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Vivipary in Indian Cupressaceae and its Ecological Consideration

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Abstract: Vivipary is common in angiosperms especially in mangroves but rare in gymnosperms. The present study reports the incidence of viviparous germination in some members of sub-Himalayan Indian Cupressaceae *Cupressus torulosa* D. Don. and *Biota orientalis* Endl. and its ecological significance. This unusual occurrence of vivipary may be due to certain environmental conditions such as high humidity, production and function of phytohormones, seed size and embryonic or adult water relationship or may be hereditary. In the present genera vivipary is suggestive of an adaptive response to frosting in the area during winter.

Key words: Vivipary, cupressaceae, ecological significance, frosting

INTRODUCTION

Struggle for existence is the inherent characteristic of all living organisms. Vivipary is one such feature, which ensures propagation of its own kind in adverse condition. In this type of germination, the growth of embryo continues until it pierces the seed coat, while still attached to the mother plant, without cessation of activity. Viviparous seeds proceed directly to germinate, while still attached to the mother plant, without undergoing the stage of desiccation. This is typical of certain mangrove species, although occasionally evident in some non-mangrove taxa and different lower groups of plants.

Embryos of viviparous species cannot tolerate the maturation drying that is usually a prerequisite condition for dormancy and consequent metabolic quiescence. They proceed directly to the germination phase. Thus, viviparous embryos maintain high tissue moisture contents throughout ontogeny so cannot dry and therefore, do not enter a dormant phase. In contrast desiccation-tolerant embryos, are capable of drying. In addition, differences in the production and function of plant hormones also induce vivipary. Some species sprout viviparously under certain environmental conditions, such as, unusually high humidity or flooding. Although, the tendency for vivipary is dependent on environmental stimuli, but may be heritable and thus genetically based (Walker-Simmons, 1988). Also, some mutant genotypes produce seeds that germinate prematurely on the parent plant. These viviparous nondormant phenotypes reflect altered production of phytohormones or signal transduction pathways, reduced sensitivity to dormancy-inducing phytohormones and modified embryonic and adult water relations. Evidence indicates that Abscisic Acid (ABA) is necessary for attaining desiccation tolerance and thereby dormancy. As a result, viviparous embryos, exhibit low quantities of ABA throughout embryo development.

Seeds of ABA-deficient mutants exhibit reduced protein accumulation and lack of dormancy, which leads to viviparous germination. Moreover the occurrence of calcium also appears to be at lower concentrations in the embryos of viviparous mangroves than those of nonviviparous nonmangroves (Elizabeth, 2000).

Seeds of gymnosperms are generally non-dormant and active metabolism commences when placed under conditions favourable for germination. It has been observed that in many cases viviparous mode of germination occurs as a means for tiding over the unfavourable environmental conditions. It commonly occurs in plants growing in calcareous and saline soil (Mayer and Poljakoff-Mayber, 1963). Mangrove plants such as *Rhizophora* sp., *Aegialitis rotundifolia* show viviparous growth and is considered as an ecological adaptation to halophytic habitat. In other angiosperms it is an alternative method of propagation prevalent in *Agave*, *Artocarpus* and *Sechium* and in certain varieties of mangoes (Singh and Lal, 1937). Vivipary is also noted in hepatics (D'Rozario and Bera, 2006) and some ferns such as *Asplenium*, *Woodwardia*, *Adiantum*, *Camptosorus*, *Cystopteris*, *Diplazium*, *Tectaria* and *Dennstaedtia scabra* (Mickel, 1967; D' Rozario *et al*., 2001). It is a rare phenomenon in gymnosperms and reported in *Ephedra trifurca* (Coulter and Chamberlain, 1955), *Ginkgo biloba* (Favre-Duchartre, 1958), *Podocarpus makoyi* (Lloyd, 1902), *P. macrophyllus* (Mahabale, 1961), *Pinus wallichiana* (Wali and Tiku, 1965) and in *Biota orientalis* (Gahalain *et al*., 2006). In the

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present study, viviparous germination in *Cupressus torulosa* D. Don. (Cupressaceae) is reported for the first time and detail information of vivipary in *Biota orientalis* Endl. is enumerated and possible ecological significance discussed.

MATERIALS AND METHODS

Twigs of *Biota orientalis* Endl. and *Cupressus torulosa* D. Don. with female cones attached and seeds borne on it showing initial stage of *in situ* viviparous germination were collected from Ranikhet, Kausani and Nainital, Northwestern region of India during the last week of October, 2007. The materials were brought to the plains (Kolkata) to study the effect of environmental factors on viviparous growth.

In two earthen pots, each measuring 12 inches in length and 8 inches in breadth, a 4 inches thick layer of moistened saw dust bed was prepared. Isolated cone bearing seeds of *Cupressus torulosa* and *Biota orientalis* were placed in each bed of the moistened saw dust, watered at frequent intervals and viviparous growth pattern observed (Table 1).

Twigs with female cones of *Cupressus torulosa* and *Biota orientalis* attached were placed in specimen trays and moistened with sprinkles of water. Both the earthen pots and the specimen trays with the samples were kept in a moist, cool and shady place in the plains (Kolkata) under natural environmental conditions. The average temperature, humidity and rainfall during November to early December, 2007 was noted. The specimens were frequently watered to prevent it from drying. The average temperature ranged between 13 to 26°C, humidity 55-80% and rainfall 5 mm.

Locality, altitude, precipitation, edaphic conditions and climatic variations of the collection sites are enumerated in the Table 2.

RESULTS

During a botanical excursion in late October of 2007 in the sub-Himalayan regions of Northwestern India the present authors noted the occurrence of vivipary in *Biota orientalis* and *Cupressus torulosa*. Seeds of both the taxa started germinating while attached to the cone scales on the twigs (Fig. 1a, b). After being brought to the plains in Kolkata it developed further and various stages of growth were observed during November to early December, 2007. Initially the root emerges piercing through the seed coat. Root apex of *Biota orientalis* was observed to be white in color and glossy in appearance while that of *Cupressus torulosa* reddish in colour (Fig. 1h, i). When the hypocotyl is about 3.2-4.0 cm long in *Biota orientalis* and 1.0-1.8 cm in *Cupressus torulosa,* the shoot apex pierces through the cotyledons. After 7 days growth, the viviparous embryos reveals the two cotyledonary leaves which turned green in colour (Fig. 1c, d). They are club shaped, measuring 0.8-1.2 cm in *Biota orientalis* and 0.6-1.0 cm in *Cupressus torulosa* and show parallel venation.

Seven to ten days later the hypocotyl in both the genera shows brown and dried appearance at the apical portion. Keen observation shows that a brownish cuticular covering develops on the outer surface of the hypocotyl, which is easily separable. It is thus seen that in reality the root apex do not dry up, but develops a cuticular covering (Fig. 1e).

Seeds of isolated cones of *Biota orientalis* and *Cupressus torulosa* collected from the same region were placed in saw dust and sand in the plains in November, 2007. Seven days later the seeds started germinating with the radical coming out first and then the plumule with the cotyledonary leaves (Fig. 1f, g). Growth of the seedlings of cones attached to the twigs and isolated ones continued till the first week of February, 2008; thereafter

Table 1: Rate of viviparous germination in the members of Cupressaceae under study

Species	No. of isolated female cones placed in tray with saw dust	No. of seeds per female cone	No. of seeds per cone showing vivipary	Percentage of vivipary (%)
Biota orientalis	10	8-12	3-6	35-45
Cupressus torulosa	10	35-40	2-4	6-12

Table 2: Locality, altitude, precipitation, edaphic conditions and climatic variations of the collection sites

Locality	Latitude/Longitude	Altitude	Rain fall/Snow fall	Temperature/Humidity	Soil condition
Ranikhet	34°N-81°02′ E	1829 mt.	127 cm. rainfall Snowfall during December, January, February	3°-7°C in winter/27.5°C in summer 54%	Sandy loam
Nainital	29°N-79°28′E	2623 mt.	255cm Snow fall during December, January, February	4°-8°C in winter/30°C in summer. 64%	Sandy soil
Kausani (Mukteswar)	29°28′N 79°39′E	2286 mt.	177cm. Snow fall during December, January, February	1°-8°C in winter/10-26°C in summer 48%	Sandy loam
Kolkata	22°35′N88°23′E	Mean sea level	100 cm. No snow fall	9°-11°C in winter/28°-40°C in summer 71.6%	Alluvial

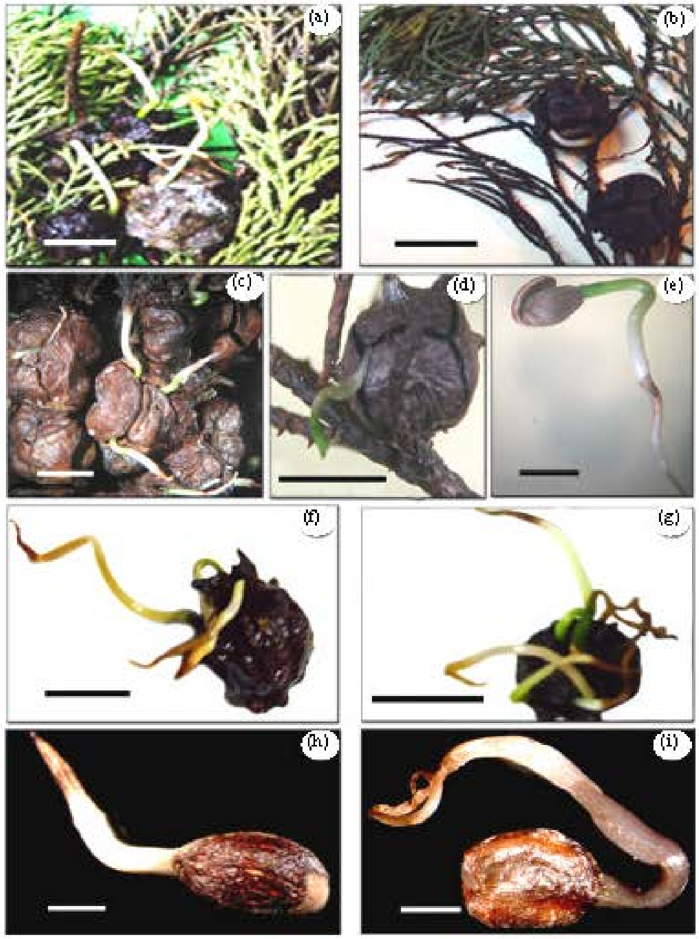

Fig. 1: Scale bar is 1 cm in a-g, 5 mm in e, 2 mm in h, i. (a) *Biota orientalis*: Twigs showing attached cones with viviparously germinating seeds, (b) *Cupressus torulosa*: Twigs showing attached cones with viviparously germinating seeds, (c) *Biota orientalis*: Some detached cones showing germinating seeds, (d) *Cupressus torulosa*: Some detached cones with viviparous germinating seeds, (e) *Biota orientalis*: A single germinating seed showing radicle with cuticular covering at the apical portion, (f) *Biota orientalis*: A single cone showing profusely germinating seeds, (g) *Cupressus torulosa*: A single cone showing profusely germinating seeds, (h) *Biota orientalis*: A single germinating seed and (i) *Cupressus torulosa*: A single germinating seed

the seedlings gradually became dry and shriveled. It did not develop further and withered away.

It was further observed that in *Biota orientalis* the average number of seeds per cone is 8 to 12, each measuring 6 to 8 mm in length and weighing 1.3 to 1.5 mg on an average, of which 8 to 10 seeds showed viviparous germination attached to the twigs and 3 to 6 in the isolated cones. In *Cupressus torulosa* seeds per cone is 35 to 40, each seed measuring 4 to 6 mm in length and weighing 0.6 to 0.8 mg on an average, of which 6 to 8 showed vivipary in the cones attached to the twigs and 2 to 4 in the isolated ones. So, viviparous germination rate is higher in *Biota orientalis* than in *Cupressus torulosa* (Table 1).

DISCUSSION

Vivipary is a natural and common phenomenon in mangroves to escape physiologically dry condition. In other groups, it is either an alternative method for propagation, to overcome unfavourable environmental condition and tide over cold and dry periods or to escape the snowy coverage (D'Rozario *et al*., 2001). It was observed that viviparous seedlings of the present materials did not develop in the plains beyond the month of February, which could possibly be due to the increasing temperature not suitable to the growth of the young seedlings. Viviparous germination in *Biota orientalis* and *Cupressus torulosa* reported may be an adaptive feature against the retarding influence of adverse conditions of frosting. The areas from which the materials were collected are usually covered by snow during the winter periods from November to February. As such vivipary could be an adaptive feature and a means for better and ensured seed germination against the retarding influence of adverse conditions in snow covered areas and low temperature conditions.

Previous records of vivipary in gymnosperm such as *Ephedra trifurca*, *Ginkgo biloba, Podocarpus makoyi*, *P. macrophyllus*, *Pinus wallichiana* and *Biota orientalis* have only reported the occurrence of vivipary in natural habitat. The present report includes the observation of the occurrence of vivipary in *Biota* and *Cupressus* both under *in situ* and *ex situ* conditions. Failure in further growth under *ex situ* condition is due to the unfavourable climatic conditions for the growth of the viviparous plants. Ecological criteria are therefore important in viviparous germination particularly in habitats under stress.

Rao (1988) observed that seed germination and seedling growth of *Cupressus torulosa* varied with respect to light quality, temperature and osmotic water stress. Germination was reduced by continuous dark or far-red light and by osmotic water stress. At higher soil moisture stress seedlings of *Cupressus torulosa* attained greater height. This indicates that external factors regulate germination process.

Rawat and Ghildival (2006) has reported that soaking of the seeds for 24 h in GA_3 solution had shown maximum germination in *A. pindrow* (45.0±4.19%), *C. torulosa* (57.0±3.40%) and *P. smithiana* (56±6.01%) as compared to untreated (control) seeds. It has also been observed that GA_3 treatment caused an appreciable shortening of the germination period by 10 days. Therefore, seeds of these commercially important tree species should be pre-treated particularly with GA_3 for 24 h for getting enhanced germination. Seeds of each of the three species reflect poor germination in nature due to snow cover, seed decay, prevalence of excess water and lack of maintenance, however, because of increasing demand for large quantities of tree seeds for reforestation programmes, pre-sowing treatments are useful to improve the rate and percentage of germination. The present record of vivipary in *Cupressus torulosa* and *Biota orientalis* may also be possibly due to increase GA_3 which induced early germination and so ensured propagation in the frosted environment. But this is yet to be confirmed through biochemical analysis.

Seed size is an important factor in determining the dispersal distance, growth and survival of seedlings (Augspurger and Hogan, 1983; Foster, 1986). Smaller seeds are less competent in establishment and exhibit less seedling vigour (Marsall, 1986; Ganeshaiah and Shanker, 1991). In contrast, larger seeds have better survival probabilities (Amstrong and Westoby, 1993). Correlation between seed size and days for germination indicates that larger seeds have delayed germination than smaller ones. Generally, relatively larger seeds confer an advantage to a developing embryo when seedlings compete for limited resources (Murali, 1997). This is evident from the fact that larger seeds have more endosperm content and so can defer germination process. Correlation between seed size and days for germination indicates that smaller seeds germinates faster than larger seeds (Murali, 1997).

Both *Biota orientalis* and *Cupressus torulosa* have very small sized seeds and low weight and so germinate immediately after maturation.

The number of seeds per cone is found to be inversely proportional to the rate of vivipary. This indicates that possibly low seed production is compensated by high rate of vivipary in *Biota orientalis* than in *Cupressus torulosa* for ensured and effective propagation of the plant particularly in the snowy coverage.

The presence of hypocotyl and root cuticle in the early stage of development or young condition as observed in the present materials is not an unusual feature and has been observed in some angiosperms in the young roots (Martin and Juniper, 1970).

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