Acacia dealbata Link. (Silver Wattle), an invasive species growing in high altitudes of the Himalaya

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Acacia dealbata is native to Australia. The genus *Acacia* (wattles) belongs to the family Mimosaceae. There are almost 1,380 species of *Acacia* found throughout the world and close to 1,000 of these are found in Australia as well as 144 species in the African region (including Madagascar), 89 species in Asia and about 185 species in North and South America[1]. In India, there are about 22 indigenous species of *Acacia*, distributed throughout the plains. However, all species that yield wattle are exotic and have been introduced from Australia. It is presumed that it was introduced in the Nilgiris in 1840, where it became naturalized and it has also been planted in the Himalaya (Shimla, Nainital and Almora hills). Several workers have reported and deposited specimens of *A. dealbata* in BSI Dehradun, e.g. M. A. Rau (BSD 17172) in 1961 reported it from Bhawoli (Kumaon), G. G. Malhotra (BSD 59247) in 1963 from Nagnath (Garhwal), T. A. Rao (BSD 1957) in 1957 from Kalmatia (Kumaon), P. C. Pant (BSD 17173) in 1961 from Ranikhet (Kumaon), U. C. Bhattacharya (BSD 35309) in 1964 from Deolsari (Tehri-Garhwal), A. A. Ansari (BSD 15994) in 1980 from Candoli (Pauri-Garhwal), G. N. Madhuwal (BSD 69404) in 1976 from Nagdev garden (Pauri-Garhwal) and R. D. Gaur (GUH 16206) in 1999 from Naugoankhal (Pauri-Garhwal). We found *A. dealbata* in the interior Kedarnath Wildlife Sanctuary at an altitude of 2,200 m between 30°36′54″N lat. and 79°11′59″E long. The voucher specimen of the plant species was collected and deposited in the Garhwal University Herbarium (GUH) with accession number JAB-GUH-20576. Till date there is no report of this species from this largest protected area as well as from such high elevations of Garhwal Himalaya.

A. dealbata is a problem species in Portugal[2], northwest Spain, where it is threatening the native flora and becoming a serious environmental problem[3], and in France and Italy, where it is locally dominant in the Mediterranean littoral[4]. One of the most invasive species of current concern in Europe is *A. dealbata*, which is reducing populations of native species and hence biodiversity[5]. *A. dealbata* is an invasive alien plant of the Indian Himalayan region[6]. Ecosystem structure and functioning are often seriously affected by invasive *Acacia* species, leading to ecological homogenization of the landscape. Management of *Acacia* is difficult due to its tendency to invade native forest and cultivated areas, resulting in serious problems[7]. Wattles threaten native habitats by competing with indigenous vegetation, replacing grass communities, reducing native biodiversity and increasing water loss from riparian zones[8]. *A. dealbata*, *A. melanoxylon* and *A. longifolia* are the most prolific invaders in France, Italy, Portugal and Spain, especially in the conservation areas. The most widespread species is probably *A. dealbata*, a tree that is widely naturalized in southern Europe[4]. The invasion of interiors of the Himalayan region by this species is an indication of what we should expect in the future. With global warming, many such species are expected to invade the higher altitudes of the Himalaya, replacing and threatening the biodiversity of the area. We need methods to eradicate them or halt their spread immediately.

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Seismicity near Jaitapur, India

This note is with regard to the commentary, 'Historical and future seismicity near Jaitapur, India' by Bilham and Gaur. The paper has many errors and misjudgements as shown below.

The authors write: 'Indeed, Jaitapur has frequently experienced intensity VII shaking from such earthquakes'[1]. This is not true; figure 3 in their paper shows no earthquakes causing such intensity near Jaitapur. The only two shocks, shown in this figure as giving intensity VI, are the Koyna (1967) and Ratnagiri (1965) shocks and these are more than 100 and 50 km away from the site respectively. At Jaitapur, the Koyna main shock caused only intensity V (ref. 2) and the Ratnagiri earthquake may have caused the same or less.

In the correction communicated later[3], the authors write that earthquakes of intensity V and VI might have been felt in Jaitapur area and not VII. Such intensities may, at the most, cause cracks in ordinary houses, but will not render any damage to well-designed nuclear power plants (NPP).

While the location of Jaitapur is given as 16°35′N, 73°20′E in the text, it is wrongly considered in their analysis and in Figure 2 *b* at near 17°N. Many inferences are erroneous as the location considered is 45 km closer to the Koyna seismic zone. Though the authors say that 4–5 shocks have occurred within 50 km of Jaitapur, no such earthquake has been located by the Koyna network operating since 1962 and the local network of five stations operating since 2004 around Jaitapur. The above-mentioned shocks are from Koyna, more than 50 km away. Probably due to the wrong latitude considered, the shocks have been assessed to occur near Jaitapur.

The authors write: 'Estimates of seismic risk to the planned Jaitapur nuclear power plant assessed from a short dataset of only the past few centuries, may not, therefore, represent the true risk to the plant.' For NPPs, the risk is not assessed by historical earthquake data alone, but is based on geological studies and review of geophysical and seismotectonic studies; this has been done in Jaitapur. They also point out that large earthquakes at distances > 100 km can produce significant shaking; all such possible sources have been considered in the seismotectonic evaluation of the site and hence it is not a problem.

The widely accepted magnitudes of the Koyna and Latur earthquakes are 6.3 (ref. 2) and 6.2 respectively, and not 6.4 and 6.3 as indicated by the authors. Also, the distance of the Koyna earthquake is wrongly written to be < 30 km in the second paragraph, which is corrected in the fifth paragraph as 110 km. The authors write: 'Jaitapur lies in a similar setting to Latur and Koyna where earthquakes of $M_w \approx 6.5$ have occurred within the past half century. Such an earthquake in the close vicinity of Jaitapur may not occur for many thousands of years, but although unlikely, it could occur within the lifetime of the nuclear power plant.' But Koyna and Latur are in a postulated Koyna–Kurdwadi Rift[4], more than 50 km north of Jaitapur. Hence, they are not in the same geological setting. The authors probably mention a similar setting based on their crest and trough stress model. However, this model lacks authentication and there is no agreement even among the proponents. Vita-Finzi[5] suggests six crests and troughs, while Bilham and Gaur suggest only two.

They mention that coastal regions may have been stressed by rising sea level since the Last Ice Age and that it has been proposed that deglaciation after the Last Ice Age perturbs the stress field. However, the rising sea level can perturb only a small stress onshore. A 120 m water-level rise in the ocean may cause additional 12 bar stress on the ocean floor vertically down; horizontally, only 10% of it (1.2 bar)[6] may reach near-shore areas. This is negligible compared to stresses of ~ 2000 bar required for the fracturing of rocks. Moreover, slow perturbation over thousands of years may be accommodated in adjustments of shallow layers or slow uplift.

The paper has a simple arithmetic error: a strain of 1 in 10,000 (10^{-4} strain = 100 microstrain) should only be 10 microstrain.

It is written that the marine terrace or offshore normal fault underlies onshore and Jaitapur. The quoted reference (ref. 5 in the commentary) does not mention it; also, no such fault has been found to exist in the area. The Coulomb stress transfer from Koyna earthquake of *M* 6.3 across 100 km may be < 0.1 bar, while the rocks/faults need to be stressed to 2000 bar, and the stress drop during earthquakes may be 100–200 bar. Hence the effect of Koyna earthquake at Jaitapur is too small when stresses close to failure have already been considered.

There are two deep seismic profiles, Koyna I (75 km north of Jaitapur) and Koyna II (150 km north of Jaitapur)[7], which are eastward from the coast and ~ 150 km in length. These profiles are to the south and north of the Koyna reservoir respectively. A NNW thrust fault dipping east was detected 15 km east of Koyna; this was not the causative fault for the Koyna earthquake, as this quake was along a NNE trending strike–slip fault. Moreover, this fault may not extend further south as it is limited by a NW trending normal fault in the Warna area. No fault is observed near the coast or along the continental divide.

A 50 km long NNW trending escarpment passing to the west of Jaitapur was identified by Powar and Patil[8]. The Geological Survey of India (GSI) team studied this lineament along 10 km southward from Jaitapur during 2003–2005, and did not find any evidence of faults. During March 2012, a team of geologists from the Institute of Seismological Research, Gandhinagar examined around 10 areas along this lineament for a stretch of 50 km, where rivers/streams are shifted towards north on the eastern side of the escarpment; a team of about 30 geologists/geophysicists (from GSI, Oil and Natural Gas Corporation Limited, including the present author) thoroughly studied the areas around Jaitapur and up to 8 km south of it. The Tertiary laterite is not disturbed at any of the 10 locations. The location near Girye, 8 km south of Jaitapur, was most thoroughly studied as change in the river course appears to be most prominent here. A tributary of the River Vagothan follows the escarpment for ~ 3 km; along this straight NNW trend of escarpment, the laterite is not disturbed. If a 50–100 km long fault is formed, it will have fractures, gouge material and sheared rocks; no such features were found. Though shifting of river/stream courses and deposition of thin Miocene beds in small isolated basins indicates the possibility of faulting in pre-Miocene times, no evidence could be found.

R. Nagarajan (Indian Institute of Technology-Bombay, Mumbai) has examined the history, historical naval hydrograph charts, old SoI topographic sheets and aerial photographs of the area (pers. commun.). He believes that changes in the river course in the coastal area are due to sediment deposition from the sea and from upstream, aided by reclamation activities rather than any neotectonic activities. In most cases, changes have happened in the last 100 years or less.

Numerous bore logs at different locations on both sides of the NNW lineament around Jaitapur and up to 8 km south of it do not show any material/anomaly that supports the presence of faults (e.g. slickensides, fault breccias) within the laterite or sedimentary rocks overlying Deccan basalts. The Vijaydurg fort and several cannon-cum-watch towers built on nearby hillocks with laterite rocks (without any mortar) ~ 400–500 years ago are intact, indicating absence of any severe earthquakes at least in the past half millennium.

It is good that the authors[1] have penned their concern for the safety of the Jaitapur NPP site. This note is to assure them and the readers that all apprehensions raised have been considered by the geologists and seismologists involved in site investigations.

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