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Mudskipper (Gobiidae: Oxudercinae) fauna of Northern Gulf of Khambhat with two new record of the species from Gujarat, India

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ABSTRACT

In the present study the mudskipper (Gobidae: oxudercinae) fauna of estuarine region of Northern Gulf of Kahmbhat, Gujarat, India is studied. The specimens were collected from three different sites viz Kamboi, Nada and Gandhar located on the northern part of Gulf of Khambhat during low tide using hand picking method. Total four different species of mudskippers were identified that includes Boleophthalmus dussumieri Valenciénnes, 1837, Periophthalmus waltoni Koumans, 1955, Apocryptes bato (Hamilton, 1822) and Scartelaos histophorus (Valenciennes, 1837). Amongst the four species reported B. dussumieri and P. waltoni are commonly observed in the estuarine and mangrove mudflats of Gujarat state while A. Bato and S. histophorus are reported first time from Gujarat state. The detailed description of all the species is given in the report.

Keywords: Mudskipper, Gujarat, Estuaries, Taxonomy, Mudflats

INTRODUCTION

Mudskippers belong to family Gobiidae, subfamily Oxudercinae, are restricted to the coastal and estuarine area, and are exclusively found in the tropical and subtropical regions, with the geographical distribution ranging from Indo-pacific region to the Atlantic coast of Africa [1-3]. Mudskippers have specific types of physiological and morphological adaptive characters which help them to live amphibious life [3-5]. The taxonomy of subfamily Oxudercinae was very confusing but has been revised by Murdy [1]. Currently, mudskippers make a group of 34 well established species belonging to 7 different genera [1, 6-11]. Out of 34 species of mudskippers reported worldwide, 9 different species of mudskippers like *Boleophthalmus boddarti* (Pallas, 1770), *Boleophthalmus dussumieri* Valenciénnes, 1837, *Periophthalmus barbarus* (Linnaeus, 1766) , *Periophthalmus waltoni* Koumans, 1955, *Periophthalmodon schlosseri* (Pallas, 1770), *Periophthalmodon septemradiatus* (Hamilton, 1822), *Apocryptes bato* (Hamilton, 1822), *Scartelaos histophorus* (Valenciennes, 1837) and *Scartelaos tenuis* (Day, 1876) were reported from different coastal areas of India [12,13]. Gujarat state has the longest coastline in the country and two gulfs; Gulf of Kachchh and Gulf of Khambhat. The ecosystem diversity is very rich in Gulf of Khambhat comprising of mangroves, estuaries, creeks and vast intertidal mud flats. The estuarine region of Mahi is covered by mudflats while the Dhadhar estuarine region is covered by mangrove forest [14, 15]. Out of 9 species of mudskippers reported from India, 5 species were reported from Gujarat which includes *B. dussumieri, P. barbarous, P. waltoni, P. septemradiatus* and *S. tenuis* [12,16,17]. The present study adds two more species like *A. bato* and *S. histophorus* to the mudskipper species list of Gujarat state.

MATERIALS AND METHODS

In the present study three different study sites were selected along the Mahi and Dhadhar estuarine region along northern Gulf of Khambhat. One study site named Kamboi (22°12'54.0" N and 72°36'36.9"E) is located at the mouth of Mahi estuary while other two study sites named Nada (21°54'38.60"N and 72°34'43.30"E) and Gandhar (21°54'02.9"N and 72°37'35.0") are located in Dhadhar estuarine region (Fig. 1). All the study sites represent different kinds of marine ecosystems like mudflats and mangroves. The Mahi estuarine region has open mudflat habitat without mangrove cover while, the Dhadhar estuarine region represents the mangrove mudflat habitat. Natural mangrove habitat is observed at Nada while the mangrove vegetation observed in Ghandhar was restored about 15 years back [13]. *Avicinia marina* is the dominant mangrove species observed in the Dhadhar estuarine region.

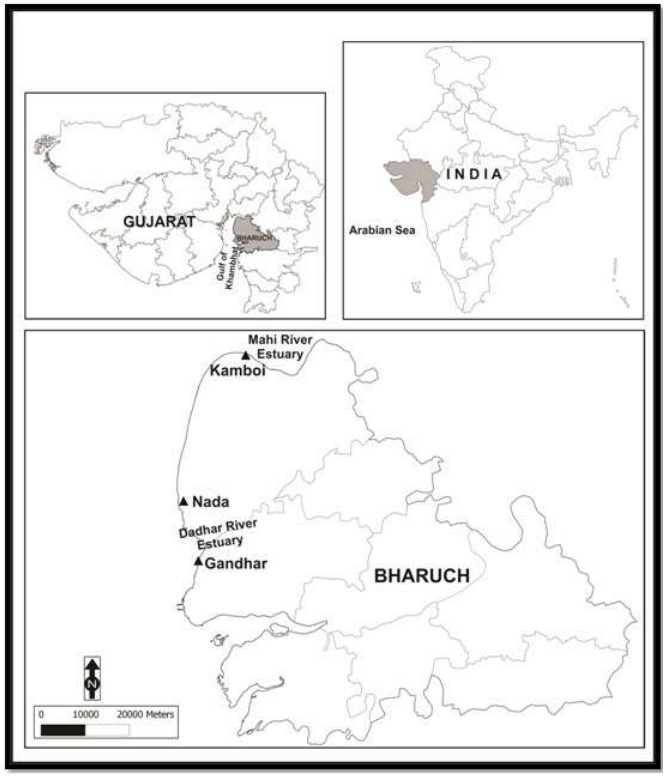

Fig. 1. Map of study area

All the sites were searched for the collection of mudskipper specimens during the low tide time. Handpicking method was adopted for the collection of the specimens. Sometimes diluted formalin (10%) was also poured into the burrow to catch the specimens. All the specimens were stored in ice box and brought to the lab. Detailed morphometry of the all the specimen was carried out using digital vernier calipers with nearest tenth of millimeter. Different measurements like total fish length (SL), head length (HL), head depth (HD), caudal fin length (CL), anal fin length (AL), pelvic fin length (PL), first dorsal fin base length (D1L), second dorsal fin base length (D2L) were recorded. The species were identified using different identification keys [1]. The latest scientific name and classification was adopted from WoRMS website. All the specimens were preserved in 10% neutral formalin and deposited in the Zoology Museum, Department of Zoology, Faculty of Science, The M. S. University of Baroda, Vadodara, Gujarat, India.

RESULTS AND DISCUSSION

In the present study total 14 specimens were collected from three different sites and four different species *viz*. *Boleophthalmus dussumieri*, Valenciénnes, 1837, *Periophthalmus waltoni* Koumans, 1955, *Apocryptes bato*

(Hamilton, 1822) and *Scartelaos histophorus* (Valenciennes, 1837) were identified. Detailed description of the species is given below.

Taxonomy
Order : Perciformes
Family: Gobidae
Sub family: Oxudercinae

***Boleophthalmus dussumieri* Valenciénnes, 1837 (Fig. 1a, 1b)**
Synonyms
Boleophthalmus dentatus Valenciénnes, 1837 *in* Cuvier and Valenciénnes, 1837: 208, fig. 355
Boleophthalmus chamiri Holly, 1929: 64

Material examined:
Total 4 specimens were collected from Kamboi (1 specimen), Nada (2 specimen) and Gandhar (1 specimen). The measurements of different morphological characters of the specimens are presented in table 1.

Table 1: Morphological measurements of *B. dussumeiri*

Morphological characters	
Fish length (SL) (cm)	15.95 ± 1.37
Head length (HL) (cm)	3.9 ± 0.29
Caudal fin length (CL) (cm)	3.97 ± 0.66
Dorsal fin 2 length (D2L) (cm)	5.27 ± 0.39
Anal fin base (cm)	4.92 ± 0.30
CL/SL (%)	25 ± 0.04
HL/SL (%)	24 ± 0.01

Diagnosis
Total elements in second dorsal fin D2 24- 28; caudal fin length (CL) 21.9 t0 25.3% of total fish length (SL); total elements in caudal fin 24-27; longitudinal scale count 103-185; predorsal scales 48-56; head length (HL) 23.6 to 28.7% of total fish length (SL); first elements of D2 unsegemented and unbranched; lower jaw teeth notched; the three canines in the upper jaw near both symphysis elongated and protruding; height of D1 more in males and larger canine teeth; Dorsum and flank bluish grey to light brown in color in fresh specimen; numerous dark brown speckels on dorsal side of head, gill cover, chicks, muscular portion of pectoral fins; ventral portion of body pale in color; D1 light grey with numerous dark spots on the interradial membrane, D2 gray in color column of pale blue spots on the interradial membrane, caudal fin with gray to blackish rays; body color light brown, grayish blue or purplish in preserved specimens [1]

Remarks
The species has wide spread distribution in Indo-Pacific region. The species is reported from Persian gulf, Oman [1] and Pakistan [20]. In India the species is frequently reported from Bay of Bengal; Tamilnadu; Maharashtra [21] and Gujarat [12,22,23]

***Periophthalmus waltoni* Koumans, 1955 (Fig. 1c, 1d)**
Synonyms
Periophthalmus waltoni Koumans, 1941: 288

Materials examined
Total 3 specimens were collected but 2 specimens (1 specimen Kamboi; 1 specimen Gandhar) were not in the good condition so only one specimen (1 specimen Nada) was used in the study. The measurements of different morphological characters of the specimens are presented in table 2.

Table 2: Morphological measurements of *P. waltoni*

Morphological characters	
Fish length (SL) (cm)	12.9
Head length (HL) (cm)	2.5
Head width (HD) (cm)	2.4
Caudal fin length (CL) (cm)	2.4
Dorsal fin 2 length (D2L) (cm)	3.2
Anal fin base (cm)	2.7
Pelvic fin length (PL) (cm)	1.7
HW/SL (%)	18.6
PL/SL (%)	13.17
AL/SL (%)	20.93
D2L/SL (%)	24.8

Diagnosis

Pelvic fins united for about one half of their length; D1 moderate in height with rounded margins; no stripes on fin only few white spots visible posteriorly; dusky stripe present infra marginally on D2; dorsal fins not connected by membrane; D1 with 10-13 spines; longitudinal scale count 91 -121; head width 13.7 -21.9% of SL; pelvic fin length 11.8 – 13.9% of SL; length of anal fin base 16. 2 – 21.0% of SL; length of D2 base 23.2 – 27.2 % of SL; total D2 elements 13-14, total anal fin elements 11 – 12. Color of head and trunk grey in color in fresh specimen; gill cover and chick with small which spot and few dusky blotches; series of 7 irregular black blotches present on the dorsam; 1-8 spines of D1 light grey in color with yellowish margin; margins of D2 transparent in color; 3 black blotches present on caudal peduncle; caudal fin brownish grey in color; anal and pelvic fins blackish brown with pale margins; body color grey and remnant of white spot present on head in preserved specimen [1].

Remarks:

The species is widely distributed in mudflats areas from Arabian Gulf to western coast of India, the species is so far reported from Persian Gulf, Iraq and Pakistan [1]. In India, the species is reported from Gulf of Kachchh [25]; the species also occurs on east coast of India but the reports needs conformation.

***Apocryptes bato* (Hamilton, 1822) (Fig. 1e, 1f)**

Synonyms

Gobius bato Hamilton, 1822: 40 pI. 37, Fig. 10
Apocryptes bato Valenciennes *in* Cuvier and Valenciennes, 1837: 143
Apocryptes batoides Day, 1876: 301, pI. 66, fig. 3

Material examined:

Only one specimen was collected from mangrove mudflat of Nada study site. The measurements of different morphological characters of the specimens are presented in table 3.

Table 3: Morphological measurements of *A. bato*

Morphological characters	
Fish length (SL) (cm)	10.2
Head length (HL) (cm)	2.4
Caudal fin length (CL) (cm)	2.8
Dorsal fin 2 length (D2L)	1.9
Anal fin base	1.5
HL/SL	23.52
CL/SL	27.45

Diagnosis

Total number of elements in D2 21-23; total number of elements in anal fin 20-24; head length 21.9 – 23.9 % of SL; caudal fin length 22.6 – 23.9 % of SL; body color yellow brown to brown in preserved specimen; 6-7 vertical narrow bars present alongside anterior most coursing from dorsum through pectoral fin; in some cases the bars may be discontinuous and in some instances black blotches replace the bars; the body is slippery in fresh specimens with pale green color and numerous black dots; under parts white in color with a silver gloss on both the sides [1, 26].

Remarks
The species is widely distributed from east coast of India to South East Asia [18] and Australia [28]. The species is reported from Hongkong [29], China [18] and Thiland [30]. In Indian subcontinent the species is reported from Ganges River delta to Burma [31]. The species is reported from mudflats of east coast of India [32]. The species is also reported from Bombay located on western coast of India [18]. In the present study the species is first time reported from the mangrove mudflats of Gujarat where the species occurs with other sympatric species like *Scartelaos histophorus*.

***Scartelaos histophorus* (Valenciennes, 1837) (Fig. 1g, 1h)**
Synonyms
Gobius virdis Hamilton, 1822, pI. 32, fig. 12
Gobius virdis Otto, 1821
Boleophthalmus histophorus Valenciennes *in* Cuvier and Valenciennes, 1837: 210
Boleophthalmus sinicus Valenciennes *in* Cuvier and Valenciennes, 1837: 215
Boleophthalmus chinensis Valenciennes *in* Cuvier and Valenciennes, 1837: 215
Boleophthalmus aucupatorius Richardson, 1845: 87
Apocryptus macropthalmus Castelnau, 1873: 87
Gobiosoma guttulatum Macleay, 1878: 357, pI, 9, fig. 6
Gobiosoma punctularum De Vis, 1884: 445
Boleophthalmus novaeguinea Hase, 1914: 535, fig. 8

Material examined
Total 8 specimens were collected from Nada (5 specimens) and Gandhar (3 specimen) study sites. The measurements of different morphological characters of the specimens are presented in table 4.

Table 4: Morphological measurements of *S. histophorus*

Morphological characters	
Fish length (SL) (cm)	12.91 ± 1.20
Head length (HL) (cm)	1.71 ± 0.15
Head depth (HD) (cm)	1.47 ± 0.55
Caudal fin length (CL) (cm)	2.64 ± 0.43
Dorsal fin 1 base length (D1L) (cm)	0.61 ± 0.06
Dorsal fin 2 base length (D2L) (cm)	5.35 ± 0.52
Anal fin base (cm)	5.14 ± 0.48
HD/SL (%)	11.74±0.64
CL/SL (%)	20.37 ± 2.63
D1L/SL (%)	4.78 ± 0.68

Diagnosis
Prominent barbell present on the ventral midline near symphysis of lower jaw; 19-31 teeth present in the upper jaw; head depth 10.1 - 12.4 % of SL; caudal fin length 18.5 to 12. 4 % of SL; length of D1 base 5.7 – 7.5 % of SL; 4- 7 vertical narrow bluish grey colored bars present on trunk; no large black spots or stripes present on the posterior half of D2; D2 and anal fins connected to caudal fin by a membrane. Body color greenish blue dorsally and pale blue ventrally in fresh specimen; scattered bluish spots present on trunk; few small bluish spots present on the trunk; 7 narrow vertical bars present on trunk; first bar present dorsal to genital papilla; second bar present dorsal to second anal fin element; third bar present dorsal to 5^{th} element; fourth bar dorsal to 9^{th} element; fifth bar dorsal to 14^{th} element; sixth bar dorsal to 17^{th} element and seventh bar dorsal to 21^{th} anal fin element; bluish spot present between fourth and fifth vertical bar; second dorsal fin dusky in color with randomly arranged blue spots; bluish spots present on the caudal fins forming 3 -5 narrow vertical lines; anal fin transparent; pectoral and pelvic fin dusky in color. Body color slate grey to brown in preserved specimens.

Remarks
The species is widely distributed in Indo- West Pacific region specifically from Pakistan [1], China, Japan [34] and Australia [28]. In India, the species is reported from Ganges delta [26] on the eastern coast while on the western coast the species is reported from Mumbai [18]. In the present study the species is first time reported from the mangrove mudflats of Gujarat where the species occurs with other sympatric species like *A. bato*.

In the present study total four species of mudskippers belonging to four different genera were reported. Out of four species reported *B. dussumeiri* and *P. waltoni* were reported from all the study sites which imply that the species utilizes wide range of micro habitat. *A. bato* was reported from Nada study site only which imply that the species requires specific kind of micro habitat for the survival.

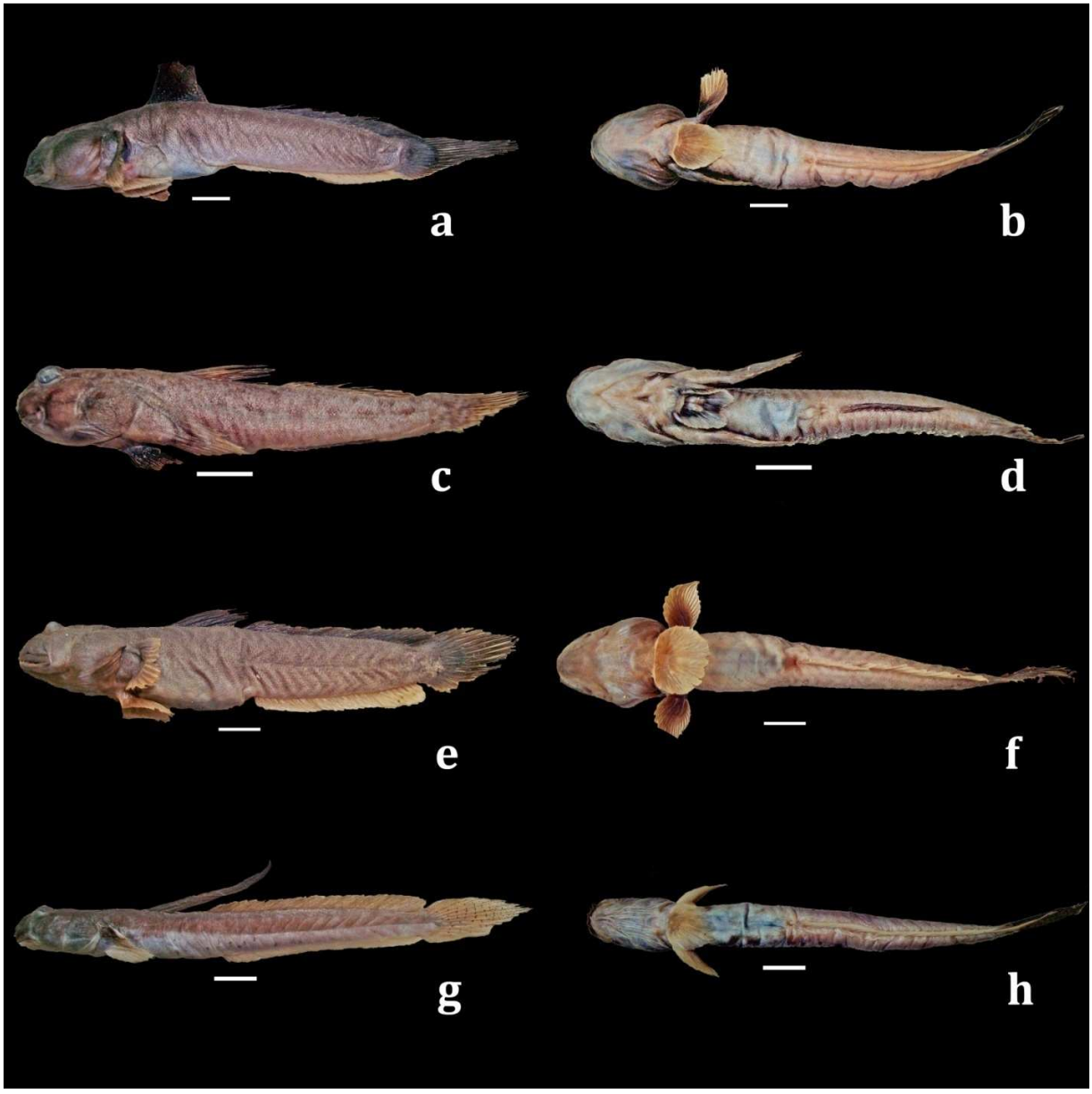

Fig. 2 Mudskipper species diversity; (a, b) *Boleophthalmus dussumieri*, Valenciénnes, 1837 (c, d) *Periophthalmus waltoni* Koumans, 1955 (e, f) *Apocryptes bato* (Hamilton, 1822) (g, h) *Scartelaos histophorus* (Valenciennes, 1837). (line bar represent 1 cm scale, all photographs are of preserved specimens)

CONCLUSION

Oxudercine gobiids (Mudskippers) are found in the soft muddy bottoms or mangrove mudflats of Indo – West pacific region [1,3]. Mudskipper species utilizes different kinds of micro habitat and construction burrows of different shapes. The mudskipper burrow increases aeration in the mangrove mud which on the other hand provides oxygen to the burrow dwelling fishes for the development of their larvae [38]. Mudskippers live in a very fragile and

sensitive ecosystem and any changes in the biotic and abiotic parameters of the ecosystem can affect their population, because of this particular character they can be used as a bio monitor species of pollution [39]. In the present study only four species of mudskippers have been reported and more studies are required to draw the picture of mudskipper diversity and distribution pattern along the coastal areas of Gujarat state.

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