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Reproductive biology and feeding habit of *Coilia dussumieri* Valenciennes, 1848 (Actinopteri: Engraulidae): A review

Mousumi Akhter [1], Md. Monjurul Hasan [2, *], Abu Bakker Siddique Khan [1], Md. Rahamat Ullah [2], Aovijite Bosu [2], Farhana Yasmin [2], Mohammed Ashraful Haque [2], Md. Amirul Islam [3] and Yahia Mahmud [4]

[1] *Bangladesh Fisheries Research Institute, Marine Fisheries and Technology Station, Cox's Bazar-4700, Bangladesh.*
[2] *Bangladesh Fisheries Research Institute, Riverine Sub-Station, Khepupara, Patuakhali-8650, Bangladesh.*
[3] *Bangladesh Fisheries Research Institute, Riverine Station, Chandpur-3602, Bangladesh.*
[4] *Bangladesh Fisheries Research Institute, Headquarter, Mymensingh-2201, Bangladesh.*

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Abstract

Coilia dussumieri, regularly referred to as the goldspotted grenadier anchovy, is a ray-finned fish species that pertains to the Engraulidae family. Estuaries and maritime waters bordering Bangladesh, Myanmar, and India are home to it. On top of that, it can be found from Thailand south to Java and the Malay Peninsula. Any species' genetic features must be scrutinized in order to govern its population smoothly and figure out whether it is well-suited for culture. Fish biology encompasses a broad spectrum of disciplines, consisting of an in-depth overview of their stature, progression, gonado-somatic index (GSI), prime mating period, and fetal growth. Biology regarding consumption and procreation has been the focus of numerous research efforts in the recent past. The main goal of this review work is to bring together the disparate information, identify the knowledge gaps for additional research on this fish species, and provide aqua culturists with some information for future, more in-depth research on the culture, management, and breeding of *Coilia dussumieri*.

Keywords: *Coilia dussumieri*; Growth; GSI; Fecundity; Spawning; Feeding

1. Introduction

Anchovies are freshwater and estuarine aquatic animals of the family Engraulidae (Order: Clupeiformes), closely connected to herring and marked by a large jaw. Anchovies are common forage fish that circulate widely in tropical and subtropical waters. *Coilia dussumieri* (Valenciennes, 1848) is known as gold-spotted grenadier anchovies in England, referred to as Mandeli in Bombay and Gujarat, and called "Oluua maach" in coastal areas of Bangladesh [1]. According to [9], *C. dussumieri* is a widespread species in Bangladesh, Indonesia, Malaysia, Myanmar, Pakistan, Singapore, Sri Lanka, Thailand, and Vietnam. This type of fish, *C. dussumieri*, follows a systematic migration pattern between freshwater and the sea, engaging not only in reproduction but also in intensive feeding, as mentioned in [21]. Ostracods, isopods, mysids, and fish eggs or larvae make up its main diet. It is dioecious in nature, demonstrates external fertilization, breeds in open water where eggs can be disseminated, and can withstand a wide variety of salinities [22]. The inner continental shelf's open coastal areas, which provide food and protection from predators, are where most anchovies give birth to their young. It arranged the eggs spherically and in a buoyant or pelagic form [4]. The body is constricted and elongated, the inferior mouth covered with cycloid scales, and fatty tissue deposits. Since *C. dussumieri* has been stated to relocate between the outer region and the oceanic shelf in most saline estuary territories, it is likely that it spawns in the coastal area close to the Ye River Estuary [26]. According to gonad studies, the main spawning season occurs in May and June. Fecundity ranged from 723 to 6200, with fish weighing between 3.05 g and 11.87 g and

* Corresponding author: Md. Monjurul Hasan

10.2 to 13.3 cm in length, respectively [23]. The stock assessment and dynamics of *Coilia dussumieri* along India's northwest coast were the main subjects of [6] investigation in 1988. *C. dussumieri's* fishery and biology were studied by [17] on the coast of West Bengal. The male-to-female ratio was 1:0.15, according to their statistics. [13] revised *C. dussumieri's* early life ordination in Myanmar's southern coastal region. There is some literature on the *C. dussumieri* population dynamics in the Bangladeshi Cox's Bazar region [14] [16]. However, little is known about the reproductive biology and dietary habits of the Mid-Southern coastal area. The ambition of this research endeavor was to comprehend more concerning the reproductive biology of *C. dussumieri* on the Kuakata coast in Bangladesh. The overarching objective of this study is to help safeguard Bangladesh's fisheries and strengthen the country's blue economy through investigating the reproductive biology and feeding routines of *C. dussumieri.*

2. Material and methods

From online databases that incorporate Google Scholar, Web of Science, Academia, and Scopus, multiple studies on the reproductive biology of *C. dussumieri* were acquired. The biological makeup of the gold-spotted grenadier anchovy was touched upon in this review, comprising food and nourishment, sex ratio, size at first maturity, fecundity, reproduction, season, colour, size, habitat, geographical distribution, breeding, spawning cycle, and ponderal index. Spotting out the biology of *C. dussumieri*, which can be detected on Bangladesh's Mid-Southern coast, will be substantially smoother through the course of this comprehensive review.

Classification

- Phylum: Chordata
- Class: Actinopterygii
- Order: Clupeiformes
- Family: Engraulidae
- Genus: *Coilia*
- Species: *C. dussumieri* (Valenciennes, 1848) (Source: [34])

3. Diagnostic characters

A convex tummy and a downward-curved body were trademarks of *C. dussumieri*. A minimal, spine-like scute is positioned beforehand at the dorsal-fin origin, maxilla that is surprisingly diminutive and doesn't entirely stretch to the exterior of the gill concealment. The very first premaxilla is expansive; there are two premaxillae. Little dentition in the jaw. serrae wholly loosely assembled on average possess tiny gill rakers. A branchiostegal ray has 10 to 12 (hardly ever 9) strands, embarking on the first third of the torso, with a dorsal fin that sweeps uphill. The caudal fin and anal fin are hyperlinked at the back via a minimum of 80 fin rays across every fin, tiny and substantially pointed caudal fin accomplish rendering throughout the isthmus. There are numerous proximal transverse grooves and only a few sparsely reticulated streaks on the anterior portions along the flanks. Conceptually, the greatest permissible dimension is 20 cm, and customary wholehearted diameters oscillate between 13 and 17 cm [12]. On the abdominal cavity, flanks, isthmus, inferior jaw's edge, cheek, and gill cover, ridges of golden or iridescent pigment can be discerned behind the veil of scales.

4. Feeding biology

[13] asserts that *C. dussumieri* predominantly devours copepod nymphs in conjunction with prawn, fish, crab, cypris, mysid, polychaete, isopod, and sagitta larvae. According to [17] the frequency of copepods and ostracods in the gastrointestinal tract constituted only 14.7% and 8.8%, respectively. Fish larvae rendered up 3.5% of the potential stomach content, whereas *Acetes* spp. acquired 23.7%. *C. dussumieri*'s preferred nutrient sources manifest as copepods and other *Acetes* species. [35] investigated the feeding regime of *C. dussumieri*.

The feeding activity rose proportionally with the size of the fish, reaching its peak between May and August and hitting its lowest point from January to April. Fishes measuring less than 12.5 cm primarily consumed zooplankton, particularly copepods, Cladocera, and foraminifera. Beyond this size threshold, their diet shifted mainly to nekton, with *Acetes* constituting 61.20% and teleost juveniles making up 27.16% of their diet. [5] encountered an association between the measurements of the copepod nauplius and *C. dussumieri* in Great South Bay, New York, and attributed this intimacy to anchovy longevity. According to [31], circumstance promotes taking note of divergence in the species' general state of health, which can be modulated by an assortment of instances, notably the provision of nourishment. The optimal

physiological state between September and February may have been attributed to better gastrointestinal requirements throughout this period.

5. Reproductive biology

The five stages of maturity were considered to categorize the female *C. dussumieri* into one of five stages based on the egg maturation stages. These developmental stages were referred to as (i) immature, (ii) maturing, (iii) ripening, (iv) ripe, and (v) spent [18-19] [20] [25] [27].

- Stage I. Immature

Ovaries between 10 mm and 22.5 mm in length include many microscopic, yolkless eggs as well as small, completely transparent elongated ovaries with diameters ranging from 0.07472 mm to 0.1868 mm [7].

- Stage II. Maturing

Granular, slightly enlarged ovaries between the lengths of 13 and 36 mm. Along with the supply of entirely transparent, immature ova, there are also a few maturing ova present. These are white, opaque, and loaded with yolk. The greatest diameter of mature ova is 0.7472 mm, although their typical size is 0.5604 mm [7].

- Stage III. Ripening

The ovary is flat and gray, densely packed with easily distinguishable eggs. It varies in length from 19 to 38 mm. The eggs are sizable, round, and rich in yolk. They expand to a thickness of 0.08406 mm and develop a noticeable perivitelline space. Most of them have a diameter larger than 1.0274 mm, with the possibility of exceeding this size despite their origin [7].

- Stage IV. Ripe

The samples contained no fish that were ripe. Although [3] found a few fish in this stage, [15] likewise could not find any ripe specimens [7].

- Stage V. Spent

The ovaries exhibited characteristics of being flaccid, bloodshot, and contracted, measuring between 26 and 28 mm in length. Within these ovaries, a significant portion consisted of immature and small maturing ova with a diameter of up to 0.5604 mm, alongside a smaller quantity of larger remaining ova ranging from 1.0 mm to 1.23 mm. These larger ova were transparent, featured segmented yolks, and contained 10 to 15 oil globules. Subsequently, the oocytes were categorized into distinct groups: 1) unyoked; 2) partially yoked; 3) advanced yoked; 4) with a wandering nucleus or appropriately hydrated. From August to March, the majority of the ovaries displayed advanced maturation stages, transitioning to immature and recovering stages from April to July. In September, nearly 40% of the females exhibited early spawning stage activity. The reproductive season of the serial spawner *C. dussumieri* spans from August to March according to [13].

5.1 Gonado-Somatic Index

The average Gonadosomatic Index (GSI) values increased from August to February, reaching their peak in September. Lower levels were observed between April and June. [13] highlighted a significant reproductive phase occurring from late winter to late summer, along with a recuperation period from April to June, based on the relatively high GSI values recorded between August and March. Interestingly, only a few early entrants (TL>30 mm) were observed in summer, which appears to mark the conclusion of the reproductive season. These early recruits typically appear in winter and spring, presenting an intriguing pattern. Although the Gonadosomatic Index (GSI) is relatively low, spawning is expected to begin in the winter. This is attributed to the presence of numerous individuals measuring 76-92 mm in total length (TL), which join adults in deeper bay areas. Additionally, the optimal fish condition observed between September and February, aligning with GSI peaks according to [33], further supports the likelihood of spawning during the winter months. Serial spawner *Coilia dussumieri* has a reproductive phase of August through March, which is timed to the extending photoperiod in the watershed area of the Ye River Estuary. Serial spawn is highlighted by the appearance of ripe folks between October and February that transmit eggs at multiple phases of development (Oocytes 1, 2, 3, and 4 being the most prominent). Monthly changes in gonadosomatic index were notably influenced by factors such as bottom

temperature (20.52%), net primary productivity (13.10%), and chlorophyll-a (3.21%). Additionally, the predator-prey weight ratio was significantly associated with bottom temperature, accounting for 38.66% of the variation [35].

5.2 Ponderal Index

The Ponderal index was calculated by [7].

$$K=W/L^3\times10^7$$

Where, K=Ponderal index, W=Weight of fish in gram, L=Total length of fish in mm.

The sums of ponderal index values were calculated repeatedly to obtain the average numeric values for each size group and month. As noted in reference [24], adolescents generally display higher K values compared to older fish. Assessing the initial maturity involves estimating the changes in K values at different lengths. The K values exhibit seemingly random fluctuations between the length categories of 91-95 mm and 121-125 mm in both sexes. The absence of a clear pattern in K values across entirely different length groups may be attributed to significant variations in the fish size at different maturation stages. According to reference [25], the seasonal variations in K levels do not align with the fish's spawning season.

5.3 Size at first maturity (Lm)

In determining the size of initial maturity, any females carrying eggs exceeding 0.1868 mm were considered as fish in the maturation process, indicating their readiness to reproduce in the months ahead [7]. Females reach sexual maturity at 6 or 7 months and 12 cm in total length. A single female can give birth to two young every year, with a maximum of six months spanning each spawning. As reported by Naung [13], the individual sizes varied from 18 to 112 mm total length (TL), with the majority falling within the range of 22 to 56 mm TL. Female maturity, as determined through gonadal assessments [24], occurred between 131 and 140 mm. The overall total length ranged from 7.0 cm to 21.0 cm, and the sex ratio (F/M) was 1.09. Females typically reach sexual maturity at 14.7 cm, while males attain sexual maturity at 14.5 cm [35].

5.4 Fecundity

The fish's length and weight range between 10.2 and 13.3 cm and 3.05 g and 11.87 g, respectively, while fecundity was between 723 and 6200. A female measuring 10.2 cm in length and weighing 3.05 g had a minimum of 723 oocytes. A female with a weight of 11.87g and a length of 13.3cm turned out to have up to 6200 oocytes. The documented fecundity was 3131.5 on average. The absolute fecundity spanned from 4254 to 21,334 eggs, averaging 10,607. The diameter of the eggs showed a range of 240 μm to 960 μm, with a distinctive peak occurring at 701–800 μm [35]. According to [17], their proportion of mature eggs to body mass ranged from 149.52 to 3752.21, with an average of 404.36. Each spawning is projected to yield between 1200 and 4200 eggs, contingent upon the species.

5.5 Spawning season

The nesting and nursery areas are along the outer edge of the 40-metre isobath. In India, the pre-monsoon months (March to May) are when spawning and recruiting are at their greatest. [2] initially described *C. dussumieri* as an offshore grower with a long-lasting spawning period in 1952 [15]. Pragmatically, fish in stage III (ripening) occur from October to March, with most squandered fish being taken in December. The ripening (III) stage ratio was increased during the *C. dussumieri* spawning season, which lasted from September to March [7]. Most members of the Engraulidae family typically reproduce in coastal areas, and their eggs and larval stages migrate into estuaries and bays, where they benefit from shelter and ample food resources [28-29]. By approaching recruitment sites adjacent to the estuary's sandy beach and reducing high death rates for eggs, larvae, and young of the year during this crucial time, *C. dussumieri* may be able to maximize recruitment there [30]. The potential spawning can be determined by dividing the quantity of eggs in the most developed stage by the remaining maturing eggs within the total count [11]. Assessment and recruitment of the spawning season in the Ye River estuary were conducted by [13]. He discovered that reproduction occurs between August and March, with September having the highest GSI value. The gonads of both males and females undergo considerable cyclical morphological changes just before accomplishing full maturity. In the pre-spawning stage, which lasts from January through February, the gonads fully mature. The idea that this species spawns when there is an abundance of food fits with the optimal conditions for *C. dussumieri* during the period of spawning. Despite [31] view that the spawning period is one of high energetic loss and consequently low condition. According to [32], the food consumed during the actual spawning period must provide most of the energy needed for spawning. The body's gametes undergo release between the months of March and July, triggering fertilization (the spawning period), and after spawning, an entirely fresh crop of germinal cells is formed (the post-spawning period), which gradually matures

throughout the rest of the year to get primed for the following season [16]. According to [8], *C. mystus* in the Chinese Yangtze River Estuary encountered an extensive spawning season across the same months. The lower Yangtze River's female *C. ectenes* commenced breeding close to May, according to [10].

6. Conclusion

There have been many endeavors to comprehend the dietary and mating biology of *C. dussumieri,* mainly in Bangladesh and India, but there isn't much splurge there that can aid the fisheries for this species. Only adult fish have had their feeding succession and dietary choices, along with their size and weight categorization, extensively analyzed. For any age cohort or substantial variance in dietary preferences, there is no such exhaustive information accessible. Added to that, it is tenebrous when eggs and larvae come up and how long it takes for them to progress to deployment size. On the other hand, there is a wealth of expertise addressing the biology of this fish species' breeding; every research effort has revealed the superiority of males over females in the population, and most of them have labelled *C. dussumieri* as a low embryonic fish. Although discrepancies in breeding rhythm and hatching recapitulation have been noted in previously charted data, this data additionally fails to provide any pertinent research on the hyperlink between breeding regularity and hydrodynamic and photoperiodic factors. Therefore, there is a plethora of accessibility for research in this discipline to make high-profile contributions to our grasp of the biology of feeding and reproduction in *C. dussumieri.*

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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