International Journal of Ecology and Environmental Sciences 34 (1): 49-54, 2008

Impact of River Salinity on Fish Diversity in the South-West Coastal Region of Bangladesh

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ABSTRACT

Saline water intrusion is a major problem and conflicting issue in south-west coastal region of Bangladesh. The present study provides an assessment of changes of fish diversity with the changes of salinity level in the nearby river over the last thirty years. This study is carried out through semi-structured questionnaire survey in selected villages of different salinity prone areas such as high saline zone and moderate saline zone, namely Paikgacha and Rampal, respectively. The increased salinity has negative impact on fish diversity in this region. Local people's perception, experts' judgment was used in detecting decreasing of fish diversity with increasing in river salinity. The study has revealed that in Paikgacha, the salinity varies approximately within the range from 20,000 to 45,000 micromhos and in Rampal it is from 10,000 to 30,000 micro-mhos. Due to increased salinity, the fish species in Paikgacha and Rampal have been reduced from 29 to 12 and 24 to 19 species respectively during the period 1975-2005. Dominancy of very few salinity tolerant species is increasing in both areas but it is more visible in Paikgacha than Rampal.

Key Words: Fishermen, perception, trend analysis, expert choice, Paikgacha, Rampal

INTRODUCTION

The southwest coastal region of Bangladesh has a very complicated situation regarding fresh water and saline water interaction. Changes in tide and fresh-water flow result in the advance and retreat of the salinity limit. Under this process, during the wet season, local rainfall associated with flood flows from upland regions keeps the salinity limit near the coastline. Again, salinity starts increasing and introducing upland from the beginning of November with the cessation of the rains and consequent reduction of river flows (Pramanik 1986). The upland fresh water flowing from the Ganges through the Gorai-Madhumati channel governs the state of the salinity of the southwestern region. But the Ganges outflow during the lean period has been reducing since the commissioning of the Farraka barrage in 1975 (Rahman et al 2000). As a result of the reduced flow of water to the southwest region, the intrusion of saline water progressively upstream has made the region vulnerable to increasing salinity. Because of salinity intrusion a significant change has taken place in fisheries sector. In the case of fishery, increased salinity affects spawning ground leading to substantial reductions in the inland open water fishery (Rabbi and Ahmed 1997). Various fish species cannot get feasible environment in this region for reproduction (Ali 1999). As a result, fish diversity is reduced. But, fish diversity, a major portion of biodiversity is in fact correlated with the stability and resilience of an ecosystem which would have positive relationship with the well being of the existing species structure including the humans (Sengupta 2001). As a result, reduced fish diversity is a serious threat to the environment and local peoples foodstuff. With time these impacts will be severe if no measure is taken to manage this. So, salinity is now recognized as a serious crisis in terms of ecological sustainability at southwest coastal region of Bangladesh. This study was focused on the changes of fish diversity due to change of river water salinity based on the perception of local fishermen.

METHODOLOGY

The study area was selected randomly considering the factor that the area should have high or moderate saline zone. Considering the fact, Paikgacha under Khulna district (highly saline zone) and Rampal under Bagerhat district (moderately saline zone) was selected. The location map of the study area is shown in Figure 1.

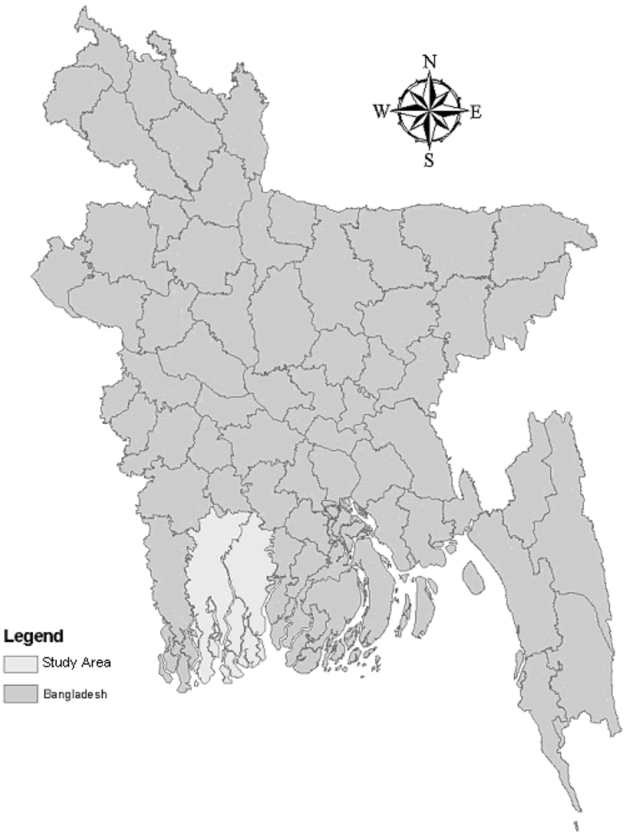

Figure 1. Location map of the study area

Two unions were selected from the two sub-districts and from each union two villages were selected because two salinity measuring stations of Bangladesh Water Development Board (BWDB) for Shibsa river of Paikgacha and Passur river of Rampal are very close to the study area. Salinity data of these rivers represents the salinity state of the selected regions. Yearly maximum salinity level series of 27 years (1975 – 2004; 3 yr missing) of these two rivers was collected from hydrology department of BWDB. The statistical trend analysis was carried whether the time series data of salinity has the statistically significant positive trend or not in both two regions. The procedure of testing linear trends is described herein:

Assume that y_t, $t = 1, \ldots, N$ is an annual time series and N is sample size. Simple linear trend can be written as

Where, D and M are the parameters of the regression model. Rejection of hypothesis $M = 0$ can be considered as a detection of a linear trend. The hypothesis that $M = 0$ is rejected if

in which R is the cross-correlation coefficient between the sequences $y_1, \ldots, y_N$ and $1, \ldots, N$ and is the quantile of the student t distribution with $\nu = N - 2$ degrees of freedom. Then, trend line was drawn by using MS Excel which represented the changed level of salinity graphically from the year 1975 to 2004.

To collect the fish diversity and related data, a semi-structured questionnaire through purposive sampling was prepared for the study. The sample size was determined following the principle of Berensen and Levine (1992) and this was 35 and 45 for Paikgacha and Rampal respectively. Household was selected as the sampling unit considering the factors that one member of each household was permanent resident of the study area and was involved with fish farming. The minimum age of each respondent was considered 60 years so that they could provide more accurate information of the 1975 situation when thair age was 30 years. The mean age of respondents of Paikgacha (n=35) and Rampal (n=45) was 67.66 ± 10.61 and 66.38 ± 6.54 yr respectively. The year 1975 was selected as the base year as it reflected the year of lowest salinity level in the study area. Data of three years (1975, 1990, and 2005) with an interval of 15 years were undertaken for the analysis of the situation. The interval was relatively high so that fishermen could assess the changes clearly with this long year variation. As it was impossible to collect quantitative data about amount of fish species for the previous years; numeric values 0 to 10 were assigned against the qualitative data collected from respondents. Here, rank 0 represents non-availability of a species and 10 represents highly available for the species. Rank 0 to 10 was used to detect the subtle change of qualitative amount. Based on the quantification of qualitative data, diversity calculation was accomplished.

Shannon Diversity Index (H'), Species richness index (d) and Species evenness index (e), Index of dominance (c) following the methods described in Odum (1969), Shannon and Weaver (1963) and Simpson (1949) are mostly used in biodiversity calculation and these are the appropriate calculation of biodiversity. An actual number of individuals per species is obligatory to use the biodiversity index. As fish related previous data for the study area was no longer available to calculate diversity even in the fishery department, the above indices were not used. Instead, fishermen's perception was used for better approximation of the changes of fish diversity. The fishermen whom were interviewed were the residents of the villages of Charbanda and Golbunia of Paikgacha; Gonabelai and Durgapur of Rampal. Finally, to detect the actual factors which are responsible for biodiversity degeneration experts' choice was used.

RESULTS AND DISCUSSION

Assessment of changes of salinity

The yearly maximum salinity level series of 27 years in Shibsa river of Paikgacha and in Passur river of Rampal have been considered for a comparison of the two study areas (Figure 2). It is shown that salinity level in Shibsa of Paikgacha is always higher than the salinity level in Passur of Rampal because Passur gets more upstream discharge through Nabaganga river from the Gorai channel. In Paikgacha, it ranges approximate from 20,000 to 45,000 micro-mhos and in Rampal it is from 10,000 to 30,000 micro-mhos. Therefore, it is said that Paikgacha is under High Saline Zone (HSZ) and Rampal is in Moderate Saline Zone (MSZ) because it falls under the defined ranges (FAP 1993). In the study, the regression test for linear trend was carried out for

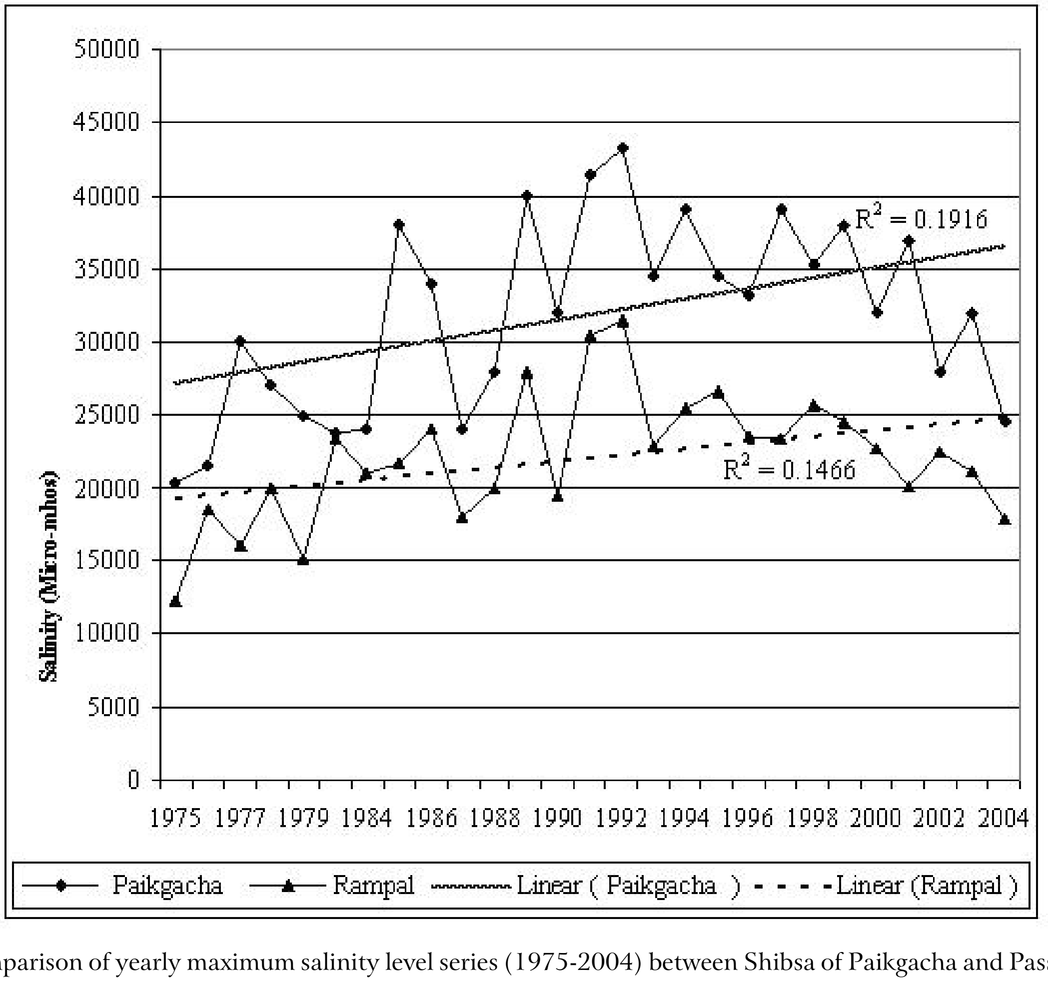

Figure 2: Comparison of yearly maximum salinity level series (1975-2004) between Shibsa of Paikgacha and Passur of Rampal

Table 1. Result of trend analysis of salinity level series of Shibsa and Passur river

	Correlation coefficient R	Trend: test statistic Tc	Critical value $T1\text{-}\alpha/2, v$ p=0.0 5 (t distribution)
Shibsa (Paikgacha)	0.438	2.195	2.06
Passur (Rampal)	0.383	2.073	2.06

the annual maximum salinity level series of the measuring station of BWDB at Shibsa and Passur river from the year 1975 to 2004. The result of trend analysis (Table 1) shows that at 5% significance level, calculated T (Tc) is 2.195 and 2.073 for Paikgacha and Rampal respectively, which is greater than the tabulated T value. So, the time series data of salinity has the statistically significant positive trend in both regions which eventually indicate the increased level of salinity from 1975 to 2004. The trend line is also shown graphically in Figure 2.

Assessment of Change in Fish Diversity

To assess the changes of fish diversity, perception of local fishermen in Paikgacha and Rampal was used. About hundred percent respondents in both two regions thought that amount of fish caught were gradually decreasing. When they were asked how much fish they caught in 1975, 1990, 2005; they responded qualitatively. Through the qualitative data it was difficult to assess the changes. Then, they were asked to put the value in between 0 and 10 against their qualitative amount per species; they chose the comparative number through their inherent capacity. Based on assigned ranking, statistical analysis (mean and standard deviation) for Paikgacha (HSZ) and Rampal (MSZ) was carried out. The result of the analysis in different years is shown in Table 2. The mean value represents the average rank among the respondents and standard deviation represents the variation of their perception. The lower value of standard deviation in the study indicates accuracy of the approximation of amount of fish species. If we ignore the decimal places of mean value, Table 2 indicates that in 1975, 29 species were present in Paikgacha (HSZ). Availability of fresh water species was reduced and 3 species were extinct in 1990. But in 2005, only 12 species was present of which none was of fresh water species. In Rampal (MSZ), 24 species were present in 1975, but presently there is only 19 species.

The change in abundance of every species in Paikgacha and Rampal is graphically presented in Figure 3 and Figure 4 respectively. Figure 3 shows that 17 fresh water fish species including *Labeo rohita, Catla catla, Anabas testudineus, Clarius batrachus* disappeared in 2005 in Paikgacha. Amounts of only few species like *Penaeus monodon*, *Oreochromis mossambica, Mystus vittatus* increased because these are saline water-friendly species. Figures 3 and 4 also show that only few species were playing dominant role in 2005 in both the regions but in 1975, a number of species were present in large amounts which can be compared with dominancy and

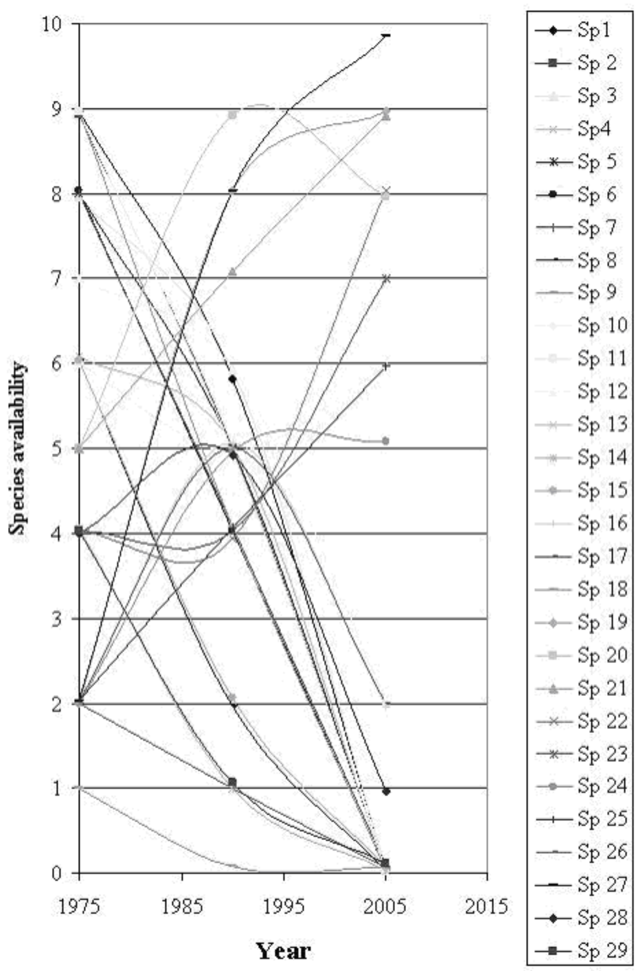

Figure 3: Changing pattern of amount of fish caught for every species in Paikgacha (HSZ) based on assigned rank.

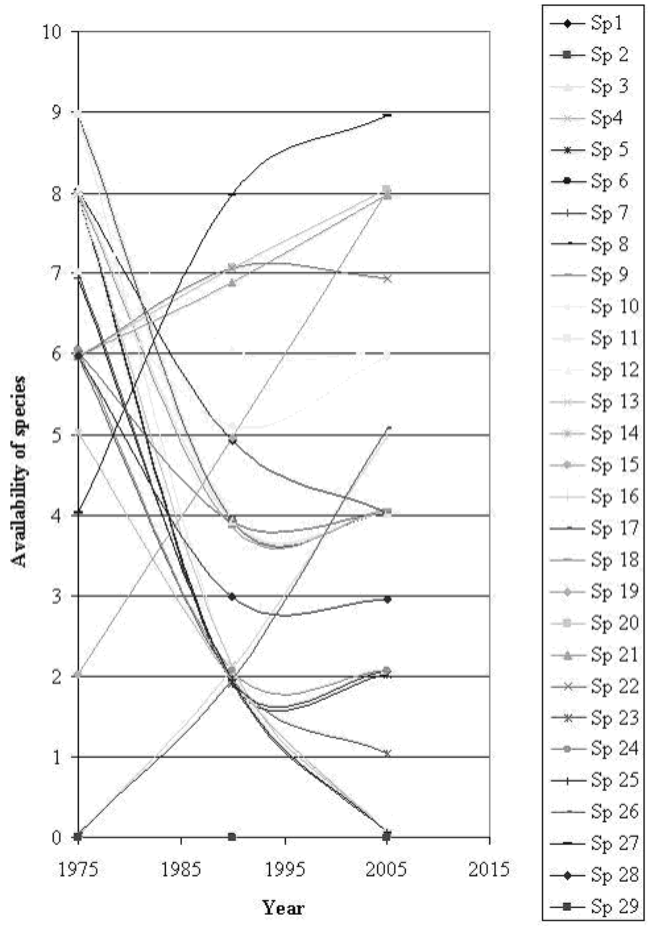

Figure 4: Changing pattern of amount of fish caught for every species in Rampal (MSZ) based on assigned rank.

evenness of species. A comparison of Figures 3 and 4 indicates that fish diversity changed both in Paikgacha and Rampal but it is noticeable in Paikgacha rather than Rampal due to high degree of salinity.

Through an open ended question in the questionnaire, the factors responsible for such changes of fish diversity were captured. About cent percent local fisher-men assumed that salinity is the only factor which is responsible for such changes. As the fishing habit and other instruments, which they used in fishing, were remained unchanged and salinity is increasing signi-ficantly, their perception is reliable.

There are several factors like salinity, pH, acidity, nutrients, climatic conditions and other constituents etc which are responsible for fish diversity degeneration. To detect which factors are responsible in our study area, six resource persons were interviewed who were working with fishery of the study area. All of them mentioned that other factors than salinity remained more or less unchanged which are able to create biodiversity degeneration. They remarked that salinity level was changed noticeably in the study area. So salinity is a stressed condition which changes the fish diversity in study area.

CONCLUSION

The study findings show that fish diversity of the study area is reducing with the increase of salinity. The reduced fish diversity eventually decreases the fish production of native species and creates extinction of several species. These consequences eventually create instability in the socio-economic sector of the study area in terms of increased poverty of local fishermen.

So, salinity is now a major problem in south west coastal region of Bangladesh. The Government should take immediate steps for reducing salinity level of the study area. The reduction of salinity level in south west region of Bangladesh can be accomplished by increasing freshwater flow from the Ganges through the Gorai-Madhumati channel.

ACKNOWLEDGEMENTS

The research reported here represents part of an academic research by the first author at the Environmental Science Discipline, Khulna University. We are grateful to the inhabitants of Paikgacha and Bagerhat for their help and cooperation during data collection there. Anonymous referees are also greatly acknowledged for reviewing the paper.

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Table 3. Statistics of assigned rank (Mean±SD) against qualitative amount of fish caught by the fishermen of Paikgacha (HSZ) and Rampal (MSZ) in different years

Species ID & Name	Paikgacha (HSZ)			Rampal (MSZ)		
	1975	1990	2005	1975	1990	2005
1. *Labeo rohita*	8.97±0.86	5.83±0.51	0.06±0.24	8.02±0.54	4.93±0.39	4.02±0.36
2. *Catla catla*	8.94±0.94	5.00±0.42	0.03±0.17	8.98±0.66	3.93±0.39	4.02±0.15
3. *Cirrhinus mrigala*	7.97±0.62	5.91±0.45	0.06±0.24	8.04±0.37	3.93±0.39	4.02±0.34
4. *Labeo calbasu*	6.09±0.61	5.03±0.51	0.03±0.17	0.04±0.08	0.03±0.02	0.07±0.05
5. *Anabas testudineus*	8.00±0.59	5.00±0.24	0.03±0.17	7.98±0.26	1.91±0.36	2.02±0.15
6. *Channa punctatus*	8.03±0.51	4.03±0.30	0.03±0.03	8.00±0.21	1.96±0.30	2.07±0.33
7. *Clarius batrachus*	8.00±0.54	4.09±0.29	0.09±0.28	7.02±0.34	1.93±0.33	0.04±0.30
8. *Heteropneustes fossillis*	6.03±0.75	1.97±0.30	0.03±0.17	0±0	0±0	0±0
9. *Puntinus sp.*	8.97±0.45	4.09±0.29	0.03±0.17	8.00±0.30	3.84±0.42	4.07±0.33
10. *Glossogobius giuris*	6.00±0.34	4.97±0.30	5.97±0.38	7.02±0.26	5.11±0.32	5.98±0.34
11. *Amblypharyngodon mola*	8.97±0.45	4.97±0.30	0.03±0.17	8.98±0.34	2.11±0.32	0.07±0.45
12. *Channa striatus*	7.00±0.42	5.94±0.42	2.03±0.30	8.02±0.26	6.07±0.45	6.02±0.15
13. *Barilius bola*	4.06±0.42	1.00±0.32	0.03±0.17	7.98±0.26	2.13±0.41	0.07±0.33
14. *Channa marulius*	4.06±0.42	0.01±0.32	0.03±0.17	5.02±0.26	1.96±0.30	0.04±0.30
15. *Colisa fasciatus*	6.03±0.30	2.06±0.42	0.06±0.34	0.04±0.08	0±0	0±0
16. *Cyprinus carpio*	2.00±0.24	5.06±0.42	1.97±0.17	0.02±0.15	2.09±0.29	4.98±0.15
17. *Hypophthalmichthys molitrix*	2.03±0.38	5.00±0.24	2.00±0.24	0.04±0.21	1.96±0.30	5.07±0.33
18. *Nandus nandus*	1.00±0.34	0.09±0.37	0.06±0.34	0±0	0±0	0±0
19. *Oreochromis mossambica*	2.00±0.24	8.03±0.38	8.97±0.17	2.02±0.26	4.96±0.30	8.02±0.34
20. *Mystus vittatus*	5.00±0.54	8.91±0.51	7.97±0.17	5.98±0.26	7.07±0.33	8.04±0.21
21. *Mugil sp.*	5.00±0.00	7.09±0.28	8.91±0.37	5.98±0.26	6.89±0.38	7.98±0.34
22. *Latias calciter*	4.03±0.30	3.94±0.42	8.03±0.17	5.96±0.21	7.07±0.39	6.93±0.33
23. *Pangasius pangasius*	4.03±0.17	4.03±0.38	7.00±0.24	5.98±0.26	1.98±0.45	1.04±0.37
24. *Mystus vittatus*	2.00±0.34	4.97±0.38	5.09±0.37	6.04±0.37	2.07±0.39	2.07±0.33
25. *Mastacembelus pancalus*	2.30±0.30	4.06±0.42	5.97±0.38	6.93±0.39	1.96±0.30	0.07±0.33
26. *Chanda sp.*	1.06±0.24	0.09±0.37	0.06±0.34	6.02±0.26	3.91±0.42	4.02±0.34
27. *Penaeus monodon*	2.03±0.30	8.03±0.45	9.86±0.43	4.02±0.40	7.98±0.34	8.96±0.37
28. *Macrobrachium rosenbergii*	4.00±0.24	4.91±0.37	0.97±0.30	5.98±0.26	2.98±0.26	2.96±0.37
29. *Oxygaster bacaila*	4.03±0.38	1.06±0.42	0.11±0.32	0.02±0.04	0.06±0.10	0±0

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