Preliminary Observations on Fruit Ripening, Predation and Seed Dispersal in the Wild *Momordica* Species

K Joseph John[1]* and VT Antony[2]
[1] *National Bureau of Plant Genetic Resources, KAU (PO), Thrissur-680656, Kerala, India*
[2] *Regional Herbarium Kerala, St. Berchmans' College, Changanacherry-686101, Kerala, India*

The present paper presents observations on fruit ripening and dispersal, predation and seed dispersal in the wild *Momordica* species. Fruit morphology of the genus *Momordica* L. is highly adapted for bird dispersal. Association of specific species of birds in seed dispersal and ant predation in seed germination was observed. An understanding of the biotic agents involved in the perpetuation of biological processes is a prerequisite for devising a holistic conservation strategy for the wild *Momordica* genepool.

Key Words: *Momordica*, Phenology, Fruit ripening, Seed predation and Dispersal

Introduction

The genus *Momordica* L. (Family Cucurbitaceae) assumes significance for conservation of genetic diversity in India by virtue of being the wild relative of cultivated bitter gourd, besides their direct utility as nutritious vegetables and multipurpose medicinal plants. Six species occur in India and among them, *M. dioica* Roxb. and *Momordica charantia* var. *muricata* (Willd.) Chakrav. have wider distribution scattered over the entire geographical territory (Joseph, 2005; Joseph *et al*., 2006; Joseph and Antony, 2007). *M. Sahyadrica* Joseph & Antony is endemic to the Western Ghats (Joseph and Antony, 2007) and *M. balsamina* L. is restricted to the arid belt of Rajasthan and Gujarat (Joseph, 2005). *M. cochinchinensis* (Lour.) Spreng., commonly known as 'sweet gourd', occurs in a wild state in Andaman Islands and North-eastern states (Bharathi *et al.*, 2006). *M. subangulata* ssp. *renigera* deWilde (Teasle gourd), a native of northeast India, is now cultivated in the whole North East, West Bengal and Andaman Islands (Joseph *et al*., 2006). *M. charantia* and *M. balsamina* are monoecious annuals whereas the rest of the species dealt here are dioecious perennials with tuberous roots. All are essentially seed propagated though vegetative propagation through adventitious tubers is observed in *M. subangulata* ssp. *renigera*.

However, a perusal of its status in *ex situ* holdings and genebanks indicate its poor representation and neglect in the existing biodiversity conservation programmes. For devising a sound conservation strategy for the wild genepool of *Momordica*, taking into account its present conservation status and perceived threat of genetic erosion, it is mandatory to have a good understanding of the phenology and reproductive biology of the genus.

Phenology involves different stages in the lifecycle of the plant/species such as sprouting of dormant tubers and seed germination, flowering, fruit ripening and senescence. Fruit ripening is a genetically determined and regulated event that prepares the fruit or seed for dispersal. However, the control mechanism in ripening varies because of the species diversity and variation in morphology of the fruit (Brady, 1987). Ripening is regarded primarily as a manifestation of senescence of the fruit in which intercellular organization begins to break down (Sucher, 1973). The work on ripening of fruits has been restricted to horticultural crops especially to temperate pome and stone fruits, and citrus, avocado and mango to some extent (Hulme, 1971). The most readily apparent phenomena in the ripening process are colour changes which involve chlorophyll loss resulting in subsequent synthesis of new pigments, alterations in flavour, changes in acidity, astringency, sweetness and softness of the fleshy tissues (Rhodes, 1970).

Materials and Methods

In the germplasm characterization plot, ten plants each of *M. charantia* var. *muricata*, *M. balsamina*, *M. subangulata* spp. *renigera*, *M. sahyadrica* and *M. dioica* were observed regularly during the *Kharif* season during 2002, 2003 and 2004. Fruits of all the five taxa were observed from female flower opening to bursting of orange ripe fruits through colour breaker, mature ripe and red ripe stages. Ten fruits in each species were tagged the day after pollination, days taken to reach bursting of fruits were calculated and major morphological stages associated with ripeness recorded. As stage of harvest for vegetable is also important, the time up to which the seeds remain tender and soft, while attaining maximum

Author for Correspondence: E-mail: josephjohnk@rediffmail.com

size and weight was determined in another set of ten fruits in each species by passing a sharp knife through the fruit from 10th to 18th day of fruit development.

In the germplasm characterization plots, observations were recorded on fruit presentation, seed predation and dispersal. Bird activity in and around *Momordica* vines were observed at close quarters from a hidden place. Vernacular names of common birds were used to record the bird visits and then their zoological identity was later confirmed with the ornithologists of Kerala Forest Research Institute, Peechi, Kerala. Polythene sheets were spread below the bearing vines and fallen seeds (de-pulped) if any were counted. Similarly, seed predation was calculated by placing 100 seeds each with both washed and red fleshy aril intact on a newspaper sheet and observing their predation by various species of ants.

Results and Discussion

Ripeness in fruits is determined using several methods and these methods vary depending upon the fruit type and specific requirement. The visual assessment of appearance is the simplest method. The changes in colour from green to yellow or orange is effective in many crops. Fruit ripening and loosening from the plant are considered as indicators of maturity in a variety of fruits (Jackson, 1986). There are several approaches to quantify the ripening process. The number of days required to reach fruit maturity from full bloom is a reliable indicator (Jackson, 1986).

M. balsamina has the shortest and *M. subangulata* ssp. *renigera* has the longest ripening span (Table 1). Build up of red tinge in spine tips do not indicate seed coat hardening in *M. subangulata* ssp. *renigera*, whereas, full size and turgid appearance are a reliable indicator of fruit maturity. Physiologically mature fruits soften within 24-48 hours from harvesting in *M. sahyadrica* and *M. dioica*, whereas, *M. subangulata* ssp. *renigera* fruits remain green and fresh for longer periods. Thus, *M. subangulata* ssp. *renigera* has better keeping quality and shelf life than others.

Mature fruits in all species attain full size, become bright in colour (green or whitish green or off white), fruit surface is turgid, with bumps and tubercle bases spread out. When the fruits begin to ripen, the exterior colour changes to orange yellow and the pulp (seed aril and placenta) becomes gelatinous and scarlet red. Coinciding with colour changes, the fruit pulp loses bitterness and becomes sweet. Fruits start developing yellow colour and then change to orange colour gradually and uniformly in *M. subangulata* ssp. *renigera* whereas in all other taxa, fruits change colour suddenly and is localized and spreads within a day or two. Thus, in *M. subangulata* ssp. *renigera*, redness cannot be taken as indicator of ripeness. The fruits remain intact until bursting open in to three or more pieces from base, usually in a star like configuration. Ripe fruits do not abscise, as the pendant fruit stalks remain strong and split fruit wall dry up and shrivel or wither and crumble due to rain and sun.

Species of frugivorous birds and ants feeding on seeds are given in Table 2. *Megalima lineata* (barbet) is often a pest of coffee estates, feeding on coffee berries. It is interesting to note that highest population of *M. sahyadrica* is found in coffee estates, hence adding credence to bird dispersal. Although crows, koyal, crow-phesant ('uppan') and sparrows were found as infrequent visitors, seed feeding was not observed. Even though, seeds per fruit varied from 15.0 to 30.0 (up to 50.0 in *M. sahyadrica*), no depulped seed was found on the floor (the fleshy fruit wall is not eaten by any of these birds), giving credence to the inference that while feeding on the fleshy aril, the seeds are gulped. All the *Momordica* species have very thick seed coat, enabling their passage through bird gut undamaged, but slightly reduced in size as it is partially digested. Strong pendulous fruit stalks, attractive orange red colour, fruits splitting open from base and rolling back and expanding in a star like configuration exhibiting rows of scarlet red aril (covered seeds), and small round or flat dented seeds are adaptations for bird dispersal. Ethnobotanical interviews

Table 1. Observations on various stages of fruit maturity

Species	No. of days to full fruit size	No. of days to colour breaker	No. of days to red stage	No. of days to bursting stage	No. of days to seeds remain tender
M. charantia var. *muricata*	12	25	26-27	29-30	8
M. balsamina	9	22	24	25	8
M. dioica	15	28	29	30-31	12
M. sahyadrica	15	30	31	32-33	12
M. subangulata ssp. *renigera*	18	20	35	38	15

Table 2. Seed dispersal and predation in various *Momordica* species

Species	Biotic agent	Zoological name	Common/vernacular name	Activity
M. charantia	Ant	*Myrmicaria* Saeeuders sp.	Koonan	Feeding on red sweet aril
var. muricata	(Family	*Odontomachus* Latrelli sp..	Katturumbu	Carrying dry seeds and storing
	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu*	it in ant hives
	Bird	*Rufus treepie*	South Indian Tree Pie	Feeding fleshy aril, gulping
		Megalima viridis	Small green barbet	seeds
		Pycnonotus sp.	Red whiskered bulbul	
M. dioica	Ant	*Odontomachus* Latrelli sp.	Katturumbu	Feeding on red sweet aril
	(Family	*Myrmicaria* Saeeuders sp.	Koonan	Carrying dry seeds and storing
	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu	it in ant hives
		Solenopsis Westw. sp.	Neyyurumbu*	
	Bird	*Pycnonotus* sp.	Red whiskered Bulbul Barbet	Feeding fleshy aril, gulping
		Megalima viridis		seeds
M. sahyadrica	Ant	*Odontomachus Latrelli* sp.	Katturumbu	Feeding on red sweet aril
	(Family	*Myrmicaria* Saeeuders sp.	Kooonam	Carrying dry seeds and storing
	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu	it in ant hives
		Crematogaster Leud sp.	Small black ants	
	Bird	*Megalima viridis*	Small green barbet	Feeding fleshy aril, gulping
		Rufus treepie	Tree Pie	seeds
		Pycnonotus sp.	Bulbul	
M. *subangulata*	Ant	*Odontomachus Latrelli* sp.	Katturumbu	Feeding on red sweet aril
ssp.	(Family	*Myrmicaria* Saueeders sp.	Koonan	Carrying dry seeds and storing
renigera	Formicidae)	*Monomorium* Mayx sp.	Shavam theeni urumbu	it in ant hives
	Bird	*Megalima lineata*	Lineated barbet	Feeding fleshy aril, gulping
		Rufus treepie	Tree Pie	seeds
		Pycnonotus sp.	Bulbul	

*observed to feed only on aril

with the tribal inhabitants and spotting of *M. dioica* seedlings rooted in crevices of stonewalls add further credence to the involvement of birds in seed dispersal (Joseph, 2005).

Ripe fruits of all species were found densely covered with ants and they were predating on red fleshy sweet aril. Many species of ants were found carrying dry seeds of *M. dioica*, *M. sahyadrica* and *M. subangulata* ssp. *renigera* and were recovered from their hives. Besides, carrying to small distance, ant feeding may help to scarify the seeds by releasing formic acid. *M. dioica* seeds are reported to contain up to 39 percent oil (Dubey and Gaur, 1990). The ant genera falling under Formicidae family in general has been reported as primary seed dispersing ants and Crematogaster species has been found as an important dispersal agent in tropical forests (Beattie, 1985).

The unit of dispersal (diaspore) is seed in the case of *Momordica*. A two-pronged strategy for dispersal is evident; colourful arils as food reward for birds and oiliferous seeds for dispersal by ants. The fleshy aril (sarcotesta) is of placental origin and it turns to scarlet crimson colour on ripening. The sweet and slimy aril attracts a host of birds, snails and ants. Seed coat is hard enough and passes unharmed through the guts and bird dispersal is the rule in the genera. The fallen seeds on the floor are carried to a small distance (even up to 8 m) by ants.

The place of production of seeds does not have the carrying capacity to grow and sustain all of them. An unhealthy competition is avoided by dispersing seeds even at the danger of some casualities. Dependence on animals for seed transport means that the plants are susceptible to dispersal failure when their seed vectors become rare or extinct. Disruption of this mutualism can have serious consequences for the maintenance of plant/species populations. This again highlights the need for devising a holistic approach to conservation of *Momordica* genepool involving the biotic agents as well.

References

Beattie AJ (1985) *The Evolutionary Eecology of Ant-Plant Mutualisms*. Cambridge University Press, Cambridge.

Bharathi LK, G Naik and Vishal Nath (2006) An exquisite vegetable variety. *ICAR News.* **12(4):** 14-15.

Brady CJ (1987) Fruit ripening. *Ann. Rev. Plant Physiol.* **38:** 155-178.

Dubey AK and AS Gaur (1989) Studies on pollen germination and storage in kakrol (*Momordica dioica* Roxb.). *Haryana J. Hort. Sci.* **18(1-2):** 119-122.

Hulme AC (1971) *The Biochemistry of Fruits and Their Products* Vol II. Academic Press, New York.

Jackson JE (1986) Third International Symposium on Research and Development of Orchard Plantation Systems. *Acta Hort.* **160:** 1-420.

Joseph John K (2005) *Studies on Ecogeography and Genetic Diversity of the Genus Momordica L. in India.* Ph.D. Thesis, Mahatma Gandhi University, Kottayam, India.

Joseph JK, VT Antony and YC Roy (2006) On the occurrence, distribution and taxonomy of *Momordica subangulata* Blume ssp. *renigera* (G. Don) de Wilde in India. *Genet. Resour. Crop Evol.* **54(6):** 1327-1332.

Joseph JK and VT Antony (2007) *Momordica sahyadrica* sp. *nov*. (Cucucrbitaceae), an endemic species of Western Ghats of *India Nord. J. Bot.* **24(5):** 539-542.

Rhodes MJC (1970) The climacteric and ripening of fruits. In: AC Hulme (ed.) *The Biochemistry of Fruits and Their Products* Vol 1. Academic Press, New York, pp. 521-533.

Sucher JA (1973) Senescence and postharvest physiology. *Ann. Rev. Plant Physiol.* **24:** 197-224.