Impact of eco-hydrological factors on growth of Asian stinging catfish

Heteropneustes fossilis (Bloch, 1794) in Wetland Ecosystem

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ABSTRACT
Our research demonstrates the impacts of eco-hydrological factors (Temperature, rainfall, dissolved oxygen, pH, total dissolved solids and alkalinity) on the growth of Asian stinging catfish Heteropneustes fossilis (Bloch, 1794) in the Ganjer Beel wetland ecosystem, northwestern Bangladesh. This study was conducted in the Gajner Beel wetland ecosystem which is located at Sujanagar under Pabna District, NW Bangladesh. Eight hundreds forty five (845) fish individuals were collected from January to December 2019. Total length (TL) and body weight (BW) were measured using measuring board and electronic balance with 0.01cm and 0.01g, precision. Length-weight relationship was calculated by this equation: \( W = a \times L^b \). TL was ranged from 6.30–24.10 cm and BW was 1.20–83.94 g. Overall growth pattern (GP) was positive allometric of H. fossilis in this wetland. Among the eco- hydrological factors temperature, DO and pH showed significant correlation with the growth pattern of H. fossilis. Finally, these findings will be useful for further studies and to suggest sound policy for the sustainable management of H. fossilis in the wetland ecosystems.

INTRODUCTION
A wetland is an area of land contiguous to a river or stream that expanses from the banks of its channel to the base of the encircling valley walls and which flooded during periods of high discharge (Goudie, 2004). Additionally, Beels are made by cataclysm of low-lying lands during diluvium, where some water becomes entrapped even after flood waters get off back from the flood plains (Banglapedia, 2004). Gajner Beel is situated at Sujanagar, Pabna in the northwestern (NW) Bangladesh. This Beel used as an imperative
feeding and spawning ground by many freshwater fish species. Near about 0.5 million people of surrounding villages of this Beel are directly or indirectly reliant on this wetland for their livelihood (Mazid et al. 2005).

Catfish are most important for relative biological studies because their phylogenetic position places them near to a common fish ancestor than most bony fish (Liu et al., 2016). The stinging catfish Heteropneutes fossilis (Bloch, 1794), is the part of Heteropneustidae family (Siluriformes) generally known as the ‘Shingi or Singhee’ in Bangladesh (Rahman et al., 2019a). It is extensively distributed in Bangladesh, India, Pakistan, Laos, Myanmar, Nepal, Sri Lanka, and Thailand (Talwar and Jhingran, 1991). Adults live in ditches, ponds, marshes, swamps, and sometimes in muddy rivers (Halwart and Gupta, 2004). This catfish is an important food fish as it contains high amounts of protein, iron (226 mg/100g) and calcium (Saha and Guha, 1939) and they also have high market price (Alok et al., 1993). H. fossilis is categorized as least concern both in Bangladesh (IUCN Bangladesh, 2015) and worldwide (IUCN, 2020).

Knowledge about the length-weight relationships (LWRs) of a fish species is essential to transformation of their length form into the weight. Although the LWRs are mostly helpful for the researcher for observing the well-being of fishes (Ecoutin et al., 2005; Hossain et al., 2009; Hassan et al., 2020). It is broadly used in the exploration of fishery data, typically because of the firmness and time mandatory to record weight in the field (Andrade and Camos, 2002). Estimation of stock size, production, recruitment and mortality of fish growth are used as a very important tools and it also used to manage the fisheries resources (Issac, 1990; Tracey et al., 2007).

Climate change is considered as an important hazard to fisheries along with other different risk such as overfishing, pollution and habitat deterioration (Rose, 2005; Sabbir et al., 2020). Climatic factors mainly temperature and rainfall has constant effect on fish growth and survival (Shoji et al., 2011; Sabbir et al., 2020). Temperature is the most significant climatic factor regulating the progresses of larval accumulations of freshwater as well as marine species (Houde and Zastrow, 1993; Jakobsen et al., 2009). Similarly, rainfall is a basic climatic factor influencing the entire chain of hydrological events through runoff and river inflow (Patrick, 2016). To ensure comprehensive fish health, it is urgent to maintain an optimum DO (dissolved oxygen) level for physiological and metabolic activities. The DO requirement increases with increasing fish size during grow out period (Abdel-Tawwab et al., 2015). Alternatively, pH indicates whether the habitat is acidic or alkaline condition. Higher level of pH (9-14) not only affects fish by denaturing cell membranes but also alter other water quality parameters (Brown and Sadler, 1989).

However, a very few researches have been done on different aspects including LWRs (Alam and Ferdaushy, 2015) and length-weight relationships (LWRs) (Muhammad et al., 2017; Alam and Ferdaushy, 2015; Das et al., 2015; Hossain et al., 2017; Khan et al., 2012; Rahman et al., 2019a). To the best of our knowledge, there was
no works on this aspect of \textit{H. fossilis} in the Gajner Beel even though whole the world. Therefore, this is the first study which gives clear explanation on the effect of eco-hydrological parameters on growth of \textit{H. fossilis} in the Gajner Beel Wetland Ecosystem, northwestern Bangladesh.

**MATERIALS AND METHODS**

**Study site and sampling**

Eight hundreds forty five individuals of \textit{H. fossilis} were collected during January to December 2019 from the Gajner Beel, NW Bangladesh (Fig. 1). Samples (70–90 individuals/month) were gathered from the fisher. Seine net, and gill net were used by fishers to catch the fish samples. Fishes were instantly kept in ice on the spot and on the arrival to laboratory fixed them with 10% buffered solution.

![Fig. 1. Sampling sites in the Gajner Beel (indicated by red circle), northwestern Bangladesh.](image)

**Fish measurement**

Lengths were measured (e.g., TL, SL) by using a measuring board and total weight (BW) were taken by an electronic balance. Sex was identified by the help of meristic and morphometric features of this fish.

**Growth pattern**

According to Le Cren (1951), LWRs was calculated by: $W = a \times L^b$. The parameters $a$ and $b$ were estimated by: $\ln(W) = \ln(a) + b \ln(L)$. In addition, 95% CL of $a$ and $b$ and the $r^2$ were estimated. According to Froese (2006) unacceptable outliers were omitted. Student test (t-test) was used to approve $b$ were significantly different from the isometric value ($b = 3$) (Sokal and Rohlf, 1987).
Eco-climatic parameters
To evaluate the effect of eco-hydrological features on growth of *H. fossilis*, monthly ecological parameters were recorded from the sampling site by using HACH (HQ 40d) digital multi-meter. The collected parameters were temperature (°C), pH and dissolved oxygen (mg/L), TDS (mg/L) and alkalinity (mEq/L). Further, the data of monthly rainfall (mm) were collected from meteorological station of Dhaka, Bangladesh.

Statistical analyses
GraphPad Prism 6.5 software was used for the statistical analyses. Normality of the data was checked before analysis through Violin and Box plot. Moreover, the Pearson/Spearman rank test was used to correlate the growth and eco-hydrological parameters. Statistical analyses were performed at 5% (p < 0.05) level of significant.

RESULTS

Growth pattern
The descriptive statistics (TL, BW and estimated parameters of the LWR) of *H. fossilis* in the Gajner Beel were shown in Tables 1 & 2, and LWR is demonstrated in Figure 2. Data (TL, BW) normality was checked with violin and box plot (Fig. 3). Also, normality of regression parameter (*a*) and allometric coefficient (*b*) were checked with box plot (Fig. 4).

![Length-weight relationships of *Heteropneustes fossilis* from the Gajner Beel, northwestern Bangladesh.](image)

**Fig. 2.** Length-weight relationships of *Heteropneustes fossilis* from the Gajner Beel, northwestern Bangladesh.
Fig. 3. Violin and box plot of total length and body weight of *Heteropneustes fossilis* from the Gajner Beel, northwestern Bangladesh.
Fig. 4. Box plot of regression parameter ($a$) and allometric coefficient ($b$) of *Heteropneustes fossilis* from the Gajner Beel, northwestern Bangladesh.
**Table 1:** Descriptive statistics on the length (cm) and weight (g) measurements of *Heteropneutes fossilis* (Bloch, 1794) in the Gajner *Beel*, northwestern Bangladesh

<table>
<thead>
<tr>
<th>Month</th>
<th>n</th>
<th>TL (cm)</th>
<th>BW (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>January</td>
<td>97</td>
<td>7.7</td>
<td>16.6</td>
</tr>
<tr>
<td>March</td>
<td>52</td>
<td>15.10</td>
<td>23.80</td>
</tr>
<tr>
<td>April</td>
<td>84</td>
<td>9.90</td>
<td>16.90</td>
</tr>
<tr>
<td>May</td>
<td>46</td>
<td>10.30</td>
<td>21.70</td>
</tr>
<tr>
<td>June</td>
<td>57</td>
<td>16.30</td>
<td>24.10</td>
</tr>
<tr>
<td>August</td>
<td>79</td>
<td>9.20</td>
<td>18.90</td>
</tr>
<tr>
<td>October</td>
<td>90</td>
<td>11.00</td>
<td>20.90</td>
</tr>
<tr>
<td>November</td>
<td>51</td>
<td>9.90</td>
<td>14.10</td>
</tr>
<tr>
<td>December</td>
<td>68</td>
<td>6.70</td>
<td>14.20</td>
</tr>
</tbody>
</table>

Notes: n, sample size; M, male; F, female; TL, total length (cm); W, body weight (g); min, minimum; max, maximum; SD, standard deviation; CL, confidence limit

Maximum and minimum length was 6.30–24.10 cm TL and BW was 1.20–83.94 g. Maximum TL was found in June and minimum was in December. In the Gajner *Beel* wetland ecosystem, isometric growth ($b=3.07$) are found of *H. fossilis*. Monthly variations of TL, BW and allometric coefficient ($b$) values are shown in Figure 5. Negative growth pattern was found in January and December. Isometric in May and November as well as rest months are showed positive allometric growth. LWR was highly significant (p<0.01), with $r^2$ values ≥ 0.970.
Table 2: Descriptive statistics and estimated parameters of the length-weight relationships (BW = axTL^b) of *Heteropneutes fossilis* (Bloch, 1794) in the Gajner Beel, northwestern Bangladesh

<table>
<thead>
<tr>
<th>Month</th>
<th>n</th>
<th>Regression parameters</th>
<th>GT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>January</td>
<td>97</td>
<td>0.0098</td>
<td>2.72</td>
</tr>
<tr>
<td>February</td>
<td>96</td>
<td>0.0032</td>
<td>3.12</td>
</tr>
<tr>
<td>March</td>
<td>52</td>
<td>0.0023</td>
<td>3.29</td>
</tr>
<tr>
<td>April</td>
<td>84</td>
<td>0.0020</td>
<td>3.30</td>
</tr>
<tr>
<td>May</td>
<td>46</td>
<td>0.0050</td>
<td>3.05</td>
</tr>
<tr>
<td>June</td>
<td>57</td>
<td>0.0014</td>
<td>3.46</td>
</tr>
<tr>
<td>July</td>
<td>70</td>
<td>0.0024</td>
<td>3.32</td>
</tr>
<tr>
<td>August</td>
<td>79</td>
<td>0.0038</td>
<td>3.15</td>
</tr>
<tr>
<td>September</td>
<td>55</td>
<td>0.0027</td>
<td>3.25</td>
</tr>
<tr>
<td>October</td>
<td>90</td>
<td>0.0045</td>
<td>3.10</td>
</tr>
<tr>
<td>November</td>
<td>51</td>
<td>0.0049</td>
<td>3.04</td>
</tr>
<tr>
<td>December</td>
<td>68</td>
<td>0.0062</td>
<td>2.91</td>
</tr>
</tbody>
</table>

Notes: n, sample size; a, b are length-weight relationships parameter; CL, confidence limit; r^2, co-efficient of determination; GT, growth type; -A, negative allometric growth; I, isometric growth; +A, positive allometric growth

Maximum and minimum length was 6.30–24.10 cm TL and BW was 1.20–83.94 g. Maximum TL was found in June and minimum was in December. In the Gajner Beel wetland ecosystem, isometric growth (b=3.07) are found of *H. fossilis*. Monthly variations of TL, BW and allometric coefficient (b) values are shown in Figure 5. Negative growth pattern was found in January and December, Isometric in May and November as well as rest months are showed positive allometric growth. LWR was highly significant (p<0.01), with r^2 values ≥ 0.970.
Impact of eco-hydrology on growth of *H. fossilis*

**Fig. 5.** Monthly variations of total length, body weight and allometric coefficient (*b*) of *Heteropneustes fossilis* in the Gajner Beel, northwestern Bangladesh.

**Eco-climatic parameters**

The growth pattern statistically highly correlated with temperature, DO and pH. However, Rainfall, TDS and alkalinity did not expose any significant correlation with the growth (Table 3). The relationship between *b* and eco-climatic factors are presented in Figure 6 and changes of allometric coefficient *b* values with the changes of hydrological parameters (Temperature, DO and pH) demonstrated in Figure 7.
Fig. 6. Relationship between growth pattern ($b$ values) and different hydrological parameters of *Heteropneutes fossilis* in the wetland ecosystem, northwestern Bangladesh.
Fig. 7. Changes of allometric coefficient ($b$) with the changes of hydrological parameters (Temperature, DO and pH) of *Heteropneutes fossilis* in the wetland ecosystem, northwestern Bangladesh.
Table 3: Relationship between eco-climatic factors with growth pattern of *Heteropneutes fossilis* (Bloch, 1794) in the Gajner Beel, northwestern Bangladesh

<table>
<thead>
<tr>
<th>Relationships</th>
<th>$r_s / r_p$ values</th>
<th>95% CL of $r_s$</th>
<th>$P$ values</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. vs. $b$</td>
<td>$0.6595 r_p$</td>
<td>0.1376 to 0.8948</td>
<td>0.0196</td>
<td>*</td>
</tr>
<tr>
<td>Rain vs. $b$</td>
<td>$-0.5053 r_s$</td>
<td>-0.0967 to 0.8367</td>
<td>0.0938</td>
<td>ns</td>
</tr>
<tr>
<td>DO vs. $b$</td>
<td>$-0.6210 r_p$</td>
<td>-0.8810 to -0.0731</td>
<td>0.0311</td>
<td>*</td>
</tr>
<tr>
<td>pH vs. $b$</td>
<td>$0.7114 r_p$</td>
<td>0.2323 to 0.9127</td>
<td>0.0095</td>
<td>**</td>
</tr>
<tr>
<td>TDS vs. $b$</td>
<td>$0.0001 r_s$</td>
<td>-0.5739 to 0.5741</td>
<td>0.9997</td>
<td>ns</td>
</tr>
<tr>
<td>Alkalinity vs. $b$</td>
<td>$-0.5481 r_s$</td>
<td>0.8536 to 0.0378</td>
<td>0.0650</td>
<td>ns</td>
</tr>
</tbody>
</table>

Note: Temp, temperature (°C); Rain, rainfall (mm); DO, dissolved oxygen (mg/l); TDS, Total dissolve solids; $b$, growth pattern; $r_s$, Spearman rank correlation values; $r_p$, Pearson rank correlation values; CL, confidence limit; $P$, level of significance; ns, not significant; *significant; **highly significant.

**DISCUSSION**

In our research, the maximum length of *H. fossilis* was 24.10 cm in TL which is smaller than 31.0 cm in TL in the Ganga River, India (Khan *et al*., 2012) and 26.80 cm in TL from an earlier study in the Gajner Beel, Bangladesh (Rahman *et al*., 2019a). Knowledge about maximum length is vital to estimate the growth parameters, which is important for development of fisheries resource and their management (Khatun *et al*., 2018, 2019; Parvin *et al*., 2018; Rahman *et al*., 2019b, Nima *et al*., 2020). Based on Froese (2006) $b$ values should keep in the range of 2.5–3.5. In our study, all the $b$ values are within the predictable range. According to Tesch (1971), $b$ values near to 3.0, indicating that fish grow isometric, larger than 3.0 indicate positive allometric and smaller than 3.0 revealed negative allometric. In the current study, over all $b$ value was 3.07 that indicate isometric growth of *H. fossilis* in the Gajner Beel, wetland ecosystem, NW Bangladesh. Positive growth pattern was observed by Khan *et al*. (2012) ($b$=3.14) from the Ganga River, India and Rahman *et al*. (2019a) ($b$=3.08) from the Gajner Beel,
Bangladesh. However, Hossain et al. (2017), in an earlier study in the Gajner Beel during which period, reported isometric growth ($b=3.01$), which is in similar with our study.

However, the fluctuation in growth pattern occur because of some factors such as sex, habitat availability, gonad ripeness, level of stomach fullness, seasonal effect, well-being of fish health, preservation method and deviations in the length class (Hossain et al., 2013, 2018), which are not accounted in this study.

Growth of *H. fossilis* was showed significant relation with temperature, DO and pH. Fish is a poikilothermic animal. Habitat temperature controls the fish body growth rate, temperature, food consumption, and various body functions because of fish is poikilothermic animal (Houlihan et al., 1993; Azevedo et al., 1998; Sigurd et al., 2008). Throughout the study, the maximum water temperature was recorded in May ($31.0^\circ C$) and the minimum was in January ($19.0^\circ C$). Freshwater fish have an optimum growing temperature in the range of 25- 30°C (El-Shebly et al., 2007; Shah et al., 2008; Hossain et al., 2013). The $b$ value showed a positive correlation with temperature. The highest rainfall was observed in June and no precipitation was occurred in the month of December. Rainfall doesn’t show any relation with growth. DO is considered the most vital parameter due to its necessity for aerobic metabolism (Timmons et al., 2001). DO and pH also revealed correlation with growth. According to Biswas and Panigrahi (2015) desired level of DO is 5.0 to 15.0 mg/l. At least 3.0-5.0 mg/l DO is needed of for survive. Similarly, pH is also considered crucial for any aquatic ecosystem. If the pH value of any aquatic ecosystem is more acidic (pH < 4.5) or more alkaline (pH > 9.5) for long time, growth and reproduction will be diminished (Ndubuisi et al., 2015). In our study, the monthly DO level ranged from 4.82 to 8.30 mg/l and pH ranged from 5.58 to 7.65 indicating a suitable habitat for fresh water fisheries resources in the Gajner Beel, (NW) Bangladesh.

**CONCLUSION**

In summary, our research describes the effect of eco-hydrological factors (Temperature, rainfall, dissolved oxygen, pH, total dissolved solids and alkalinity) on growth of *H. fossilis* in a wetland ecosystem. Growth pattern was isometric and it was correlated with temperature, DO and pH. These parameters were within the suitable range for *H. fossilis* in the Gajner Beel wetland ecosystem. So, it would be the helpful tool for fishery scientist and researcher to prompt the management approaches for the stocks of *H. fossilis* in the Gajner Beel wetland ecosystem and contiguous ecosystems.

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