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Mini Review

A Systematic Review about the Anatomy of Asian Swamp Eel *(Monopterus albus)*

Ayah Rebhi Hilles[1]*, Syed Mahmood[2]* and Ridzwan Hashim[1]

[1]*Department of Biomedical Sciences, International Islamic University Malaysia, Malaysia*

[2]*Department of Pharmaceutical Engineering, University Malaysia Pahang, Malaysia*

***Corresponding author:** Ayah Rebhi Hilles, Department of Biomedical Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

Syed Mahmood, Department of Pharmaceutical Engineering, Faculty of Engineering Technology, University Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

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Taxonomy and Distribution of Asian Swamp Eel

Asian swamp eel, *Monopterus albus* belongs to the family synbranchidae of the order synbranchiformes [1]. The Asian swamp eel is commonly found in paddy field and it is native to the tropical and subtropical areas of northern India and Burma to China, Thailand, Philippines, Malaysia, Indonesia, and possibly north-eastern Australia [2]. The swamp eel can live in holes without water with the help of their respiratory organs. Some fishery scientists say that they pass their summer in the hole, but sometimes coming out from the hole to take oxygen. Most swamp eels are nocturnal species and often spend their daytime hiding under stones and mud or having a burrowing habit [3]. Sometimes, it uses air-filled buccal cavities to float its snout above water surfaces. In its native range, it is rarely seen by human since it is a nocturnal predator which is usually active at night and bury itself in soft sediments [2]. *M. albus* is very hardy and adaptive to adverse environments compared to other fishes [4]. It usually burrows deep inside the mud during prolonged deficiency of water [5]. It can also move over dry land for short distances [6].

Anatomical Components and Physiological Activities of Asian Swamp Eel

Cardiovascular system

The heart in Asian swamp eel consists of four chambers placed in series: sinusvenosus, thin-walled atrium, muscular ventricle and bulbus arteriosus which is an outflow tract [7]. The cardiovascular system possesses a remarkable adaptability during seasonal thermal changes [8]. Regardless the cardiovascular adaption, the performance in *M. albus* haven't improved at high temperatures [9], however, some studies reported that heat-tolerant myoglobin which is isolated from *M. albus* has thermally stable structure [10]. The autonomic control of cardiovascular system during air and water-breathing was discovered by the infusion of β-adrenergic antagonist propranolol and muscarinic antagonist atropine [11]. It has been indicated that the ventilatory and cardiovascular of eel are able to regulate hypoxia to meet the O_2 demands of their tissues [12].

Respiratory system

M. albus has four internal gill slits and five gill arches, the anterior three arches only have gills. It is an air breather. The ratio of aerial and aquatic respiration is 3 to 1. When aerial respiration is not possible, *M. albus* can depend on aquatic respiration [13]. It can breathe atmospheric oxygen by rising to the water's surface, protruding their snouts to inhale mouthfuls of air and then sink to the bottom in resting position [14]. Sometimes, Asian swamp eel use their air-filled buccal cavities to float their snouts above the water's surface [15]. While, they can absorb the atmospheric oxygen via a highly vascularized breathing apparatus [16]. They can stay for months in moist mud during dry season due to their myocardial sensitivity, as it becomes high when oxygen diminishes. In this condition their buccal cavity in the respiratory system plays an important role which provides oxygen-rich myocardial blood [17]. It has been reported that *M. albus* has a low tolerance to hypoxia even though it still can maintain access to air during summer while remaining in moist mud [18], because it has high blood oxygen affinity as their O_2 has high carrying capacity [19].

Immune system

The innate immune defence in Asian swamp eel consists of a large number of cellular and humoral factors which play an important role as the first line of defence mechanism against infective agents [20]. Unlike mammals, their immunity is different; they respond to immunization by producing antibodies with lower affinity to the antigen as well as their secondary response has a low-affinity maturation [21]. It has been documented that they have antibacterial peptides which consider an important factor for the innate immune defence even after vaccination when a specific

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immune response already matured [22]. It has been suggested that the interferon regulatory factors in *M. albus* play an important role in the immune system to protect it against bacterial, viral and parasitic infections [23].

Reproductive system

The reproductive system of the female Asian swamp eel consists of a single tubular ovary, located above the digestive system and attached to the dorsal wall of the body cavity and to the gut by mesenteries. The ovary occupies almost the entire body cavity and it is covered by a conspicuous muscular wall [24]. It has been recorded that heat shock protein 10 (Hsp10) in *M. albus* can suppress insulin-like growth factor-1 receptor Igf1r which is essential sex-differentiation gene [25]. Although *M. albus* is one species of Asian swamp eel but its reproductive behaviour differs significantly from other Asian swamp eel species [26].

Digestive system

Monopterus has a short digestive tract. The gut extends along its body, the length of the gut starts from the posterior end of the pharynx to the anus [13]. The alimentary canal in Asian swamp eel is comparatively short, it consists of an oesophagus, stomach and intestine which separated into a duodenum and small intestine. The stomach, partially covered by the liver, lies on the left side; they have a true anatomical stomach. The common bile and pancreatic duct open into the duodenum below the pyloric sphincter [27]. The weakest digestive enzyme is a protease, while the most active ones are amylase [28] and lipase [29].

Conclusion

Although there are many fish species can move over the land, but Asian swamp eel is a unique air breathing fish as they showed a significantly extended tolerance to survive in the wet muddy areas up to seven months without even food and water. That fact that eel is not an ordinary fish, therefore this review focused on reviewing the anatomical structure of *M. albus*.

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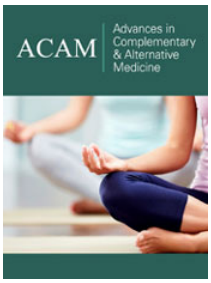

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