat polusi, laju metabolisme, berat badan dan umur dari gastropoda itu sendiri (68). Ditemukan nilai kadar Cu pada *N. lineata* (2,80 - 4,40 mg/g) dan Pb (38.55 - 53.35 mg/g) dari zona intertidal. Berdasarkan penelitian (69) ditemukan pula nilai Cu (0,10 - 0,84 mg/g) dan Pb (0,03 - 0,08 mg/g) pada *C. Cingulata*.

Nilai konsentrasi logam berat Pb dan Cu pada *A. granosa, N. balteata*, *C. cingulata* dan *C. obtuse* menunjukkan bahwa nilainya masih dibawah baku mutu yang ditelah ditetapkan. Baku mutu yang logam berat untuk moluska mengacu pada FAO (1983) dimana untuk Pb (1,5 mg/kg) dan Cu (10 mg/kg). Artinya keempat biota ini tercemar logam berat Pb dan Cu dengan kadar yang masih aman untuk dikonsumsi oleh masyarakat. Keempat biota ini termasuk ke dalam biota konsumsi dan memiliki baku mutu kandungan logam berat Cu sebesar 20 ppm (Rahma *et al*. 2019). Hubungan antara parameter kualitas air dengan konsentrasi logam berat pada air, sedimen dan biota makrobentos ditunjukkan oleh suhu, salinitas dan pH yang ditentukan oleh jenis biota yang dianalisis dan lokasi stasiun.

Makrozoobentos memiliki sifat *filter feeder* yang memungkinkan dapat menyerap sejumlah logam berat yang berada pada perairan. Perbedaan kandungan logam berat dalam biota menurut (49), dapat disebabkan oleh beberapa faktor diantaranya perbedaan jenis spesies, kemampuan fisiologis organisme dan kondisi lingkungannya. *Neoleanira tetragona* di lokasi penelitian memiliki kandungan logam berat Pb dan Cu yang rendah. Hal ini dapat disebabkan karena kondisi lingkungan dan konsentrasi logam berat dalam sedimen juga tergolong rendah.

***Bioconcentration Factor* (BCF)**

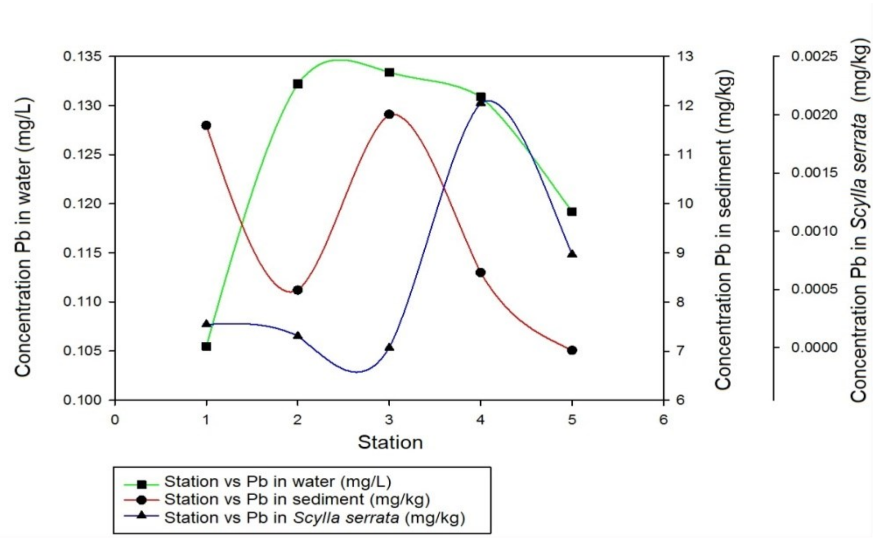
Faktor biokonsentrasi digunakan untuk mengetahui tingkat akumulasi logam berat Pb dan Cu pada *S. serrata* terhadap logam berat air dan sedimen (Gambar 12). Pada penelitian ini, BCF *S. serrata* terhadap air untuk logam tidak dapat ditentukan, karena logam berat Cu pada air tidak terdeteksi. Berdasarkan hasil perhitungan nilai BCF logam Pb *S. serrata* terhadap sedimen berkisar 0,000012 – 0,000244. Sedangkan nilai BCF logam Cu *S. serrata* terhadap sedimen berkisar 0,0069 – 0,0185.



Gambar 12. Faktor Biokonsentrasi (BCF) Logam Berat Pb dan Cu

Distribusi Logam Berat pada Air, Sediment, dan *Scylla Serrata*

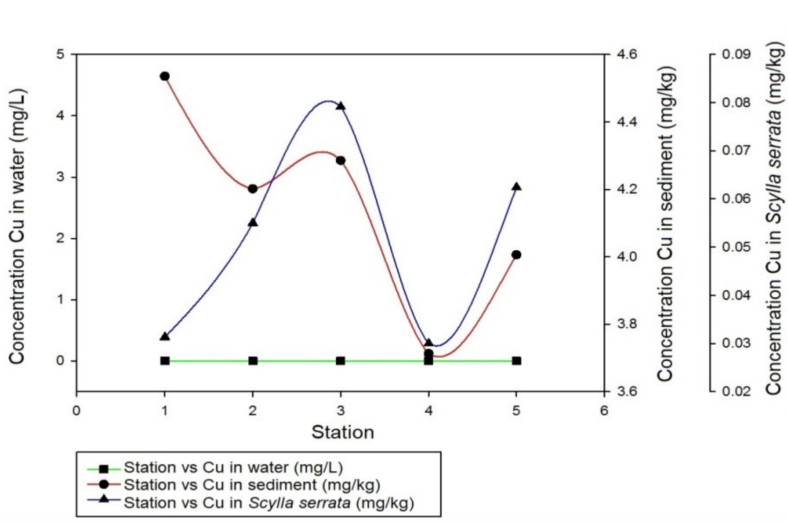
Distribusi logam berat Pb pada air, sedimen, dan *Scylla serrata* menunjukkan sebaran yang fluktuatif (Gambar 13). Konsentrasi logam berat tertinggi terdapat pada sedimen di seluruh stasiun. Kemudian diikuti dengan konsentrasi Pb pada air dan konsentrasi Pb terendah terdapat pada *Scylla serrata*.



Gambar 13. Distribusi Logam Berat Pb

Stasiun 1 menunjukkan hasil yang bervariasi dimana logam berat Pb pada sedimen menunjukkan nilai yang tinggi, sedangkan pada air dan *Scylla serrata* menunjukkan nilai yang rendah dibandingkan dengan stasiun lain. Logam berat Pb sedimen dan *Scylla serrata* memiliki pola yang menurun, sedangkan pada air memiliki pola yang meningkat. Stasiun 3 menunjukkan pola logam berat Pb air dan *Scylla serrata* cenderung sama dengan stasiun 2, sedangkan pada sedimen memiliki pola meningkat dengan signifikan. Logam berat Pb pada air dan sedimen di stasiun 4 memiliki pola menurun, sedangkan pada *Scylla serrata* memiliki pola yang meningkat dengan signifikan. Pada stasiun 5 menunjukkan logam berat Pb pada air, sedimen, dan *Scylla serrata* memiliki pola yang sama yaitu menurun.

Hasil distribusi logam berat Cu pada pada sedimen tertinggi di seluruh stasiun. Kemudian diikuti dengan konsentrasi Cu pada *Scylla serrata*, sedangkan pada air tidak terdeteksi (Gambar 14).

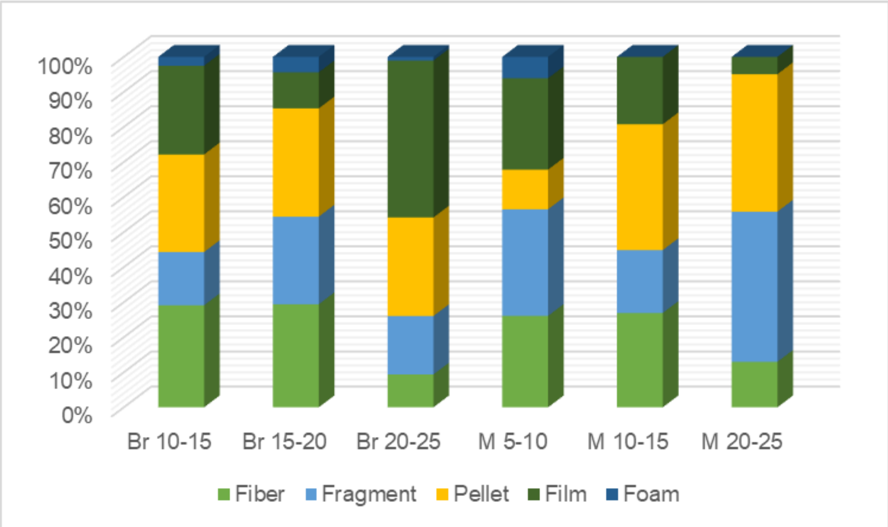


Gambar 14. Distribusi Logam Berat Cu

Konsentrasi Cu sedimen dan *Scylla serrata* pada stasiun 1 menunjukkan pola yang berbeda, konsentrasi Cu pada sedimen stasiun 1 menunjukkan konsentrasi tertinggi dibandingkan dengan stasiun lainnya, sedangkan pada *Scylla serrata* menunjukkan konsentrasi yang rendah dibandingkan dengan stasiun lainnya. Pada stasiun 2 konsentrasi Cu pada sedimen memiliki pola yang menurun, sedangkan pada *Scylla serrata* memiliki pola yang meningkat. Pada stasiun 3, 4, dan 5 menunjukkan pola yang sama antara sedimen dan *Scylla serrata* dimana pada stasiun 3 mengalami kenaikan, stasiun 4 mengalami penurunan, dan pada stasiun 5 mengalami kenaikan.

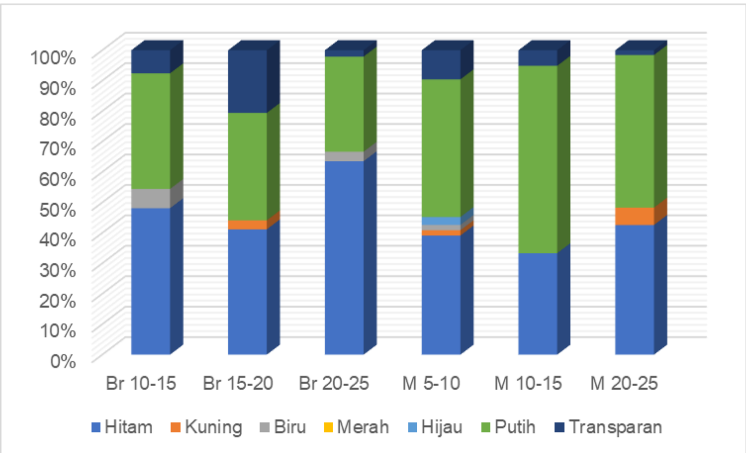
D. Bioakumulasi Mikroplastik Pada Biota Bentik Dari Pesisir Sumatera Selatan

Biota yang dianalisis kandungan mikroplastik (MPs) yaitu kerang *A. granosa*. Pemilihan ini didasarkan oleh perannya yang menjadi salah satu komoditas laut terbesar di Sumatera Selatan sedangkan perairannya diyakini menjadi sumber masuknya bahan pencemar MPs karena intensitas aktivitas antropogenik tinggi di perairan. Lokasi pengambilan sampel di kawasan perairan Sungai Barong dan Sungai Musi. Sampel diukur berdasarkan ukuran yang kemudian dibagi menjadi tiga kategori ukuran (kecil, sedang, besar).



Gambar 15. Karakterisasi mikroplastik berdasarkan jenis

Berdasarkan Gambar 15, mikroplastik yang ditemukan meliputi 5 jenis yaitu fiber, fragmen, pellet, film, dan foam. MPs jenis foam menjadi yang paling sedikit ditemukan diantara jenis lainnya. MPs fiber ditemukan pada kisaran 9% - 29%, MPs fragment ditemukan pada kisaran 15% - 43%, MPs pellet berkisar 11% - 39%, MPs film berkisar antara 5% - 45%, dan MPs foam berkisar 0% - 6%.



Gambar 16. Karakterisasi mikroplastik berdasarkan warna

Berdasarkan Gambar 16, mikroplastik yang ditemukan meliputi 7 warna yaitu hitam, kuning, biru, merah, hijau, putih, dan transparan. MPs hitam dan putih sangat dominan ditemukan di semua sampel dengan lebih dari 30%. MPs hitam ditemukan pada kisaran 33% - 64% sementara MPs putih berada ditemukan pada kisaran 31% - 62%. MPs transparan berkisar 2% - 21%, MPs Biru dan Kuning berkisar antara 0% - 6%, dan MPs hijau berkisar 0% - 3%.

Spesies *A. granosa* hidup di dasar perairan dan sebagian besar dihabiskan dengan mencari makan di permukaan subsrat (70,71). Terkait dengan perilakunya tersebut, maka terdapat hubungan antara kelimpahan MPs yang mengendap di dasar perairan dengan total bioakumulasi MPs pada organisme makrozoobentos ini. MPs dapat terakumulasi ke dalam tubuh organisme melalui saluran makannya lalu menyebar ke seluruh jaringan tubuh (72,73). Intensitas paparan yang tinggi akan menyebabkan gangguan kesehatan bahkan kematian pada organisme. Dampak jangka panjangnya yaitu hilangnya keseimbangan sistem ekologi sedangkan partikel MPs terus berpindah dari satu organisme ke organisme lain melalui proses biomagnifikasi.

Penilaian potensi MPs beracun dapat dilakukan dalam dua perspektif sekaligus yakni penilaian kuantitatif MPs dan penilaian kuantitatif antioksidan pada organisme makrozoobentos. Keduanya memiliki hubungan yang linier, bahwa semakin tinggi tingkat paparan MPs maka level antioksidannya juga semakin kuat. Senyawa-senyawa bioaktif yang berhasil teridentifikasi bersifat antioksidan dalam respon fisiologis organisme yaitu jenis senyawa flavonoid, senyawa fenolat, peroksidase dan senyawa protein (74).

D. **STATUS LUARAN**: Tuliskan jenis, identitas dan status ketercapaian setiap luaran wajib dan luaran tambahan (jika ada) yang dijanjikan. Jenis luaran dapat berupa publikasi, perolehan kekayaan intelektual, hasil pengujian atau luaran lainnya yang telah dijanjikan pada proposal. Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran wajib dan luaran tambahan melalui BIMA.

Status Luaran Penelitian Tahun 2022
Jenis : Jurnal Internasional Bereputasi (Luaran Wajib)
Identitas : International Journal of Conservation Science (ISSN: 2067-533X) – Terindeks Scopus Q2
Status : Published

Jenis : Jurnal Internasional Bereputasi (Luaran Tambahan)
Identitas : Regional Studies in Marine Science (ISSN: 2352-4855) – Scopus Q2
Status : Submit

E. **PERAN MITRA:** Tuliskan realisasi kerjasama dan kontribusi Mitra baik *in-kind* maupun *in-cash* (untuk Penelitian Terapan, Penelitian Pengembangan, PTUPT, PPUPT serta KRUPT). Bukti pendukung realisasi kerjasama dan realisasi kontribusi mitra dilaporkan sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra diunggah melalui BIMA.

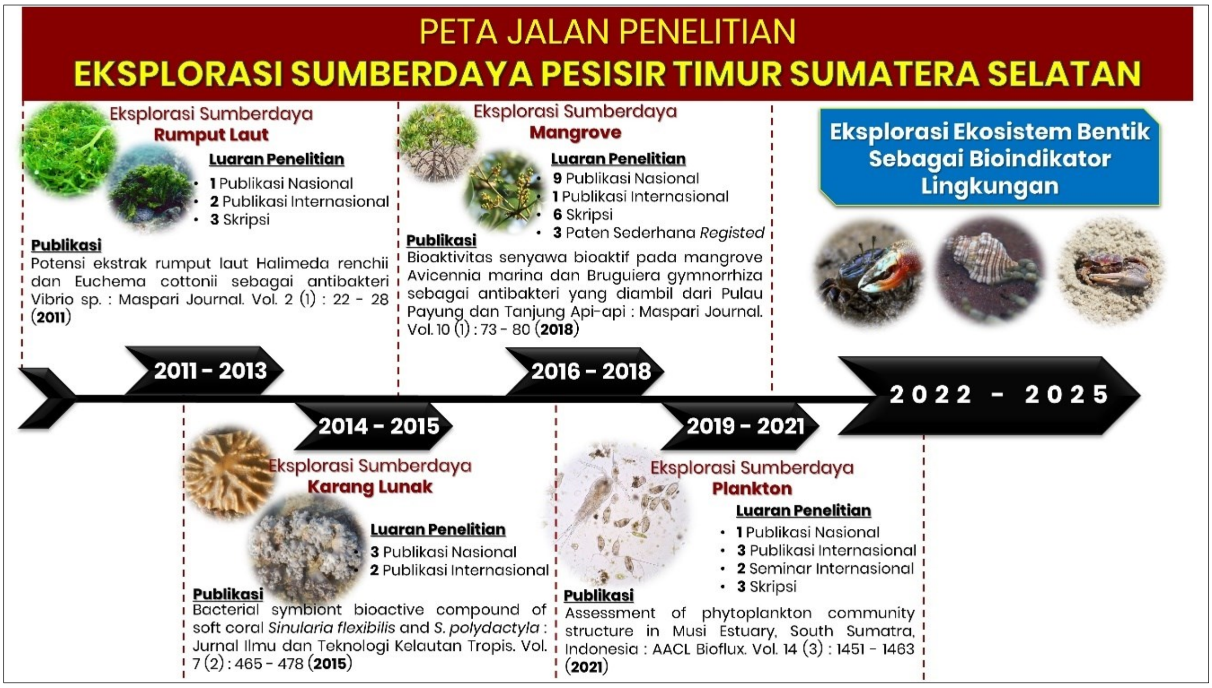
-

F. **KENDALA PELAKSANAAN PENELITIAN**: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Penelitian ini melibatkan beberapa mahasiswa S1 dalam pengerjaannya sekaligus menjadi studi tugas akhir mereka. Keterlibatan secara langsung tersebut membutuhkan waktu yang cukup panjang secara administrasinya sehingga jalannya penelitian ini sedikit terlambat terutama pada topik tekanan mikroplastik pada ekosistem bentik. Namun seiring berjalannya waktu, keterlambatan jadwal tersebut tetap dikejar sesuai target perminggunya. Secara umum, pelaksanaan tiap tahap penelitian tidak memiliki hambatan yang signifikan, namun tim telah berusaha secara optimal dalam mencapai target capaian.

G. **RENCANA TAHAPAN SELANJUTNYA:** Tuliskan dan uraikan rencana penelitian di tahun berikutnya berdasarkan indikator luaran yang telah dicapai, rencana realisasi luaran wajib yang dijanjikan dan tambahan (jika ada) di tahun berikutnya serta *roadmap* penelitian keseluruhan. Pada bagian ini diperbolehkan untuk melengkapi penjelasan dari setiap tahapan dalam metoda yang akan direncanakan termasuk jadwal berkaitan dengan strategi untuk mencapai luaran seperti yang telah dijanjikan dalam proposal. Jika diperlukan, penjelasan dapat juga dilengkapi dengan gambar, tabel, diagram, serta pustaka yang relevan. Jika laporan kemajuan merupakan laporan pelaksanaan tahun terakhir, pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai.

Semua data yang dikumpulkan akan dilakukan analisis data sebagai bagian dari pengerjaan penelitian ini untuk mendukung tujuan besar Peta Jalan Penelitian. Analisa terhadap data akan dilakukan oleh semua anggota tim untuk menemukan fenomena-fenomena terbaru yang mendukung kebaharuan ilmu pengetahuan sebagai salah satu unsur yang wajib ada dalam penulisan artikel ilmiah khususnya pada jurnal-jurnal internasional bereputasi yang menjadi luaran penelitian untuk tahun pertama dan kedua serta buku untuk tahun kedua.



Gambar 9. Peta jalan penelitian

Kegiatan penelitian yang dilakukan telah menghasilkan data-data yang mendukung tujuan besar Peta Jalan Penelitian yaitu Eksplorasi Ekosistem Bentik sebagai Bioindikator Lingkungan (Gambar 9). Selanjutnya, kajian tersebut akan bermanfaat pada pengembangan bidang *Marine Bioprospecting*. Hasil penelitian tersebut diharapkan akan diimplementasikan sebagai sebuah produk yang bermanfaat bagi sosial ekonomi masyarakat dan pengembangan produk kesehatan berbasis sumber daya alam dan pesisir. Sejalan dengan kegiatan penelitian yang terus berlanjut, artikel hasil penelitian akan terus diproses untuk publikasi sebagai luaran penelitian pada tahun yang sama dengan tahun kegiatan dan tahun berikutnya.

H. DAFTAR PUSTAKA: Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan kemajuan yang dicantumkan dalam Daftar Pustaka.

1. Mangale VY, Kulkarni BG. Morphological Study of Fiddler Crabs in Mumbai Region. Adv Biores. 2013;4(3):86–91.
2. Shih H-T, Hsu J-W, Wong KJH, Ng NK. Review of the mudflat varunid crab genus Metaplax (Crustacea, Brachyura, Varunidae) from East Asia and northern Vietnam. Zookeys. 2019;877:1–29.
3. Shih H-T, Lee J-H, Ho P-H, Liu H-C, Wang C-H, Suzuki H, Teng S-J. Species diversity of fiddler crabs, genus Uca Leach, 1814 (Crustacea: Ocypodidae), from Taiwan and adjacent islands, with notes on the Japanese species. Zootaxa. 2016;4083(1):57–82.

4. Shukla M, Patel B, Trivedi J, Vachhrajani K. Brachyuran crabs diversity of Mahi and Dhadhar estuaries, Gujarat, India. Res J Mar Sci. 2013;2321:1296.

5. Rianta P, Ernawati W, Chen G, Chen S. Diversity and abundance of mangrove fiddle crabs, genus Uca (Decapoda, Ocypodidae) at a mangrove in Kema, North Sulawesi, Indonesia. Acta Oceanol Sin. 2018;37(12):92–96.

6. Liu Y, Yang T-T, Xin Z-Z, Liu Q-N, Zhang D-Z, Tang B-P. The complete mitochondrial genome sequence of Metaplax longipes (Grapsoidea: Varunidae). Mitochondrial DNA Part B. 2019;4(1):1280–1282.

7. Chen J, Xing Y, Yao W, Xu X, Zhang C, Zhang Z, Liu Q. Phylomitogenomics reconfirm the phylogenetic position of the genus Metaplax inferred from the two grapsid crabs (Decapoda: Brachyura: Grapsoidea). PLoS One. 2019;14(1):e0210763.

8. Chen P, Zhang Y, Zhu X, Lu C. Distribution of crabs along a habitat gradient on the Yellow Sea coast after Spartina alterniflora invasion. PeerJ. 2019;7:e6775.

9. Marin IN. New data on the distribution of hairy-clawed shore crabs of the genus Hemigrapsus (Decapoda: Varunidae) along the Russian mainland coast of the Sea of Japan. Russ J Mar Biol. 2013;39(4):301–305.

10. Wójcik D, Normant M, Dmochowska B, Fowler A. Impact of Chinese mitten crab Eriocheir sinensis on blue mussel Mytilus edulis trossulus–laboratory studies of claw strength, handling behavior, consumption rate, and size selective predation. Oceanologia. 2015;57(3):263–270.

11. Webster J, Clark P, Morritt D. Laboratory based feeding behaviour of the Chinese mitten crab, Eriocheir sinensis (Crustacea: Decapoda: Brachyura: Varunidae): fish egg consumption (De Haan, 1835). Aquat Invasions. 2015;10(3):313–326.

12. Davie P, Xuan N. A new species of Metaplax (Crustacea: Brachyura: Varunidae: Cyclograpsinae) from Vietnam. Raffles Bull Zool. 2003;51:379–386.

13. Mohanty B, Nayak A, Dash B, Rout SS, Charan Kumar B, Patnaik L, Dev Roy MK, Raman A, Raut D. Biodiversity and ecological considerations of brachyuran crabs (Crustacea: Decapoda) from Devi estuary–mangrove region on the east coast of India. Reg Stud Mar Sci. 2019;32:100865.

14. Murniati D. Pola Dominansi Capit Pada Uca spp. (Decapoda: Ocypodidae). Berk Hayati. 2010;16:15–20.

15. Murniati D, Afriadi R. Kepiting Uca di hutan mangrove Indonesia. Tinjauan aspek biologi dan ekologi untuk eksplorasi. .

16. Perez DM, Heatwole SJ, Morrell LJ, Backwell PRY. Handedness in fiddler crab fights. Anim Behav. 2015;110:99–104.

17. Darnell MZ, Rittschof CC, Rittschof J, Beach C, Rittschof D. Autotomy of the major claw stimulates molting and suppresses feeding in fiddler crabs. J Exp Mar Bio Ecol. 2018;509:66–70.

18. Levinton J. Thermal stress: The role of body size and the giant major claw in survival and heat transfer of a fiddler crab (Leptuca pugilator). J Exp Mar Bio Ecol. 2020;530–531:151428.

19. Crane J. Fiddler crabs of the world: Ocypodidae: genus Uca. Princeton University Press.

20. Shih H-T, Chan BKK, Ng PKL. Tubuca alcocki, a new pseudocryptic species of fiddler crab from the Indian Ocean, sister to the southeastern African T. urvillei (H. Milne Edwards, 1852)(Crustacea, Decapoda, Brachyura, Ocypodidae). Zookeys. 2018;(747):41.

21. Akash M, Chowdhury GW. First record of the Bengal fiddler crab Uca (Austruca) bengali Crane, 1975 (Braychura: Ocypodidae) from Kuakata National Park, Bangladesh. Dhaka Univ J Biol Sci. 2017;26(2):199–203.

22. Shih H-T, Ng PKL, Davie PJF, Schubart CD, Türkay M, Naderloo R, Jones D, Liu M-Y. Systematics of the family Ocypodidae Rafinesque, 1815 (Crustacea: Brachyura), based on phylogenetic relationships, with a reorganization of subfamily rankings and a review of the taxonomic status of Uca Leach, 1814, sensu lato and its subgenera. Raffles Bull Zool. 2016;64.

23. Apreshgi KP, Dhaneesh K V, Radhakrishnan T, Kumar A. DNA barcoding of fiddler crabs Uca annulipes and U. perplexa (Arthropoda, Ocypodidae) from the southwest coast of India. J Mar Biol Assoc India. 2016;58(1):101–104.

24. Karagozlu MZ, Kim J-I, Choi T-J, Dinh T Do, Kim C-B. The complete mitochondrial genome of

Hemigrapsus penicillatus (De Haan, 1835) (Decapoda, Varunidae). Mitochondrial DNA Part B. 2018;3(1):261–262.

25. Tang B-P, Liu Y, Xin Z-Z, Zhang D-Z, Wang Z-F, Zhu X-Y, Wang Y, Zhang H-B, Zhou C-L, Chai X-Y, Liu Q-N. Characterisation of the complete mitochondrial genome of Helice wuana (Grapsoidea: Varunidae) and comparison with other Brachyuran crabs. Genomics. 2018;110(4):221–230.

26. Feng J, Huang Q, Chen H, Guo J, Lin G. Restoration of native mangrove wetlands can reverse diet shifts of benthic macrofauna caused by invasive cordgrass. J Appl Ecol. 2018;55(2):905–916.

27. Liao Y, Shou L, Tang Y, Gao A, Chen Q, Yan X, Chen J. Influence of two non-indigenous plants on intertidal macrobenthic communities in Ximen Island Special Marine Protected Area, China. Ecol Eng. 2018;112:96–104.

28. McLay C, Kitaura J, Fukui Y, Wada K. Molecular phylogenetic position of the New Zealand sentinel crab, Macrophthalmus (Hemiplax) hirtipes (Jacquinot, in Hombron & Jacquinot, 1846)(Decapoda, Brachyura, Macrophthalmidae). Crustaceana. 2010;83(11):1315–1326.

29. Marin IN. Estuarine crabs of the Okhotsk Sea and the Sea of Japan: rare species and new records. Ukr J Ecol. 2017;7(4).

30. Nour OSEDM, Stumpp M, Moron Lugo SC, Barboza FR, Pansch C. Population structure of the recent invader Hemigrapsus takanoi and prey size selection on Baltic Sea mussels. Aquat Invasions. 2020;15(2):297–317.

31. Perez DM, Christy JH, Backwell PRY. Choosing a mate in a high predation environment: female preference in the fiddler crab Uca terpsichores. Ecol Evol. 2016;6(20):7443–7450.

32. da Silva Vianna B, Miyai CA, Augusto A, Costa TM. Effects of temperature increase on the physiology and behavior of fiddler crabs. Physiol Behav. 2020;215:112765.

33. Begum S. Macrobenthic Assemblage in the Rupsha-Pasur River System of the Sundarbans Ecosystem (Bangladesh) for the Sustainable Management of Coastal Wetlands. In Coastal Wetlands: Alteration and Remediation. Springer; p.751–776.

34. De C. Geological and Geotechnical Significance. In Mangrove Ichnology of the Bay of Bengal Coast, Eastern India. Springer; p.233–276.

35. Caro T. The functional significance of coloration in crabs. Biol J Linn Soc. 2018;124(1):1–10.

36. Takeshita F. Color changes of fiddler crab between seasons and under stressful conditions: patterns of changes in lightness differ between carapace and claw. J Exp Mar Bio Ecol. 2019;511:113–119.

37. Zulfahmi I, Marlinda R, Nisa C, Paujiah E, Irfannur I, Rinaldi R, Purnama NR, Mandasari M. Size distribution, length-weight relationship and condition factor of three species male fiddler crab from jaboy mangrove wetland, Sabang, Indonesia. In IOP Conference Series: Materials Science and Engineering. IOP Publishing; p.42112.

38. Presilda CJ. Sexual dimorphism in the carapace of mud crab (Scylla serrate, Forsskal, 1775) in Magallanes, Agusandel Norte using Geometric Morphometric Analysis. Comput Ecol Softw. 2018;8(4):88.

39. Kitaura J, Wada K, Nishida M. Molecular Phylogeny of Grapsoid and Ocypodoid Crabs with Special Reference to the Genera Metaplax and Macrophthalmus. J Crustac Biol. 2002;22(3):682–693.

40. Zengel S, Pennings SC, Silliman B, Montague C, Weaver J, Deis DR, Krasnec MO, Rutherford N, Nixon Z. Deepwater Horizon Oil Spill Impacts on Salt Marsh Fiddler Crabs (Uca spp.). Estuaries and Coasts. 2016;39(4):1154–1163.

41. Lourenço PM, Catry T, Granadeiro JP. Diet and feeding ecology of the wintering shorebird assemblage in the Bijagós archipelago, Guinea-Bissau. J Sea Res. 2017;128:52–60.

42. De Grande FR, Colpo KD, Queiroga H, Cannicci S, Costa TM. Contrasting activity patterns at high and low tide in two Brazilian fiddler crabs (Decapoda: Brachyura: Ocypodidae). J Crustac Biol. 2018;38(4):407–412.

43. Wamepa K, Purwoko A, Kamal M. Studi Populasi Burung Wader (Charadriiformes) pada Akhir Musim Migrasi di Semenanjung Sembilang Banyuasin, Sumatera Selatan. J Penelit Sains. 2019;20(3):77–80.

44. Bramwell G, Schultz AG, Sherman CDH, Giraudeau M, Thomas F, Ujvari B, Dujon AM. A review of the

potential effects of climate change on disseminated neoplasia with an emphasis on efficient detection in marine bivalve populations. Sci Total Environ. 2021;775:145134.

45. Subramanian R, Retnamma J, Nagarathinam A, Loganathan J, Singaram P, Chandrababu V. Seasonality of macrobenthic assemblages and the biotic environmental quality of the largest monsoonal estuary along the west coast of India. Environ Sci Pollut Res. 2021;28(28):37262–37278.

46. Jamani S, Gholizadeh M, Patimar R, Fathabadi A. Identification and Abundance of Macrobenthic in Estuary of the Gharehsou River. J Fish. 2021;74(1):31–43.

47. Zvonareva SS, Kantor YI, Nguyen TTH, Britayev TA. Diversity and Long-Term Dynamics of the Macrobenthos in a Mangrove Plantation and Two Natural Associations of Khanh Hoa Province, Vietnam. Biol Bull. 2020;47(9):1115–1125.

48. Ramses, Ismarti, Amelia F, Rozirwan, Suheryanto. Diversity and abundance of polychaetes in the west coast waters of Batam Island, Kepulauan Riau Province-Indonesia. AACL Bioflux. 2020;13(1):381–391.

49. Rozirwan, Melki, Apri R, Fauziyah, Agussalim A, Hartoni, Iskandar I. Assessment the macrobenthic diversity and community structure in the Musi Estuary, South Sumatra, Indonesia. Acta Ecol Sin. 2021;41(4):346–350.

50. Susilo VE, Dewi MIP, Mujiono N, Subchan W, Prihatin J. The diversity of Gastropoda in grati lake district pasuruan east java. In Journal of Physics: Conference Series. IOP Publishing; p.12008.

51. Kantharajan G, Pandey PK, Krishnan P, Samuel VD, Bharti VS, Purvaja R. Molluscan diversity in the mangrove ecosystem of Mumbai, west coast of India. Reg Stud Mar Sci. 2017;14:102–111.

52. Abdollahi R, Darzi SE, Rahimian H, Naderloo R. Biodiversity of intertidal and shallow subtidal habitats in Abu Musa Island, Persian Gulf, Iran, with an updated species checklist. Reg Stud Mar Sci. 2020;33:100975.

53. Amorim RM, Delgado J de F, Neto JAB, Crapez M, Fernandez CS, e Negrello Filho OA, Fonseca EM. The benthic macrofauna along the estuarine gradient of the Paranaguá estuary. Reg Stud Mar Sci. 2020;39:101459.

54. Guan Q, Liu J, Batzer DP, Lu X, Wu H. Snails (Mollusca: Gastropoda) as potential surrogates of overall aquatic invertebrate assemblage in wetlands of Northeastern China. Ecol Indic. 2018;90:193–200.

55. Hossain MB. Trophic functioning of macrobenthic fauna in a tropical acidified Bornean estuary (Southeast Asia). Int J Sediment Res. 2019;34(1):48–57.

56. Jayachandran PR, Nandan SB, Jima M, Joseph P, Xavier NDD, Sreedevi OK, Prabhakaran MP, Joseph KJ. Macrobenthic functional feeding groups in a microtidal monsoonal estuary (Kodungallur–Azhikode estuary, India). Reg Stud Mar Sci. 2019;25:100444.

57. Joshua TJ, Toefy R, Sparks C, Kirkman SP, Samaai T. Macro-benthic invertebrate assemblages in the Betty's Bay marine protected area (Kogelberg region South Africa). Reg Stud Mar Sci. 2018;22:1–8.

58. Park JM, Huh S-H. Epibenthic invertebrate fauna in the southern coast of the East Sea, Korea. J Asia-Pacific Biodivers. 2018;11(2):217–222.

59. Rehitha T V, Ullas N, Vineetha G, Benny PY, Madhu N V, Revichandran C. Impact of maintenance dredging on macrobenthic community structure of a tropical estuary. Ocean Coast Manag. 2017;144:71–82.

60. Suratissa DM, Rathnayake U. Effect of pollution on diversity of marine gastropods and its role in trophic structure at Nasese Shore, Suva, Fiji Islands. J Asia-Pacific Biodivers. 2017;10(2):192–198.

61. Yan J, Xu Y, Sui J, Li X, Wang H, Zhang B. Long-term variation of the macrobenthic community and its relationship with environmental factors in the Yangtze River estuary and its adjacent area. Mar Pollut Bull. 2017;123(1–2):339–348.

62. Youssef M, Madkour H, Mansour A, Alharbi W, El-Taher A. Invertebrate shells (mollusca, foraminifera) as pollution indicators, Red Sea Coast, Egypt. J African Earth Sci. 2017;133:74–85.

63. Giraldes BW, Al-Thani JAKH, Dib S, Engmann A, Alsaadi HA, Vethamony P, Alatalo JM, Yigiterhan O. Target gastropods for standardizing the monitoring of tar mat contamination in the Arabian Gulf. Reg Stud Mar Sci. 2022;53:102328.

64. Steinhausen SL, Agyeman N, Turrero P, Ardura A, Garcia-Vazquez E. Heavy metals in fish nearby

electronic waste may threaten consumer’s health. Examples from Accra, Ghana. Mar Pollut Bull. 2022;175:113162.

65. Gong Y, Chai M, Ding H, Shi C, Wang Y, Li R. Bioaccumulation and human health risk of shellfish contamination to heavy metals and As in most rapid urbanized Shenzhen, China. Environ Sci Pollut Res. 2020;27(2):2096–2106.

66. EL-Shenawy NS, Loutfy N, Soliman MFM, Tadros MM, Abd El-Azeez AA. Metals bioaccumulation in two edible bivalves and health risk assessment. Environ Monit Assess. 2016;188(3):139.

67. El Nemr A, El-Said G, Ragab S, Khaled A, El-Sikaily A. The distribution, contamination and risk assessment of heavy metals in sediment and shellfish from the Red Sea coast, Egypt. Chemosphere. 2016;165:369–380.

68. Gawad SSA. Concentrations of heavy metals in water, sediment and mollusk gastropod, Lanistes carinatus from Lake Manzala, Egypt. Egypt J Aquat Res. 2018;44(2):77–82.

69. Kesavan K, Arumugam M, Vellathi V, Kumar BS. Heavy metal accumulation in molluscs and sediment from uppanar estuary, southeast coast of India. Thalassas. 2013;29:15–21.

70. Belal AAM. Macro-benthic invertebrates as a bio-indicator for water and sediment quality in Suez Bay, Red Sea. Egypt J Aquat Res. 2019;45(2):123–130.

71. Yunita F, Leiwakabessy F, Rumahlatu D. Macrozoobenthos community structure in the coastal waters of Marsegu Island, Maluku, Indonesia. Int J Appl Biol. 2018;2(1):1–11.

72. Hastuti AR, Lumbanbatu DTF, Wardiatno Y. The presence of microplastics in the digestive tract of commercial fishes off Pantai Indah Kapuk coast, Jakarta, Indonesia. Biodiversitas J Biol Divers. 2019;20(5).

73. Bayo J, Rojo D, Martínez-Baños P, López-Castellanos J, Olmos S. Commercial gilthead seabream (Sparus aurata L.) from the Mar Menor Coastal Lagoon as hotspots of microplastic accumulation in the digestive system. Int J Environ Res Public Health. 2021;18(13):6844.

74. Bakshi M, Ghosh S, Chakraborty D, Hazra S, Chaudhuri P. Assessment of potentially toxic metal (PTM) pollution in mangrove habitats using biochemical markers: A case study on Avicennia officinalis L. in and around Sundarban, India. Mar Pollut Bull. 2018;133:157–172.

1. **LUARAN WAJIB**

Nama Jurnal: International Journal of Conservation Science
(https://ijcs.ro/)
Status: ***Published*** **(Scopus/Q2) (https://www.scopus.com/sourceid/21100223164)**

Judul Artikel: An Ecological Assessment of Crab's Diversity Among Habitats of Migratory Birds at Berbak-Sembilang National Park Indonesia

(https://ijcs.ro/public/IJCS-22-68_Rozirwan.pdf)

2. **LUARAN TAMBAHAN**

Nama Jurnal: Regional Studies in Marine Science

(https://www.sciencedirect.com/journal/regional-studies-in-marine-science)

Status: ***Submited*** **(Scopus/Q2) (https://www.scopus.com/sourceid/21100390177)**

Judul Artikel: Mollusks diversity in the protected coastline of Berbak-Sembilang National Park Indonesia

INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 13, Issue 3, July-September 2022: 961-972 www.ijcs.ro

AN ECOLOGICAL ASSESSMENT OF CRAB'S DIVERSITY AMONG HABITATS OF MIGRATORY BIRDS AT BERBAK-SEMBILANG NATIONAL PARK INDONESIA

Rozirwan ROZIRWAN[1,*], Fauziyah FAUZIYAH[1], Redho Yoga NUGROHO[2], Melki MELKI[1], Tengku Zia ULQODRY[1], Fitri AGUSTRIANI[1], Ellis Nurjuliasti NINGSIH[1], Wike Ayu Eka PUTRI[1], Afan ABSORI[3], Muhammad IQBAL[4]

[1] Department of Marine Science, Faculty of Mathematics and Natural Science, Sriwijaya University, Jalan Palembang-Prabumulih KM 32, Indralaya, South Sumatra, Indonesia 30862

[2] Environmental Management Study Program, Graduate Program, Sriwijaya University, Jalan Padang Selasa 524, Palembang, South Sumatra, Indonesia 30139

[3] Center of Berbak and Sembilang National Park, Komplek Istana Madinatuna 114, Talang Jambe, Palembang, South Sumatra, Indonesia 30961

[4] Biology Programme, Faculty of Science, Sriwijaya University, Jalan Padang Selasa 524, Palembang, South Sumatra, Indonesia 30139

Abstract

Crabs have an important role in the food chain among the habitat of migratory birds at Berbak-Sembilang National Park (BSNP), due to it is the main food for these birds' population. The purpose of this study was to record the crabs' species found among the habitat of migratory birds at BSNP. The methodology used is a survey by measuring environmental parameter data and sampling crabs, where the identification of species is carried out morphologically and analyzed with references. The results showed that there were three species of crabs found on the BSNP coast, where it was identified as a species of Uca dussumieri (Edwards, 1852) (C1), Metaplax longipes (Stimpson, 1858) (C2), and Metaplax distinct (Edwards, 1852) (C3). Habitat of crabs are found on fine muddy substrates at a depth of about 60 to 80 cm, pH 6.08 to 6.2, salinity 27 to 29 psu, temperature 29 to 30 ºC, nitrates and phosphates in water 6.69 mg L^{-1} and 0.197 mg L^{-1}. This condition is very suitable for the growth of crabs. In the future, research should be carried out on chemical-ecological interactions of crabs and another biota.

***Keywords**: Benthic; Crustacean; Migratory birds; Mud crab; Berbak-Sembilang National Park*

Introduction

Crabs are a group of crustaceans that are easily found in the Berbak-Sembilang National Park area, which is the main food source for migratory birds while in transit twice a year. The birds are reported to have originated from Siberia in the Northern Hemisphere and Australia in the Southern Hemisphere. The birds are reported to be transiting October-November from Siberia in the northern hemisphere to Australia in the southern hemisphere, and they will transit in March-April to return to the north [1]. In the transit season, the number of birds that have been reported reaches 1600 individuals for resting and foraging for food in marine life. Crabs are their main food in the intertidal area of this habitat [2-4].

* Corresponding author: rozirwan@unsri.ac.id

Morphologically, the crab has a very hard carapace to protect its body, it also has a pair of claws as a means of capturing prey and defense from predators. In addition, he can run quickly into the mud using four pairs of legs. It has a color and pattern adapted to the clarity of the waters or the substrate of its habitat, such as it is bright or lighter in sandy or rocky areas. Instead, it will be dark in turbid or muddy waters [5-9]. In general, the intertidal area of the Berbak-Sembilang National Park is mud-substrate, especially in the habitat of migratory birds. Therefore, these crabs are classified as mud crabs and are very suitable for their growth [10].

Based on this information, the ecological role of crabs in the food chain in the Berbak-Sembilang National Park area is very important. Therefore, this study is indispensable for a report on the crab species that feed on migratory birds, which will greatly assist further research in the area.

Experimental part

Sampling site

Habitat crabs is a transit area for migratory birds in the Berbak-Sembilang National Park, Indonesia, which is an estuary area with extensive mangrove vegetation. The migratory birds species in this area are *Calidris alpina*, *Charadrius mongolus*, *Limosa lapponica*, *Limosa limosa*, *Limonodromus semipalmatus*, *Numenius arquata*, *Tringanebularia*, and *Tringa tetanus* [11]. Besides that, stork and shorebirds were also found [12]. However, at the sampling time of 25 October 2020, there was no large flock of migratory birds due to it was not the bird's arrival season, namely November and March. This region and its surroundings have a mud substrate, is commonly covered by mangrove *Avicennia marina* species [13-15], and is directly affected by the freshwater masses from the Barong and Banyuasin rivers [16, 17]. Map of sampling location is presented on (Fig. 1).

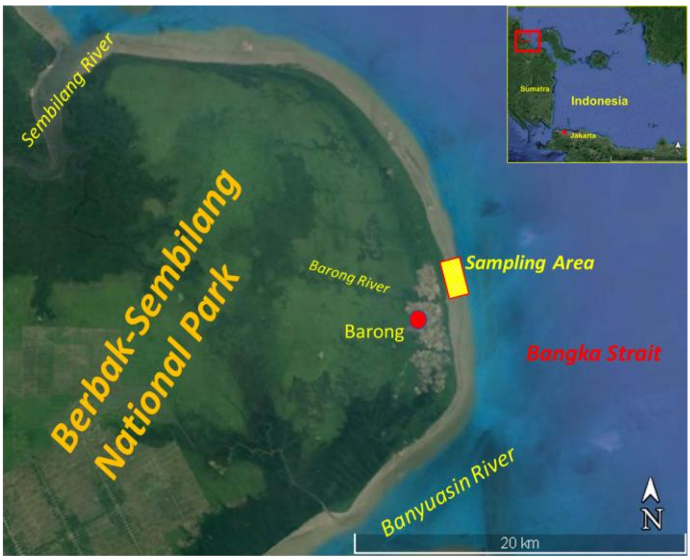


Fig. 1. Sampling site

Methods

This research was conducted using a survey method, with the location of the coordinate points 2.1638972 S and 104.9075056 ˚E. Crabs were randomly sampled by being captured in mud, washed with clean water in the plastic sample, and added with 10% formalin solution.

Environmental parameters such as salinity, temperature, pH, current, dissolved oxygen, nitrate, and phosphate are measured as supporting data.

In the laboratory, the samples were rinsed with clean water. The carapace, abdomen, legs, joints and claws were measured and weighed. Morphological identification was carried out by refer to [18-23].

Results and discussion

There were three species of crab found in the sampling location which were identified as *Uca dussumieri* (Edwards, 1852) (C1), *Metaplax longipes* (Stimpson, 1858) (C2), and *Metaplax distinct* (Edwards, 1852) (C3). The mass supply of freshwater from the Barong and Banyuasin Rivers causes the color of the water to become cloudy because it is influenced by high suspended materials (Fig. 2).

On the substrate, fine black mud was found with a depth of 60 to 100 cm. The results of the environmental parameter measured salinity was 27 to 29 psu, temperature was 29 to 30°C, pH was 6.08 to 6.2, nitrate and phosphate were 6.69 and 0.197 mg L^{-1}.

Fig. 2. Crabs habitat of migratory birds ground at Berbak-Sembilang National Park

Species of Uca dussumieri (Edwards, 1852) (C1)

There were 14 individuals coded C1-14 of the station observation. Morphologically, it looked unique in the size of the claws, which was bigger in one (Fig. 3).

Fig. 3. Details of the morphological characters *Uca dussumieri* (Edwards, 1852) species (C1) that are considered for morphometric analysis: (a) carapace, (b) cheliped, (c) leg, (d) abdomen

When the big claw is damaged or broken, it will grow back or the other claws will enlarge. It is colored bright yellowish, and rash or serrated on the surface of the dactylus, propodus and carpus. The carapace resembles a trapezoid with a wider anterior side and a pointed tip, it is called the trapezoidal carapace. It colored brownish black, dark brown and blackish orange [24]. The eyeball is black and round with a long eye shaft approaching the anterior end of the carapace. This crab has five pairs of legs, one pair in the front of the claw, and four pairs of walking legs. The abdomen is bluish in the shape of an elongated triangle.

Based on the morphological characteristics, this species is classified as a fiddler crab, it has similarities with several other species such as *Uca demani* and *Uca urvillei* [25, 26]. It can be found in muddy areas of mangrove areas [27, 28]. The results of the morphometric measurements of this species are detailed in Table 1.

Table 1. Morphometric data of *Uca dussumieri* (Edwards, 1852) species (C1)

Data	Number Code (C1)	Sample Size (mm) Min - Max	Average
Carapace Data			
Anterior carapace width (ACW)	1	12.8 – 25	18.15
Posterior carapace width (PCW)	2	5.5 – 14.27	9.92
Internal carapace width (ICW)	3	9.85 – 25	13.86
Carapace length (CL)	4	6.66 – 11.83	9.08
Eye stalk length (ESL)	5	4.72 – 9.59	6.98
Cheliped Data			
Dactyl major length (DML)	6	20.38 – 54.82	34.71
Dactyl minor length (DmL)	6	11.25 – 21.11	16.71
Propodus major width (PMW)	7	6.01 – 12.1	8.9
Propodus minor width (PmW)	7	1.72 – 2.81	2.1
Walking Leg Data			
1^{st} Leg length (1LL)	8	14.13 – 28.23	20.98
2^{nd} Leg length (2LL)	8	12.69 – 31	22.3
3^{rd} Leg length (3LL)	8	12.72 – 28.08	21.05
4^{th} Leg length (4LL)	8	11.15 – 24.45	17.73
Abdomen Data			
Abdomen length (AL)	9	5.21 – 12.83	8.43
Abdomen width (AW)	10	5.6 – 11	8.29

Spesies Metaplax longipes (Stimpson, 1858) (C2)

Only one individual was obtained at the sampling site, it had a dark brown carapace, but lighter carapace color elsewhere was also found (Fig. 4). The carapace is a rounded square with a shorter underside or is called a squarish or subquadrate carapace. This species has a pair of claws that are the same size and longer than four pairs of walking legs. The claws are orange-brown, while other features are the very long propodus part, short dactyl, and the cheliped surface is quite smooth [26]. The eyeball is black with the length of the eye shaft extending to the anterior end of the carapace.This crab has five pairs of legs consisting of one pair of claws and four walking legs. The second and third walking feet are longer than the first and fourth legs. The abdomen is light brown, and has an elongated triangular shape. The genus of this species is Metaplax from the family Varunidae. Based on the morphology and phylogenetic tree, this species has similarities with *Metaplax takahashii*, *Cyclograpsus granulosus*, *Helice wuana*, and *Eriocheir japonica* [26, 29]. Almost all species of this genus are found in muddy habitats near mangrove ecosystems, they are also found in sandy substrate dominated by seawater [29-31]. The results of the morphometric measurements of this species are detailed in Table 2.

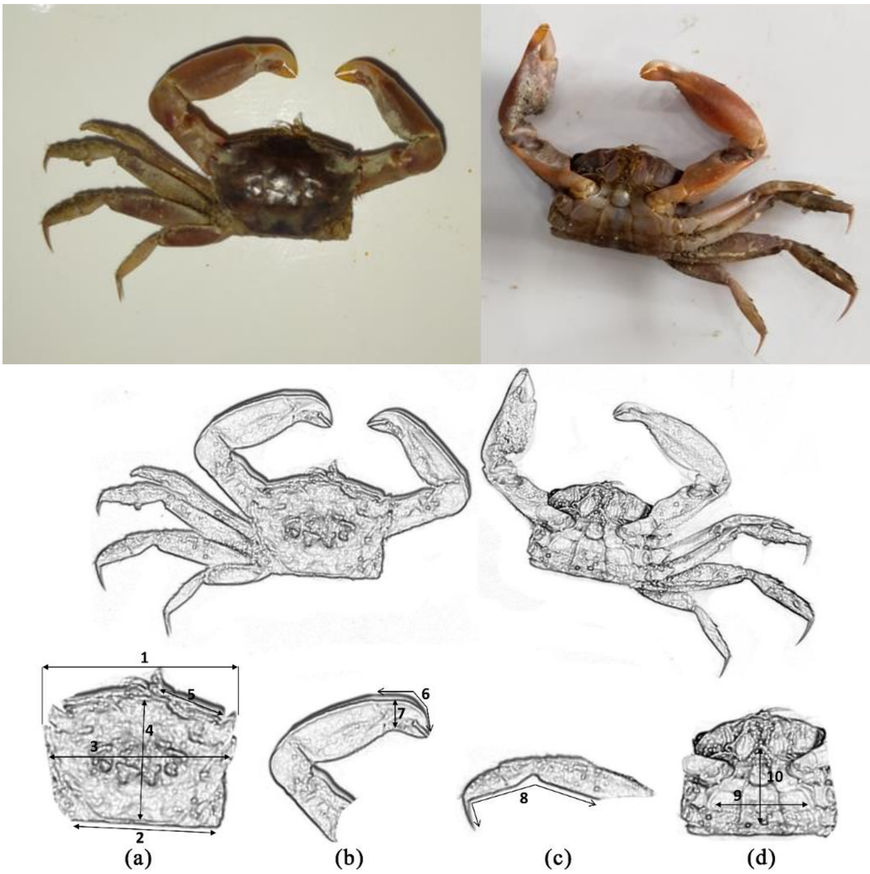


Fig. 4. Details of the morphological characters *Metaplax longipes* (Stimpson, 1858) (C2) species that considered for morphometric analysis:
(a) carapace, (b) cheliped, (c) leg, (d) abdomen

Table 2. Morphometric data of *Metaplax longipes* (Stimpson, 1858) (C2) species

Data	Number Code (C2)	Sample Size (mm)	Average
Carapace Data			
Anterior carapace width (ACW)	1	11	11
Posterior carapace width (PCW)	2	6	6
Internal carapace width (ICW)	3	8.92	8.92
Carapace length (CL)	4	6.16	6.16
Eye stalk length (ESL)	5	3.35	3.35
Cheliped Data			
Dactyl length (DL)	6	22.3	22.3
Propodus width (PW)	7	5.7	5.7
Leg Data			
1st Leg length (1LL)	8	15.2	15.2
2nd Leg length (2LL)	8	19.87	19.87
3rd Leg length (3LL)	8	19.99	19.99
4th Leg length (4LL)	8	12.76	12.76
Abdomen Data			
Abdomen length (AL)	9	7.22	7.22
Abdomen width (AW)	10	2.57	2.57

Species of Metaplax distinct (Edwards, 1852) (C3)

Two individuals were captured in the sampling location (Fig. 5). The carapace is rectangular with slightly rounded sides and a lower side that is shorter than the top which is called a subquadrate or squarish. The carapace is predominantly dark brown color, with both anterior sides tapering. The claws of this species are short and small compared to the walking legs, this indicates the sex of the female, because this female species has a pair of claws that are shorter and smaller than the male species [32, 33]. The claws are predominantly blackish red with orange dactyls. The two eyeballs are round black with a stem that extends almost to the outer side of the anterior. There are five pairs of legs, one pair of claws and four pairs of walking legs. The sizes of the second and third walking legs are longer than the first and fourth walking legs. This species is female, with a broad and rounded triangular abdomen [34]. This species has similarities with *Metaplax gocongensis* and *Metaplax indica* [7]. It is classified in the Varunidae family, also called crabs with muddy estuarine habitats, found mostly in mangrove areas and sandy beaches [31, 35]. The results of the morphometric measurements of this species are detailed in Table 3.

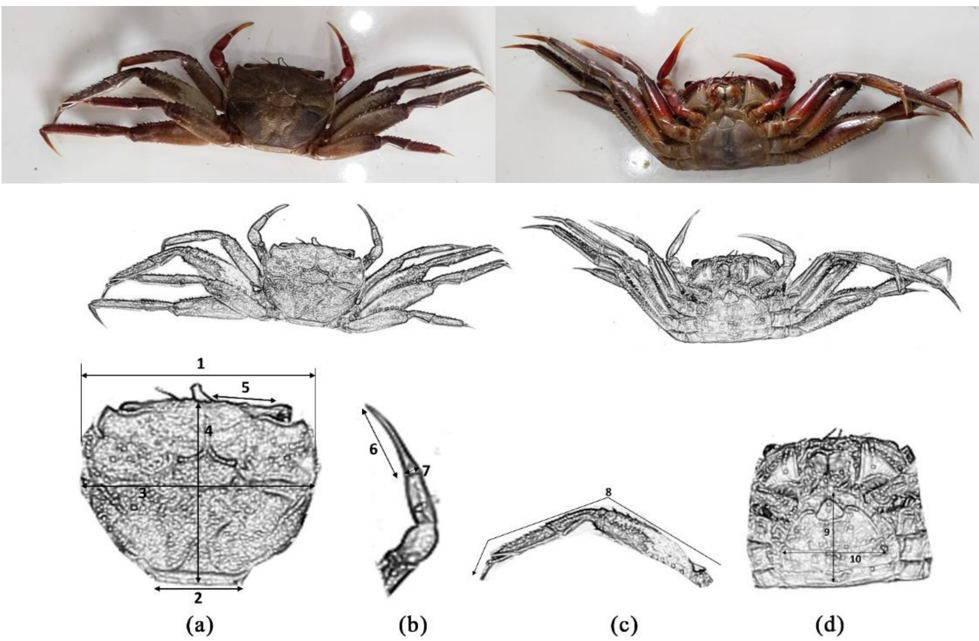


Fig. 5. Details of the morphological characters *Metaplax distinct* (Edwards, 1852) (C3) species that considered for morphometric analysis: (a) carapace, (b) cheliped, (c) leg, (d) abdomen

Table 3. Morphometric data of *Metaplax distincta* (Edwards, 1852) (C3) species

Data	Number Code (C3)	Sample Size (mm) Min-Max	Average
Carapace Data			
Anterior carapace width (ACW)	1	24.05 - 24.98	24.52
Posterior carapace width (PCW)	2	11.62 – 11.79	11.71
Internal carapace width (ICW)	3	22.41 – 22.42	22.42
Carapace length (CL)	4	11.04 – 12.29	11.67
Eye stalk length (ESL)	5	5.87 – 6.24	6.06
Cheliped Data			

Data	Number Code (C3)	Sample Size (mm) Min-Max	Average
Dactyl length (DL)	6	28.33 – 28.85	28.59
Propodus width (PW)	7	3.37 – 3.46	3.42
Leg Data			
1st Leg length (1LL)	8	37.76 - 38.85	38.31
2nd Leg length (2LL)	8	49.93 – 50.09	50.01
3rd Leg length (3LL)	8	54.96 – 55.18	55.07
4th Leg length (4LL)	8	41.59 - 45.55	43.57
Abdomen Data			
Abdomen length (AL)	9	17.29 – 17.41	17.35
Abdomen width (AW)	10	15.71 – 16.34	16.03

Discussion

The identification of crab species is determined based on its morphological shape. Several parts of the crab body are used as references in identification, such as the shape and pattern of the carapace, the shape and color of the claws, the shape of the eyes, the shape and number of legs, and the pattern of the abdomen [18, 36]. The carapaces of the three crab species found at the sampling location show the trapezoidal and squarish shapes, these correspond to the 14 carapace forms described by [23], the crab carapace shape is divided into 14 parts, namely longitudinally rectangular, transversely rectangular, squarish, trapezoidal, pentagonal, hexagonal, transversely hexagonal, transversely ovate, longitudinally ovate, transversely subovate, triangular, circular, subcircular, and pyriform.

Uca dussumieri (Edwards, 1852) (C1) species is unique in a pair of claws of different sizes, one larger than the other, but the shape and pattern of the claws are shown to be the same. Several studies have reported the uniqueness of the crab *Uca dussumieri* (Edwards, 1852) species. The uniqueness of the claws in this species, if there is damage or breakage, it will grow back to its original state. The process of growing a claw can be done in two ways, namely: first, it grows in the part where it is broken, and second, it grows on the part of the smallest claw that becomes enlarged [37-40]. *Uca dussumieri* (Edwards, 1852) is a fiddler crab from the Ocypodidae family [41, 42].

Uca dussumieri (Edwards, 1852) (C1) species is strongly suspected to be the *Uca dussumieri* (Edwards, 1852) species. Based on the shape and color of the carapace, this species is shown to be trapezoidal and blackish brown, while the claws are yellowish white [21]. The *Uca dussumieri* (Edwards, 1852) species is included in the crab that lives in the mud. This is also reported by [25]. Habitat of *Uca dussumieri* (Edwards, 1852) (C1) was collected around the muddy substrate mangrove area of Berbak-Sembilang National Park. This has a similarity to the *Uca dussumieri* (Edwards, 1852) habitat found by [43].

The *Metaplax longipes* (Stimpson, 1858) (C2) species have a squarish or subquadrate carapace form [26]. The carapace is dark brown with two sharp serrations on the anterior end. It has a pair of pincers the same size, cheliped this species is very long, especially the propodus, but the dactyl is relatively short and orange brown. Morphologically, this species is quite confusing to identify, but it is suspected as a species of *Metaplax longipes* (Stimpson, 1858). This species belongs to the family Varunidae is also known as the Thoracotrematan crabs family [44, 45]. The morphology of *Metaplax longipes* (Stimpson, 1858) is very similar to that of the Sesarmidae from the Grapsidae family, but the phylogenetic results are grouped into Varunidae [26, 29, 30], and it belongs to the deposit feeder crab class [46, 47].

Morphologically, *Metaplax distinct* (Edwards, 1852) (C3) has a subquadrate carapace shape, like a box and the posterior carapace tends to be rounded, is dark brown-black in color and the claws colori s reddish-black with an orange chela. This carapace is the same as the species of the Varunidae group, but differs in the shape of the smaller claws, this indicates that it is a female type, where the species of the Varunidae group have a very small pair of claws compared to the male species. In addition, the abdomen is triangular shape [37, 48]. This species can live in habitats on muddy to sandy beaches [35]. It is also found in mangrove or estuary areas [4, 49]. In some cases, this species is found with a lighter carapace color, this is due to the environment in which it lives [50, 51]. Darker carapaces are found in muddy areas, while lighter carapaces are found in substrate areas that tend to be sandy [52].

Overall, the crabs found in this study are thought to belong to the small crabs from the Ocypodidae and Varunidae families. The two families also have something in common, as reported [53], that some of the Metaplax in the Varunidae group have the same behavioral characteristics as the Ocypodidae. The morphology and way of life also have similarities with the Macrophtalmus genus of Ocypodidae. All species found have habitats in the muddy mangrove ecosystem. Crabs have a role as a food source for several predators such as shorebirds and fish [54, 55], while in the Berbak-Sembilang National Park area as feeding ground migratory birds.

The three types of crabs found sare an important analysis in the future. Furthermore, this crab data can be used to explore bioactive compounds and also to correlate the benefits and disadvantages of migratory birds as a typical organism that crosses the Berbak-Sembilang National Park area.

Conclusions

Three types of crabs caught around migratory bird habitats in Berbak-Sembilang National Park were identified as *Uca dussumieri* (Edwards, 1852), *Metaplax longipes* (Stimpson, 1858) and *Metaplax distinct* (Edwards, 1852). The environmental parameter conditions are very suitable for the growth of these crabs. In addition to the fine mud substrate habitat, this is the first reported in the region, and it is also found to be a major source of food by migratory birds. In the future, research should be carried out on ecological interactions and compound content in crabs and other biota.

Acknowledgments

The research of this article was funded by Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (Grant Number: 245/E5/PG.02.00.PT/2022). We thank you for surveying team to N.P Sari, A.W Walen, Novrialdi, Agung, K. Pangestu and all assistants of Marine Bioecology Laboratory for giving supports to accomplish this work.

References

[1] M.N. Janra, A. Mursyid, I.G. Aadrean, M. Ringga, M. Ikhsan, *Shorebird surveys at the Coast of West Sumatra Province, Indonesia: 2017-2018*, **Stilt**, **72**, 2018, pp. 27–32.

[2] A. Purwoko, W.J. Wolff, *Low biomass of macrobenthic fauna at a tropical mudflat: An effect of latitude?*, **Estuarine, Coastal and Shelf Science**, **76**(4), 2008, pp. 869–875.

[3] S. Almaniar, Rozirwan, Herpandi, *Abundance and diversity of macrobenthos at Tanjung Api-Api waters*, *South Sumatra*, *Indonesia*, **AACL Bioflux**, **14**, 2021, pp. 1486–1497.

[4] Rozirwan, Melki, R. Apri, Fauziyah, A. Agussalim, Hartoni, I. Iskandar, *Assessment the*

macrobenthic diversity and community structure in the Musi Estuary, South Sumatra, Indonesia, **Acta Ecologica Sinica**, **41**(4), 2021, pp. 346–350.

[5] Q. Li, L. Zu, Y. Cheng, N.M. Wade, J. Liu, X. Wu, *Carapace color affects carotenoid composition and nutritional quality of the Chinese mitten crab, Eriochier sinensis*, **LWT**, **126**, 2020, pp. 109286.

[6] L.L. Costa, A. Soares-Gomes, I.R. Zalmon, *Burrow occupation rates and spatial distribution within habitat of the ghost crab Ocypode quadrata (Fabricius, 1787): Implications for impact assessments*, **Regional Studies in Marine Science**,2021, pp. 101699.

[7] P. Davie, N. Xuan, *A new species of Metaplax (Crustacea: Brachyura: Varunidae: Cyclograpsinae) from Vietnam*, **Raffles Bulletin of Zoology**, **51**, 2003, pp. 379–386.

[8] H. Fazhan, K. Waiho, I. Al-Hafiz, N.A Kasan, S.D. Ishak, N. Afiqah-Aleng, S. Tola, M. Ikhwanuddin, *Composition, size distribution, length-weight relationship of sympatric mud crab species (Scylla) and the case of presumed hybrids*, **Estuarine, Coastal and Shelf Science**, **250**, 2021, pp. 107154.

[9] A. Leoville, R. Lagarde, H. Grondin, L. Faivre, E. Rasoanirina, N. Teichert, *Influence of environmental conditions on the distribution of burrows of the mud crab, Scylla serrata, in a fringing mangrove ecosystem*, **Regional Studies in Marine Science**, **43**, 2021, pp. 101684.

[10] S. Sharifian, E. Kamrani, H. Saeedi, *Global biodiversity and biogeography of mangrove crabs: Temperature, the key driver of latitudinal gradients of species richness*, **Journal of Thermal Biology**, **92**, 2020, pp. 102692.

[11] M. Iqbal, D. Mulyana, H. Martini, A. Setiawan, I. Yustian, H. Zulkifli, *Updating recent checklist of shorebirds in Banyuasin Delta (Sembilang), South Sumatra, Indonesia*, **Stilt The Journal for the East Asian-Australasian Flyway**, **73**, 2020, pp. 69–71.

[12] W.J.M. Verheugt, H. Skov, F. Danielsen, *Notes on the birds of the tidal lowlands and floodplains of South Sumatra province, Indonesia*, **Kukila**, **6**(2), 1992, pp. 53–84.

[13] Rozirwan, H.I. Muda, T.Z. Ulqodry, *Antibacterial potential of Actinomycetes isolated from mangrove sediment in Tanjung Api-Api, South Sumatra, Indonesia*, **Biodiversitas Journal of Biological Diversity**, **21**(12), 2020.

[14] Rozirwan, Melki, R. Apri, R.Y. Nugroho, Fauziyah, A. Agussalim, I. Iskandar, *Assessment of phytoplankton community structure in Musi Estuary, South Sumatra, Indonesia*, **AACL Bioflux**, **14**, 2021, pp. 1451–1463.

[15] Rozirwan, R.Y. Nugroho, M. Hendri, Fauziyah, W.A.E. Putri, A. Agussalim, *Phytochemical profile and toxicity of extracts from the leaf of Avicennia marina (Forssk.) Vierh. collected in mangrove areas affected by port activities*, **South African Journal of Botany**, **150**, 2022, pp. 903–919.

[16] Rozirwan, Fauziyah, P.I. Wulandari, R.Y. Nugroho, F. Agustriani, A. Agussalim, F. Supriyadi, I. Iskandar, *Assessment distribution of the phytoplankton community structure at the fishing ground, Banyuasin estuary, Indonesia*, **Acta Ecologica Sinica**, 2022.

[17] A. Saputra, R.Y. Nugroho, R. Isnaini, Rozirwan, *A review: The potential of microalgae as a marine food alternative in Banyuasin Estuary, South Sumatra, Indonesia*, **Egyptian Journal of Aquatic Biology and Fisheries**, **59**, 2021, pp. 1053–1065.

[18] A. Ungfors, *Sexual maturity of the edible crab (Cancer pagurus) in the Skagerrak and the Kattegat, based on reproductive and morphometric characters*, **ICES Journal of Marine Science**, **64**(2), 2007, pp. 318–327.

[19] C. Shelley, A. Lovatelli, **Mud crab aquaculture A practical manual**, FAO Fisheries and Aquaculture Technical Paper, Rome, 2011.

[20] Z. Zhang, W. Zhang, C. Mu, R. Li, W. Song, Y. Ye, C. Shi, L. Liu, H. Wang, C. Wang, *Identification and characterization of a novel galectin from the mud crab Scylla paramamosain*, **Fish & Shellfish Immunology**, **98**, 2020, pp. 699–709.

[21] J. Crane, **Fiddler crabs of the world: Ocypodidae: genus Uca**, Princeton University Press, New Jersey, 2015.
[22] J. Zeil, J.M. Hemmi, *The visual ecology of fiddler crabs*, **Journal of Comparative Physiology A**, **192**(1), 2006, pp. 1–25.
[23] R. Naderloo, **Atlas of crabs of the Persian Gulf**, Springer, Tehran, 2017.
[24] V.Y. Mangale, B.G. Kulkarni, *Morphological Study of Fiddler Crabs in Mumbai Region*, **Advances in Bioresearch**, **4**(3), 2013.
[25] H.-T. Shih, J.-H. Lee, P.-H. Ho, H.-C. Liu, C.-H. Wang, H. Suzuki, S.-J. Teng, *Species diversity of fiddler crabs, genus Uca Leach, 1814 (Crustacea: Ocypodidae), from Taiwan and adjacent islands, with notes on the Japanese species*, **Zootaxa**, **4083**(1), 2016, pp. 57–82.
[26] H.-T. Shih, J.-W. Hsu, K.J.H. Wong, N.K. Ng, *Review of the mudflat varunid crab genus Metaplax (Crustacea, Brachyura, Varunidae) from East Asia and northern Vietnam*, **ZooKeys**, **877**, 2019, pp. 1–29.
[27] M. Shukla, B. Patel, J. Trivedi, K. Vachhrajani, *Brachyuran crabs diversity of Mahi and Dhadhar estuaries, Gujarat, India*, **Research Journal of Marine Sciences**, **2321**, 2013, pp. 1296.
[28] P. Rianta, W. Ernawati, G. Chen, S. Chen, *Diversity and abundance of mangrove fiddle crabs, genus Uca (Decapoda, Ocypodidae) at a mangrove in Kema, North Sulawesi, Indonesia*, **Acta Oceanologica Sinica**, **37**(12), 2018, pp. 92–96.
[29] Y. Liu, T.-T. Yang, Z.-Z. Xin, Q.-N. Liu, D.-Z. Zhang, B.-P. Tang, *The complete mitochondrial genome sequence of Metaplax longipes (Grapsoidea: Varunidae)*, **Mitochondrial DNA Part B**, **4**(1), 2019, pp. 1280–1282.
[30] J. Chen, Y. Xing, W. Yao, X. Xu, C. Zhang, Z. Zhang, Q. Liu, *Phylomitogenomics reconfirm the phylogenetic position of the genus Metaplax inferred from the two grapsid crabs (Decapoda: Brachyura: Grapsoidea)*, **PLOS ONE**, **14**(1), 2019, pp. e0210763.
[31] P. Chen, Y. Zhang, X. Zhu, C. Lu, *Distribution of crabs along a habitat gradient on the Yellow Sea coast after Spartina alterniflora invasion*, **PeerJ**, **7**, 2019, pp. e6775.
[32] I.N. Marin, *New data on the distribution of hairy-clawed shore crabs of the genus Hemigrapsus (Decapoda: Varunidae) along the Russian mainland coast of the Sea of Japan*, **Russian Journal of Marine Biology**, **39**(4), 2013, pp. 301–305.
[33] D. Wójcik, M. Normant, B. Dmochowska, A. Fowler, *Impact of Chinese mitten crab Eriocheir sinensis on blue mussel Mytilus edulis trossulus–laboratory studies of claw strength, handling behavior, consumption rate, and size selective predation*, **Oceanologia**, **57**(3), 2015, pp. 263–270.
[34] J. Webster, P. Clark, D. Morritt, *Laboratory based feeding behaviour of the Chinese mitten crab, Eriocheir sinensis (Crustacea: Decapoda: Brachyura: Varunidae): fish egg consumption (De Haan, 1835)*, **Aquatic Invasions**, **10**(3), 2015, pp. 313-326.
[35] B. Mohanty, A. Nayak, B. Dash, S.S. Rout, B.C. Kumar, L. Patnaik, M.K.D. Roy, A. Raman, D. Raut, *Biodiversity and ecological considerations of brachyuran crabs (Crustacea: Decapoda) from Devi estuary–mangrove region on the east coast of India*, **Regional Studies in Marine Science**, **32**, 2019, pp. 100865.
[36] C. Keenan, P. Davie, D. Mann, *A revision of the genus Scylla De Haan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae)*, **The Raffles bulletin of zoology**, **46**, 1998, pp. 1–29.
[37] D.M. Perez, S.J. Heatwole, L.J. Morrell, P.R.Y. Backwell, *Handedness in fiddler crab fights*, **Animal Behaviour**, **110**, 2015, pp. 99–104.
[38] M.Z. Darnell, C.C. Rittschof, J. Rittschof, C. Beach, D. Rittschof, *Autotomy of the major claw stimulates molting and suppresses feeding in fiddler crabs*, **Journal of Experimental Marine Biology and Ecology**, **509**, 2018, pp. 66–70.
[39] J. Levinton, *Thermal stress: The role of body size and the giant major claw in survival and heat transfer of a fiddler crab (Leptuca pugilator)*, **Journal of Experimental Marine

Biology and Ecology, **530**–**531**, 2020, pp. 151428.
[40] F.W. Tina, M. Jaroensutasinee, K. Jaroensutasinee, *Effects of body size, resident status and handedness on fighting behaviour of the fiddler crab, Uca bengali Crane, 1975*, **Crustaceana**, **88**(7–8), 2015, pp. 775–789.
[41] M. Akash, G.W. Chowdhury, *First record of the Bengal fiddler crab Uca (Austruca) bengali Crane, 1975 (Braychura: Ocypodidae) from Kuakata National Park, Bangladesh*, **Dhaka University Journal of Biological Sciences**, **26**(2), 2017, pp. 199–203.
[42] H.-T. Shih, B.K.K. Chan, P.K.L. Ng, *Tubuca alcocki, a new pseudocryptic species of fiddler crab from the Indian Ocean, sister to the southeastern African T. urvillei (H. Milne Edwards, 1852)(Crustacea, Decapoda, Brachyura, Ocypodidae)*, **ZooKeys**,(747), 2018, pp. 41.
[43] K.P. Apreshgi, K. V Dhaneesh, T. Radhakrishnan, A. Kumar, *DNA barcoding of fiddler crabs Uca annulipes and U. perplexa (Arthropoda, Ocypodidae) from the southwest coast of India*, **Journal of the Marine Biological Association of India**, **58**(1), 2016, pp. 101–104.
[44] M.Z. Karagozlu, J.-I. Kim, T.-J. Choi, T. Do Dinh, C.-B. Kim, *The complete mitochondrial genome of Hemigrapsus penicillatus (De Haan, 1835) (Decapoda, Varunidae)*, **Mitochondrial DNA Part B**, **3**(1), 2018, pp. 261–262.
[45] B.-P. Tang, Y. Liu, Z.-Z. Xin, D.-Z. Zhang, Z.-F. Wang, X.-Y. Zhu, Y. Wang, H.-B. Zhang, C.-L. Zhou, X.-Y. Chai, Q.-N. Liu, *Characterisation of the complete mitochondrial genome of Helice wuana (Grapsoidea: Varunidae) and comparison with other Brachyuran crabs*, **Genomics**, **110**(4), 2018, pp. 221–230.
[46] J. Feng, Q. Huang, H. Chen, J. Guo, G. Lin, *Restoration of native mangrove wetlands can reverse diet shifts of benthic macrofauna caused by invasive cordgrass*, **Journal of Applied Ecology**, **55**(2), 2018, pp. 905–916.
[47] Y. Liao, L. Shou, Y. Tang, A. Gao, Q. Chen, X. Yan, J. Chen, *Influence of two non-indigenous plants on intertidal macrobenthic communities in Ximen Island Special Marine Protected Area, China*, **Ecological Engineering**, **112**, 2018, pp. 96–104.
[48] B. da Silva Vianna, C.A. Miyai, A. Augusto, T.M. Costa, *Effects of temperature increase on the physiology and behavior of fiddler crabs*, **Physiology & behavior**, **215**, 2020, pp. 112765.
[49] S. Begum, **Macrobenthic Assemblage in the Rupsha-Pasur River System of the Sundarbans Ecosystem (Bangladesh) for the Sustainable Management of Coastal Wetlands, In Coastal Wetlands: Alteration and Remediation**. Springer, Cham, 2017.
[50] T. Caro, *The functional significance of coloration in crabs*, **Biological Journal of the Linnean Society**, **124**(1), 2018, pp. 1–10.
[51] F. Takeshita, *Color changes of fiddler crab between seasons and under stressful conditions: patterns of changes in lightness differ between carapace and claw*, **Journal of Experimental Marine Biology and Ecology**, **511**, 2019, pp. 113–119.
[52] I. Zulfahmi, R. Marlinda, C. Nisa, E. Paujiah, I. Irfannur, R. Rinaldi, N.R. Purnama, M. Mandasari, *Size distribution, length-weight relationship and condition factor of three species male fiddler crab from jaboy mangrove wetland, Sabang, Indonesia*, **IOP Conference Series: Materials Science and Engineering - The 5th Annual Applied Science and Engineering Conference**, 20-21 April 2020, Bandung Barat, Indonesia, p. 42112.
[53] J. Kitaura, K. Wada, M. Nishida, *Molecular Phylogeny of Grapsoid and Ocypodoid Crabs with Special Reference to the Genera Metaplax and Macrophthalmus*, **Journal of Crustacean Biology**, **22**(3), 2002, pp. 682–693.
[54] S. Zengel, S.C. Pennings, B. Silliman, C. Montague, J. Weaver, D.R. Deis, M.O. Krasnec, N. Rutherford, Z. Nixon, *Deepwater Horizon Oil Spill Impacts on Salt Marsh Fiddler Crabs (Uca spp.)*, **Estuaries and Coasts**, **39**(4), 2016, pp. 1154–1163.

[55] G. Dumitru, E. Todirascu-Ciornea, L. Hritcu, I.G. Sandu, *Studies of some morphological and biochemical parameters concerning the health condition of some fish species from Prut River, Romania*, **Revista de Chimie**, **69**(5), 2018.

Received: May 12, 2021
Accepted: August 2, 2022

Regional Studies in Marine Science

Mollusks diversity in the protected coastline of Berbak-Sembilang National Park Indonesia

--Manuscript Draft--

Manuscript Number:	
Article Type:	Research Paper
Keywords:	Bivalve, Gastropod, Macrobenthos, Mollusks diversity, Protected coastline
Corresponding Author:	Rozirwan Rozirwan, Ph.D Sriwijaya University Indralaya, South Sumatra INDONESIA
First Author:	Rozirwan Rozirwan, Ph.D
Order of Authors:	Rozirwan Rozirwan, Ph.D
	Fauziyah Fauziyah
	Redho Yoga Nugroho
	Tengku Zia Ulqodry
	Wike Ayu Eka Putri
	Afan Absori
	Iskhaq Iskandar
Abstract:	Mollusks are filter feeder biota that has a role as a food source in aquatic ecosystems. Presumably, there has been a decrease in its diversity on the protected coastline of Berbak-Sembilang National Park (BSNP), due to fluctuations of changes in water quality parameters that threaten the sustainability of another biota in the web food system. The purpose of this study was to describe the diversity of mollusks and their correlation with water quality parameters in the protected coastline area of BSNP. The research methodology was carried out, namely: water quality data collection (salinity, dissolved oxygen, pH, temperature, brightness, current, nitrate, and phosphate), mollusk sampling, diversity analysis was used by Shannon-Wiener and Simpson index, and correlation analysis was used by principal component analysis (PCA) and similarity analysis. The results showed that there were 28 species of mollusks which were classified into two classes: Bivalve 79% with 7 species, and Gastropod 49% with 21 species. Water quality parameters were found in normal conditions with a mean pH value of waters 7.29±0.59, salinity 30.38±1.30 ppt, DO 7.78±0.78 mg L-1, temperature 29.49±0.14 oC, brightness 15.45±6.18%, current velocity 0.18 ± 0.12 m s-1, nitrate 6.08±0.48 mg L-1, and phosphate 0.18±0.01 mg L-1. The mollusks abundance means 263.25 ind m-2, and the diversity is categorized as low H'<1 except stations 2 and 4, it is supported by the dominant species namely: Anadara granosa 37.61% and Nutricola sp 35.47%. Based on PCA correlation and similarity analysis is shown that two clusters of mollusks diversity distribution area are formed, namely; open coastal areas are characterized by higher temperature, nutrients, salinity, pH, currents, and brightness, and estuary clusters are characterized by higher dissolved oxygen and mollusk abundance.
Suggested Reviewers:	Reza Naderloo University of Tehran College of Science rnaderloo@ut.ac.ir
	M Belal Hossain Noakhali Science and Technology University Faculty of Fisheries and Marine Science mbhnstu@gmail.com
	Haitao Wu Northeast Institute of Geography and Agroecology Chinese Academy of Sciences wuhaitao@iga.ac.cn

Dr. Rozirwan, M.Sc
Department of Marine Science
Sriwijaya University
Indralaya, Indonesia 30862
+62 81371711885
rozirwan@unsri.ac.id

Prof. Jong Seong Khim
Editor-in-Chief
Regional Studies in Marine Science
August 29, 2022

Dear Prof. Jong Seong Khim
I am pleased to submit an original research article entitled “Mollusks diversity in the protected coastline of Berbak-Sembilang National Park Indonesia” by Rozirwan, Fauziyah, Redho Yoga Nugroho, Tengku Zia Ulqodry, Wike Ayu Eka Putri, Afan Absori, and Iskhaq Iskandar for publication in the Regional Studies in Marine Science. We previously explored the community structure of macrobenthos in Musi River and Api-api Cape, South Sumatra (Almaniar et al., 2021; Rozirwan et al., 2021). The two previous studies were near by to the location of this study that was in a protected area. This manuscript was constructed to explore the community stucture of mollusks in the mud flat that was protected area of Berbak Sembilang National Park, South Sumatra. The results of this study were important to be published as a reference for further research.

In this manuscript, bivalves and gastropods had dominant presence and abundance allowed for their role as a significant food source for migratory birds in the mangrove mud flat. This study implicitly revealed the existence of mollusks in influencing ecological processes in the mangrove mud flat of Berbak Sembilang National Park, South Sumatra.

We believe that this manuscript is appropriate for publication by the Regional Studies in Marine Science because it is appropriate with the journal’s aims and scope https://www.sciencedirect.com/journal/regional-studies-in-marine-science/about/aims-and-scope.

This manuscript has not been published and is not under consideration for publication elsewhere. We have no conflicts of interest to disclose, but we do respectfully request that Prof. Jong Seong Khim review our manuscript.

Thank you for your consideration

Sincerely

Dr. Rozirwan
Department of Marine Science
Sriwijaya University

Highlights

- We report two biggest classes of mollusks in the protected coastline of Berbak-Sembilang National Park.
- Bivalves are more diverse although two species are dominant in muddy intertidal areas.
- *Anadara granosa* dan *Nutricola* sp. were commonest species.
- Water quality parameters affect the biodiversity distribution of mollusks

Mollusks diversity in the protected coastline of Berbak-Sembilang National Park Indonesia

Rozirwan[a], Fauziyah[a], Redho Yoga Nugroho[b], Tengku Zia Ulqodry[a], Wike Ayu Eka Putri[a], Afan Absori[c], Iskhaq Iskandar[d]

[a] Department of Marine Science, Faculty of Math and Natural Science, Sriwijaya University, Jalan Palembang-Prabumulih KM 32, Indralaya, Ogan Ilir 30862, South Sumatra, Indonesia
[b] Environmental Management Study Program, Graduate Program, Sriwijaya University, Jalan Padang Selasa 524, Palembang, South Sumatra 30139, Indonesia
[c] Center of Berbak and Sembilang National Park, Komplek Istana Madinatuna 114, Talang Jambe, Palembang 30961, South Sumatra, Indonesia
[d] Department of Physics, Faculty of Math and Natural Science, Sriwijaya University, Jalan Palembang-Prabumulih KM 32, Indralaya, Ogan Ilir 30862, South Sumatra, Indonesia

[*] Corresponding author: rozirwan@unsri.ac.id
Phone: +62 81371711885

Abstract

Mollusks are filter feeder biota that has a role as a food source in aquatic ecosystems. Presumably, there has been a decrease in its diversity on the protected coastline of Berbak-Sembilang National Park (BSNP), due to fluctuations of changes in water quality parameters that threaten the sustainability of another biota in the web food system. The purpose of this study was to describe the diversity of mollusks and their correlation with water quality parameters in the protected coastline area of BSNP. The research methodology was carried out, namely: water quality data collection (salinity, dissolved oxygen, pH, temperature, brightness, current, nitrate, and phosphate), mollusk sampling, diversity analysis was used by Shannon-Wiener and Simpson index, and correlation analysis was used by principal component analysis (PCA) and similarity analysis. The results showed that there were 28 species of mollusks which were classified into two classes: Bivalve 79% with 7 species, and Gastropod 49% with 21 species. Water quality parameters were found in normal conditions with a mean pH value of waters 7.29±0.59, salinity 30.38±1.30 ppt, DO 7.78±0.78 mg L^{-1}, temperature 29.49±0.14 ^{o}C, brightness 15.45±6.18%, current velocity 0.18 ± 0.12 m s^{-1}, nitrate 6.08±0.48 mg L^{-1}, and phosphate 0.18±0.01 mg L^{-1}. The mollusks abundance means 263.25 ind m^{-2}, and the diversity is categorized as low H'<1 except stations 2 and 4, it is supported by the dominant species namely: *Anadara granosa* 37.61% and *Nutricola* sp 35.47%. Based on PCA correlation and similarity analysis is shown that two clusters of mollusks diversity distribution area are formed, namely; open coastal areas are characterized by higher temperature, nutrients, salinity, pH, currents, and brightness, and estuary clusters are characterized by higher dissolved oxygen and mollusk abundance.

Keywords*:* Bivalve, Gastropod, Macrobenthos, Mollusks diversity, Protected coasline

1. Introduction

Mollusks are a group of aquatic benthic, which are infauna and epifauna with limited movement. Its existence is very vulnerable to be influenced by various changes in environmental quality. Aquatic subtracts such as mud, sand, and rocks are reported to have many differences in the diversity of these biotas. Diversity mollusks are very easy to find at the bottom of the water with a substrate of mud and sand (Abdelhady et al., 2019; Kabir et al., 2014; Rozirwan et al., 2021a). Although also found in rock substrates (Joesidawati, 2018; Sahidin et al., 2018), mollusks on mud substrates were found to be more diverse due to the nature of their filter feeders, especially in mangrove ecosystems (Ariyanto, 2019; Islamy and Hasan, 2020; Rozirwan et al., 2021a). On the other hand, the mollusks were a major food source for demersal fish and seabirds (Crooks, 2002). Several species of shorebirds, storks, and seabirds were found to prey on mollusks (Iqbal et al., 2020; Janra et al., 2018). Various threats will reduce the diversity of mollusks in various habitats. Most of the larval stages of macrofauna were planktonophagous, as food for large zooplankton and fish, which significantly affected the number and species composition of macrofauna (Liu et al., 2019; Rozirwan et al., 2021b).

Berbak-Sembilang National Park (BSNP) is an estuary area located on the coast of Sumatra Island with a long coastline covered by a wide mangrove forest. they are supported by a thick and nutrient-rich mud substrate which has an impact on increasing the abundance and diversity of biota, especially benthic organisms. There are 32 mangrove species in BSNP with an area of 70,263 hectares (Ratmoko et al., 2021). Nevertheless, this area has decreased from year to year due to many factors such as forest fires, coastal abrasion, forest encroachment by residents, and the creation of pond shrimp farming (Sarno et al., 2018). The destruction of mangrove forests has a very significant impact on decreasing the abundance and diversity of benthic organisms, especially the mollusk phylum, where their limited movement causes them to adapt to the fluctuation's environmental changes (Wu et al., 2018). Furthermore, the linkage of mollusks with mangrove ecosystems is very high, because mangroves are the main food source, and thick silt is a very suitable habitat for their growth (Feng et al., 2018).

The dynamics of changing water quality have an impact on decreasing the mollusks community structure in an area, it will be exacerbated by an increase of the anthropogenic waste (Calle et al., 2018; Suratissa and Rathnayake, 2017; Zaki et al., 2021). However, a decrease in mollusks diversity can also occur in protected areas such as the BSNP, especially in the coastal areas, which are vulnerable to environmental changes. This has a significant impact on the diversity of mollusks as a sessile biota with very limited movement (Almaniar et al., 2021; Reis et al., 2021). In addition, the discharge of water masses from land carrying suspended substances and organic matter has an impact on increasing the distribution of abundance and diversity of mollusks (Fonseca et al., 2020; Rehitha et al., 2017), this occurs naturally and continuously over time (Marsden and Baharuddin, 2015; Yan et al., 2017).

This study aims to examine the diversity of mollusks in the protected coastline of BSNP. In addition, it is also to update data on mollusks as the largest group of benthic organisms reported in the tropical coastal area of the eastern part of Sumatra Island.

2. Materials and Methods

2.1 Study area

The Berbak-Sembilang National Park (BSNP) is a mangrove forest conservation area of about 2,051 km² (Sarno et al., 2018; Sarno et al., 2017). This area has a thick mud subtract, sourced from some rivers around it such as the Sembilang river, Barong river, and Banyuasin river. In addition, this coastal area has endemic biota such as the Sembilang fish (*Plotusus canius*), the giant freshwater turtle (*Chitra indica*), the saltwater crocodile (*Crocodylus porosus*), and a habitat for several types of shorebirds, storks, and migratory birds (Iqbal et al., 2020). Macrobenthos in this area is the main food of these birds.

The protected coastline of the BSNP was specifically targeted for this study (**Fig. 1**). BSNP is located on the western coast of the Bangka Strait, South Sumatra, which is an estuary area formed from a mixture of freshwater masses from the mainland of Sumatra with seawater masses from the Melaka Strait and the South China Sea (Rozirwan et al., 2019). The BSNP coastline has dynamic water quality parameters, which are during the rainy season and the dry season. In the rainy season, freshwater discharge from the mainland will increase which results in a decrease in salinity, brightness, and an increase in nutrients. In addition, high mangrove waste will increase water fertility. In contrast, in the dry season, there are clearer waters, and an increase in salinity, due to the dominant influence of seawater masses. Overall, the BSNP estuary shows a dynamic environment, where water quality parameters are directly/indirectly influenced by different seasons and/or episodic events of freshwater input to the offshore (Ratmoko et al., 2021).

This research was conducted at eight observation stations in the protected coastline of BSNP waters with a length of about 60 km. Stations 1 and 2 represent the bay area and the open coast. Stations 3, 4, and 5 represent river estuary areas, while Stations 6, 7, and 8 represent open shore areas and migratory bird habitats.

Fig. 1. Map of sampling stations in Berbak-Sembilang National Park

2.2 Data collection and sampling processing

Data on the water physical parameters (i.e. pH, salinity, dissolved oxygen, temperature, brightness, and current speed) are carried out *in*-situ with three repetitions at the observation station, respectively. Measurements used for the water pH with a pH meter, salinity with a hand refractometer, dissolved oxygen (DO) with a DO meter, temperature with a digital thermometer, brightness with Secchi disk, and current speed with a current meter. Nitrate and phosphate measurements used a spectrophotometer.

Mollusks samples were collected on sediments with a depth of 20 cm and a transect area of 1 x 1 m. A sampling at the station was carried out three times, respectively. Then the samples were put into plastic samples and labeled by each station for further analysis. The mollusks sample obtained was separated from sediment, washed with clean water, and preserved with 8% formalin

(Weerman et al., 2011), and samples identified by refer to (Hibberd, 2009; Purchon, 2013; Sturm et al., 2006).

2.3 Statistical analysis

Data analysis on water quality parameters was described using MS Excel software. The mollusks abundance data were analyzed of total percentage and total individual per species. The species diversity data were analyzed by the Shannon-Winner index (H ') and the Dominance Index by Simpson (C). Principle component analysis (PCA) was used to analyze the correlation between water quality parameters and the abundance and diversity of mollusks and the similarity of stations were analyzed by Bray-Curtis dissimilarity analysis using XLSTAT 2021.

3. Results

3.1 Water quality parameters of Berbak-Sembilang National Park

The results of the measurement of the quality of waters in the coastal area of BSNP show that the conditions are relatively stable or normal for the growth of mollusks. The average pH value of the waters was obtained under normal conditions of 7.29 ± 0.59, as well as salinity of 30.38 ± 1.30 ppt, although there was a slight decrease at station 8 (28 ppt), this is normal in the estuary area.

Dissolved oxygen (DO) and temperature in all observation stations were categorized in good condition with mean values were 7.78 ± 0.78 mg L^{-1} and 29.49 ± 0.14 ºC, but brightness showed a low mean value of 15.45 ±6.18%, especially in the estuary area. rivers, namely: stations 3, 4, and 5. The flow velocity was found to be decreasing in the bay or estuary area with an average value of 0.18 ± 0.12 m s^{-1}, while the distribution of nitrate and phosphate concentrations was shown to be relatively even with a mean of 6.08 ± 0.48 mg L^{-1}, and 0.18 ± 0.01 mg L^{-1} (**Table 1**).

Table 1

Water quality parameters of Berbak-Sembilang National Park

3.2 Mollusks species of community structure

The composition of mollusks in all observation stations was found to be only two classes which were dominated by Bivalve 79% and Gastropod 21%. The distribution of these two classes is uneven, where they are only found at certain stations.

Fig. 2. Mollusks community structure in Berbak-Sembilang National Park

A total of 28 species of mollusks were identified in BSNP, nominated by the Gastropod class with 21 species, while the Bivalve class with 7 species. However, the abundance of Bivalves was found more than Gastropod. The distribution of the abundance and diversity of species was found to be uneven, such as *Anadara granosa*, which was found in almost all observation stations, but more species were found in only one or two at the station.

Table 2
Mollusks species of Berbak-Sembilang National Park

3.3 Mollusks abundance and diversity

The overall mean value of individuals mollusks at the study sites was 263.25 ind m^{-2}. The highest abundance found at station 4 is 531 ind m^{-2}, station 3 is 495 ind m^{-2}, station 6 is 333 ind m^{-2}, and station 5 is 297 ind m^{-2}, while others are taken as the average found. Two species of mollusks were found to dominate, namely: *Anadara granosa* 37.61% and *Nutricola* sp. 35.47%, both of which are from the Bivalve class, in contrast to the abundance of the Gastropod class which was dominated by *Pterygia dactylus* 5.56% and *Volema pyrum* 2.14%. In addition, the distribution of the Bivalve class was found to be more even than that of Gastropod.

Fig. 3. Percentage of mollusks species of Berbak-Sembilang National Park

Given the diversity of species, the Shannon-Wiener index (H ') all decreased significantly at almost all low-category observation stations (Station 1, 3, 5, 6, 7, and 8), unless there were two stations in the moderate category (Station 2 and 4). This is also supported by the Simpson index value (C), where species dominance occurs in almost all locations (**Fig. 4**).

Fig. 4. Diversity index of mollusks of Berbak-Sembilang National Park

3.4 Correlation between water quality parameters with mollusks abundance and diversity of Berbak-Sembilang National Park

The results of the relationship between water quality parameters and mollusks abundance and diversity at the study location obtained Eigenvalues Cumulative 82.61%, five groups were formed, namely: four groups formed on the F1 and F2 axes, while the others were formed on the F3 axis. Besides that, the similarity between the observation stations was formed by two clusters coded MB1 and MB2 (**Fig. 5**).

Based on **Fig. 5a-5b**, *the first group* contributing from the positive F1 axis illustrated that stations 1 and 8 are characterized by higher temperatures, concentrations of nitrate and phosphate, which is thought to be influenced by a larger supply of land. *The second group* is formed on the negative F1 axis by showing that stations 3 and 5 are characterized by a higher abundance of mollusks, where they are located just around the mouth of the Sembilang river. *The three group*s are formed on the positive F2 axis which is illustrated that Station 6 with a stronger characteristic of current velocity and water brightness, is assumed that the location is directly facing the open sea. *The fourth group* is formed on the negative F2 axis where station 4 is characterized by higher oxygen, presumably, there is an influence of the mixing area between the water mass of the river and the sea. *The fifth group* is formed on the positive F3 axis, it is found that stations 2 and 7 are characterized by more stable salinity and pH, this is thought to reduce the influence of the freshwater mass from the river.

Fig. 5. Correlation between water quality parameters with mollusks abundance and diversity, (a) F1 and F2 axes; (b) F3 axes; (c) Dendrogram dissimilarity

The results of the similarity analysis calculated by the Bray-Curtis dissimilarity index (**Fig. 5c)** showed that the distribution of mollusks abundance and diversity was significantly similar, formed two clusters (MB1 and MB2). An average similarity value of 83.74%. MB1 clusters are formed at stations 1, 2, 6, 7, and 8 which are on the open coast. These clusters are characterized by higher temperature, salinity, pH, nutrient brightness, and water currents. This is thought to be due to the strong influence of the seawater mass area of the Melaka Strait and the South China Sea.

The MB2 cluster is formed by stations 3, 4, and 5, located at the mouth of the river mouth, characterized by dissolved oxygen and a higher abundance of mollusks compared to other locations. Continuous fluctuation in water quality parameters is thought to have an impact on the dominance of several species at each station. The two clusters illustrated that the abundance and diversity of mollusks on the protected coastline of BSNP were significantly affected by changes in water quality parameters.

Discussion

The fluctuation of water quality parameters in all observation stations of the Berbak-Sembilang National Park (BSNP) was found to be slightly different, and this is a good condition for the growth of aquatic biota, especially mollusks. There are several parameters found to decrease in the estuary area, such as brightness and speed of currents, this is due to the impact of the stirring of the water mass from the land with the seawater mass formed in the mixing area. This was also reported by (Guerra-García et al., 2021; Lv et al., 2019; Pelletier et al., 2021; Rozirwan et al., 2022; Saputra et al., 2021).

There are 28 species of mollusks found on the protected coastline of the BSNP, grouped into two classes, namely Bivalve 79% with 7 species, and Gastropod 21% with 27 species. The individual composition of the Bivalve class is more dominant than that of Gastropod, although the number of species is lower. Bivalves have a high tolerance ability to changes in environmental parameters (Bramwell et al., 2021). This composition has also been reported on the west coast of India (Subramanian et al., 2021), in the estuary of the Gharehsou River (Jamani et al., 2021), in a mangrove plantation and two natural associations of Khanh Hoa, Vietnam (Zvonareva et al., 2020). In contrast to the reported that Polychaeta is more dominant in Yangtze River Estuary and the Batam Island, Indonesia (Ramses et al., 2020), Gastropod is found to be dominant in Estuary Musi (Rozirwan et al., 2021a), Gastropod is also dominant in grate lake district Pasuruan East Jawa (Susilo et al., 2021), Gastropods dominated of Mumbai, west coast of India (Kantharajan et al., 2017). This indicates that the individual distribution of the two classes of mollusks is highly dependent on their habitat.

The abundance of mollusks was found to be quite high, which increased significantly in the estuary area compared to the open coastal area. This is thought to be influenced by the discharge of water masses from the land carrying more suspended material and nutrients. Besides that, the meeting of water masses creates a mixing area which has an impact on increasing the fertility of the waters. This condition is very suitable for the growth and reproduction of the mollusk community as aquatic sessile biota. This total abundance was higher than that reported by (Abdollahi et al., 2020; Amorim et al., 2020; Guan et al., 2018; Hossain, 2019; Jayachandran et al., 2019; Joshua et al., 2018; Park and Huh, 2018; Rehitha et al., 2017; Suratissa and Rathnayake, 2017; Yan et al., 2017; Youssef et al., 2017).

There are two species found to dominate in BSNP, namely: *Anadara granosa* 37.61% and *Nutricola* sp. 35.47%, classified in the Bivalve class (Opa et al., 2021; Saffian et al., 2020; Wells et al., 2021). Gastropod class abundance was shown by *Pterygia dactylus* 5.56% and *Volema pyrum* 2.14% species (Amarasinghe et al., 2021; Rekha et al., 2021; Susilo et al., 2021). The distribution of *A. granosa* and *Nutricola* sp. species were found to be more even than other species. This species is reported to have a stronger survival ability (Bramwell et al., 2021; Li et al., 2020; Marsden and Baharuddin, 2015). In contrast to what was reported by (Noh et al., 2019), identified bivalves of *Mactra veneriformis* and *Cyclina sinensis* were more resistant to the organic matter in the Geum River estuary.

The relationship between water quality parameters on abundance and diversity of mollusks in the protected coastline in BSNP is characterized by higher temperature and nutrients in the river mouth area, while the brightness and flow velocity are lower. The discharge of inland water masses through rivers is affected, where it brings temperature, nutrients, and suspended materials to a higher level and there is a mixing of freshwater and seawater which makes the current slowdown. The number of individual mollusks in the estuary area is higher and more diverse than others. This was also reported by (Amorim et al., 2020), that the benthic community responded to oxygen concentrations, salinity, and particle size. The BSNP open coastal areas are characterized by higher temperature, nutrient, salinity, pH, current, and brightness parameters. It is assumed that the influence of seawater masses from the Malacca Strait and the South China Sea is more dominant, it has an impact on the decline in mollusks diversity. (Xingzhong et al., 2002) pointed out that macrofauna was sensitive to the changes in the pelagic environment. (Xingzhong et al., 2002) found that along the estuary gradient, benthic species number increased with the increase of salinity. The salinity gradient was the dominant factor determining the distribution pattern of mollusks in protecting the coastline of BSNP, and currents play a role in water mass distribution and diversity of mollusks with limited movement, especially on juvenile faces (Reis et al., 2021).

There are two clusters for mollusk habitat in BSNP, namely: the open coastal cluster and the estuary water cluster. The open coastal cluster found the diversity of mollusks slightly lower than the estuary cluster dominated by the Bivalve class. It is shown that the freshwater mass of the river is more suitable for the growth and reproduction of mollusks than the open coast. Variation in macrobenthic diversity may be primarily attributed to changes in stem density and salinity (Lv et al., 2019). As estuaries are complex diverse ecosystems, benthic communities are controlled by a combination of factors, such as salinity, pH, tidal fluctuation, dissolved oxygen, sediment composition, and organic matter, and no single factor could be considered as an ecological 'master' factor (Hossain and Hossain, 2021).

Conclusions

There are 28 species of mollusks found on the protected coastline of Berbak-Sembilang National Park, classified into two classes, bivalves 79% with 7 species, and gastropods 49% with 21 species. Water quality parameters were found under normal conditions and supported for mollusk growth. The abundance was found to be uneven, both in the estuary area and on the open sea coast. The diversity of species is categorized as low, this is supported by the species that dominate, namely; *Anadara granosa* 37.61% and *Nutricola* sp. 35.47%. Based on PCA, it shows that the observation stations in open coastal areas are characterized by higher nutrients, salinity, pH, currents, and temperatures, while the estuary areas are characterized by higher dissolved oxygen and mollusk abundance. Similarity analysis has formed that the two clusters of distribution of mollusk diversity in BSNP, namely open coastal areas and river estuaries, are both significantly different influenced by water quality fluctuations.

Credit authorship contribution statement

Rozirwan: Sampling, identification, Formal analysis, Writing – original draft. **Fauziyah**: sampling, identification, writing. **Redho Yoga Nugroho**: Sampling, identification, Formal analysis, Writing – original draft. **Tengku Zia Ulqodry**: Formal analysis, reviewing. **Wike Ayu Eka Putri**: Formal analysis, writing, reviewing, and editing. **Afan Absori**: formal analysis sediment fractions. **Iskhaq Iskandar**: reviewing, and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The research of this article was funded by Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (Grant Number: 245/E5/PG.02.00.PT/2022). The authors would like to thank the head of Berbak and Sembilang National Park Centre for the support of the sampling facility in the field and the permits to enter the BSNP protected area. We also to thank the head and all assistants of Marine Bioecology Laboratory for supporting the accomplishment of this work.

Reference

Abdelhady, A.A., Khalil, M.M., Ismail, E., Fan, J., Zhang, S., Xiao, J., 2019. Water chemistry and substrate type as major determinants of molluscan feeding habit and life–mode in lagoon sediments. Estuar. Coast. Shelf Sci. 220, 120–130.

Abdollahi, R., Darzi, S.E., Rahimian, H., Naderloo, R., 2020. Biodiversity of intertidal and shallow subtidal habitats in Abu Musa Island, Persian Gulf, Iran, with an updated species checklist. Reg. Stud. Mar. Sci. 33, 100975.

Almaniar, S., Rozirwan, Herpandi, 2021. Abundance and diversity of macrobenthos at Tanjung Api-Api waters, South Sumatra, Indonesia. AACL Bioflux 14, 1486–1497.

Amarasinghe, A.A.T.N., Eswaramohan, T., Gnaneswaran, R., 2021. Gastropods Diversity in Thondaimanaru Lagoon (Class: Gastropoda), Northern Province, Sri Lanka. J. Geosci. Environ. Prot. 9, 21–30.

Amorim, R.M., Delgado, J. de F., Neto, J.A.B., Crapez, M., Fernandez, C.S., e Negrello Filho, O.A., Fonseca, E.M., 2020. The benthic macrofauna along the estuarine gradient of the Paranaguá estuary. Reg. Stud. Mar. Sci. 39, 101459.

Ariyanto, D., 2019. Food preference on Telescopium telescopium (Mollusca: Gastropoda) based on food sources in mangrove ecosystem. Plant Arch. 19, 913–916.

Bramwell, G., Schultz, A.G., Sherman, C.D.H., Giraudeau, M., Thomas, F., Ujvari, B., Dujon, A.M., 2021. A review of the potential effects of climate change on disseminated neoplasia with an emphasis on efficient detection in marine bivalve populations. Sci. Total Environ. 775, 145134.

Calle, P., Monserrate, L., Medina, F., Delgado, M.C., Tirapé, A., Montiel, M., Barzola, O.R., Cadena, O.A., Dominguez, G.A., Alava, J.J., 2018. Mercury assessment, macrobenthos diversity and environmental quality conditions in the Salado Estuary (Gulf of Guayaquil, Ecuador) impacted by anthropogenic influences. Mar. Pollut. Bull. 136, 365–373.

Crooks, J.A., 2002. Predators of the invasive mussel Musculista senhousia (Mollusca: Mytilidae). Pacific Sci. 56, 49–56.

Feng, J., Huang, Q., Chen, H., Guo, J., Lin, G., 2018. Restoration of native mangrove wetlands can reverse diet shifts of benthic macrofauna caused by invasive cordgrass. J. Appl. Ecol. 55, 905–916. https://doi.org/https://doi.org/10.1111/1365-2664.12987

Fonseca, E.M., Fernandes, J.R., Lima, L.S., Delgado, J., Correa, T.R., Costa, P.M.S., Neto, J.A.B., Aguiar, V.M.C., 2020. Effects of dredged sediment dumping on trace metals concentrations and macro benthic assemblage at the continental shelf adjacent to a tropical urbanized estuary. Ocean Coast. Manag. 196, 105299.

Guan, Q., Liu, J., Batzer, D.P., Lu, X., Wu, H., 2018. Snails (Mollusca: Gastropoda) as potential surrogates of overall aquatic invertebrate assemblage in wetlands of Northeastern China. Ecol. Indic. 90, 193–200.

Guerra-García, J.M., Navarro-Barranco, C., Ros, M., Sedano, F., Espinar, R., Fernández-Romero, A., Martínez-Laiz, G., Cuesta, J.A., Giráldez, I., Morales, E., 2021. Ecological quality assessement of marinas: An integrative approach combining biological and environmental data. J. Environ. Manage. 286, 112237.

Hibberd, T., 2009. Field identification guide to Heard Island and McDonald Islands benthic

invertebrates. Deep. Res. Part Ii-Topical Stud. Oceanogr. 53, 985–1008.
Hossain, I., Hossain, M.B., 2021. Community structure of macrobenthos in homestead ponds of Noakhali coast, Bangladesh. Acta Ecol. Sin. 41, 611–619.
Hossain, M.B., 2019. Trophic functioning of macrobenthic fauna in a tropical acidified Bornean estuary (Southeast Asia). Int. J. Sediment Res. 34, 48–57.
Iqbal, M., Mulyana, D., Martini, H., Setiawan, A., Yustian, I., Zulkifli, H., 2020. Updating recent checklist of shorebirds in Banyuasin Delta (Sembilang), South Sumatra, Indonesia. Stilt J. East Asian-Australasian Flyw. 73, 69–71.
Islamy, R.A., Hasan, V., 2020. Checklist of mangrove snails (Mollusca: Gastropoda) in south coast of pamekasan, Madura Island, East Java, Indonesia. Biodiversitas J. Biol. Divers. 21, 3127–3134.
Jamani, S., Gholizadeh, M., Patimar, R., Fathabadi, A., 2021. Identification and Abundance of Macrobenthic in Estuary of the Gharehsou River. J. Fish. 74, 31–43.
Janra, M.N., Mursyid, A., Aadrean, I.G., Ringga, M., Ikhsan, M., 2018. Shorebird surveys at the Coast of West Sumatra Province, Indonesia: 2017-2018. Stilt 72, 27–32.
Jayachandran, P.R., Nandan, S.B., Jima, M., Joseph, P., Xavier, N.D.D., Sreedevi, O.K., Prabhakaran, M.P., Joseph, K.J., 2019. Macrobenthic functional feeding groups in a microtidal monsoonal estuary (Kodungallur–Azhikode estuary, India). Reg. Stud. Mar. Sci. 25, 100444.
Joesidawati, M.I., 2018. Mollusc Communitiess at Coastal Kemantren, Paciran, Lamongan. Oceanogr. Fish. Open Access J. 6, 57–65.
Joshua, T.J., Toefy, R., Sparks, C., Kirkman, S.P., Samaai, T., 2018. Macro-benthic invertebrate assemblages in the Betty’s Bay marine protected area (Kogelberg region South Africa). Reg. Stud. Mar. Sci. 22, 1–8.
Kabir, M., Abolfathi, M., Hajimoradloo, A., Zahedi, S., Kathiresan, K., Goli, S., 2014. Effect of mangroves on distribution, diversity and abundance of molluscs in mangrove ecosystem: a review. Aquac. Aquarium, Conserv. Legis. 7, 286–300.
Kantharajan, G., Pandey, P.K., Krishnan, P., Samuel, V.D., Bharti, V.S., Purvaja, R., 2017. Molluscan diversity in the mangrove ecosystem of Mumbai, west coast of India. Reg. Stud. Mar. Sci. 14, 102–111.
Li, Q., Wang, G., Wang, H., Shrestha, S., Xue, B., Sun, W., Yu, J., 2020. Macrozoobenthos variations in shallow connected lakes under the influence of intense hydrologic pulse changes. J. Hydrol. 584, 124755.
Liu, K., Lin, H., He, X., Huang, Y., Li, Z., Lin, J., Mou, J., Zhang, S., Lin, L., Wang, J., 2019. Functional trait composition and diversity patterns of marine macrobenthos across the Arctic Bering Sea. Ecol. Indic. 102, 673–685.
Lv, W., Zhou, W., Zhao, Y., 2019. Effect of freshwater inflow on self-restoration of macrobenthic diversity in seaward intertidal wetlands influenced by reclamation projects in the Yangtze estuary, China. Mar. Pollut. Bull. 138, 177–186.
Marsden, I.D., Baharuddin, N., 2015. Gastropod growth and survival as bioindicators of stress

associated with high nutrients in the intertidal of a shallow temperate estuary. Estuar. Coast. Shelf Sci. 156, 175–185.
Noh, J., Yoon, S.J., Kim, H., Lee, C., Kwon, B.-O., Lee, Y., Hong, S., Kim, J., Ryu, J., Khim, J.S., 2019. Anthropogenic influences on benthic food web dynamics by interrupted freshwater discharge in a closed Geum River estuary, Korea. Environ. Int. 131, 104981.
Opa, E.T., Kepel, R.C., Lasabuda, R., Kusen, J.D., Paruntu, C.P., Djamaluddin, R., Boneka, F.B., Mantiri, D.M.H., 2021. Ecological suitability of mangrove tourism in Mantehage Island as the outermost small island in North Sulawesi, Indonesia. Aquac. Aquarium, Conserv. Legis. 14, 120–129.
Park, J.M., Huh, S.-H., 2018. Epibenthic invertebrate fauna in the southern coast of the East Sea, Korea. J. Asia-Pacific Biodivers. 11, 217–222.
Pelletier, M., Cobb, D., Rocha, K., Ho, K.T., Cantwell, M.G., Perron, M., Charpentier, M.A., Buffum, H.W., Hale, S.S., Burgess, R.M., 2021. Benthic macroinvertebrate community response to environmental changes over seven decades in an urbanized estuary in the northeastern United States. Mar. Environ. Res. 169, 105323.
Purchon, R.D., 2013. The biology of the Mollusca. Elsevier.
Ramses, Ismarti, Amelia, F., Rozirwan, Suheryanto, 2020. Diversity and abundance of polychaetes in the west coast waters of Batam Island, Kepulauan Riau Province-Indonesia. AACL Bioflux 13, 381–391.
Ratmoko, I.A., Budianta, D., Ridho, R., Wildayana, E., Idrus, Z., Nuryamsasni, N., 2021. Analytic hierarchy process for zonation review of Sembilang National Park, Banyuasin Regency, South Sumatera Province, Indonesia, in: IOP Conference Series: Earth and Environmental Science. IOP Publishing, p. 12019.
Rehitha, T. V, Ullas, N., Vineetha, G., Benny, P.Y., Madhu, N. V, Revichandran, C., 2017. Impact of maintenance dredging on macrobenthic community structure of a tropical estuary. Ocean Coast. Manag. 144, 71–82.
Reis, A., Alves, A.T., Dórea, A., Beneli, T.M., Santos Freitas, T.S., Barros, F., 2021. Distribution and movement of the mangrove gastropod Littoraria angulifera. Estuar. Coast. Shelf Sci. 250, 107145. https://doi.org/https://doi.org/10.1016/j.ecss.2020.107145
Rekha, K., Anbalagan, S., Dinakaran, S., 2021. Distributional ecology of snails (Gastropoda: Mollusca) in seasonal ponds of Tamil Nadu, South India. Acta Ecol. Sin. 41, 410–415.
Rozirwan, Fauziyah, Wulandari, P.I., Nugroho, R.Y., Agutriani, F., Agussalim, A., Supriyadi, F., Iskandar, I., 2022. Assessment distribution of the phytoplankton community structure at the fishing ground, Banyuasin estuary, Indonesia. Acta Ecol. Sin. https://doi.org/https://doi.org/10.1016/j.chnaes.2022.02.006
Rozirwan, Iskandar, I., Hendri, M., Apri, R., Supardi, Azhar, N., Mardiansyah, W., 2019. Distribution of phytoplankton diversity and abundance in Maspari island waters, South Sumatera, Indonesia, in: IOP Conference Series: Journal of Physics. IOP Publishing, p. 012105. https://doi.org/10.1088/1742-6596/1282/1/012105
Rozirwan, Melki, Apri, R., Fauziyah, Agussalim, A., Hartoni, Iskandar, I., 2021a. Assessment the

macrobenthic diversity and community structure in the Musi Estuary, South Sumatra, Indonesia. Acta Ecol. Sin. 41, 346–350. https://doi.org/https://doi.org/10.1016/j.chnaes.2021.02.015

Rozirwan, Melki, Apri, R., Nugroho, R.Y., Fauziyah, Agussalim, A., Iskandar, I., 2021b. Assessment of phytoplankton community structure in Musi Estuary, South Sumatra, Indonesia. AACL Bioflux 14, 1451–1463.

Saffian, N.S., Peng, C.T.C., Ilias, N., Hwai, A.T.S., 2020. Overview and challenges of blood cockle culture in Malaysia, in: IOP Conference Series: Earth and Environmental Science. IOP Publishing, p. 12020.

Sahidin, A., Zahidah, Z., Hamdani, H., Riyantini, I., Sewiko, R., 2018. The Biodiversity of Gastropods in Karapyak Rocky Shores, Pangandaran Region, West Java Province, Indonesia. Omni-Akuatika 14, 79–85.

Saputra, A., Nugroho, R.Y., Isnaini, R., Rozirwan, 2021. A review: The potential of microalgae as a marine food alternative in Banyuasin Estuary, South Sumatra, Indonesia. Egypt. J. Aquat. Biol. Fish. 59, 1053–1065. https://doi.org/10.21608/EJABF.2021.170654

Sarno, S., Suwignyo, R.A., Dahlan, Z., Munandar, M., Ridho, M.R., 2018. Reproductive phenology of Bruguiera sexangula (Lour.) Poir. in Berbak and Sembilang National Park, South Sumatra. Berk. Penelit. Hayati J. Biol. Res. 23, 62–69.

Sarno, Suwigyo, R.A., Dahlan, Z., Munandar, Ridho, M.R., Aminasih, N., Harmida, Armanto, M.E., Wildayana, E., 2017. The phenology of Sonneratia alba J. Smith in Berbak and Sembilang National Park, South Sumatra, Indonesia. Biodiversitas J. Biol. Divers. 18, 909–915.

Sturm, C.F., Pearce, T.A., Valdés, Á., 2006. The mollusks: a guide to their study, collection, and preservation. Universal-Publishers.

Subramanian, R., Retnamma, J., Nagarathinam, A., Loganathan, J., Singaram, P., Chandrababu, V., 2021. Seasonality of macrobenthic assemblages and the biotic environmental quality of the largest monsoonal estuary along the west coast of India. Environ. Sci. Pollut. Res. 28, 37262–37278.

Suratissa, D.M., Rathnayake, U., 2017. Effect of pollution on diversity of marine gastropods and its role in trophic structure at Nasese Shore, Suva, Fiji Islands. J. Asia-Pacific Biodivers. 10, 192–198.

Susilo, V.E., Dewi, M.I.P., Mujiono, N., Subchan, W., Prihatin, J., 2021. The diversity of Gastropoda in grati lake district pasuruan east java, in: Journal of Physics: Conference Series. IOP Publishing, p. 12008.

Weerman, E.J., Herman, P.M.J., Van de Koppel, J., 2011. Macrobenthos abundance and distribution on a spatially patterned intertidal flat. Mar. Ecol. Prog. Ser. 440, 95–103.

Wells, F.E., Sanpanich, K., Tan, S.K., Duangdee, T., 2021. The Marine and Estuarine Molluscs of Thailand. Lee Kong Chian Nat. Hist. Museum, Natl. Univ. Singapore, Singapore 195.

Wu, N., Li, F., Rousseau, D.-D., 2018. Terrestrial mollusk records from Chinese loess sequences and changes in the East Asian monsoonal environment. J. Asian Earth Sci. 155, 35–48.

Xingzhong, Y., Jianjian, L., Hong, L., 2002. Distribution pattern and variation in the functional groups of zoobenthos in the Changjiang Estuary. Acta Ecol. Sin. 22, 2054–2062.

Yan, J., Xu, Y., Sui, J., Li, X., Wang, H., Zhang, B., 2017. Long-term variation of the macrobenthic community and its relationship with environmental factors in the Yangtze River estuary and its adjacent area. Mar. Pollut. Bull. 123, 339–348.

Youssef, M., Madkour, H., Mansour, A., Alharbi, W., El-Taher, A., 2017. Invertebrate shells (mollusca, foraminifera) as pollution indicators, Red Sea Coast, Egypt. J. African Earth Sci. 133, 74–85.

Zaki, M.R.M., Zaid, S.H.M., Zainuddin, A.H., Aris, A.Z., 2021. Microplastic pollution in tropical estuary gastropods: Abundance, distribution and potential sources of Klang River estuary, Malaysia. Mar. Pollut. Bull. 162, 111866.

Zvonareva, S.S., Kantor, Y.I., Nguyen, T.T.H., Britayev, T.A., 2020. Diversity and Long-Term Dynamics of the Macrobenthos in a Mangrove Plantation and Two Natural Associations of Khanh Hoa Province, Vietnam. Biol. Bull. 47, 1115–1125.

Fig. 1. Map of sampling stations in Berbak-Sembilang National Park

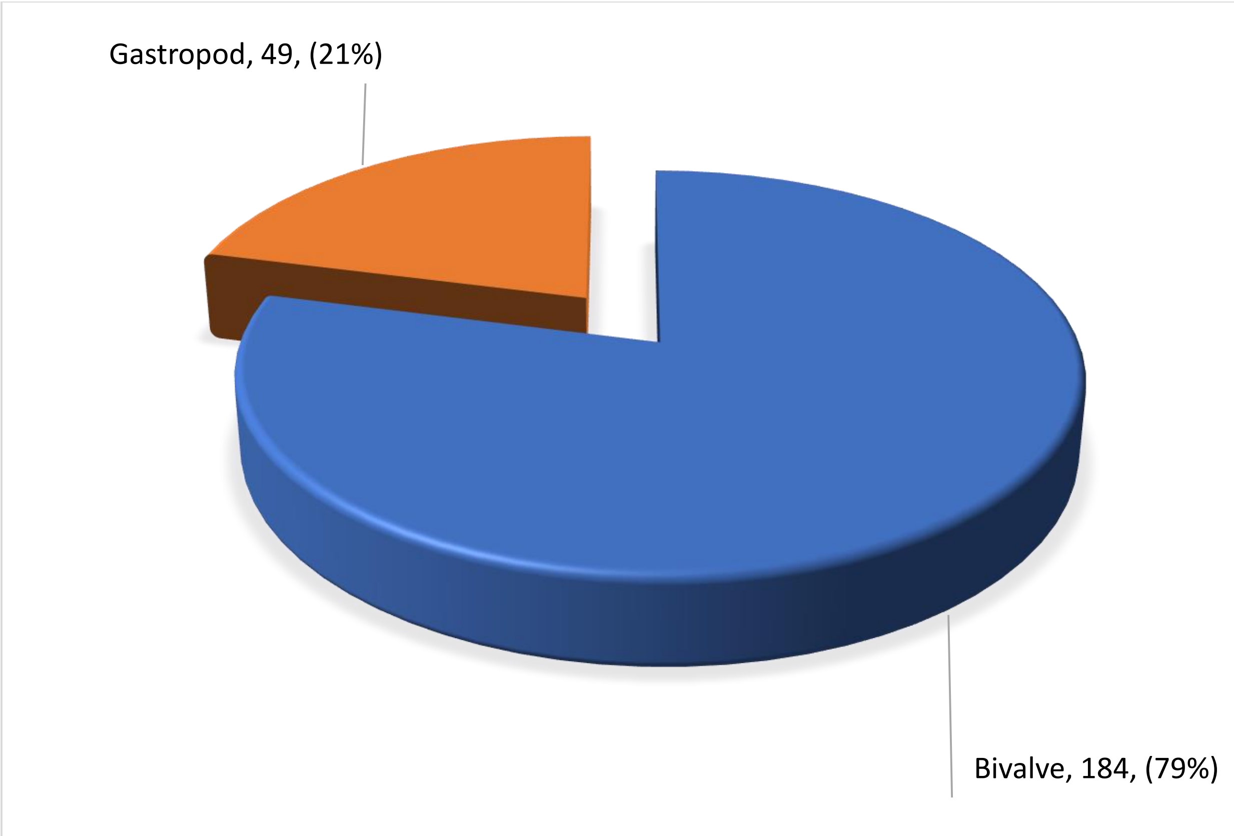


Fig. 2. Mollusks community structure in Berbak-Sembilang National Park

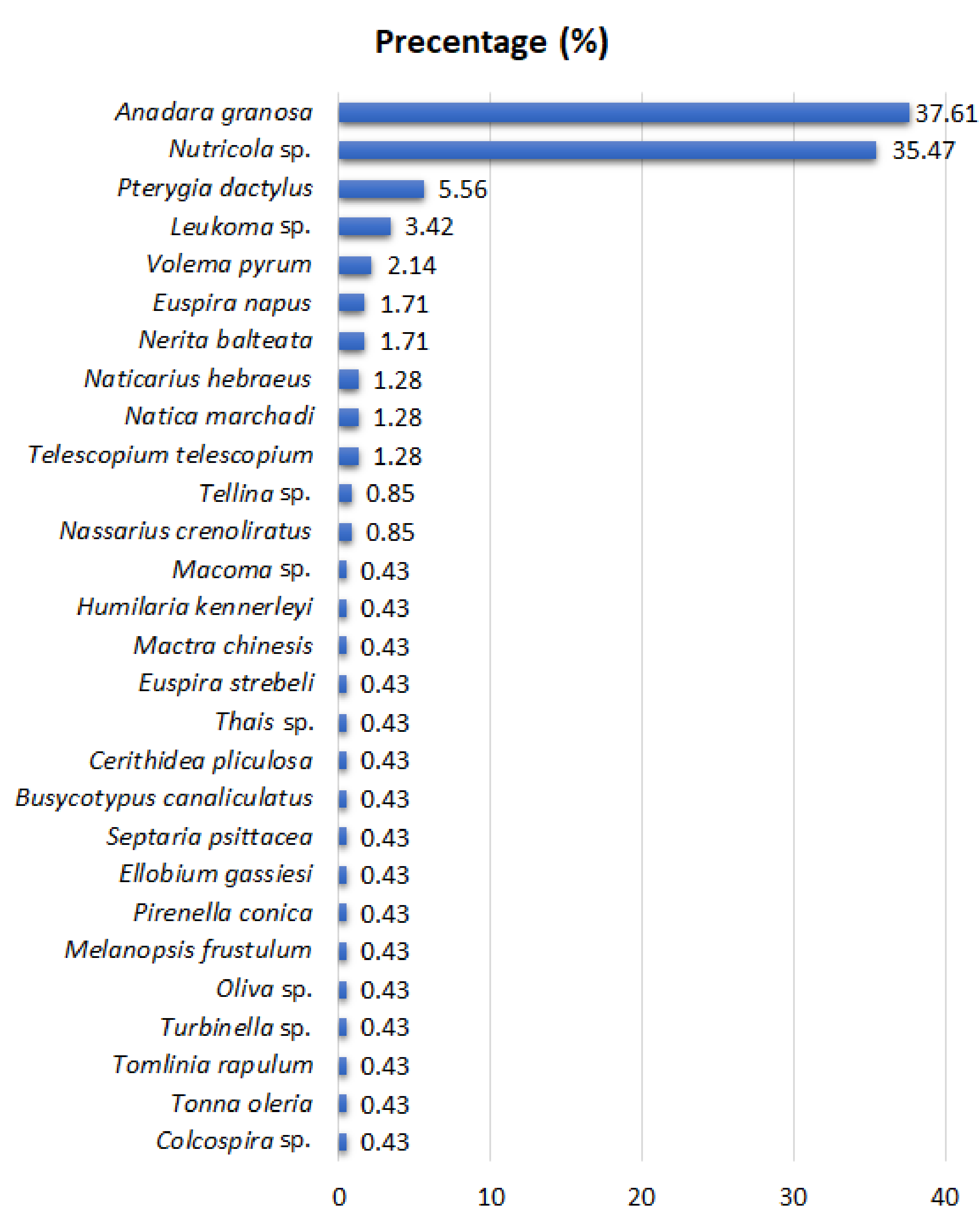


Fig. 3. Percentage of mollusks species of Berbak-Sembilang National Park

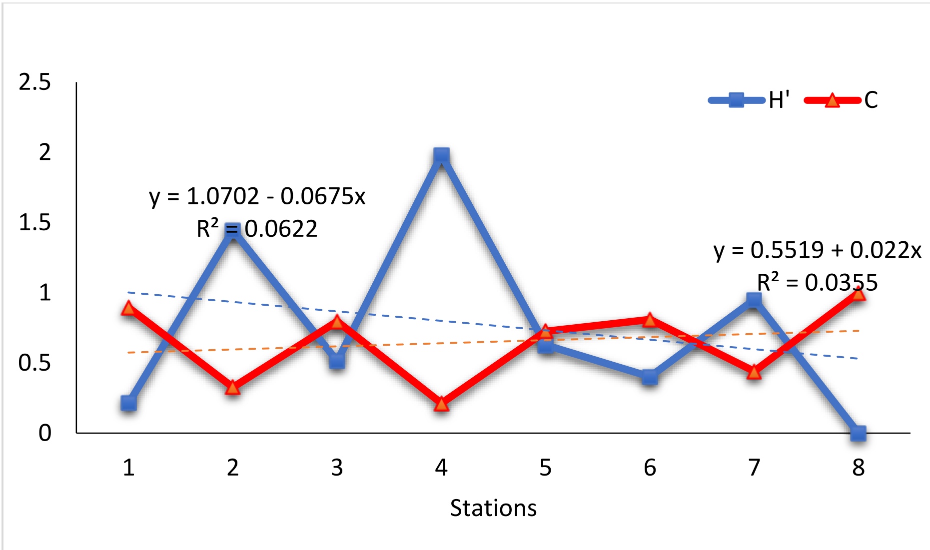


Fig. 4. Diversity index of mollusks of Berbak-Sembilang National Park

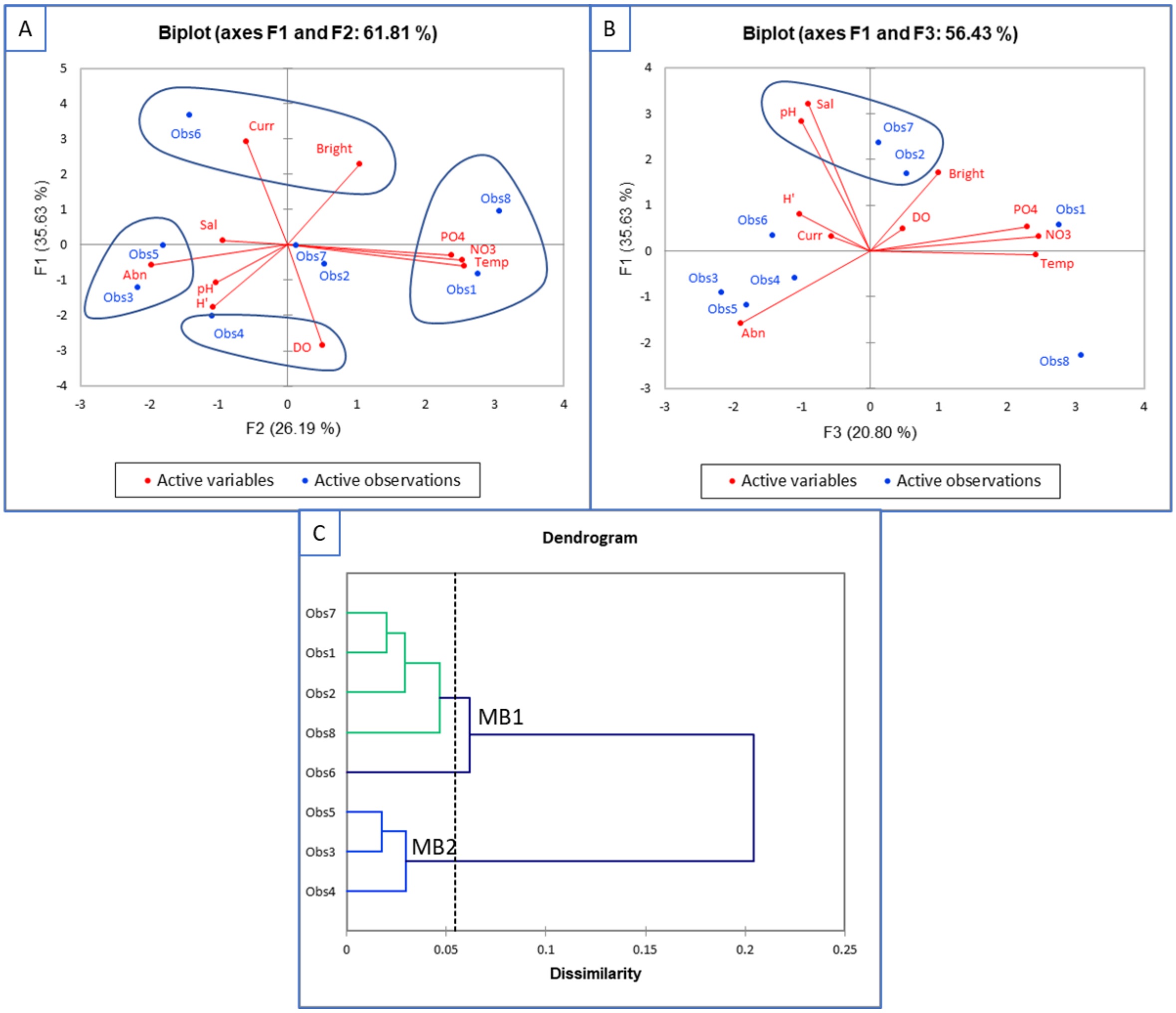


Fig. 5. Correlation between water quality parameters with mollusks abundance and diversity, (a) F1 and F2 axes; (b) F3 axes; (c) Dendrogram dissimilarity

Table 1
Water quality parameters of Berbak-Sembilang National Park

No	Water quality	Stations							
		1	2	3	4	5	6	7	8
1	pH	7.41	7.46	7.51	7.46	7.01	7.17	8.20	6.08
2	Salinity (ppt)	30.00	32.00	30.00	30.00	30.00	31.00	32.00	28.00
3	DO (mg L^{-1})	8.63	8.37	8.50	8.03	7.48	6.30	7.60	7.30
4	Temperature (^oC)	29.65	29.63	29.42	29.40	29.35	29.36	29.43	29.69
5	Brightness (%)	17.56	20.89	10.87	6.52	8.70	24.36	17.72	16.98
6	Current Speed (m s^{-1})	0.08	0.19	0.08	0.13	0.16	0.47	0.15	0.18
7	NO_3 (mg L^{-1})	6.67	6.20	5.45	6.24	5.53	5.66	6.23	6.69
8	PO_4 (mg L^{-1})	0.20	0.19	0.16	0.19	0.17	0.17	0.19	0.20

Table 2

Mollusks species of Berbak-Sembilang National Park

No	Class	Species	Stations							
			S1	S2	S3	S4	S5	S6	S7	S8
1	Gastropod	*Colcospira* sp.	-	+	-	-	-	-	-	-
2	Gastropod	*Nassarius crenoliratus*	-	+	-	-	+	-	-	-
3	Gastropod	*Tonna oleria*	-	+	-	-	-	-	-	-
4	Gastropod	*Tomlinia rapulum*	-	+	-	-	-	-	-	-
5	Gastropod	*Turbinella* sp.	-	+	-	-	-	-	-	-
6	Gastropod	*Oliva* sp.	-	+	-	-	-	-	-	-
7	Gastropod	*Melanopsis frustulum*	-	-	+	-	-	-	-	-
8	Gastropod	*Telescopium telescopium*	-	-	+	+	-	-	-	-
9	Gastropod	*Nerita balteata*	-	-	+	+	-	-	-	-
10	Gastropod	*Pirenella conica*	-	-	+	-	-	-	-	-
11	Gastropod	*Ellobium gassiesi*	-	-	-	+	-	-	-	-
12	Gastropod	*Euspira napus*	-	-	-	+	+	-	-	-
13	Gastropod	*Natica marchadi*	-	-	-	+	-	-	-	-
14	Gastropod	*Naticarius hebraeus*	-	-	-	+	-	-	-	-
15	Gastropod	*Septaria psittacea*	-	-	-	+	-	-	-	-
16	Gastropod	*Pterygia dactylus*	-	-	-	+++	-	-	-	-
17	Gastropod	*Busycotypus canaliculatus*	-	-	-	+	-	-	-	-
18	Gastropod	*Cerithidea pliculosa*	-	-	-	+	-	-	-	-
19	Gastropod	*Thais* sp.	-	-	-	+	-	-	-	-
20	Gastropod	*Volema pyrum*	-	-	-	+	-	-	-	-
21	Gastropod	*Euspira strebeli*	-	-	-	-	-	-	+	-
22	Bivalve	*Anadara granosa*	+	+++	+++	+++	+	+	-	-
23	Bivalve	*Leukoma* sp.	-	++	-	-	-	-	-	-
24	Bivalve	*Mactra chinesis*	-	-	+	-	-	-	-	-
25	Bivalve	*Humilaria kennerleyi*	-	-	-	+	-	-	-	-
26	Bivalve	*Tellina* sp.	-	-	-	-	+	-	-	-
27	Bivalve	*Nutricola* sp.	-	-	-	-	+++	+++	-	+++
28	Bivalve	*Macoma* sp.	-	-	-	-	-	-	+	-

Noted: - is not found, +: <50 ind m^{-2}, ++: 50-100 ind m^{-2}, and +++: >100 ind m^{-2}

Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: