

**Table 1.** Details of sample preparation and time period of pulverization

Sample no.	Description
QA-5	Pulverized in agate cup for 5 min
QA-15	Pulverized in agate cup for 15 min
WC-5	Pulverized in tungsten-carbide cup for 5 min
WC-15	Pulverized in tungsten-carbide cup for 15 min
WC-30	Pulverized in tungsten-carbide cup for 30 min

**Table 2.** Comparison of analytical results of tungsten, cobalt and tantalum in International Standard Reference Materials analysed by Pro-Trace program

Element (ppm)	GSD-6		GSD-12		GSS-11		GSS-6	
	Certified value	Obtained value	Certified value	Obtained value	Certified value	Obtained value	Certified value	Obtained value
W	25	23.3	37	35.3	6.9	7.6	90	79.3
Co	24.4	22.2	8.8	7.2	11.6	9.9	7.6	6.2
Ta	0.75	<LLD	3.2	<LLD	–	<LLD	5.3	1.4

LLD, Less than detection limit.

**Table 3.** Results of tungsten, cobalt and tantalum obtained in the quartz samples prepared

Elements (ppm)	QA-5	QA-15	WC-5	WC-15	WC-30
W	0.00	0.00	1982	2511	2827
Co	0.00	0.00	265	322	393
Ta	<LLD	<LLD	<LLD	<LLD	<LLD

It was observed that no tungsten and cobalt was detected in the samples pulverized in the agate cup. The sample pulverized in the tungsten-carbide cup for 5 min, recorded 1982 ppm of tungsten and 265 ppm of cobalt. At the same time, the sample pulverized for 30 min showed 2827 ppm of tungsten and 393 ppm of cobalt. This shows that samples pulverized for a longer time contain more tungsten and cobalt and the

concentration is commensurate with the duration of the pulverization period.

The study reveals that a good amount of tungsten and cobalt get transferred into the sample during pulverization from the tungsten-carbide cup. The contamination of tungsten and cobalt from the pulverizing cup may lead to erroneous interpretation of data, since these are not the inherent constituents of the original source.

1. Fritsch GmbH, *Operating Instruction Manual, Version 1, Vibrating Cup Mill Pulverisette 9*, Germany, 1995; <http://www.fritsch.de>
2. Potts, P. J., *A Handbook of Silicate Rock Analysis*, Blackie, Glasgow, 1992, pp. 226–325.
3. Potts, P. J. and Webb, P. C., *J. Geochem. Explor.*, 1992, **44**, 251–296.
4. Jenkins, R., Gould, R. W. and Gedcke, D., *Quantitative X-ray Spectrometry*, 1995, vol. 20, 2nd edn, pp. 388–428.
5. Bhaduri, S. K., Banerjee, D., Ghosh, J. B., Saha, C., Roy, N. K. and Das, D. K., *Indian Min.*, 2005, **59**, 115–122.
6. Reference Manual Pro-Trace Section, SuperQ Version 4A, 2004, 1st edn.
7. Longerich, H. P., *X-ray Spectrom.*, 1995, **24**, 123–136.
8. Govindoraju, K., *Geostandard Newsletter, Special Issue*, July 1994, XVIII, pp. 15–53.

ACKNOWLEDGEMENTS. We thank B. K. Mohanty, Deputy Director General, Geological Survey of India, North Eastern Region, Shillong for permission to publish this paper.

Received 21 July 2008; revised accepted 25 November 2008

G. C. SAIKIA\*  
T. K. SINHA  
F. KHARSHING

*Geological Survey of India,  
North Eastern Region,  
Chemical Division,  
Nongrim Hills,  
Shillong 793 003, India  
\*For correspondence.  
e-mail: gobin@sancharnet.in*

## *Elysia bangtawaensis* Swennen (Nudibranch) from the mangrove habitat of Mandovi estuary, Goa (central west coast), India

*Elysia bangtawaensis* Swennen was recorded in mangrove swamps from polyhaline (salinity 18–30 PSU) and mesohaline (salinity 5–18 PSU) regions during November–January 2007–08. The population was mainly confined to the protected, shadowed water pools, and algal and seagrass patches associated with the mid and lower intertidal zones of the estuary. The percentage frequency occurrence

(% FO) of *E. bangtawaensis* varied from 10 to >90 at different stations, while the average density ranged from 0 to 400 nos/m<sup>2</sup>. The population was found to be declining during January.

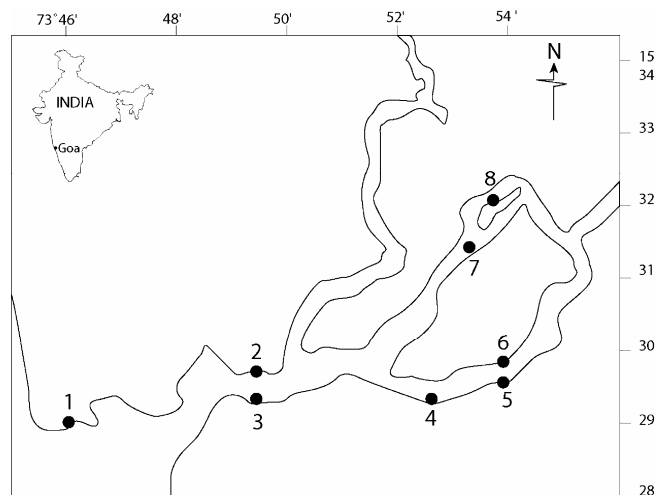
During regular monitoring of mangrove habitats, aggregation of *Elysia* sp. was noticed from mangrove swamps in the mesohaline zone (Figures 1, 2a and b) in November 2007. Sixty species of

*Elysia* out of 339 nudibranch species have been reported worldwide, of which five species occur in the Indo-Pacific region<sup>1,2</sup>. Three species found to be associated with mangrove habitats, and *E. bangtawaensis* and *E. cf. expansa* have been recorded<sup>3,4</sup> from Asia, while *E. australis* occurs in Australia<sup>5</sup>. Three species of *Elysia* have been recorded in association with green algal beds exclusively

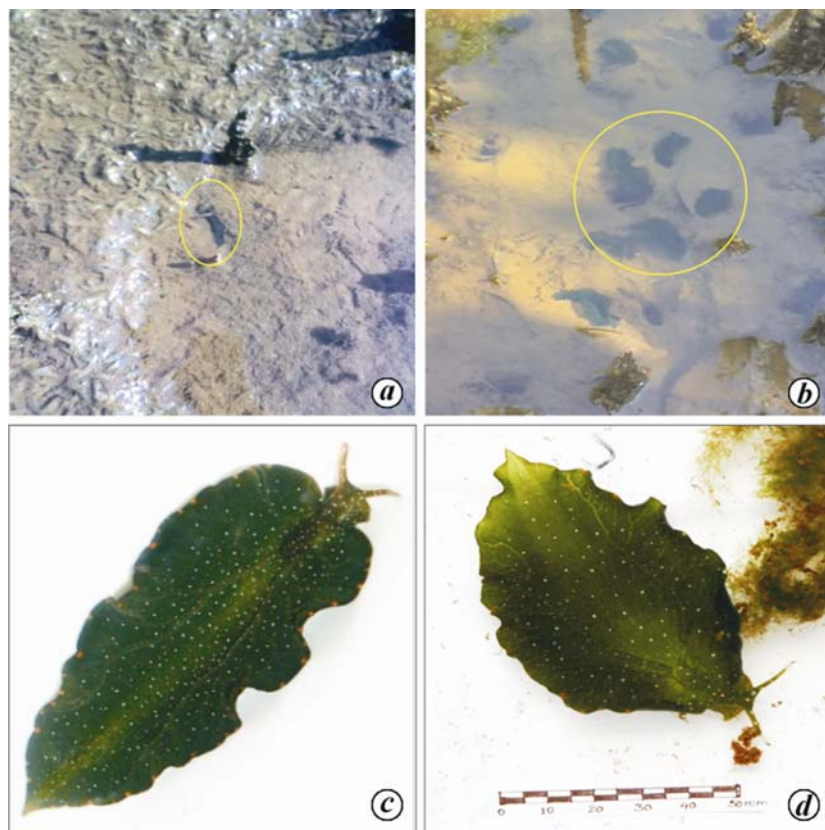
from the marine environment<sup>6-8</sup>. *Elysia cf. expansa*, however, has been reported<sup>4</sup> in association with mangroves from the east coast of India.

Eight stations (Figure 1) in mangrove swamps along Mandovi estuary, covering

various salinity zones (euhaline, polyhaline and mesohaline) were studied fortnightly for distribution of *Elysia*. Samplings were carried out at ebb during November 2007 to January 2008, for collection and monitoring of aggregation of *Elysia*.



**Figure 1.** Geographical positions of sampling stations.



**Figure 2.** *Elysia bangtawaensis* from various habitats. **a**, *E. bangtawaensis* in seagrass beds associated with mangroves from Goa, India. **b**, Aggregation of *E. bangtawaensis* in mangrove habitats of Goa. **c**, *E. bangtawaensis* from mangrove habitats of Thailand. **d**, *E. bangtawaensis* from mangrove habitats of Goa, India.

Quantification of *Elysia* population and associated algae was done using quadrant (size 25 cm<sup>2</sup>) method. At each station, ten quadrants were randomly placed to evaluate density and percentage frequency occurrence (% FO). Density (nos/m<sup>2</sup>) and % FO data for three months from station nos 5 to 8 were pooled and expressed on average basis. The relevant ecological data such as temperature (air, water and substrate), salinity, pH, DO (dissolved oxygen) from ambient environment were obtained from existing literature<sup>9-11</sup>. Specimens were preserved in 4% sea water–formaldehyde immediately after collection. Surface sediments and overlaying water from the vicinity of the *Elysia* population were also collected and preserved in Lugol's solutions and 4% formaldehyde. One millilitre of concentrated phytoplankton sample was analysed using Segwick rafter counting chamber and the counts were averaged and expressed as the number of cells/l. Taxonomic identification of organisms and associated flora was done using the standard literature<sup>9,11-14</sup> and various relevant websites<sup>1,2</sup>.

*E. chilkenis*, *E. grandifolia*, *E. rufensens*, *E. tomentosa* and *E. cf. expansa* have already been recorded from Indian waters. The *Elysia* described here was relatively large (length 35–40 mm and width at centre 10–15 mm) in size with thin, flattened parapodia. Coloured spots on the body and parapodia were similar to that of *E. bangtawaensis* described from mangrove habitats of Thailand<sup>3</sup> (Table 1 and Figure 2 *c* and *d*). Considering the close resemblance with various features of *E. bangtawaensis*, i.e. habit and habitat, climate and geographic distribution, the present organism was identified as *E. bangtawaensis*. This form has also been described from intertidal swamps of Drainage creek, northern New South Wales, Australia<sup>15</sup>.

The aggregation of *E. bangtawaensis* was found to be confined to the mid-stream regions (station nos 5–8) of relatively lower salinity. It was observed to be totally absent from station nos 1 to 4 in the polyhaline zones. The population density and % FO varied from 0 to 200 nos/m<sup>2</sup> and 10 to 50% respectively, at station nos 5–7, while they varied from 200 to 400 nos/m<sup>2</sup> and 70 to 90% respectively in station no. 8 (Table 2). The population declined from mid-January 2008.

The present form of *Elysia* was confined to the mid-reaches of estuarine

## SCIENTIFIC CORRESPONDENCE

**Table 1.** Comparative characters of *Elysia bangtawaensis*, Swennen from mangrove swamps of Thailand and Goa (India)

Characteristics	Thailand (Source: Swennen <sup>3</sup> )	Goa (India) (Present study)
Colour	Dark green	Dark green
Length (mm)	35–43 mm	35–40 mm
Central width (mm)	–	10–15 mm
Number of brown-orange spots on the margin of parapodia	12–40	15–25
Number of white spots on body and parapodia	Numerous	Numerous

**Table 2.** Geographical correlation of sampling locations of ecological status of *E. bangtawaensis* and nature of associated habitat

Stations no.	Latitude (N)	Longitude (E)	Occurrence of <i>Elysia</i>	Density (nos. m <sup>-2</sup> )	% FO	Habitat
1	15°30'38"	73°46'49.1"	–	0	0	M, MS, A, P
2	15°30'19.6"	73°50'15.4"	–	0	0	M, MS, A, S, P
3	15°29'56.6"	73°50'18.1"	–	0	0	M, MS, A, P
4	15°30'19.9"	73°52'42.2"	–	0	0	M, MS, A, P
5	15°25'17.5"	73°54'36.2"	+	0–10	10–50	M, MS, A, P
6	15°30'32.5"	73°54'44.3"	+	0–50	10–50	M, MS, A, P
7	15°32'25"	73°53'55.8"	+	0–200	10–60	M, MS, A, S, P
8	15°32'46.1"	73°54'27.2"	+	200–400	70–90	M, MS, A, S, P

M, Mangrove; MS, Mangrove substrate; A, Algae; S, Seagrass; P, Phytoplankton; % FO, Percentage of frequency occurrence; +, Present; –, Absent.

**Table 3.** Phytoplankton population ( $n \times 10^4 l^{-1}$ ) from the ambience of *E. bangtawaensis* Swennen, Mandovi estuary, Goa

Species	Surface water sample	Surface sediment sample	Total	Percentage (%)
<i>Chaetoceros</i> sp.	0.1	–	0.1	1.66
<i>Gyrosigma balticum</i>	0.1	0.4	0.5	8.34
<i>Coscinodiscus</i> sp.	0.3	0.2	0.5	8.34
<i>C. eccentricus</i>	0.4	0.1	0.5	8.34
<i>Pleurosigma elongatum</i>	0.1	0.8	0.9	15.00
<i>P. angulatum</i>	–	0.1	0.1	1.66
<i>Pleurosigma</i> sp.	0.4	0.1	0.5	8.34
<i>Rhizosolenia alata</i>	0.1	0.2	0.3	5.00
<i>Leptocylindrus danicus</i>	0.1	–	0.1	1.66
<i>Diploneis robustus</i>	–	0.4	0.4	6.66
<i>D. smithii</i>	–	0.2	0.2	3.34
<i>Amphora lineolata</i>	–	0.2	0.2	3.34
<i>Pinnularia alpinia</i>	–	0.4	0.4	6.66
<i>Pinnularia</i> sp.	0.2	0.4	0.6	10.00
<i>Cocconeis pediculus</i>	–	0.2	0.2	3.34
<i>Cymbella marina</i>	–	0.4	0.4	6.66
<i>Asterionella japonica</i>	–	0.1	0.1	1.66
Total	1.8	4.2	6	100

mangroves, either in association with algal and seagrass beds and protected, shaded water pools or waterlogged swamps, from the mid and lower intertidal zones. Meadows of *Halophila beccarii* Aschers were found to be associated with mixed algae dominated by *Chaetomorpha linum*, *Enteromorpha flexuosa*, *Rhizoclonium riparium*, *Cladophora patentiramea*, *Ulothrix* sp., *Oscillatoria* sp., *Lyngbya martensiana*, *Phormidium tenue*, *Catenella impudica*, *Caloglossa leprieurii*, *Polysiphonia lanosa* and *Ceramium* sp.

The total phytoplankton cell count in surface water from stations nos 5 to 8 was found to be  $1.8 \times 10^4 l^{-1}$ , while the same was  $4.2 \times 10^4 l^{-1}$  in surface sediments. Genera like *Pleurosigma* (25%), *Coscinodiscus* (16.68%), *Pinnularia* (16.66%) and *Diploneis* (10%) were predominant (Table 3).

Occurrence and population outburst of *E. bangtawaensis* during winter may be attributed to relatively lower temperature and salinity. The air, water and substrate temperatures surrounding the aggrega-

tion varied from 21.5% to 33°C, 26.5% to 29.5°C and 26.2% to 29°C respectively. Salinity of influencing waters at station nos 5–8 remained in the range 10–26 PSU, while at station nos 1–4 it usually remained higher due to the predominant tidal influence<sup>10</sup>. The dominance of *Kandelia candel*, Cyperaceae member, *Rhizoclonium riparium* and *Ulothrix* sp. from station nos 5 to 8 is suggestive of more freshwater and less tidal influences, thus lowering the salinity. Inhabitation of *E. bangtawaensis* from the mid-reaches

of the estuary and occurrence during winter suggest its preference for relatively lower temperature and salinity in ambience.

Seagrass and algal biomass increase with rising salinity and light intensity from October to February<sup>9,10</sup>. The phytoplankton population too remains rich during the post-monsoon period due to the nutrient enrichment during monsoon and adequate light<sup>16</sup>. The present data reveal relatively more growth of algae, seagrass and phytoplankton population in the mangrove habitats from the mid reaches (station nos 7 and 8) of the estuary, where *E. bangtawensis* aggregation was more predominant. These species commonly feed and are associated with green and red algae and seagrass beds<sup>2,6,17</sup>. Abundance of *E. grandifolia* has been reported during winter, associated with the richness of algal crop<sup>6</sup>. The richness of *E. bangtawensis* population from station nos 7 and 8 could therefore be attributed to the existence of algae and seagrass beds. In the absence of algae the organism prefers feeding on bacteria, phytoplankton and cyanobacteria<sup>2</sup>. The dark green colour of *E. bangtawensis* suggests its feeding preference for algae having rich chlorophyll *a* content<sup>7</sup>.

In conclusion, *E. bangtawensis* has been reported from India, contributing towards biodiversity. Ecological observations revealed its exclusive association to the mangrove swamp from the mid-reaches of the Mandovi estuary. Predominant occurrence in the mesohaline

zone of the estuary indicates its preference for lower salinity. The present findings encourage further understanding regarding ecological adaptation and biotechnological potential of *E. bangtawensis*.

1. [http://nudibranch.com.au/species\\_list.pdf](http://nudibranch.com.au/species_list.pdf), accessed on 24 May 2008.
2. <http://www.seaslugforum.net/>
3. Swennen, C., *Bull. Zool. Mus.*, Univ. Amsterdam, 1997, **16**, 34–38.
4. Bouillon, S., Connolly, R. M. and Lee S. Y., *J. Sea Res.*, 2007, **59**, 44–58.
5. Davie, P. J. F., *Wild Guide to Moreton Bay*, Queensland Museum, Brisbane, 1998, p. 408.
6. Bhosale, S. H., Jagtap, T. G. and Naik, C. G., *Mycopathologia*, 2000, **147**, 133–138.
7. Pierce, S. K., Curtis, N. E., Massey, S. E., Bass, A. L., Karl, S. A. and Finney, C. M., *Mollusc. Res.*, 2006, **26**, 23–38.
8. Ciavatta, M. L., Gresa, M. P. L., Gravagnin, M., Manzo, E., Mollo, E., D'Souza, L. and Cimino, G., *Molecules*, 2006, **11**, 808–816.
9. Jagtap, T. G. and Untawale A. G., *Indian J. Mar. Sci.*, 1981, **10**, 402–404.
10. Jagtap, T. G., Ph D thesis, Shivaji University, Kolhapur, 1985.
11. Jagtap, T. G., Bhosale, S. and Singh, C., *Aquat. Bot.*, 2006, **84**, 37–44.
12. Heurck, H. V., *A Treatise on the Diatomaceae* (translated by Buxter, W. E.), William Wesley & Son, London, 1896, p. 558.
13. Hyman, L. H., *The Invertebrates. Volume VI, Mollusca I*, McGraw-Hill, 1967, pp. 402–548.

14. Jaasund, E., *Intertidal Sea Weed in Tanzania*, University of Tromso, Norway, 1976, p. 160.
15. Burn, R. F., In *Mollusca: The Southern Synthesis. Fauna of Australia, Vol. 5, Part B* (eds Beesley, P. L., Ross, G. J. B. and Wells, A.), CSIRO Publishing: Melbourne, 1998, pp. 961–974.
16. Jagtap, T. G., In Proceedings of National Symposium of Biologica Utilization and Conservation of Mangroves (ed. Bhosle, L. J.), Shivaji University, 1986, pp. 180–187.
17. Jagtap, T. G., *Bot. Mar.*, 1996, **39**, 39–45.

ACKNOWLEDGEMENTS. We thank the Director, National Institute of Oceanography, Goa for providing the necessary infrastructure. The present document forms Contribution No. 4870 of NIO publication.

Received 10 March 2008; revised accepted 10 November 2008

T. G. JAGTAP\*  
P. S. SHENAI-TIRODKAR  
S. B. SAVANT  
V. A. KULKARNI  
Z. A. ANSARI

*National Institute of Oceanography,  
Dona Paula, Goa 403 004, India*  
\*For correspondence.  
e-mail: tanaji@nio.org

## Was Bundelkhand–Aravalli nucleus part of Ur supercontinent?

Although the origin and evolution of the earliest crust is somewhat equivocal, the discovery of ~4.4 Ga detrital zircons from the Jack Hills of Narryer gneissic terrane, Yilgarn craton, western Australia<sup>1</sup>, confirms the formation of continental crust during this time. It is generally perceived that the earliest crust formed at a number of isolated nuclei which grew and later coalesced to form protocontinents that later developed to form major continental masses. The major continental masses collided and joined together to form supercontinents.

Ur is the earliest known supercontinent which was formed at ~3.0 Ga ago<sup>2</sup>. It is believed that 3.0 Ga is the limit to which the studies relating to continents or supercontinents could be stretched. Conventionally, the age of a continent is deduced from the oldest rocks exposed in that continent. However, Rogers<sup>3</sup> argued that the age of the oldest rocks can only be taken as the age of the continent, provided the oldest rocks attained stability so that they could sustain a continent and other rocks could settle on it. It is most probable that many early formed rocks

were reworked into the crust before attaining stability. These rocks can be considered transient crust and do not qualify for the age determination of the continent.

The first continental assembly called Ur, consisted of nuclei of cratonic blocks of present-day Africa, Australia, Antarctica and India. Nuclei of the Indian plate that are grouped together in the Ur assembly are the Western Dharwar craton, Eastern Dharwar craton, Bhandara–Bastar craton and Singhbhum craton<sup>3</sup> (Figure 1). The Bundelkhand–Aravalli nucleus is not