CHAPTER 2

2.0 INTRODUCTION

The study dealt with data from observation on gross morphological features of the four selected species of juvenile freshwater fishes. They represented fishes with two types two types of cerebellar orientation; rostrally and caudally oriented. This could reveal possible relationship between the cerebellar orientations to certain features of the fishes which might have correlation with the movements. Since there were no reports regarding this matter, thus, this study would be able to provide some basis for more advanced future studies.

2.1 MATERIALS AND METHODS

The general morphological features of the fish were observed and recorded. The features looked at were body shape, existence of spines and barbels, location of eyes, shapes of caudal fin, swimming mode and movement pattern of pectoral fin. The fishes (in the range of 14-20 cm) were anaesthetized with MS 222 prior to the handling. General observation while fishes were in captivity was also made.

2.2 RESULTS

The details on morphological features of the fishes were taken into account in order to correlate those two factors with the different morphology of the cerebellum.

The body shape of a fish can portray the way it lives in its aquatic surrounding. The different body shapes reflect the adaptation of the fishes, especially in relation to their swimming movements. The fish behavior such as those related to swimming (e.g. fast or slow), its vertical common location (e.g. at the surface or at the bottom of the habitat) might have connection with its morphological features including body shape, which will give functional effects. Summary is shown in Table 2.1.

2.2.1 Morphological features of fish with rostrally directed cerebellum

Keli (*Clarias* sp.) displayed a ‘torpedo’ shape body (Figure 2.1 and 2.2). From the lateral view, the body looked elongated. It had a depressed head, compressed tail with rounded caudal fin and round body. It also had two pairs of striking barbels and spines at both pectoral and dorsal fins. The more dorsally located pair of the barbels was longer than the other pair. The eyes were located on dorso-lateral part of the head, and this allowed it to have 360° view of the surrounding.

Figure 2.1: Lateral view of *keli*.

Figure 2.2: Dorsal view of *keli*.

Just like *keli*, *baung's* (*Mystus nemurus*) body shape was also 'torpedo' shape (Figure 2.3 and 2.4). From the lateral view it also looked elongated. Other features displayed were also similar to *keli's*. This juvenile fish had a depressed head, compressed tail with forked caudal fin and round body. In contrast to *keli*, *baung* had four pairs of striking barbels; two pairs at both maxilla and mandible. The longer pair of the barbels also seemed to be more dorsally oriented compared to the other pair. Besides that, the spines were located at both pectoral and dorsal fins. The eyes were also located on dorso-lateral part of the head and hence, *baung* also have the advantage of 360° view of the surrounding.

Figure 2.3: Lateral view of *baung.*

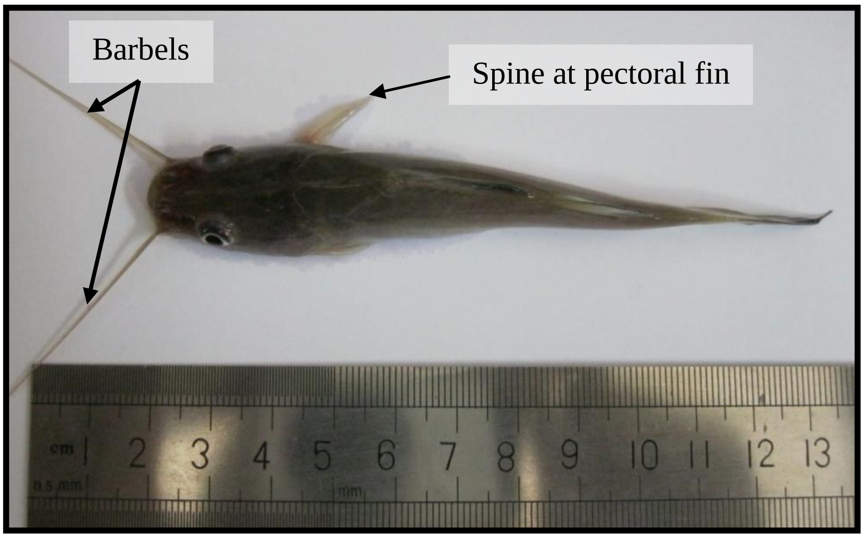

Figure 2.4: Dorsal view of *baung.*

2.2.2 Morphological features of fish with caudally directed cerebellum

In contrast to the fishes with rostrally directed cerebellum, the juvenile *jelawat* (*Leptobarbus hoeveni*) displayed a compressed body (Figure 2.5 and 2.6). The compressed body looked flattened due to the wider body in its vertical orientation. From the lateral view, the body seemed elongated. The head was broad and flattened above. It also had forked caudal fin, a pair of small barbels but the spine was absent. The eyes were located on the sides of the head and so it does not have the advantage of 360° view of the surrounding.

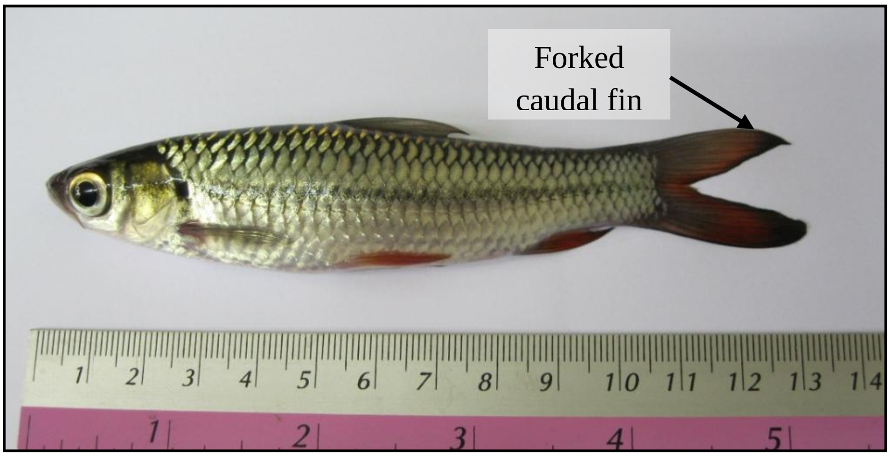

Figure 2.5: Lateral view of *jelawat.*

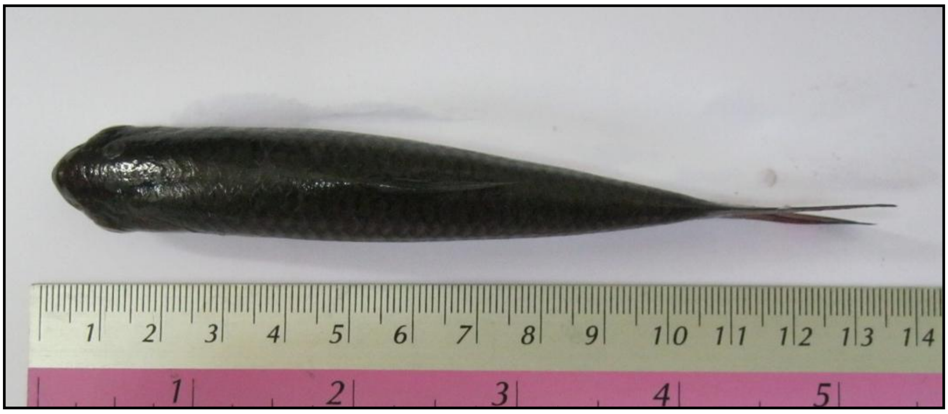

Figure 2.6: Dorsal view of *jelawat.*

As displayed by the other fish with caudally directed cerebellum (*jelawat*), *tilapia's* (*Oreochromis sp.*) body shape was a compressed body (Figure 2.7 and 2.8). Its body looked more flattened since the vertical width of the body was wider than *jelawat*. From the lateral view, the jaw appeared to be pointing upwards. This juvenile species had slightly forked caudal fin, and both barbels and the spine were absent; similar to *jelawat*. As was seen in *jelawat*, the eyes were located on the sides of the head; thus, not allowing it to have 360° view of the surrounding.

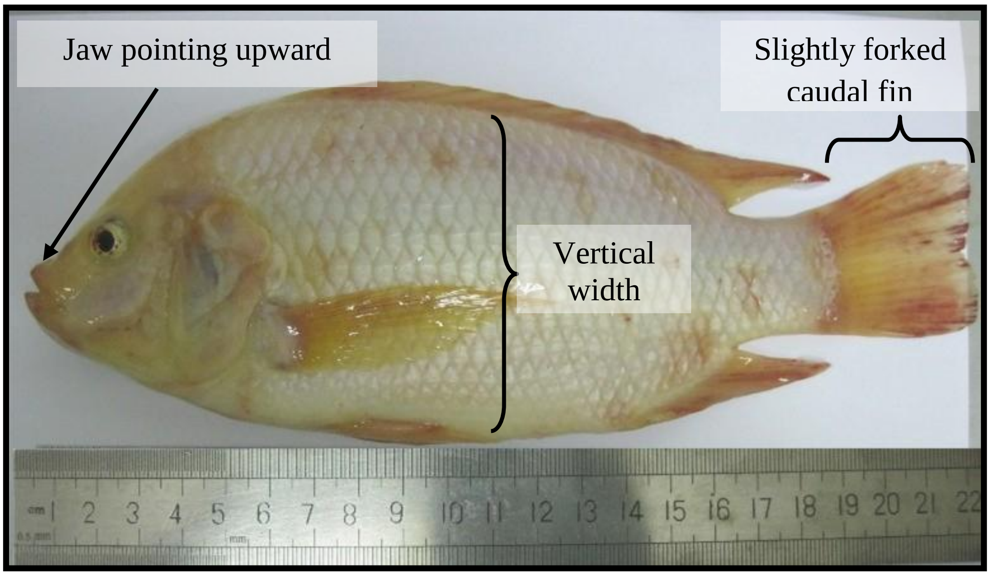

Figure 2.7: Lateral view of *tilapia*.

Figure 2.8: Dorsal view of *tilapia*.

2.3 DISCUSSION

The similarities and differences of the features of fishes studied with regards to their respective cerebellar orientation were tabulated to ease the comparison (Table 2.1). It is worth noting that the features could be easily divided along the fish cerebellar orientation, except for nature of caudal fin and swimming mode. However, for the latter, one could differentiate *tilapia* from the others since its body shape is very different compared to the other three.

Gross morphological observation of the fishes showed that other than fins, there were also extra appendages possessed by *keli* and *baung.* There were two pairs of striking barbels extending from the mouth opening. The thick cartilaginous rod which is usually round in transverse section constitutes the “core” of this organ, enabling the barbels to jut out from the body and function like ‘the walking stick of the blinds’ (Harder, 1975). Barbels are generally round in transverse section, but sometimes also appear oval. Barbels can be considered as sensory organs because it consists of taste-buds and free nerve endings. This organ helps fish to find food especially in murky water when visualization is not efficient to relay input. The free nerve endings are distributed within this simplest type of sensory organs. In vertebrates, these endings extend out from the dendrites of neurons which have somas located within the central nervous system. These dendrites go to the surface of the animal and branch out to form networks there. Apart from that, these nerve-networks are also responsible for touch-sensitivity in fishes.

Nothing is known whether this extra appendage has any relationship with the cerebellum, henceforth giving hint regarding the different orientation of cerebellum. It was interesting to note that both *keli* and *baung* which had rostrally directed cerebellum displayed two pairs of striking barbels. On the other hand, *jelawat* with caudally directed cerebellum displayed a pair of small barbels.

Table 2.1: Features of selected freshwater fishes.

FISHES / FEATURES	Rostral cerebellar orientation		Caudal cerebellar orientation	
	Keli	***Baung***	***Jelawat***	***Tilapia***
BODY SHAPE	Torpedo-shaped	Torpedo-shaped	Compressed	Compressed (with wide vertical height)
SPINES	Yes	Yes	No	No
BARBELS	Yes	Yes	Yes	No
LOCATION OF EYES	Dorso-lateral of the head	Dorso-lateral of the head	On the sides of the head	On the sides of the head
SHAPE OF CAUDAL FIN	Rounded	Forked	Forked	Slightly forked
SWIMMING MODE	Anguilliform/ Subcarangiform	Subcarangiform	Subcarangiform	Carangiform
MOVEMENT PATTERN OF PECTORAL FIN	“Semi-circle movement”	“Semi-circle movement”	“Side-to-side movement”	“Side-to-side movement”
BODY CROSS SECTION	Round	Round	Oval	Oval
VERTICAL COMMON LOCATION	Bottom-dweller	Bottom-dweller	Mid-water fishes	Mid-water fishes

Since the cerebellum plays very important role in movement, especially in fine movements and musculature control, it could be assumed that the swimming mode would also be affected by the cerebellar features. The involvement of cerebellum in fish’s motor control has been suggested by Kazumasa (2007) and co-worker. They stated that nucleus of medial longitudinal fascicles (Nflm) is the brain region that induces the swimming, while nucleus ruber plays a role in the control of appendage movement. This is as a result of the neuronal activities in corpus, valvula cerebelli, diencephalon and optic tectum.

The swimming mode of fish must have correlation with the body segmentation since the propulsion power is generated by the function of musculature and nervous system. The locomotion of fish is achieved by either movements of body and/or caudal fin or median and/or paired fin propulsion (Michael et al., 1999). Caudal fin served as a propeller, thus the shape of this fin indicates how fast the fish can swim. The fish with forked caudal fin is a fast swimmer; the deeper the fork, the faster would the fish be. As for the fish that has rounded caudal fin, it is a slow swimmer but capable of changing the action or speed swiftly; an important characteristic for predator (Yu and Wang, 2005; Aalbers et al., 2010). The finding in this study is in agreement with this established information; both *baung* and *jelawat* had forked caudal fin and they were fast swimmers. In contrast, *keli* that had rounded caudal fin was definitely a slow swimmer but very flexible and able to conduct other actions. However, *tilapia* whose caudal fin was slightly forked could be considered as fast swimmer, but slower than *baung* and *jelawat*.

The world fish database (FishBase) showed that most of our local Malaysian freshwater fishes demonstrated subcarangiform locomotion regardless what their body shapes are (Froese and Pauly, 2012). However, it was sometimes hard to determine certain fish locomotion; whether it is subcarangiform or anguilliform. This is because the anguilliform mode can merge unnoticeably into the subcarangiform mode (William and David, 1978). As mentioned earlier, both fishes with the rostrally directed cerebellum (*keli* and *baung*) had the same body shape and demonstrated the same subcarangiform swimming mode. In addition, *keli* also demonstrated the anguilliform mode. This is in agreement with Schepper et al. (2003), who reported that *Clarias gariepinus* applied the combination of both anguilliform and subcarangiform modes of movement. In contrast, *jelawat* and *tilapia* with the caudally directed cerebellum demonstrated different swimming mode from each other although they had the same body shape. *Keli, baung* and *jelawat* demonstrated the same swimming mode although they were classified as having different body shapes. However, *jelawat's* body shape is not so similar to *tilapia* which displayed a carangiform locomotion. Thus, the shape of the body is not a sole determinant of the swimming mode of a fish, but it is probably one of the contributing factors.