Dual mode of anthesis in male plants of sea buckthorn

Ladakh encompasses an area of more than 117,000 sq. km and is one among the three major regions of Jammu and Kashmir (J&K). Having an average altitude of 3600 m amsl, this region is characterized by dry climate and low annual precipitation of about 80–300 mm that results in scanty vegetation[1–3]. However, nature has blessed this extreme part of India with a marvelous gift in the form of sea buckthorn. It is the common name given uniformly to probably all species of the genus *Hippophae*. Belonging to the family Elaeagnaceae[4], sea buckthorn is a native of Asia and Europe[5,6]. The plants are highly variable in height ranging from a small bush to a tree[4], have an extensive root system[6,7] and ability to fix nitrogen[8]. The plant can withstand extreme temperatures from 43°C to –40°C and is drought-resistant[8,9]. Referred to in ancient Greek writings of Theophrastus and Dioscorides[8,9] and known for its usage in traditional Tibetan and Mongolian medicine, the plant has attracted considerable attention from researchers around the world mainly for its nutritional, medicinal and cosmetic value[9,10]. Additional uses as soil enhancer, pollution reducer, source of fodder, fire wood[1,2] and landscape management tool[11] make it invaluable for Ladakh. It, therefore, holds the potential of changing the face of this region if utilized the way it has been in China, Russia, Mongolia, Canada, etc. Two species of *Hippophae* are reported from Ladakh – *Hippophae rhamnoides* ssp. *turkestanica* Rousi and *H. tibetana* Schlecht[1].

Plants of *H. rhamnoides* ssp. *turkestanica* are dioecious and expectedly obligate outcrossers. The ratio of male to female plants varies from population to population. However, the number of males is on a higher side in most of the populations studied. A quadrat of 8 × 8 sq. m studied in Chuchot (Leh, J&K) revealed male-biased sex ratio; for every female there were 2.09 males. In some populations like Khomenibagh (Kargil, J&K), the sex ratio is nearly 1 : 1.

Individual flowers are very small. Male flowers are borne in tight racemes (Figure 1 *a*–*g*) and vary between 4 and 18 per inflorescence. These inflorescences bear a striking resemblance with the cones of gymnosperms both in dehisced (Figure 1 *f*) and undehisced (Figure 1 *l*) states. Female flowers (Figure 1 *h*–*k*) are whorled or arranged in close spirals of 3–12. Irrespective of the sex, flowers are inconspicuous, each having two tepals and a bract that encloses the flower from the outside. All their accessory organs are clothed densely in scales and stellate hairs.

Flowering begins in April. For instance, plants flower by 19 April 2006 in Leh, 14 April 2007 in Nubra valley and between 18 and 22 April 2011 in Kargil. Male flowers are the first to open in a population, with the apical ones in the raceme opening first (Figure 1 *g*). The female flowers follow after a gap of around 8–12 h. Therefore, at the functional level also, the plants are male-biased.

Anthesis in male flowers is particularly peculiar in that two patterns have been observed. (i) Opening initiates with the lateral expansion and probable repulsion of the tepals. Their apical portions, however, are still in overlapping and unexpanded state. Expansion is accompanied by the bending and repelling of tepals in a horizontal plane which leads to the formation of openings along the sides (Figure 1 *c*–*e*). By the time the apical portions of the tepals loosen and expand, the anthers start dehiscing along longitudinal slits. The apices are kept in an overlapped state till the anthers empty their contents. Pollen is shed as and when the wind blows. Anther dehiscence

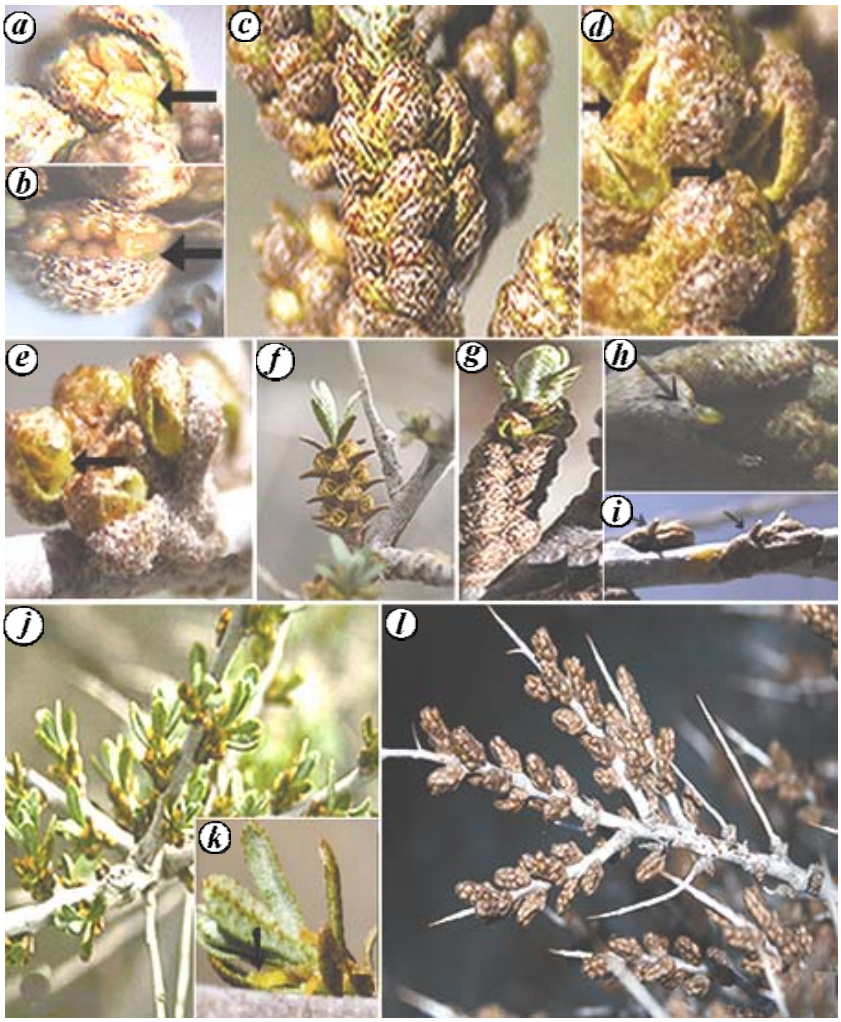

Figure 1. ***a–l***, *Hippophae rhamnoides*. Male flowers with (***a***, ***b***) apical anthesis and (***c–e***) lateral openings. ***f***, Male inflorescence in dehisced state. ***g***, Basipetal opening. ***h***, Female flower at anthesis. ***i***, Female flowers rendered naked by the withering of perianth. ***j***, ***k***, Fully opened female flowers. ***l***, Male inflorescences formed away from the main plant body.

is, thus, simultaneous with or occurs immediately before anthesis (Figure 1 *c*–*f*). (ii) In some flowers opening initiates by the expansion of the apices of the tepals, the stimulus of which then spreads laterally (Figure 1 *a* and *b*). However, what is interesting to note is that the anthers are still in an undehisced state. It takes more than 24 h for these anthers to dehisce.

About 20% of plants in a population show the dual mode of anther dehiscence. The frequency of such flowers per plant varies between 20% and 30%. It takes about 4–6 days for the male flowers to empty their contents.

It is quite possible that the two distinct patterns of anthesis are adapted to two modes of pollination; the lateral opening probably catering to the needs of wind pollination and apical opening for biotic/insect pollination. Even though flowers are inconspicuous and unattractive, a number of diverse visitors like ants, bees, houseflies and sparrows frequent the flowers for different purposes. Bees visit in the morning up to noon; duration of each visit is brief, lasting 6 sec. Ants feed on pollen and houseflies are just casual visitors. Sparrows probably prey on the aphids found in the inflorescences. Therefore, the actual role of insects in pollen transfer remains to be determined.

It is equally likely that the buds with apical anthesis are not able to empty their pollen compared to the ones with lateral opening. This is largely on account of mechanical reasons. There is a considerable space constraint inherent in the floral architecture itself. Presence of bract on one side and floral axis on other apparently keeps the flowers snuggled/squeezed. Anthers after dehiscence unload their contents inside the tepal cavity. Since the tepal opens from the top, only strong wind can take out the pollen. However, those which open laterally have two slits, one on each side. A mild breeze is enough to allow the pollen of such flowers to be carried away.

Male flowers usually differentiate on young shoots which are exserted and tend to be away from the plant body proper (Figure 1 *l*). This is an adaptation to ensure effective pollen dispersal even in small wind currents. Continuous motion of extruded young shoots on slight disturbance or slow wind facilitates pollen dispersal. Had they been amidst the older shoots, dispersal to neighbouring female plants probably would have been hampered.

Female flowers also vary in their behaviour vis-à-vis exposing their stigmas. (a) In nearly 30–40% of flowers in a population, female flowers have a persistent perianth. From this tightly closed perianth the stigma grows and protrudes out at the time of anthesis (Figure 1 *j* and *k*). (b) In many flowers, the perianth withers at an early stage of development leaving behind a naked flower bud and the emergence of stigma marks the beginning of anthesis (Figure 1 *i*).

Under such circumstances, it becomes difficult to ascertain the exact stage of anthesis. However, stigma becomes receptive 24 h after extrusion or opening and is at its peak 72–96 h after anthesis.

Female flowers protected by the perianth are at advantage because at the time of anthesis (14–27 April), the climate of Ladakh is harsh and stigmas are susceptible to desiccation. On the other hand, in flowers where the protruding stigmas are protected by the bracts, the bracts bend at the receptive stage (Figure 1 *j* and *k*) when the stigma attains a length of approximately 2 mm in 3–4 days (Figure 1 *h*).

1. Chaurasia, O. P. and Singh, B., *Cold Desert Plants, Vol. I*, Field Research Laboratory (DRDO), Leh, Ladakh, 1998.
2. Chaurasia, O. P., Basant, B., Verma, A., Ahmad, Z. and Raut, B., *Potential Fodder Plants of Ladakh*, Field Research Laboratory (DRDO), Leh, Ladakh, 2003–04.
3. Singh, L., Ali, A. and Kumar, S., *J. Plant Dev. Sci.*, 2010, **2**, 147–149.
4. Rousi, A., *Ann. Bot. Fenn.*, 1971, **8**, 177–227.
5. Code, D., Seabuckthorn – Ancient food of east and future food of west. www.seabuckthorn.com
6. Lu, R., Seabuckthorn: A multipurpose plant species for fragile mountains. International Centre for Integrated Mountain Development, Katmandu, Nepal, 1992.
7. Yao, Y. and Tigerstedt, M. A., *Euphytica*, 1994, **77**, 165–169.
8. Li, T. S. C. and Schroeder, W. R., *Hortic. Technol.*, 1996, **6**, 370–386.
9. Li, T. S. C., In *Functional Foods – Biochemical and Processing Aspects*, Technomic Publ Co Inc., Lancaster, PA, USA, 1999, pp. 329–356.
10. Li, T. S. C., In *Trends in New Crop and New Uses* (eds Janick, J. and Whiphey, A.), ASHS Press, Alexandria, VA, USA, 2002, pp. 393–398.
11. Small, E., Catling, P. M. and Li, T. S. C., Seabuckthorn (*Hippophae rhamnoides*) An ancient crop with modern virtues; www.seabuckthorn.com

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Puffer fish menace in Kerala: a case of decline in predatory control in the southeastern Arabian Sea

Since 2006, fishermen in Kerala have been complaining about the extraordinary abundance of puffer fishes (Figure 1 *a*) in the Arabian Sea during the post-monsoon period and the extensive damage it causes to their nets and catch[1,2]. These fishes are able to cut through the nylon nets once they are caught causing extensive damage to the nets (Figure 1 *b*). Also, once within the nets they bite at random on other catch, particularly valuable squids and cuttlefishes (Figure 1 *c* and *d*), decreasing their commercial value. Damage to the nets and catch has not been formally estimated, but is apparently running into several crores of rupees as per newspaper reports. The puffer fishes belonging to family Tetraodontidae are uniquely characterized by sharp, plate-like teeth (numbering four, and hence the family name; Figure 1 *e*) and a spiny or prickly, loose-skinned, rib-less body which can take in water to become a prickly or spiny ball. These