AGRICULTURAL IMPACT ON REPRODUCTIVE PERFORMANCE OF CEYLON STONE SUCKER (*GARRA CEYLONENSIS* BLEEKER, 1863)

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Introduction:

Agricultural impact on the associated ecosystem is primarily diffused in nature. There are various potential sources of stressors on fish such as physical disturbance (e.g., suspended solids), organic enrichment (e.g., farm-yard waste), toxic materials (e.g., pesticides) and development activities (e.g., channel modification). Munkittrick and McMaster [1] have developed and applied an effects-based assessment approach that involves measuring the accumulated environmental state of the system to evaluate the impacts of multiple stressors on fish populations. Environmental conditions, which impaired growth and development or reproductive success would become evident in populations and the patterns of indicator responses that depart from the reference state is used to identify the candidate stressors [2]. The intended use of biological criteria is to evaluate the effects of agricultural non-point source pollution on fish performance integrity and ecological success. We studied the usefulness of Garra ceylonensis (Family: Cyprinidae) -an endemic, algivorous freshwater fish species- as a biological indicator of agricultural pollution in Sri Lanka.

Methods:

Replicate sampling sites in the Uma-oya were selected from 3 catchment elevation levels (viz. upper, middle and lower) representing an elevation gradient design. The approximate land catchment area above each level was 48, 98 and 740 km2, respectively. All 12 sites were considered deteriorated in the Uma-oya, due to intensive exploitation for agriculture. A modified subjective scale [3] on agricultural impacts was defined for five criteria (area above under cultivation, hydrological regime, stream connectivity, morphological conditions, and nutrient organic inputs) and coded as 1= high impact, 2= medium impact and 3= low impact. Four altitudinal categories were defined: 1= sites >1,150 m; 2= >1,050 <1,150 m; 3= >950 <1,050 m; and 4= <950 m above MSL. Two reference sites in the Knuckles streams were 217 and 482 m above MSL. Despite different elevation and reproductive seasonality of Garra spp., the reference sites were considered surrogates for population performance assessments, since acceptable reference locations devoid of human impact within the Uma-oya catchment could not be found. Samples sizes were selected based on a priori power analysis. Only adult specimens of females >8.5 cm and males >7.0 cm of total length were captured. In the laboratory, voucher specimens were measured for length (L) (±0.1 cm) and weight (W) (±0.001 g) and dissected for gonad weight (±0.001 g). Five clumps of post-vitellogenic egg masses (preserved in 70% alcohol) were separated from 3 different regions (i.e., anterior, mid and posterior) along the vertical direction, blotted-dried and measured for weight (±0.001 g) and counted. Diameters (µm) of 10 eggs from each clump were measured under calibrated microscope.

Results and Discussion:

Both contamination and elevation categories showed significant differences ($p<0.001$) in fish size (L and W) and gonad size (GSI) in females. Interestingly, two categories appear to be responsive in opposite directions where significantly heavier and bigger fish were associated with high contamination category ($p<0.001$) and there was a significant size increase (in terms of length and weight of female fish) at elevations below 1,050 m. Similarly, gonad sizes were reduced in the high contamination category and were also reduced at low elevations ($p<0.001$). The larger and heavier females had significantly higher fecundity (number of eggs per female) at high contamination sites. At high contaminations, low GSIs were combined with large body sizes, as compared with bigger and heavier females below 1,050 m that had significantly ($p<0.001$) higher fecundity than higher elevation females. It has been hypothesised that larger body size in females could ensure more accommodative capacity for increased egg production [4]. Although, the regression of GSI and body weight of pre-spawning females of G. ceylonensis was highly significant among elevation categories (ANOVA $F=62.95$, $p<0.001$, $n=612$), there was a significant negative trend of fish weight (W) and GSI (Pearson correlation -0.143, $p<0.001$) implying high elevation females are trying to maximize reproductive investment over lower elevation individuals. Or higher elevation females may have earlier maturity and larger gonadal investment in response to eutrophication and increased food availability. Similarly, the largest and heavier male fish were observed in high contamination category ($p<0.001$) and there was a gradient response in

fish weight in both contamination and elevation gradients. Male fish weight was also significantly negatively correlated for all elevations (r2=76.0% ANOVA F=22.11 DF=8 p=0.002). The fish above 1,150m elevation showed the smallest size male fish ($p<0.001$) compared to the lower elevations. Both contamination scale and elevation gradient were indifferent in gonad size in males ($p>0.05$). The male GSI in all sites except lower-most site in the Uma-oya had larger gonads compared to Knuckles reference population showing strong eutrophication (nutrient enrichment) effect.

Conclusion:

Our results showed strong eutrophication response of reproductive investment in both male and female G. ceylonensis suggesting increased food availability would be a primary determinant of reproduction. However, sub-optimum gonad investment and fecundity of females at sites associated with high agricultural inputs may be due to impaired resource partitioning. Subsequent testing will examine the responses of reproductive steroids and other indicators of reproductive health to agricultural exposures.

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