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**REVIEW**

**A REVIEW ABOUT FISH WALKING ON LAND**

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A review about fish walking on land

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Abstract: Mudskippers are amphibious species inhabiting semi-terrestrial ecosystems like mudflats, mangroves, marshy swamps, intertidal regions, and estuaries. Around 34 diversified species are found across the globe. Mudskipper belongs to the Oxudercidae family and the subfamily is Oxudercinae. The occurrence of species is vastly found across the Indo-West Pacific region, the tropical western coast of Africa and in the Indian Ocean. Mudskippers are known for being the biological indicator and also an indicator of estuarine safety monitoring. They are used by people for prey-catching baits. This review paper explains the ecological indicators, taxonomy, species diversity, habitat, behavioural pattern, respiration & kinematics, feeding ecology, reproduction, nutrition content & its medicinal value, and threats to mudskippers.

Keywords: Amphibious fish, distribution, ecological indicator, mudskippers, species diversity.

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INTRODUCTION

Osche (1962) suggested that mudskippers would be useful for interpreting the transition of species from water to land. There is some evidence about the transition of fishes to tetrapods, which occurred more than 360 million years ago (Ulrich & Elliott 2013). There are about 40 species classified under 10 genera. Mudskippers predominantly inhabit the mangrove forest and mudflats of the Indo-West Pacific region, the tropical western coast of Africa, and Indian Ocean coastlines. Mudskippers are known to be burrow dwellers preferring the swampy marshes, estuaries, and the intertidal regions for their living (Murdy 1989). The feeding ecology of the Mudskipper Periophthalmus barbarous was found to be ‘opportunist feeders’ meant to be satisfying the food needs with the available resources (Chukwu & Deekae 2013). Generally, mudskippers feed on algae, detritus, diatoms, nematode, polychaetes and eggs of fishes, along with mud and sand particles (Ravi 2013).

Since long ago, researchers have explored mudskipper’s distribution pattern, species diversity, behavioural patterns and their locomotory activities. In 1989, Murdy studied the morphological features of mudskippers, which paved the way for taxonomic classification of mudskippers. Also, he hypothesized the relationship of Oxudericinae gobies with other genera and groups. Mudskipper’s early developmental age & growth, respiratory & circulatory adaptations, and feeding ecology were also studied by many researchers across the globe (Jaafar & Murdy 2017).

Due to the medicinal properties found in mudskippers, it gains commercial value either through food consumption or as traditional medicine by humans (Kanejiya et al. 2017a). Sometimes they are even used as bait for catching prey (Gadhavi et al. 2017). A few of the vernacular names used in different places for referring to mudskippers are Periophthalmus darwini, Periophthalmus sp., and Periophthalmus novaeguineaeensis as sakamo, Periophthalmus as nebesoker, Periophthalmus weberi as paraguamo, Periophthalmodon freycineti as genora, Boleophthalmus caeruleomaculatus as ebanea, Boleophthalmus sp. as poti, Scarphellos histophorus as seekakowea, Oxuderces wirzi as canipo (Polgar & Lim 2011). Mudskippers are known as ‘vaetti uluvai’ in Tamil (Ragunathan 2010).

Ecological Indicator

Monitoring the intertidal and estuarine health depending on their abundance mudskippers have direct affection towards salinity and temperature variations (Kanejiya et al. 2017c). They also contribute towards the growth of mangrove trees, when the population of mudskippers is abundant, consequently providing appropriate nutrients supporting the growth of mangroves (Shenoy et al. 2012).

Polgar (2009) attempted the studies of Malayan mudskippers as a biomonitor in mangroves concerning species area relationship (SAR) and revealed that the destruction of habitats resulted from reduced species abundance. Mudskippers bioaccumulate pollutants through ingestion as they tend to be prey for many mudflat species. Mudskippers ensure the coastal, intertidal, and estuary’s health (Polgar & Lim 2011). Studies have shown that mudskippers act as a biological indicator of addressing the severity of oil pollution in the coastal areas of the Persian Gulf. Biomarker responses of Periophthalmus waltoni were recorded and discovered that it acts as the ideal candidate for bioindicator in the coastal regions and mudflats. Correspondingly, it can be utilized for achieving sustainable development (Shirani et al. 2012).

Similarly, at Kuwait Bay, Periophthalmus waltoni acts as a bioindicator in identifying the bioaccumulation of metals (Bu-Olayan & Thomas 2008). It tends to be a feeble indicator at the Persian Gulf marine ecosystem, a biomonitor candidate-Boleophthalmus dussumieri used in the monitoring of polycyclic aromatic compounds (PAH). It might be various other environmental factors which are acting in that ecosystem leading B. dussumieri to be helpless (Sinaei & Mashinchian 2014). Metal toxicity and accumulation of metal toxicants like Zn, Cd, Pb, Cu have suggested that mudskippers are an ideal biomonitor. It was observed that their fins and liver are the biomonitors and accumulate metal toxins. Due to the contaminants of various metal pollutant, it is not recommended for human consumptions (Ikram et al. 2010).

Taxonomy

Mudskippers belong to the family Oxudercidae and the subfamily Oxudercinae. Some of the species are tabulated in Table 1 and Image 1.

Species Diversity

 Globally, 34 diverse species of mudskippers were recognized, and among them, nine were found in Indian coastlines (Murdy et al. 1989). Nearly five diversified mudskipper species have been effectively documented from Gujarat coastlines (Devendra et al. 2016). In the southeastern coast of India, mudskippers were recorded
most during the post-monsoon season, and their preferred habitats are estuarine lands and mangrove areas. A group of eight species from the Malay Peninsula and 12 species from Sumatra is present along the Straits of Malacca (Takita & Ali 1999). Earlier, there were nine species of mudskippers recorded in peninsular Malaysia (Polgar 2009). Recent studies have updated the total count to 17 in peninsular Malaysia (Khaironizam & Rashid 2005). Nineteen species have been recorded recently in the Ramsar site, Johor, Malaysia (Hui et al. 2019). Some of the mudskipper species found in Merauke District, Indonesia are Boleophthalmus boddarti, B. pectinirostris, P. takita, P. argentilineatus, Scartelaos histophorus, and Oxuderces dentatus (Elviana et al. 2019). Periophthalmus waltoni is maximally distributed along the Persian Gulf though there are many threats to its population density (Sharifian et al. 2018). There are about 24 newly recorded species during the recent studies in Indonesian waters (Pormansyah et al. 2019).

### Table 1. Taxonomic rank, genus, and species of mudskippers around the world with reference to various authors belonging to different periods.

| Tribe (taxonomic rank) | Genus | Species | References |
|------------------------|-------|---------|------------|
| 1 Oxudercini           | Parapocryptes | Parapocryptes richardsoni, Parapocryptes serpenter | Valenciennes 1846 |
| 2 Oxudercini           | Apocryptodon | Apocryptodon madurensis, Apocryptodon punctatus | Tomiyama 1934 |
| 4 Oxudercini           | Oxuderces | Oxuderces dentatus, Oxuderces wirzi | Koumans 1938 |
| 5 Periophthalmini      | Apocryptes | Apocryptes bato | Hamilton 1822 |
| 6 Periophthalmini      | Pseudapocryptes | Pseudapocryptes booneensis, Pseudapocryptes lanceolatus | Bloch & Schneider 1801 |
| 7 Periophthalmini      | Zappa | Zappa confluentus | Roberts 1978 |
| 8 Periophthalmini      | Scartelaos | Scartelaos cantorinus, Scartelaos gigas, Scartelaos histophorus, Scartelaos tenuis | Chu & Wu 1963 |
| 9 Periophthalmini      | Boleophthalmus | Boleophthalmus hirdsongi, Boleophthalmus boddarti, Boleophthalmus caesuleomaculatus, Boleophthalmus dussumieri, Boleophthalmus pelciniraristris | Pallas 1772 |
| 10 Periophthalmini     | Periophthalmodon | Periophthalmodon freycineti, Periophthalmodon schlosseri, Periophthalmodon septemradiatus, | Valenciennes 1846; Pallas 1772 Hamilton 1822 |
| 11 Periophthalmini     | Periophthalmus | Periophthalmus argentilineatus, Periophthalmus harbarus, Periophthalmus chrysopialos, Periophthalmus gracilis, Periophthalmus kaiolo, Periophthalmus malaccensis, Periophthalmus minutus, Periophthalmus modestus, Periophthalmus novaeguineaeensis, Periophthalmus novemradiatus, Periophthalmus waltoni, Periophthalmus weberi | Valenciennes 1846 Hamilton 1822 |

Living Habitat

Mudskippers inhabit riparian areas with soft and muddy plains. Also, they inhabit where the salinity level is found to be low and the place rich with benthic invertebrates (Baeck et al. 2008). Numerous species were living on the rocky coastline as much, as they occupy mudflats, mangroves, and sand flats (Gordon et al. 1968). Rehabilitating the coastal region with mangrove
saplings gives a better habitat for various species, and it was observed that large-sized mudskippers were found in the breakwater (sheltered area for mangroves) (Hashim et al. 2010). *Pseudapocryptes elongatus* is able to tolerate the salinity, and hence it survives in the open sea, coastal mangroves and inland habitat during different stages of their growth (Bucholtz et al. 2009). Mudskippers alter the environmental conditions improving the growth of young mangroves as they mix the soil with detritus (Ravi et al. 2013). Studies related to the microhabitat selection of Chinese mudskippers identified their preferences, such as salinity levels, land or water; water and air temperatures; light or dark; and various combinations among them were conveyed (Gordon et al. 1985). The major threats to the mudflats are soil erosion, macro algae, terrestrialization, and lack of estuarine water, human interference, and discharge of effluents (Ravi 2012). *Periophthalmodon septemradiatus* species is found to be the first species inhabiting and breeding from a saline environment to a completely fresh water region of the Mekong River (Mai et al. 2019). *Boleophthalmus pectinirostris* has shown behavioural preferences in choosing their microhabitat at their early juvenile stage (Chen et al. 2008). To determine the habitat selection, genomic studies were performed, and also the comparative analysis among different species were conducted (Cai 1996). Different mudskippers inhabit different microhabitats and have different burrow construction methods (Clayton 1993). Habitat selection is dependent on its ecological interactions (Polgar & Cosa 2009). Some species such as *Periophthalmodon septemradiatus* is found to survive in habitats with low salinity and far from the sea, whereas *B. boddarti* survives close to the sea with high salinity (Khaironiazam & Rashid 2003). Mudskippers preferred thick mudflat areas for carrying out their burrowing activity effortlessly (Kanejiya et al. 2017c). Burrows constructed by *Boleophthalmus boddarti* are classified as follows: burrows with single apertures represent newly constructed one, and the other single and double
openings ones currently exist. In contrast, the burrows with multiple apertures represent collapsed ones due to human interventions (Ravi et al. 2004).

**Behavioral pattern of mudskipper**

Population density is inversely proportional to the growth rate as the availability of food decreases due to an increased population. *Boleophthalmus pectinirostris* (Blue-spotted Mudskipper) is found to have the longest lifespan; seven and six years in males and females, respectively (Nanami & Takegaki 2005). A study on the terrestrial life of mudskippers with *Periophthalmus sobrinus* showed their survival capacity out of water is one and a half days. Surprisingly, there was no affection in metabolic and heart rates as well as the lactic acid concentration in blood during their living out of the water (Gordon et al. 1969). Whereas Chinese Mudskipper *Periophthalmus cantonensis* survives for two and a half days out of the water and observed medium sensitiveness of metabolism towards temperature. Starvation for 9.5 days did not affect the excretion of ammonia but affected excretion of urea (Gordon et al. 1978).

*Boleophthalmus dussumieri* has separate exit and entry for males and females. Juveniles pierce deep into mud during high tides. Adults neglect to build chimneys surrounding their holes as the consistency of the soil is between sand and clay (Rathod et al. 2019). Mudskippers growth rate is affected when being exposed to pollution at the embryonic stage (Kruijtwaagen et al. 2006). There is a significant role played by aquaporins (integral membrane proteins) for adapting themselves to the terrestrial lifestyle. The selective changes, like pore formation and substrate selection, have a substantial contribution to their adaptation to an amphibious lifestyle (Lorente-Martinez et al. 2018). The species *Periophthalmodon schlosseri* is found to be an ideal species for aquaculture and more mudskipper studies (Quang 2016). Mudskippers like *Boleophthalmus boddarti* constructs mud-walls, for territorial exclusion or spacing, territory, and reduces hostility. This is based on their abundance. These regional behavioural patterns give better knowledge about the elastic disc concept of territories (Clayton 1987). Mudflats are vital for the survival of mudskippers but global warming is a serious threat as the mudflats are greatly affected due to high temperature. Spawning season in *Scartelaos gigas* is from May to July. The growth rate is dependent on diet, water temperature, and mudflat exposure (Park et al. 2002).

Some mudskipper species tend to be more comfortable with a terrestrial lifestyle rather than an aquatic lifestyle. One among them is *Periophthalmodon schlosseri*, which has gill arrangements which are highly adaptable for air-breathing, and they spend less time in marine habitats (Takeda et al. 1999). *Boleophthalmus boddarti* builds mud walls for two significant reasons: to avoid hostility between neighbours and as assistance for feeding. Diatoms are the most preferred food for mudskippers. They prefer feeding on mud slopes as a measure of preventing intervention by their neighbours (Clayton & Wright 1989). *Periophthalmus sobrinus* prefers to live unaccompanied and rarely lives within closed groups. There were large spacings between nests and dark places were preferred for foraging (Gordon et al. 1968). The growth rates and life duration of both the sexes of *Pseudapocryptes elongatus* obtained from Sundarbans, India is four-plus years for both the sexes as the maximum age. Their growth index (Φ) is 4.394 (males) and 4.503 (females) possessing larger caudal fins (Mahadevan et al. 2019c).

The reason for aggressiveness in *Periophthalmus modestus* is the hypothalamic hormone, arginine-vasotocin (VT) (Nao et al. 2013). The foraging behaviours in *Periophthalmus waltoni* are not influenced by environmental factors. They hunt in the same area as their prey stays inside the burrow for a longer period of time (Clayton & Snowden 2000). The growth of *Boleophthalmus boddarti* has been recorded high during their juvenile period, decreasing in successive years because of maturation and spending their energy in spawning (Ravi & Rajagopal 2007).

**Respiration and kinematics**

Anatomical characteristics of mudskipper gills decide on adaptations of their habitat and *B. boddarti* is one that shows excellent adaptation to aquatic lifestyle. In comparison, terrestrial adaptations were favoured more at odds with their amphibious lifestyle (Low et al. 1988). Since mudskippers appear to change the way their skin breathes, their epidermis and skin layers have been studied in detail (Beon et al. 2012). They adapt towards terrestrial lifestyle by secreting mucus, and their head containing dense capillary network assists cutaneous respiration (Jie et al. 2003). Studies related to gaseous exchange and their demand for oxygen were done in the intertidal regions (Karen 1993). Ammonia excretion happens in mudskippers (*Periophthalmodon schlosseri*) through their head. Ammonia gets collected in their burrow through the acidification process, preventing them from reverse fluctuation (Randall et al. 2004). Mudskippers maintain the air phases according
to the tide. They can breathe both aquatically and aerially when there is a high tide, while at low tides they transfer air into their burrow for breathing (Lee et al. 2005). Comprehensive research was conducted in *Periophthalmus magnuspinatus* on cutaneous respiration and its relationship with skin layers (Park 2002). Several mudskippers reported evaporative water loss along with their behavioural adaptations (Dabruzzi et al. 2011). Significant characteristics of gills found in *Periophthalmodon schlosseri*, contribute to their ability to live inland for a longer period of time (Wilson et al. 1999). The modifications and transformations that occur in the gill respiratory vasculatures and the mudskippers of the bucco-opercular cavities were examined using the technique of corrosion casting. This has helped to define their adaptation to an amphibious lifestyle (Gonzales et al. 2011). Histological studies using the paraffin method have studied the ambiguity in the structure of the gills and simultaneously compared their aquatic and terrestrial lifestyles (Supriyati et al. 2019). For their survival, condition-specific biochemical adaptations occurred during hypoxia, where the glycolysis process is modified to provide energy during muscle movements, and lactate is accumulated (Chew & Ip 1992).

Contradictory circumstances occur concerning their adaptations between *Periophthalmodon schlosseri* and *Boleophthalmus boddarti*. Around the same time, *P. schlosseri* tends to be adaptable to a terrestrial lifestyle and is an excellent candidate for aquaculture studies related to air-breathing fish. *B. boddarti*, however, appear as opposed to the earlier one (Kok et al. 1998). Mudskipper is an anomaly that stores pre-entry air inside their burrow and has no metabolism affection. They regularly maintain their air stages and adapt them to their amphibious lifestyle (Ishimatsu et al. 1998). The essential feature of their adaptation to terrestrial life is the presence of dermal bulges, thick middle cell layer and a vascularized epidermis (Zhang et al. 2000). In low tide conditions, the intertidal fishes, like mudskippers, tend to have many options to choose from. Mudskippers either agree to be an aquatic or temporary terrestrial living being (Karen 1995). Mudskipper’s locomotion has been experimentally tested using water on gelatin and glass along with the assistance of a system for digital image processing. Wang et al. (2013) discovered through their study that mudskipper uses both body and pectoral fins for movement in the water and on gelatin, whereas they use only pectoral fins for land action. Escapism is a critical behaviour that is required for their survival. A few studies have shown that, during aquatic and terrestrial lifestyles, mudskippers alter their position as escapists (Swanson & Gibb 2004).

**Feeding ecology**

The mudskipper *Pseudapycryptes dentatus* follows herbivorous feeding patterns. Their main order is Diatoms-Bacillariophyceae, green algae and blue-green algae. Levels in size and metabolism are inversely proportional (Sarker et al. 1980). Both plants and animals were documented while studying the *Periophthalmus barbarus* stomach. This included mainly crabs, fish scales, and insects. We can recognize from this that mudskippers are opportunistic feeders and are an ideal aquaculture choice (Chukwu & Deekh 2013). As described, their key food items include -diatoms, nematode, polychaetes, fish eggs, algae, detritus, along with particles of mud and sand (Ravi 2013). It has been shown, according to the study conducted with *Periophthalmodon schlosseri*, that there are differential preferences in the selection of food products between male and female. Females preferred small-scale fish, namely *Oryzias* sp., and males over small-scale fiddler crabs because they were highly involved in land activities (Zulkifi et al. 2012). The *Periophthalmus sobrinus* feeds on small animals. Their food sources are polychaetes, polydora, terebellid, nematodes, crustaceans, coppeods, tanaids, pawns, schizopod larvae, alpheid shrimp juveniles, *Uca chlorophthalmus*, and tiny sand crab (Stebbins & Kalk 1961). The discerned food items of *Periophthalmus waltani* are crustaceans (high occurrence), snails (slightly lower occurrence), 3.4% insects (lower appearance), and fishes (least) (Mhaisen & Al-maliki 2013). *Boleophthalmus pectenirostris* selects their meal based on the abundance, availability, size of the diatoms and temperature. The size of the species reflects over its feeding apparatus (Yang et al. 2003).

*Boleophthalmus boddarti* likewise feeds on Bacillariophyta (Quang 2015). The anatomical characteristics in *Periuphthalmus kueleuteri* are examined by light and X-ray cinematography. It pushes forward with its pelvic fins when the prey gets near, and brings the jaws near to the target. Opercular bones, aid swallowing into the pharynx to position the prey. They found it easy to capture the prey in the land by biting and open mouth. It reaches the stomach via an esophagus after passing the pharyngeal jaws (Sponder & Launder 1981).

**Reproduction**

Studies were conducted in Nigeria’s lagoon swamps, which concentrated primarily on sex ratios, egg
diameters, gonadosomatic index and levels of maturation (Lawson 2010). Reports on the growth of eggs with artificial fertilization and larval reports in the species *Periophthalmus cantonensis* were carried out (Tsuahako et al. 2003). The mudskipper’s eggs were laid deep within the burrows where there is a hypoxic environment, and male mudskippers supply the oxygen by depositing oxygen through water. Once the development of the eggs is complete, they are released from the burrows and hatched by tides, making them prepare themselves during severity (Ishimatsu et al. 2007). A research on *Apocryptes bato*’s (Gobiidae) reproductive biology in the Payra River, southern Bangladesh, helped to understand the basics of reproduction in mudskippers (Ferdous et al. 2018). Studies related to reproductive biology, fertilization, maximum sizes achieved along with spawning will allow local fishermen to know the exact time of catching them, rather than disturb them during spawning seasons. The concept was prominent from the studies of sex maturation of *Boleophthalmus boddarti* (Quang et al. 2015). The species *Periophthalmodon septemradiatus* lays eggs year-round. Observing their complete duration during the maturation stages helped to understand reproductive biology and to learn about the methods of conservation (Dinh et al. 2018). Studies at intertidal swamps of the Imo River estuary dealt about the reproductive biology of *Periophthalmus barbatus* along with growth, mortality, recruitment pattern, gonadosomatic index, and spawning season (Etim et al. 2002).

**Studies on nutrition content and medicinal value**

Nutrient content of three species *Periophthalmus waltoni, Boleophthalmus dussumieri,* and *Scartelaos histophorus* were measured, such as starch, protein, and lipid. *Boleophthalmus dussumieri* is rich in nutrients and it comes from the liver. Because of this adventitious effect, people consume them in the Bhavnagar coast, Gujarat (Kanejiya et al. 2017a). Mudskippers are known to be very rich in proteins and other nutrients. They are either used in traditional medicines in countries like Malaysia or as bait and also utilized for consumption. During winter, mudskippers are caught and sold at the market by fishermen using net trap methods (Kanejiya et al. 2017b). Likewise, there are growing demands for mudskippers at Narmada estuary, Gujarat, and they are favoured by local people. As a result of this, the ecosystem can get highly exploited and can impact biodiversity (Bhakta et al. 2018). Though mudskipper meat possess nutritional benefits there are researchers stating about metal toxicity and bioaccumulation when consumed.

The research by Looi et al. (2016) concluded that the bioaccumulation of mercury in *Periophthalmodon schlosseri* did not cause any serious effects when consumed. From the evaluation of the nutrient content of *Pseudapocyptes elongatus*, it has been shown to contain sufficient protein, carbohydrate, lipid, important and non-essential amino acids, polyunsaturated fatty acid (PFA) with a greater amount than saturated fatty acid (SFA). For consumption it is highly recommended because of its nutritive value (Mahadevan et al. 2019b). Mudskippers are widely available in Nigeria and their prices are comparatively low, and they are consumed by the elderly (Edun et al. 2010). Exposure of mudskipper *Boleophthalmus boddarti* to natural radionuclides (238U, 226Ra and 210Pb and 210Po), the radionuclide concentration was found to be below the limit and therefore, did not have a profound impact in Bombay Harbour and coastal zone (Bangera & Patel 1984).

**Threats to mudskippers**

The effect on mudskipper density was recorded in the mudflats of Hathab coast, Gujarat, considering salinity and temperature as independent variables. Accordingly, mudskipper abundance and distribution have become a vital indicator for determining intertidal region health (Kanejiya et al. 2017c). Post-tsunami studies at Mudasolodai, Tamil Nadu, revealed that rapid changes in soil morphology led to changes that directly affected the mudskippers’ livelihood. For construction, they usually prefer clay-rich soil, rather than sandy soil (Ravi 2005). Although metal uptakes were increasingly high during lower salinity, the levels of salinity in the intertidal mudskipper *Periophthalmus cantonensis* did not affect the metal (Cd, Se, & Zn) concentration factors (CF) (Ni et al. 2006). Mudskippers face other menaces due to metal toxicity. To illustrate, when exposed to Cr (VI), *Boleophthalmus dentatus* causes affection in the activity of Na+, K+ and ATPase, and further affects membrane activity, also causing metabolic stress (Kundu et al. 1995). Similarly, the same has also been deduced in other studies pertaining to *Boleophthalmus dentatus* obtained from the Gulf of Katch (Lakshmi et al. 1991). The shrimp effluents collected at the mudskipper habitat in the northern Persian Gulf have proved to support mudskipper enrichment, which helps them increase their species density and length. Despite severe changes and reduced dissolved oxygen, shrimp effluents create favourable physical conditions for their growth; it survived amid these adversities (Kohan et al. 2018). Mudskippers are known for their versatile
behaviour and amphibious character. They have less understanding of the public and have lost interest. The most striking characteristic of them is their survival ability and adaptation to different environmental changes. Surprisingly, mudskippers feed on the available foodstuffs, rather than relying on specific foods. Further research can be done with them as they define themselves as an ideal candidate for aquaculture. Gills' anatomical features are specifically built to suit both the terrestrial and aquatic lifestyles. They got adapted from the initial stages of egg production to adjust to severities such as high tide, and airflow maintenance.

CONCLUSION

Mudskippers are known for their significant behaviour of adapting themselves to different environment and amphibious nature. Mudskippers are less popular among people and aren’t noticed much. Their most amazing feature is their capacity to survive and their adaptation to various changes in the environment. Surprisingly, mudskippers feed on the foodstuffs available, rather than rely on particular foodstuffs. Further research can be carried out as they may be an ideal candidate for aquaculture. The anatomical characteristics of gills are designed primarily to accommodate both the terrestrial and aquatic lifestyles. From the initial stages of egg production, they are taught to adjust themselves to severities such as high tide and maintenance of the airflow. The most striking aspect about them is their position in coastal areas as a biological indicator, pollution monitor, and estuarine health monitor.

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