JOURNAL OF TROPICAL LIFE SCIENCE

2024, Vol. 14, No. 2, 263 – 268 http://dx.doi.org/10.11594/jtls.14.02.06

Research Article

Unlocking the Mysteries of Reproduction: Exploring Fecundity and Gonadosomatic Index in the Enigmatic Bornean Pygmy Halfbeak, *Dermogenys colletei* (Meisner, 2001) (Beloniformes: Zenarchopteridae)

Kamil Latif ¹*, Lirong Yu Abit ², Abdulla-Al-Asif ¹, Leonard Umban Pengarah ¹

² Curtin Aquaculture Research Laboratories, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250,98009, Miri, Sarawak, Malaysia

Article history:	ABSTRACT
Submission November 2023 Revised January 2024 Accepted January 2024 * <i>Corresponding author</i> : E-mail: kamill@upm.edu.my	The pygmy halfbeak <i>Dermogenys colletei</i> , is known for its viviparous nature, this presents an intriguing case of relatively low fecundity, raising questions about potential compensatory reproductive strategies employed by this species. Our study delves into the examination of fecundity and the Gonadosomatic Index (GSI) in the Pygmy Halfbeak, <i>D. colletei</i> (Meisner, 2001), an intriguing viviparous fish indigenous to Sarawak, Borneo. We hypothesize that the Pygmy halfbeak, <i>D. colletei</i> , may exhibit unique reproductive adaptations to offset its low fecundity, thus enhancing its survival and fitness. To address this, we conducted a comprehensive study utilizing 28 mature female specimens of <i>D. colletei</i> , carefully measuring fecundity and GSI to shed light on the reproductive adaptations of this species. Our findings reveal that <i>D. colletei</i> indeed exhibits low fecundity, with a mean of 16.76 ± 2.01 , and a mean GSI of 12.83 ± 1.27 , providing crucial insights into the reproductive mechanisms at play in this species. These results underscore the existence of unique reproductive strategies in <i>D. colletei</i> , enabling its adaptation and persistence in Borneo's diverse aquatic ecosystems, and call for further ecological research to elucidate these mechanisms. This study lends to a better understanding of viviparous fish in Borneo and contributes to the broader field of aquatic ecology, enhancing our knowledge of species adaptations to unique ecological challenges.
	<i>Keywords:</i> Aquatic ecosystems, Reproductive adaptations, Reproductive strategies, Sarawak biodiversity, Viviparous fish

Introduction

Halfbeaks are a largely ignored group of fish which are a representation of the convergent evolution of viviparity in fish which occurred in Southeast Asia [1]. The genus *Dermogenys* is the smallest in size among the Zenarchopterids, with members inhabiting both fresh and brackish water environments [2, 3]. There are currently 12 recognized species of *Dermogenys* inhabiting Southeast Asian inland waters [4]. *Dermogenys colletei*, or the pygmy halfbeak, is relatively new to science, being first described by Amy Downing Weisner in 2001 with the type locality given as Kuching, Sarawak [4]. The pygmy halfbeak *D. colletei* has a broad distribution across Southeast Asia including Malaysian Borneo [5]. This fish inhabits small streams and ponds in both fresh and brackish water with pH ranging from neutral to acidic (approximate pH=5-7) [4, 6]. *D. collettei* can be differentiated from the superficially similar-looking forest halfbeak, *Hemirhamphodon pogonognathus* by examining the dorsal fin which begins behind the anal fin [4]. Freshwater halfbeaks are known for their elongated lower jaw protruding well beyond the shorter upper jaw [7]. Like all members of the genus *Dermogenys*, *D. colletei* are viviparous, with the young developing inside the body of their

How to cite:

¹ Department of Animal Science and Fishery, Faculty of Agricultural and Forestry Sciences, University Putra Malaysia, Bintulu Campus, Nyabau Road, 97008 Bintulu, Sarawak, Malaysia

Latif K, Abit LY, Al-Asif A, Pengarah LU (2024) Unlocking the mysteries of reproduction: Exploring fecundity and Gonadosomatic Index in the Enigmatic Bornean Pygmy Halfbeak, *Dermogenys colletei* (Meisner, 2001) (Beloniformes: Zenarchopteridae). Journal of Tropical Life Science 14 (2): 263 – 268. doi: 10.11594/jtls.14.02.06.

mothers resulting in the birth of live offspring [3]. Young halfbeaks are initially born without their asymmetrical beaks which develop as they mature [8]. The elongated lower jaw is used primarily for capturing prev on the water surface which is the primary ecological niche of this fish. Pygmy halfbeaks such as D. colletei are sexually dimorphic in terms of size whereby adult females are conspicuously larger than their male counterparts, the species is also sexually dichromatic with mature males being more brightly coloured in yellow and red than females [8, 9]. D. colletei is listed as Least Concern under the IUCN Red list. Members of the genus Dermogenys are commonly traded as ornamental fishes, frequently mislabelled under the umbrella name of D. pusilla ("wrestling halfbeak") which has caused confusion over species identity and origin. They are also of incidental economic value as food fish in regional markets of Thailand, Vietnam and Cambodia [3]. Species from the Genus Dermogenys are an especially popular table fish in Cambodia as a source of vitamin A for the locals [10]. Across Thailand, Dermogenys are also sometimes used as fighting fish for gambling, taking advantage of the combative and pugilistic nature of mature males of this genus towards each other [11].

There is a scarcity of available information about this particular fish species, but the limited data that is accessible proves to be highly valuable. This information, while sparse, offers insights into various aspects of the fish's behaviour, including shoaling and mating [1, 12, 13]. There are several reproductive strategies employed by various fish species to ensure the survival of their spawn till maturity, these differing strategies are expressed as tactics such as fecundity, spawning period and size at first maturity, the collection of information on such reproductive aspects is essential to fish biologists especially in terms of accessing conservation of fish stocks within their natural habitats [14]. There is still a lack of detailed studies on indigenous fish species of lesser economic value inhabiting the lotic systems of Malaysia [15]. Basic information on the reproductive biology of different fish species is essential to allow many wider aspects of research, such as ecology, distribution, and aquaculture, to be carried out. Gonadosomatic Index (GSI) and fecundity are both essential parameters used for analysing aspects of the reproductive biology of different fish species [16].

Currently, there is no published information

on the fecundity and GSI of *D. collettei*. Thus, the purpose of this study was to record the fecundity and GSI of *D. colletei*. We hypothesized that the Pygmy halfbeak, *D. colletei*, may exhibit unique reproductive adaptations to offset its low fecundity, thus enhancing its survival. Addressing the hypothesis, we investigated the fecundity and GSI with specific reproductive strategies employed by the Pygmy halfbeak. The current study extends to a better understanding on viviparous fish in Borneo and contributes to the broader field of aquatic ecology, enhancing our knowledge of species adaptations to unique ecological challenges.

Material and Methods *Distribution*

The known distribution of *D. colletei* are in the freshwater areas of Thailand, Malaysia, Singapore, and Indonesia (Figure 1).

Study Location, and Sampling

Quantitative samples of *D. colletei* were captured from a single stream flowing through the Universiti Putra Malaysia, Bintulu Campus (UPMKB) located within the State of Sarawak, Malaysia (Figure 2).

The sampling site was accessible by both road and foot (within 200 meters of the main road) (Coordinates: 3º 12' 43.104" N, 113º 5' 32.6328" E). The stream was generally fast flowing, broken up by deeper pools of slower-moving water and approximately less than 5 meters in maximum width and 200 cm in maximum depth (Figure 3). Fish were collected from the surface of the water using scoop nets in the daytime wherever they were spotted. A total of 28 mature female specimens at various stages of ovarian development were collected in the month of March 2022. The study was carried out from 10th March 2022 until 5th April 2022, at the Aquatic Nutrition Laboratory, Faculty of Agricultural Science and Forestry, 3rd Floor, Department of Animal Science and Fishery, Universiti Putra Malaysia.

Estimation of Fecundity

In order to determine fecundity, ovaries were removed from 18 mature female fish; dissection of specimens was carried out under a binocular stereoscopic microscope (Leica Zoom Gxm L3200 at 40 X magnification). The total number of mature oocytes within each ovary was counted for each individual fish and the average was taken as the



Figure 1. Known distribution range of Dermogenys colletei (Adapted from Information in Meisner [4]).



Figure 2. Map of stream within UPMKB, Bintulu, Sarawak, Malaysia where the samples of *Dermogenys colletei* were collected.

value of fecundity as per the methods of [17]. The diameter of the oocytes was estimated using a micrometer slide. The fecundity was determined through the equation as follows:

Fecundity = Number of mature oocytes in the

ovaries prior to spawning

Estimation of GSI

The GSI was calculated according to the following formula by Wootton et al. [18],

$$GSI = (Wg/Wt) \times 100$$

Where, Wg= Percentage of the gonadal weight Wt= Total body weight



Figure 3. Sampling location of collecting Dermogenys colletei specimen



Figure 4. Ovaries extracted from Dermogenys colletei showing mature oocytes

Ovarian weight was measured using a 2-decimal place digital scale (0.01g).

Results and Discussion

D. colletei, being a viviparous live-bearing fish species, undergoes internal fertilization, with the embryos developing within the females. These developing embryos rely exclusively on the yolk sac for their nutritional needs until they are born as fully developed fish [19–21]. Notably, our

examination of mature ovaries revealed that each female typically carries fewer than 20 eggs per fish (Figure 4).

Our investigation unveiled that the fecundity of *D. colletei* aligns with the common trend observed in most live-bearing fish, reflecting a relatively low reproductive capacity, with a calculated mean fecundity of 16.76 ± 2.01 . Additionally, the mean value of GSI of this species was 12.83 ± 1.27 (Table 1). Similar fecundity and GSI values have

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 Table 1. Fecundity and Gonadosomatic Index (GSI) (values are presented as mean value ± SE) of Dermogenys colletei

Ovarian Weight (g)	Oocyte diameter (mm)	Fecundity	GSI
0.11 ± 0.012	1.66 ± 0.03	16.76 ± 2.01	12.83±1.27



Figure 5. Incubating fish larvae of Dermogenys colletei showing the undepleted yolk sac

also been documented in certain smaller indigenous fish species, such as *Osteobrama cotio cotio* that was found in Bangladesh and *Pseudecheneis sulcata* from Nepal [22, 23].

Mature females of D. colletei were observed to produce relatively large lecithotrophic eggs, a characteristic shared with other members of the Dermogenys genus [24, 25]. These eggs provide ample nutrition to the developing embryo throughout the gestation period, ensuring their well-being until birth [19, 20, 26] (Figure 5). The calculated GSI for *D. colletei*, with a mean value of $12.83 \pm$ 1.27, emerged as a valuable parameter for the investigation of the reproductive aspects of this species, particularly in detecting its reproductive period. For finfishes, both GSI and fecundity are indicators of reproductive activity with the frequency of distribution of the different stages of gonadal maturity being determined by an association to GSI [27]. This metric holds promise for further research aimed at the understanding of the reproductive dynamics and behaviours of D. colletei.

Conclusion

This study has provided valuable insights on the fecundity and GSI of Dermogenys colletei in Bintulu, Sarawak, Malaysia. This finding hold significant implications for fish biologists and researchers interested in further exploring various aspects of this species. Specifically, the data generated in this study can serve as a foundational resource in understanding the critical factors such as the species' spawning season, aiding in the development of conservation strategies, and informing fisheries management practices. As such, this research contributes to broader understanding of the ecology and reproductive dynamics of *D. colletei*, facilitating the development of informed conservation and management efforts for this unique viviparous fish species.

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