Impact of ocean acidification on benthic foraminifera, *Ammonia beccarii, A. tepida* and *A. dentata*, in captive condition

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ABSTRACT

Ocean has absorbed one third of CO_2 from the atmosphere that has resulted in decreasing the ocean pH, a phenomenon known as ocean acidification. Ocean acidification affects many marine calcifying organisms, however, less is known about its impact on marine benthic foraminifera. To analyze the impact of ocean acidification on shell morphology of different types of benthic foraminifera (*Ammonia beccarii*, *A. tepida A. dentata*), we cultured them for 20 weeks at various acidified seawater pCO_2 conditions (400, 750, 970 and 1200 µatm). The present study investigates the functional morphology of benthic foraminifera using Scanning Electron Microscopy images and it shows that the deformation of test ornamentation, shell damage and reduction in teeth structure of all the three species. Average numbers of teeth were slightly differed between the control and treatment. The higher treatment showed that all species of foraminifera teeth structure was irregular in shape and foraminifera test surface slightly cracked and apertural area also affected during the higher treatment. Current investigation hence found that these foraminifera species are likely to be susceptible to ocean acidification.

Key words: benthic foraminifera, *Ammonia beccarii*, *A. tepida A. dentata* shell size, reduction ornamentation, CO_2, SEM

INTRODUCTION

Atmospheric CO_2 levels are currently rising faster than at any time in the past 21 million years, driven largely by anthropogenic activities such as burning of fossil fuels and land-use change (IPCC, 2007). Already ocean surface water pH has been decreased 0.1 units during the pre-industrial revolution period and is expected to drop a further 0.3 to 0.4 units by the year of 2100 (Caldeira and Wicket, 2005). Benthic foraminifera owing to their short life cycle and their high abundances, they are able to respond quickly to environmental changes and valuable tool for climate change research. The present investigation aimed to assess the impact of ocean acidification on benthic foraminifera *Ammonia beccarii, A. tepida* and *A. dentata* in captive condition.

MATRIALS AND METHODS

The manipulation of seawater chemistry was followed by Gattuso *et al.* (2010), The foraminifera culture technique was followed by Nikki Khanna *et al.* (2013).

RESULTS

S. no.	S (ppt)	T (°C)	TA µmol/kg^{-1}	TCO_2 µmol/kg^{-1}	pH	fCO_2	pCO_2	HCO3 µmol/kg^{-1}	CO_3 µmol/kg^{-1}	CO_2 µmol/kg^{-1}	OH µmol/kg^{-1}	Ω Ca	Ω Ar
Control	30 ± 1	29.0 ± 1.5	2290.142	1956.921	8.11	336.816	400.950	1705.532	242.397	9.094	9.721	6.129	4.033
Experiment -I animal with 750 ppm of pCO_2	30 ± 1	29. 1 ± 1.5	2250.632	2031.701	7.97	590.521	750.171	1850.162	165.601	15.867	6.532	4.206	2.708
Experiment- II animal with 970 ppm of pCO_2	30 ± 1	29.3 ± 1.5	2240.307	2108.751	7.72	997.301	970.950	1970.621	111.630	26.407	3.917	2.821	1.866
Experiment III animal with 1200 ppm of pCO_2	30 ± 1	29.0 ± 1.5	2245.221	2150.677	7.63	1290.491	1200.126	2025.471	91.007	34.081	3.154	2.308	1.512

SEM analysis shows that the morphological deformities observed in all the three species in different CO_2 treatment except 750 ppm, where *A. beccarii* and *A. tepida* found to be normal. In *A. beccarii,* pore sizes of test were larger than normal one in 970 and 1200 ppm of CO_2 concentration (Fig.1). Whereas in 1200 ppm CO_2 concentration, shape of the test teeth found were differed when compared to normal.

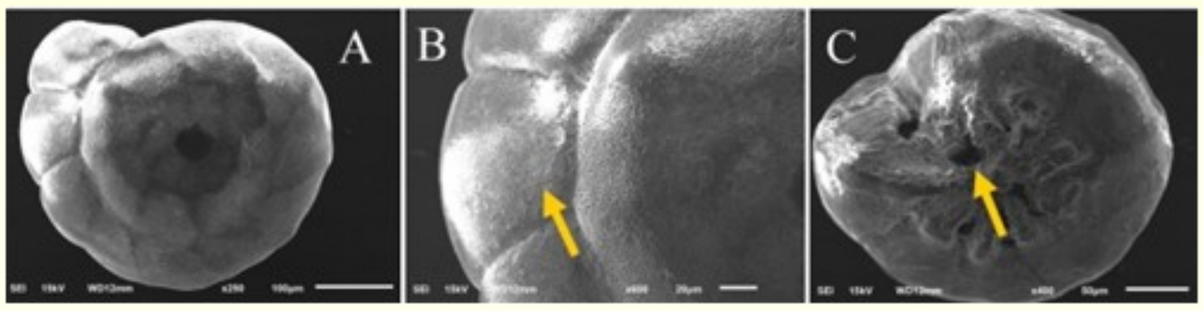

Fig.1. *A. beccarii* control (A) eroded test (arrow) at experiment II (B) cracked ventral side (arrow) at experiment III (C).

In *A. tepida*, the test teeth were dissolved and few of them totally eroded in ventral side at 970 ppm of CO_2 treatment. Surface ornamentation of the test totally dissolved at 1200 ppm of CO_2 concentration (Fig.2).

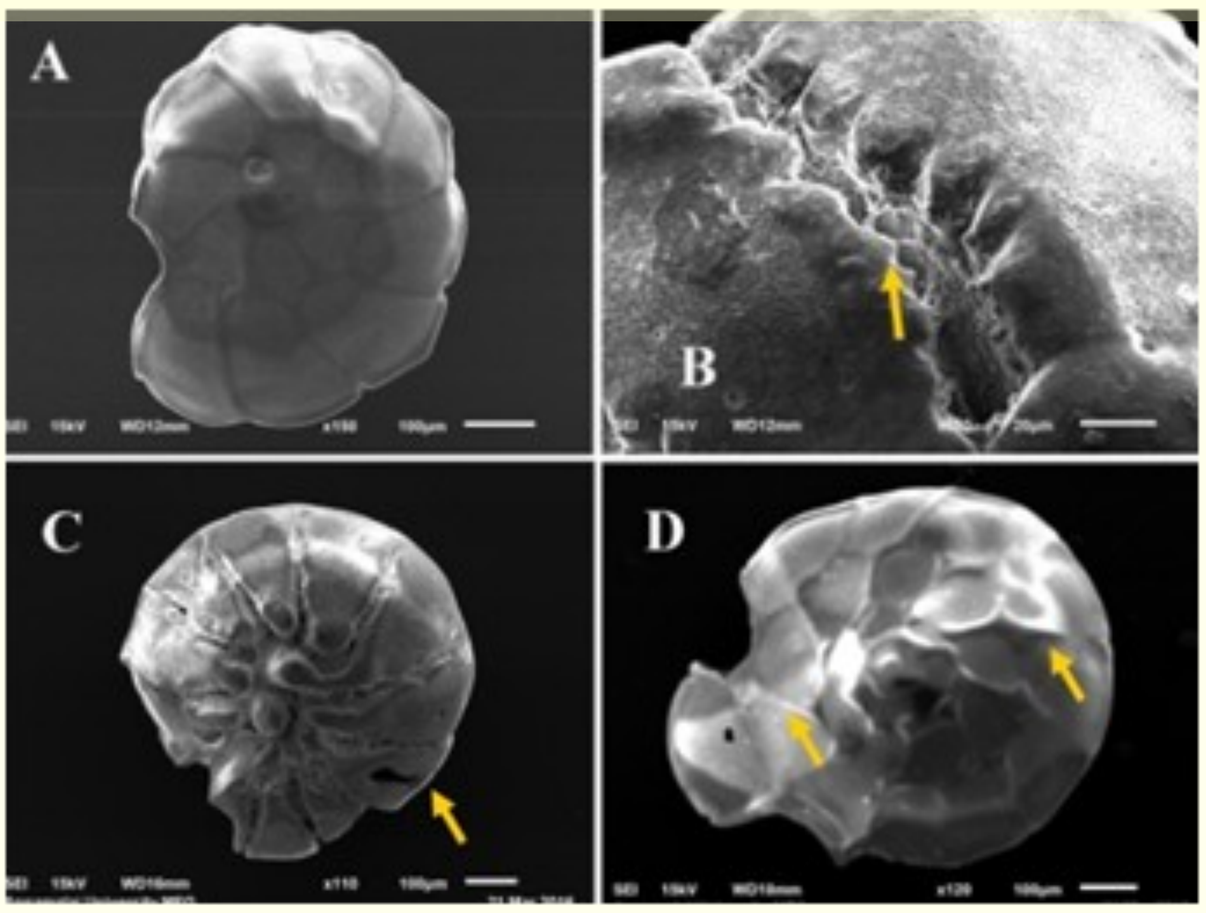

Fig.2. *A. tipeta* control (A), teeth structure at experiment I (arrow) (B), cracked structure (arrow) at experiment II (C) and dissolved surface ornamentation (arrow) at experiment III (D).

***A. dentata* shows more effect against CO_2 treatment than other two species in the present study. This species shows dissolved surface ornamentation at 750 ppm and test crack with test whorl was dissolved at few chamber in 970 ppm of CO_2 concentration. In high concentration (1200 ppm) of treatment, the dorsal side of the test surface were found dissolved with many cracks (Fig. 3).**

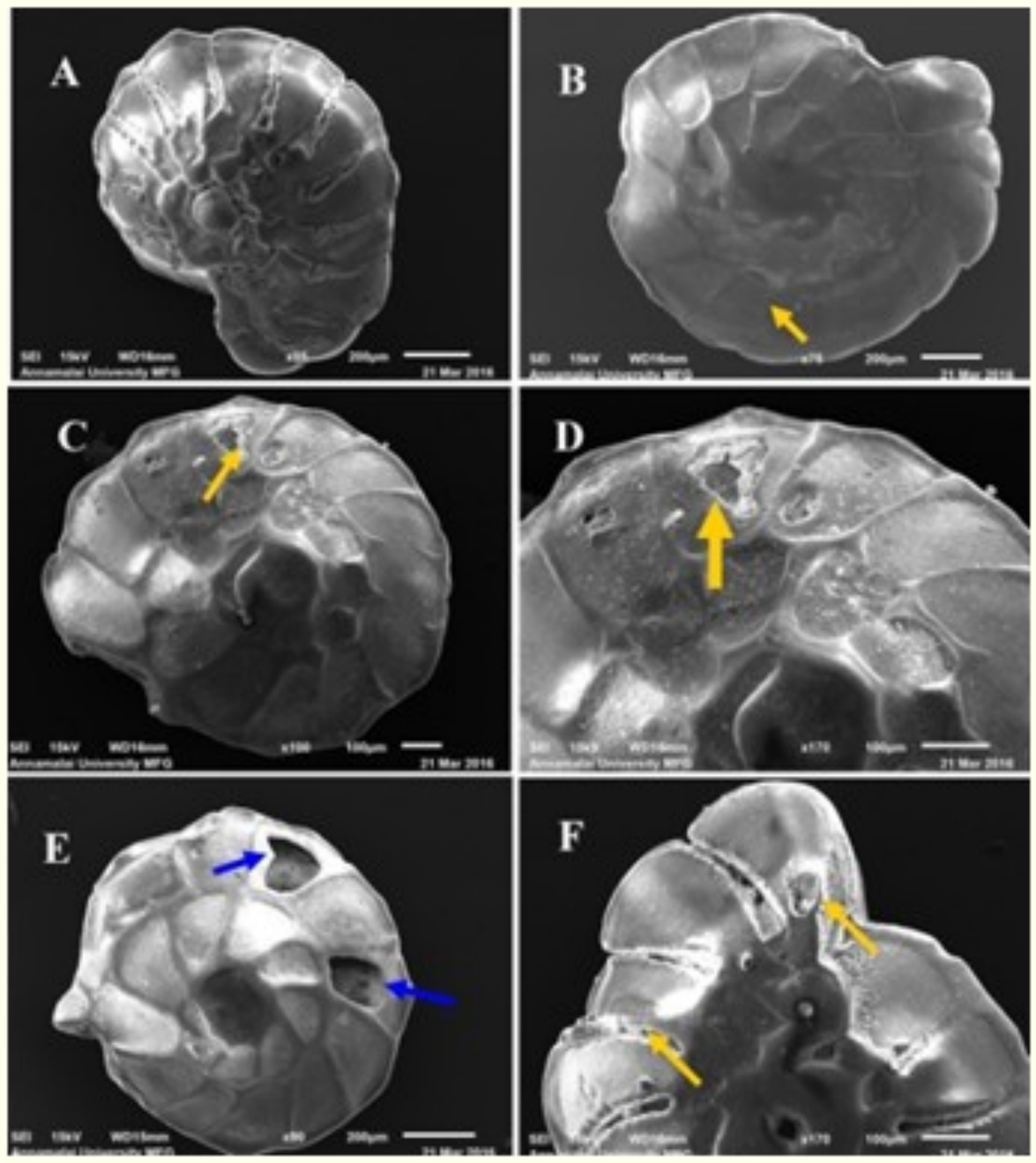

Fig.3. *A. dentata* control (A), dissolved test surface (arrow) at experiment I (B), cracked test surface (arrow) at experiment II (C), high magnification of cracked test surface (bold arrow) (D), deformed test surface (arrow) at experiment III (E) and deformed teeth (F).

CONCLUSION

The present study concludes that the 750 ppm of CO_2 concentration do not affect the *A. beccarii* and *A. tipeda,* whereas the higher concentration of treatments (970 and 1200 ppm) strongly affected the test ornamentation in all the three species. Therefore, the benthic foraminifera are most vulnerable to low pH/ocean acidification.

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REFERENCES

Nikki khanna J.A. Godbold, W.N. Austin D.M. Peterson (2013). The impact of ocean acidification on the functional morphology of foraminifera. Plos one 8 1-4.

Gattuso J.P. K. Gao K. Lee B. Rost K.G. Schulz (2010). Approaches and tools to manipulate the carbonate chemistry. Guide to best practices for ocean acidification research and data reporting. Pp 41 -52.