and consequent dwarf bamboo invasion is not controlled, the entire valley and the surrounding hills will be covered by the dwarf bamboo. There is an urgent need to put in place large-scale monitoring of fires and spread of dwarf bamboo to better gauge the spatial and temporal patterns of one, and the spatial extent of the other. The task requires active participation of stakeholders, viz. the local communities, wildlife conservationists, forest managers, government agencies and the civil society at large. Also, well-planned ecotourism will certainly be a solution for protection of these hill ranges which will conserve the unique biodiversity of the area in general and endemic ones in particular *in situ*.

1. Sala, O. E. *et al.*, *Science*, 2000, **287**, 1770–1774.
2. Sethi, N., *Down to Earth*, 2004, **12**, 27–34.
3. Misra, R., *Ecology Work Book*, Oxford and IBH, New Delhi, 1968.
4. Curtis, J. T. and McIntosh, R. P., *Ecology*, 1950, **31**, 355–434.
5. Whitford, P. B., *Ecology*, 1949, **30**, 199–208.
6. Philip, E. A., *Methods of Vegetation Study*, Henry Holt & Co., New York, 1959, p. 107.
7. Hiremath, A. J. and Sundaram, B., *Conserv. Soc.*, 2005, **3**, 26–42.
8. Bhatt, Y. D., Rawat, Y. S. and Singh, S. P., *J. Veg. Sci.*, 1994, **5**, 67–70.
9. D'Antonio, C. M. and Vitousek, P. M., *Annu. Rev. Ecol. Syst.*, 1992, **23**, 63–87.
10. D'Antonio, C. M., In *Invasive Species in a Changing World* (eds Mooney, H. A. and Hobbs, R. J.), Island Press, Washington DC, 2000, pp. 65–93.
11. Lippincott, C. L., *Nat. Areas J.*, 2000, **20**, 140–149.
12. Ewel, J. J., In *Ecology of Biological Invasions of North America and Hawaii* (eds Mooney, H. A. and Drake, J. A.), Ecological Studies, Springer-Verlag, New York, 1986, vol. 58, pp. 214–230.
13. Myers, R. L., *J. Appl. Ecol.*, 1983, **20**, 645–658.
14. Hobbs, R. J., In *Biological Invasion: A Global Perspective* (eds Drake, J. A. *et al.*), SCOPE 37, Willey, Chichester, UK, 1989, pp. 389–4405.
15. Larson, D. L., Anderson, P. J. and Newton, W., *Ecol. Appl.*, 2001, **11**, 128–141.
16. Mao, A. A. and Kataki, S. K., *Indian For.*, 1994, **120**, 515–518.
17. Mao, A. A. and Gogoi, R., *Indian For.*, 2007, **133**, 1699–1702.

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Land–ocean tectonic signatures of the Krishna–Godavari Basin, a qualitative evaluation

The Krishna–Godavari (K–G) Basin extends approximately from Nellore in the south to Kakinada in the north and forms one of the most promising petroliferous basins of the East Coast of India. The basin has a unique half crescent shape and the onland part consists of 28,000 sq. km and offshore basinal area covers 24,000 sq. km up to the isobath of 200 m. On the basis of geophysical surveys carried out by ONGC, the onshore basin is divided into three sub-basins, viz. Krishna, West and East Godavari sub-basins by two prominent NE–SW basement ridges called Bapatla and Bhimavaram–Tanuku Horsts[1].

The preliminary analysis of the bathymetry and total field magnetic data collected over the eastern continental margin of India (ECMI) between 17°N and 14°N lat. covering the area of K–G Basin and the available coastal geological and geophysical data brought out new information on land–ocean tectonic lineaments (LOTL).

The bathymetry data reveal that the water depths in the area vary from 40 m (near shore) to 3000 m (offshore). It indicates high gradient tightly packed contours over offshore Krishna Basin between 40 and 1000 m water depth whereas between Krishna and Godavari rivers, the pattern shows relatively wider shelf from 40 m to slope regions up to 2500 m water depth. The band of depth contours ranging from 1000 to 2400 m (shown as shaded portion) appears to be sheared and bounded by fault lineaments F1 and F2 (Figure 1).

Single beam bathymetry (Figure 1) contour map is overlain by the multibeam bathymetry contours. The NW–SE trending topographic rise of 500 m from the adjacent seafloor of 1750 m observed in multibeam bathymetry study[2] falls in the area where the shearing was observed in the present bathymetry data. The landward extension of this topographic rise, well depicted in the multibeam bathymetry contours probably abuts the trend of the Bhimavaram–Tanuku Ridge at the coast. Deep seismic sounding studies of Narasapur–Paloncha DSS profile[3] nearer to the coast also indicate a basement rise at a depth of 4.0 km corresponding to the Bhimavaram–Tanuku Ridge.

The total intensity magnetic anomaly map (Figure 2) exhibits two major trends in NE–SW and NW–SE direction. The amplitude of magnetic anomaly varies from –280 to +240 nT. On the basis of the anomaly signatures, the area is divided into three zones namely A, B and C. The zone A is characterized by NE–SW trending anomalies whereas the zone C is characterized by NW–SE trending anomalies. The NE–SW trending wide curvilinear anomaly zone A, approximately runs parallel to the coast within the

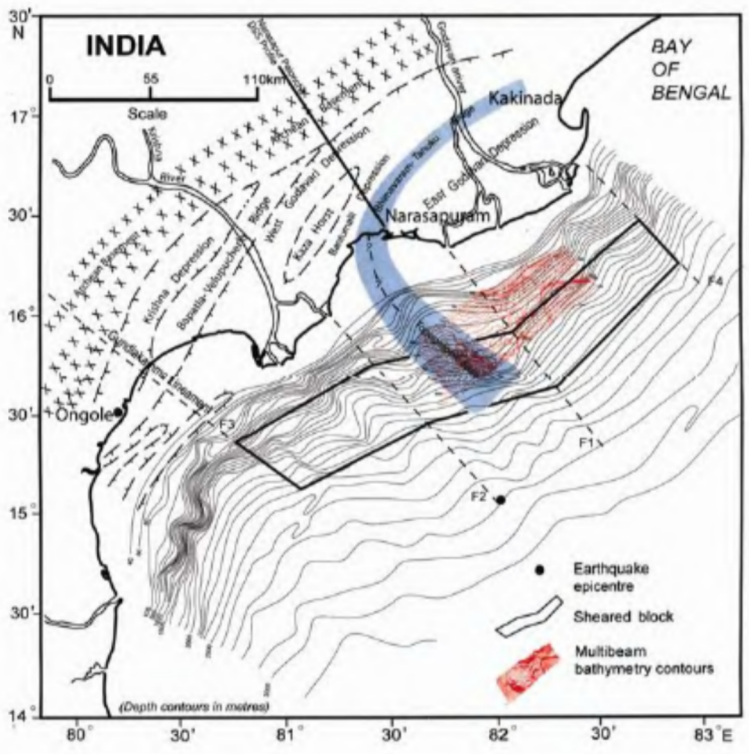

Figure 1. Map showing the bathymetry of the study area at varied contour interval (20 m, 100 m). Land tectonic lineaments are shown. Faults F1–F4 are shown over the Eastern Continental Margin of India (ECMI).

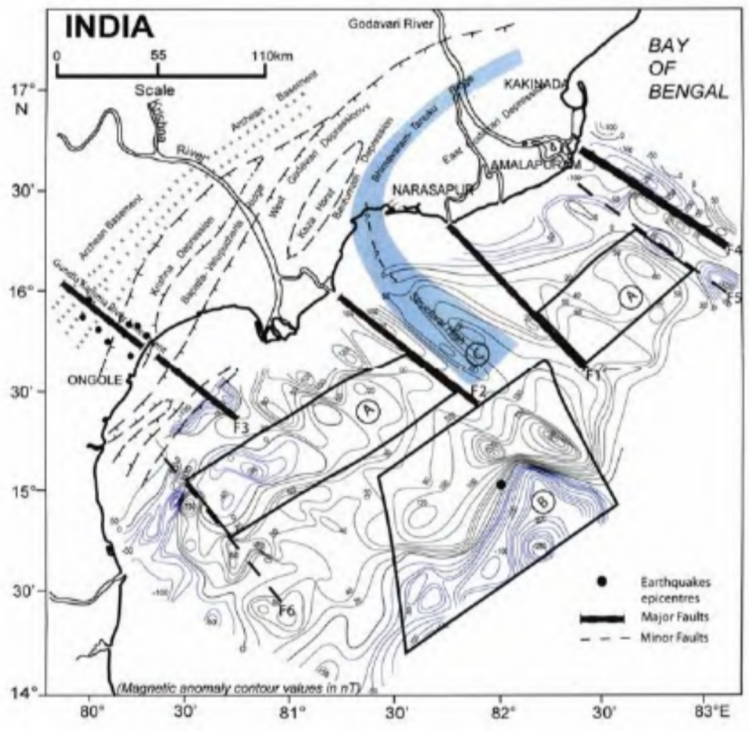

Figure 2. Map showing the total intensity magnetic anomalies. Land–ocean tectonic lineaments are shown. The anomaly zones are denoted as A, B and C.

water depths of 1000–2500 m off Ongole to Kakinada. The anomaly zone A is sheared and block shifted by an intervening NW–SE trending anomaly zone C which is bounded by two fault lineaments F1 and F2 (Figure 2). F1 and F2 may be the offshore extension of onland river lineaments off Vasishta Godavari and off Krishna River respectively. The landward extension of the NW–SE trending block C abuts the coast and the faults F1 and F2 meet the two edges of the coastal concavity. The NW–SE trending elongated positive anomaly of about 100 nT in the zone C probably suggests a basement rise. This block shifting followed by shearing was clearly observed in the band of bathymetry contours also between 1000 and 2400 m at the same region (Figure 1).

The NW–SE trending contour pattern of zone C clearly depicts that there is a marked change in the coastal tectonics as evidenced from concavity of the coast probably resulted due to the rifting and drifting process during separation of the Indian continent from Antarctica. The NE–SW trending isolated anomaly zone B of finite dimension of long wavelength and bipolar nature of 480 nT amplitude (Figure 1) around 2000 m water depth off Nizampatnam indicates an isolated source associated with earthquake of 5.0 magnitude over the central part of this anomaly.

Physiographic and lineament map[4] (Figure 2) in the Ongole region of Krishna Basin indicates a major NW–SE trending lineation of Gundlakamma River along which earthquakes of magnitude 1.0–6.0 are clustered around. This feature apparently abuts the coast north of Ongole. Focal mechanism solution shows strike-slip faulting parallel to Gundlakamma River joining the sea north of Ongole. When this lineation is extrapolated further into offshore region as fault F3 (Figure 2), it joins the magnetic zone of contrasting anomalous signature, indicating possible offshore extension of land lineament of significant earthquake activity into sea.

A band of NW–SE trending high-frequency anomaly zone ranges from +100 to –250 nT, suggests a fault lineation F4 (Figure 2) at a shallow depth (off Gautami Godavari), south of Kakinada, suggesting that the Godavari River channel is probably tectonically controlled.

The inferences suggested that the structural lineaments on the coast are

extending towards offshore up to a water depth of approximately 3000 m. Similar observations have been made suggesting the extension of land tectonic lineaments up to water depths of 3000 m over Cauvery offshore Basin of ECMI[5]. It may be surmised from our studies that it is highly essential to link coastal and offshore lineaments from geophysical data vis-à-vis earthquake activity of the entire ECMI in order to understand the factors responsible for the recent seismic activity over coastal and near shore regions.

1. Mohinuddin, S. K., Satyanarayana, K. and Rao, G. N., *J. Geol. Soc. India*, 1993, **46**, 533–539.
2. Pattan, J. N., Parthiban, G., Prakash Babu, C., Khadge, N. H., Paropkari, A. L. and Kodagali, V. N., *J . Geol. Soc. India*, 2008, **71**, 107–114.
3. Reddy, P. R., Venkateswarlu, N., Prasad, A. S. S. S. R. S. and Koteswara Rao, P., *Gondwana Res.*, 2002, **5**, 513–518.
4. Reddy, P. R. and Chandrakala, *J. Indian Geophys. Union*, 2004, **8**, 143–146.
5. Subrahmanyam, V., Subrahmanyam, A. S., Murthy, K. S. R., Murty, G. P. S., Sarma, K. V. L. N. S., Suneeta Rani, P. and Anuradha, A., *Curr. Sci.*, 2006, **90**, 578–580.

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Leafhopper's face mimics the ladybird pupae

Ladybird beetles (Coleoptera: Coccinellidae), amongst the most effective natural enemies of agricultural pests, are well known for their poisons and distastefulness. They contain alkaloids and warn predators by conspicuous body colours and patterning[1]. Ladybird beetles abundantly inhabit a variety of vegetation types throughout the world[2], and diverse arthropods such as cockroaches, leaf beetles and mastophorid spiders mimic the adult ladybirds[3,4]. However, no reports of animals mimicking the ladybird pupae are found. Given that ladybird pupae, although they are almost immobile, exhibit a conspicuous appearance and chemical defenses similar to adults[5], Batesian mimicry of the pupae is predicted to have evolved in various terrestrial habitats. We report here possible mimicry of ladybird pupae by a leafhopper in central Japan.

The black-tipped leafhopper, *Bothrogonia ferruginea* (Fabricius) (Hemiptera: Cicadellidae), widely distributed in Japan, Korea, China, Taiwan and Southeast Asia, sucks the xylem sap of various shrubs and herbs[6]. Adults of this species exhibit conspicuous yellow-green colouration with several black spots on the head and face (Figure 1 *a*), whilst nymphs are cryptic light green. The adult face explicitly resembles the pupae of ladybird beetles such as *Harmonia axyridis* (Pallas) and *Coccinella septempunctata* L. (Figure 1 *b* and *c*). Specifically, the leafhopper's face (including head and prothorax) and frontal view of a ladybird pupa are similar in size (ca. 3.5 mm), hexagonal and have

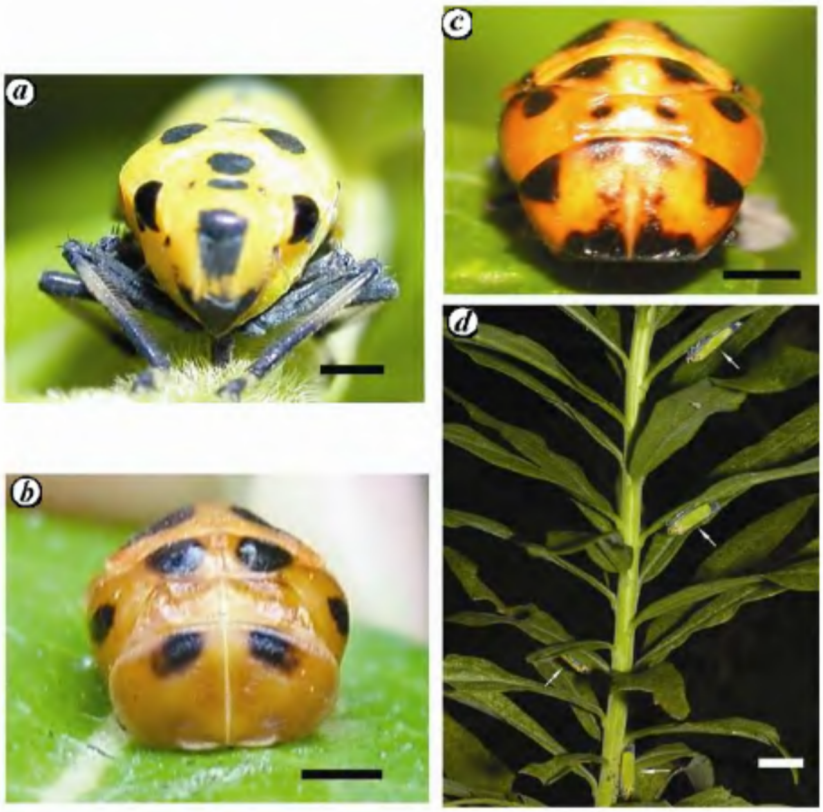

Figure 1. ***a***, Front view of an adult *Bothrogonia ferruginea* face; ***b***, Front view of a *Harmonia axyridis* pupa; ***c***, Front view of a *Coccinella septempunctata* pupa; ***d***, *B. ferruginea* adults (arrows) perching on the goldenrod *Solidago altissima* (scale: ***a***–***c*** = 1 mm; ***d*** = 10 mm).