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Morphological variations in populations of *Urginea indica* Kunth.Liliaceae

M. N. Shiva Kameshwari[1*], K. J. Thara Saraswathi[2] and M. Muniyamma[3]

[1]Department of Botany, Biosystematics Laboratory, Bangalore University, Jnanabharathi, Bangalore-560 056 (Karnataka), INDIA

[2]Department of Biotechnology, Bangalore University, Bangalore (Karnataka), INDIA

[3]Ex-Vice Chancellor, Gulbarga University, Bangalore (Karnataka), INDIA

*Corresponding author. E-mail: shiva_mn2k7@yahoo.com

Abstract: An attempt has been made to enquire into the morphological variations which leads to evolutionary divergence of populations of *Urginea indica Kunth*. In particular, there were considerable morphological variations within the species. The thirty two cytotypes showed distinct morphological differences in shape, size and colour of bulb and leaf, the length of inflorescence and flower colour. The morphological complexity is accompanied by high degree of cytological variations. Preliminary measurements of reproductive, characters have shown that no noteworthy results may be obtained in this characters except pedicel length but the vegetative character deviated significantly. Flowering and blooming time varied that also played a role in isolation of these populations. These morphological differences have a genetic basis and would be worthy in recognizing them as a separate sub specific taxon.

Keywords: *Urginea indica*, Liliaceae, Cytotype

INTRODUCTION

The genus *Urginea* Steinhill of the tribe scilleae of Liliaceae comprises about hundred species (Airy Shaw, 1966). It is represented in India by about nine species (Hemadri and Swahari, 1982). A taxonomic revision of the genus has been made by Deb and Dasgupta (1987) and they have recognized only five species in India.

U. indica occurs both in southern and in pennisular part of India including the coastal belt as well as temperate regions of the Himalayas.

U. indica commonly called as Indian squill is a geophyte with a big bulb. *U.indica* happens to be endemic to certain floristic regions of the world often occurring in remote and difficult terrains and not easily accessible. *U.indica* fairly common all over the hills on the upper parts, is particularly abundant on the slopes. During the hot season, just before the rains, flowers appear on long or short scapes.

Squill bulb has long been used as a source of medicine with biocidal applications. It is used as an anticancer agent, expectorant, and cardiac stimulant and in treating asthma, rheumatism, edema, dropsy, allergies and gout. Due to these properties, squill bulb has found its place in the British and European Pharmacopoeias. Despite the above properties, it is surprising that the genus has not attracted greater attention of the research workers in India.

In view of the above, in the present investigation on the Indian squill, 32 populations were collected representing diploid, triploid, aneuploid, tetraploid, and hexaploid from different parts of India. In the local natural population, various biotypes of this species including diploids and triploids, have been suspected to be present. The suspicion was mainly based on - vegetative characters such as height of the plant, root length, circumference of the bulb, leaf index and reproductive characters such as length of inflorescence, length of pedicel, number of flowers per plant, length of flower, stamen, gynoecium and fruit. Karyomorphological studies on 14 different populations of *Urginea indica* have been made by Shiva Kameshwari and Muniyamma (2004). Further, morphological studies are needed to prove or disprove the above speculation.

The present study aims to provide a comprehensive, description of the morphological properties of *U.indica* for the first time.

MATERIALS AND METHODS

Bulbs of 32 different populations were collected from various localities of south India and were grown in the Botanical garden of the Department of Botany, Bangalore University under uniform environmental conditions (Tables 1 and 2). Field observations and collections were made two times a year during the period of five years from 2005 to 2010. Investigations were carried out to evaluate the frequency of variations in different populations of *U. indica*. The investigation on variations were chiefly based on field studies. The methods of

Table 1. Morphological variations in *Urginea indica* Kunth.

Locality	Collection No.	Height of the plant (cms)	Length of the root (cms)	Circumference of the bulb (cms)	No. of leaves per plant	Leaf index (cms)	Length of the inflorescence (cms)	No. of flowers per plant	Length of the pedicel (cms)	Length of the flower (cms)	Length of stamen (cms)	Length of gynoecium (cm0.7s)	Length of the fruit (cms)
Kushalnagar	S & M 01	58	28	18	14	17.22	53.5	22	3	1.5	0.7	0.9	1.3
Shimoga	S & M 02	13	14	26	8	17.6	6	22	0.4	0.8	0.5	0.7	0.7
Basavanahalli	S & M 03	53.5	10	14	5	6.2	50	12	3	1.2	0.6	0.9	1.2
Ranganathittu	S & M 04	39	11.5	16	4	9.8	34.2	14	3.7	1.0	0.6	0.7	1.0
Chamundi Hills	S & M 05	15	9.5	17	6	5.4	10	14	0.3	0.6	0.3	0.6	0.7
K.R.S. Island	S & M 06	63	11	12	3	18.9	52	3	2.5	0.8	0.8	0.7	0.8
Gopala Swamy Betta	S & M 07	41	12	18	6	59.8	30	8	2	0.8	0.5	0.7	0.8
Dopae Gowdanapura)	S & M 08	33	8.5	18	8	44.0	25	12	0.5	0.9	0.4	0.9	0.8
Channamalipura (North)	S & M 09	38	8	14.5	6	67.6	3.5	14	3	1.5	0.8	07	1.3
Channamalipura (South))	S & M 10	46.5	10.5	12.5	5	49.5	40	10	0.5	0.8	0.7	0.6	0.7
Channamalipura (East)	S & M 11	42	10	13	5	60.0	36	18	1	2.2	0.3	0.9	0.7
Channamalipura (West)	S & M 12	30	4.7	11.5	2	33.0	22	10	1.2	1.2	0.8	0.7	1.2
Maddur Forest Range	S & M 13	20	10	20	5	68.2	15	14	1.5	2.0	0.4	0.9	0.7
Gorur	S & M 14	49	10	13	5	31.5	36	6	0.3	1.3	0.7	0.6	1.2
Banganavadi	S & M 15	48	8	10	5	35.0	31	8	1	0.8	0.8	0.7	0.8
Sringeri (Kudremukha)	S & M 16	35	7	7	4	25.6	28	16	1.8	1.2	0.5	0.8	1.2
Mallahalli	S & M 17	43	16	18	4	72.8	35	8	0.8	1.6	0.4	0.7	1.3
Pilaly Village (Chitradurgha)	S & M 18	15	18	21	7	25.6	10	20	0.5	1	0.6	0.6	0.9
Trichendur	S & M 19	25	21	6	8	66.0	18	22	0.4	2.0	0.3	0.9	0.8
Anchipura (Gundalpet)	S & M 20	40	8	18	6	28.0	33	4	2.3	0.8	0.7	0.6	0.6
Kalupura (Nanjangud)	S & M 21	50	14	20	6	70.0	42	6	0.6	0.8	0.6	0.9	0.8
Tuticorin Island	S & M 22	55	12	15	7	68.9	45	5	2	1.3	0.7	0.8	1.5
Hadinaru (Mysore)	S & M 23	30	6	21	5	40.0	17	5	0.3	1.3	0.5	0.9	1.0
Papanasini (Tirupati)	S & M 24	58	10	15	13	30.0	42	22	0.6	1.2	0.8	0.7	1.2
Gulbargha	S & M 25	10	20	18	4	47.5	3.5	10	1	0.8	0.3	0.8	0.6
Karighatta (Srirangapatana)	S & M 26	68	22	23	6	33.0	60	10	3.2	1	0.8	0.8	1
Chamundi Hills (Uthanahalli)	S & M 27	42	20	25	5	175.0	38	12	0.8	0.8	0.5	0.5	0.4
Bellur	S & M 28	38	12	15	6	14.0	35	6	2.5	1.2	0.5	0.9	1.5
G.K.V.K. Campus (Bangalore)	S & M 29	58	10	12	4	22.4	50	12	0.6	0.6	0.8	0.6	0.6
Sholapur (Bombay)	S & M 30	64	18	15	7	3.8	58	14	2	0.8	0.7	0.9	0.8
Nagamangala	S & M 31	16	13	25	5	57.0	7.5	24	0.1	0.8	0.4	0.4	0.6
Kadalur (East coast)	S & M 32	33	23	18	4	24.0	30	10	0.1	0.8	0.4	0.4	0.8

Table 2. *Urginea indica* Kunth various habitats

Habitat	Collection No. (Cytotype)
Open Fields	2, 29, 30
River Island	4, 6
Marine Island	22
Forest Canopy	1, 8, 9, 10, 11, 12, 14, 15, 17, 18, 20, 21, 23, 25, 28, 31
Crop Fields	3
Foot Hills	5, 7, 24, 27
Kudremukh Forest Range	16
Maddur Forest Range (Deciduous)	13
Rocky Area (Xeric)	26
Coastal Area (Saline)	19, 32

measurements of various morphological features followed the methods of Dixit and Yadav (1989). The attributes measured on each populations for their vegetative characters were height of the plant, length of root, circumference of the bulb, no of leaves / plant, leaf index from July to November and reproductive characters were length of inflorescence, length of pedicel, number of flowers / plants, length of flower, stamen, gynoecium and fruit length which starts from April to June. Morphological characters were scored in 12 plants for each population and twelve morphological parameters were recorded for each plant (Table 1) for two consecutive seasons and the averages were calculated.

RESULTS AND DISCUSSION

Morphological characters of thirty two populations of *Urginea indica* under study are tabulated in Table 1 and are depicted in Figs. 1 and 2. These are graphically represented in Figure 4 and 5. *Urginea indica* is an ideal material for the study of phenotypic plasticity and have shown considerable variation within poulations.

Thirty two populations of *U.indica* were studied and characterized by certain conspicuous features that makes them stand apart.

The morphological variations in populations of *U.indica* has long been recognized, but no prior attempts have been made to distinguish the different forms. This is probably due to the fact that no field collection ever contains both floral and vegetative feature together. Similar studies have been made by Rebecca E. Irwin (2000). Morphological differentiation in these populations in more obvious than differentiation in chromosome morphology *U.indica* species seems to comprise a stable polymorphism in which the different forms have attained reproductive isolation and genetic stability and hence, each form has retained its morphological identity.

The polygraphs (Figs. 4 and 5) are stylistic representation of the variation in morphology. These different populations of *U. indica* studied during the present investigation has revealed intriguing facts. The vegetative and reproductive characters vary in different populations. Phenotypic correlations among the 32 populations revealed that each population is phenotypically distinct in characters like size of the plant, shape of the bulb, leaf no and size, length of inflorescence. They have also been found to retain their distinctive phenotype when grown together in the garden under a uniform treatment. Of the 12 parameters that have been analysed (Figs. 4 and 5), the vegetative characters show great variations which could be used as dependable taxonomic characters at the population level. On the other hand, the reproductive characters show lesser remarkable uniformity variations. *Urginea indica* seems to be a very good material for the study of phenotypic plasticity. Deeply trilobed capsule and flattened seeds are a common feature found in all the 32 populations under study.

The shape of the bulb in populations of *U. indica* ranges from round, oval, conical, pear-shaped, globular and oboconical. Colour of the bulbs vary from yellow, brown, white and green. Diameter of the bulb ranges from 7 cms (cytotype 16) to 26 cms (cytotype 2) (Fig. 4. c). According to Dhru-pal *et al.*(1990) Growth, flowering and multiplication rate were significantly affected by big bulb size contrary, in the present study, the smallest bulb to flowered very well. Height of the plant ranges from 13 cms (cytotype 2) to 70 cms (cytotype 31) (Fig. 4.a). The leaves in all the populations are basal growing in clusters, linear or lanceolate with acute and obtuse apex. Cytotype 1 shows 3 prominent parallel veins which is a distinguishing character compared to other populations. Such viens have also been noticed in cytotype 7 and 27. Number of leaves range from 2 (cytotype 12) to 14 (cytotype 1 and 24) (Fig. 4. d). Characteristic white and green patches have been observed in population 10. Neddle-like leaves are noticed in population 30. Backward curving of the leaves was observed in population 1 and 25; leaf index of 5.4 cms was found in (cytotype 5) and highest of 175 cms in (cytotype 27) (Fig. 4. e).

The reproductive characters such as length of inflorescence varied from 6 cms. (cytotype 2) to 58 cms (cytotype 26, 30) (Fig. 4. f). Number of flowers per plant ranges from 3 (cytotype 6) to 24 (cytotype 31) (Fig. 4.g); Length of pedicel varied from 0.1 (cytotype 31) to 3.7 cms (cytotype 4) (Fig. 4.i). Length of flower and fruit lengths were almost equal ranging from 0.6 (cytotype 29) to 2.2 in (cytotype 11) (Figs. 5. h and l); Stamen length ranged from 0.3 (cytotype 5) to 0.8 (cytotype 6) (Fig. 4.j); Length of the Gynoecium ranged from 0.4 (cytotype 31)

Table 3. Cytological and reproductive variations in *Urginea indica* Kunth.

Population number	Ploidy	Chromosome Number	Blooming	In florescence / Leaves
S & M 1	Diploid	20	Night	Hysteranthus
S & M 2	Diploid	20	Forenoon	Hysteranthus
S & M 3	Aneuploid	32	Night	Hysteranthus
S & M 4	Aneuploid	34	Night	Hysteranthus
S & M 5	Aneuploid	38	Night	Hysteranthus
S & M 6	Aneuploid	36	Forenoon	Synanthus
S & M 7	Tetraploid	40	Forenoon	Synanthus
S & M 8	Tetraploid	40	Forenoon	Synanthus
S & M 9	Aneuploid	46	Night	Synanthus
S & M 10	Hexaploid	60	Forenoon	Hysteranthus
S & M 11	Tetraploid	40	Forenoon	Synanthus
S & M 12	Triploid	30	Forenoon	Synanthus
S & M 13	Tetraploid	40	Forenoon	Synanthus
S & M 14	Tetraploid	40	Forenoon	Synanthus
S & M 15	Aneuploid	38	Forenoon	Hysteranthus
S & M 16	--	--	Forenoon	Synanthus
S & M 17	--	--	Forenoon	Synanthus
S & M 18	--	--	Afternoon	Hysteranthus
S & M 19	--	--	Forenoon	Synanthus
S & M 20	--	--	Afternoon	Synanthus
S & M 21	--	--	Afternoon	Synanthus
S & M 22	--	--	Afternoon	Hysteranthus
S & M 23	--	--	Forenoon	Hysteranthus
S & M 24	Tetraploid	40	Afternoon	Synanthus
S & M 25	--	--	Forenoon	Hysteranthus
S & M 26	--	--	Afternoon	Hysteranthus
S & M 27	--	--	Afternoon	Hysteranthus
S & M 28	Tetraploid	40	Night	Synanthus
S & M 29	Diploid	20	Forenoon	Synanthus
S & M 30	Diploid	20	Forenoon	Hysteranthus
S & M 31	--	--	Afternoon	Hysteranthus
S & M 32	Diploid	20	Forenoon	Synanthus

indicate that each population represents a distinct morphocytotype. Such differences amongst different populations might have also lead to the evolution of races. Similar studies have been made by Jha and Sen (1984) and Oyewole (1987) in the diploid and polyploid Indian squills a fact strongly depecting again a cytological bases of morphological variations. Intra specific variation in *Brodiaea doughlasii* have been made by Mary E. Barkworth (1979).

Another fact worth noting is two different cytotypes appearing in the same climatic zone, i.e., diploids and tetraploids in Channamalipura. A detailed analysis of the habitat of these populations indicated a correlation of certain microclimatic conditions associated with such cytotypes.

According to Jha and Sen (1983a and b) the cytotypes do not show marked phenotypic difference between each other and considerable overlapping characters was seen between different populations. On the contrary, in the present study, the populations of *U. indica* showed marked morphological differences as well as cytological variations. The present cytotypes are morphologically distinguishable phenotypic populations. The occurrence of these forms cannot be attributed merely to phenotypic

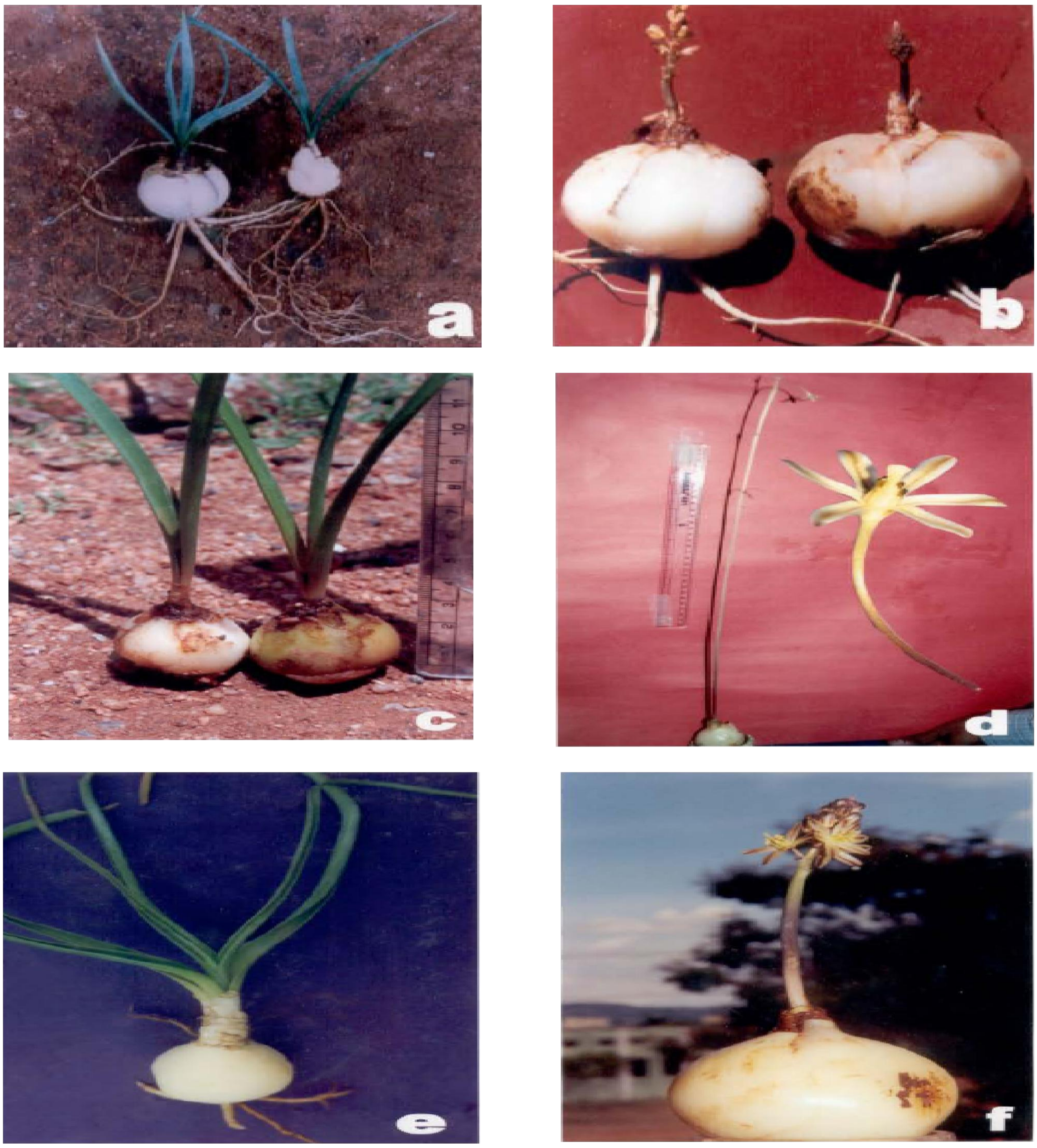

Fig. 1 (a – f). *Urginea indica in vegetative phase* (a, c and e*), Urginea indica in reproductive phase(b, d and f).*

to 0.9 (cytotype 19) (Fig. 5. k). Similar studies have been made by Kaviani (2008) and Ahmet Kahraman *et al.* (2010). In all the 32 populations studied, roots were smooth-walled but ornamentation or markings on the roots was noticed in population 7 (Fig. 4.b). Drooping flowers were seen in populations 1 and 6 (Fig. 2. h) while the remaining 30 populations show erect flowers (Fig. 1. b, d and f). Flowers in all the populations were light brown or dingy brown in colour but in population 22 yellow flowers were noticed which was characteristic of the population. The emergence of two inflorescences at a time in population 18 and was not found in any other populations (Fig. 2. j).

An interesting feature which were observed in these populations the peculiar blooming of the plants. There were three different periods of blooming, day blooming noticed in cytotypes 2, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 23, 25, 29, and 30 where as in 1, 3, 4, 5, 9, 21, 22, 24, 26, 27 and 28 night blooming was noticed. In population 18, 20, 31, the flowers bloomed in the mid day. Reproductive

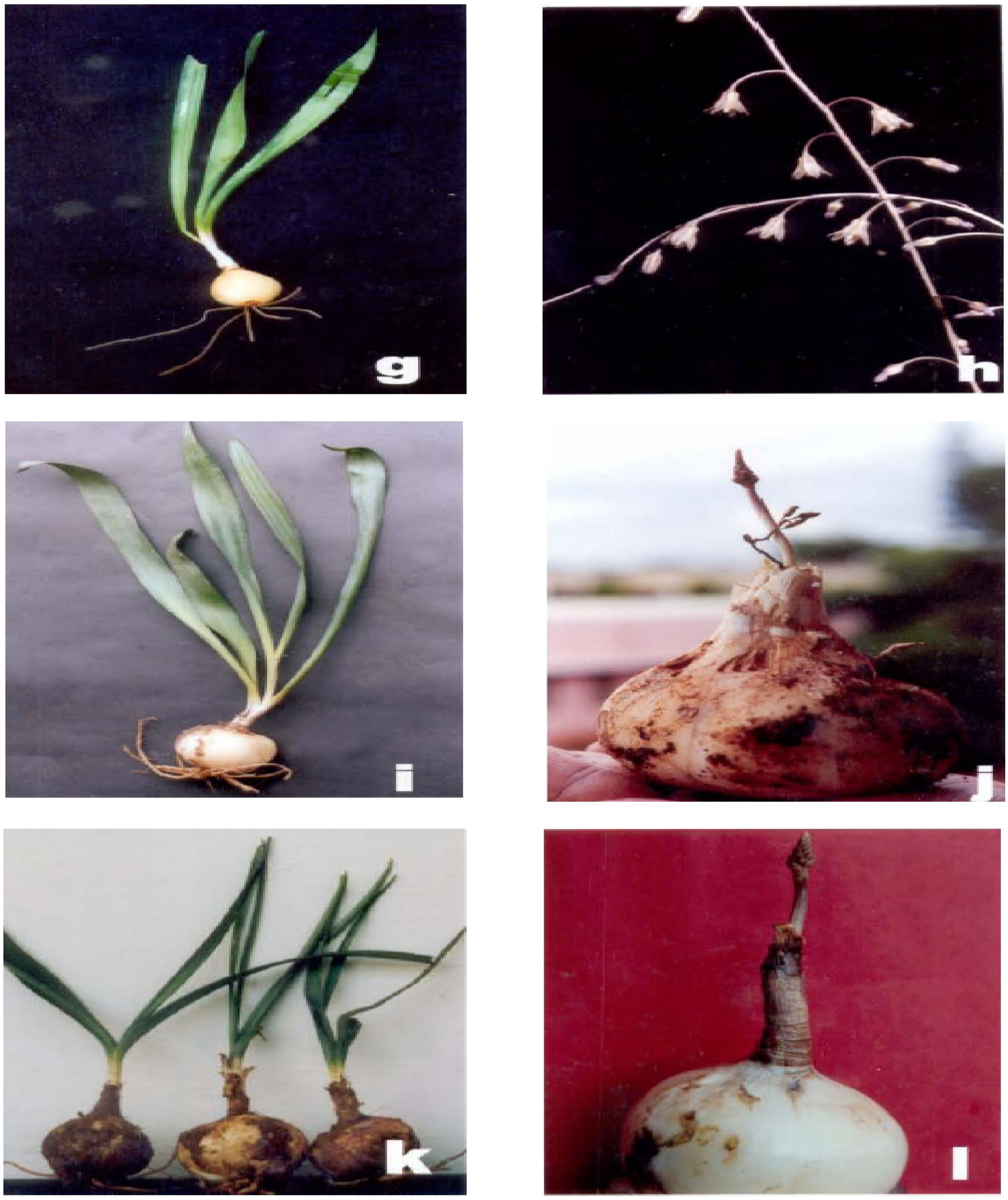

Fig. 2. *Urginea indica in Vegetative Phase*(g, i and k), *Urginea indica in reproductive phase(h, j and l)*

isolation through flowering might have played an important role in speciation and evolution of the species (Table 3).

Differences between diploids, tetraploids and aneuploids have also been noticed. Two diploid populations collected from Kushalnagar and Shimoga show differences in blooming times. Former shows night blooming with drooping flowers and the latter day blooming with sessile flowers adopressed to the scape indicating a cytological basis for behavioural variations in the blooming periods.

In fact, no two populations were alike in their morphological characters. Such population differences along with 90% uniformity within a population clearly

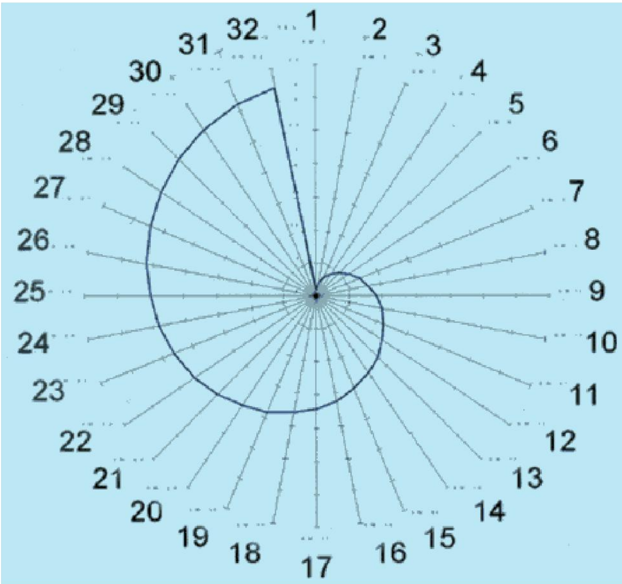

Fig. 3. *Key diagram of the polygraph of 32 different populations of Urginea indica.*

plasticity. It may be due to cytological and environmental conditions therefore, there is an incipient approach towards reproductive isolation starting with blooming and progressing towards morphological variations leading to speciation.

A noteworthy feature of the these populations was that the seeds were sterile. The Indian squill has a very effective method of vegetative propagation through the production of underground daughter bulbs in few populations.

One of the outstanding features of *U.indica* is the manner in which it adopts to seasonal peculiarities. The plants generally appear above the soil soon after the first shower and completes their vegetative and reproductive phase disseminating the seeds. The aerial part completely dries up only to reappear in the next growing season. Plants are totally devoid of leaves during flowering and become destitute of flowers after the appearance of foliage. Bulbs produce inflorescence first and the leaves appear later and in a few populations, leaves and flowers appear together.

Hooker (1892) had recorded 5 species under the genus *Urginea* steinhill. He divided them into 2 groups In some species flowers appearing before leaves – a-type Hysteranthus type. Leaves and flowers appearing together – b-type Synanthus type in the remaining species. In the present study a new record of both a and b type appearing in *U. indica* populations was noticed (Table 3).

In 5 diploids populations three show Hysteranthus and two show Synanthus types. Among 6 Aneuploids four populations show, hysteranthus and two synanthus while in 8 tetraploids Synanthus type appears in seven populations and in one population collected from Bellur it shows Hysteranthus type. Hexaploid population show Hysteranthus and triploid Synanthus type.

Plants growing in different habitats, such as open field, marine island rocky area, coastal area and in forest ranges were very different in appearance, they vary in their bulb size, leaves and length of inflorescence (Table 2). Similar studies have been made by Tateoka (1973) Carolyn *et al.* (1992) and Takahashi *et al.* (1998).

The diploids having same chromosome numbers and are found growing in various habits like open fields, forest floor and in grass land coastal areas (Table 2).

In tetraploids, all the populations were found growing in the forest ranges except population 28 collected from Bellur (found growing in foot hills). In aneuploids, there is a wide variation in their habitat found growing in crop fields, river islands, foot hills and in the forest floor. Triploids and hexaploids grow in the same habitats i.e., forest floor. These facts suggest that the thirty two populations have dissimilar conditions of existence and are evolving in their cytological and morphological features.

The variation in flowering and blooming time associated with different morphological, properties are connected with the evolutionary divergence of new populations. This phenomenon appears to be influenced by the climatic geographic and topographical conditions prevailing in the localities in which the plants grow.

A population from Ranganthittu clearly deviates from other populations in having the longest pedicel of 3.7 cms. This character seems to be singularly unique to this population (Fig. 5, i).

All populations tend to be more homogenous when collected from one area, but intrapopulational variations have been noticed in populations collected from Channamallipura. This population showed vide variations in morphology and in their chromosome numbers. These were categorized into 4 different groups and have been designated as Channamallipura North, South, East and West. Although sexual reproduction provides the highway for evolutionary, diversification, the cytotypes here have completely resorted to vegetative reproduction without seed setting. Despite this, it is noteworthy, that cytological changes have taken place.

Observations on pollen grains of only a few populations showed variability in size. Diversification in morphological and ecological characters is greater in the diploid, aneuploid and tetraploid populations of the plant. It is observed that the diploid level provides the basic level and the polyploids show further diversification.

Bengt Bentzer (1973) reported the appearance of the fertile flowers first and sterile flowers later after 2 to 5 days. In *U. indica* also a few tetraploid populations show sterile and fertile flowers appearing together.

These morphological variations along with cytological

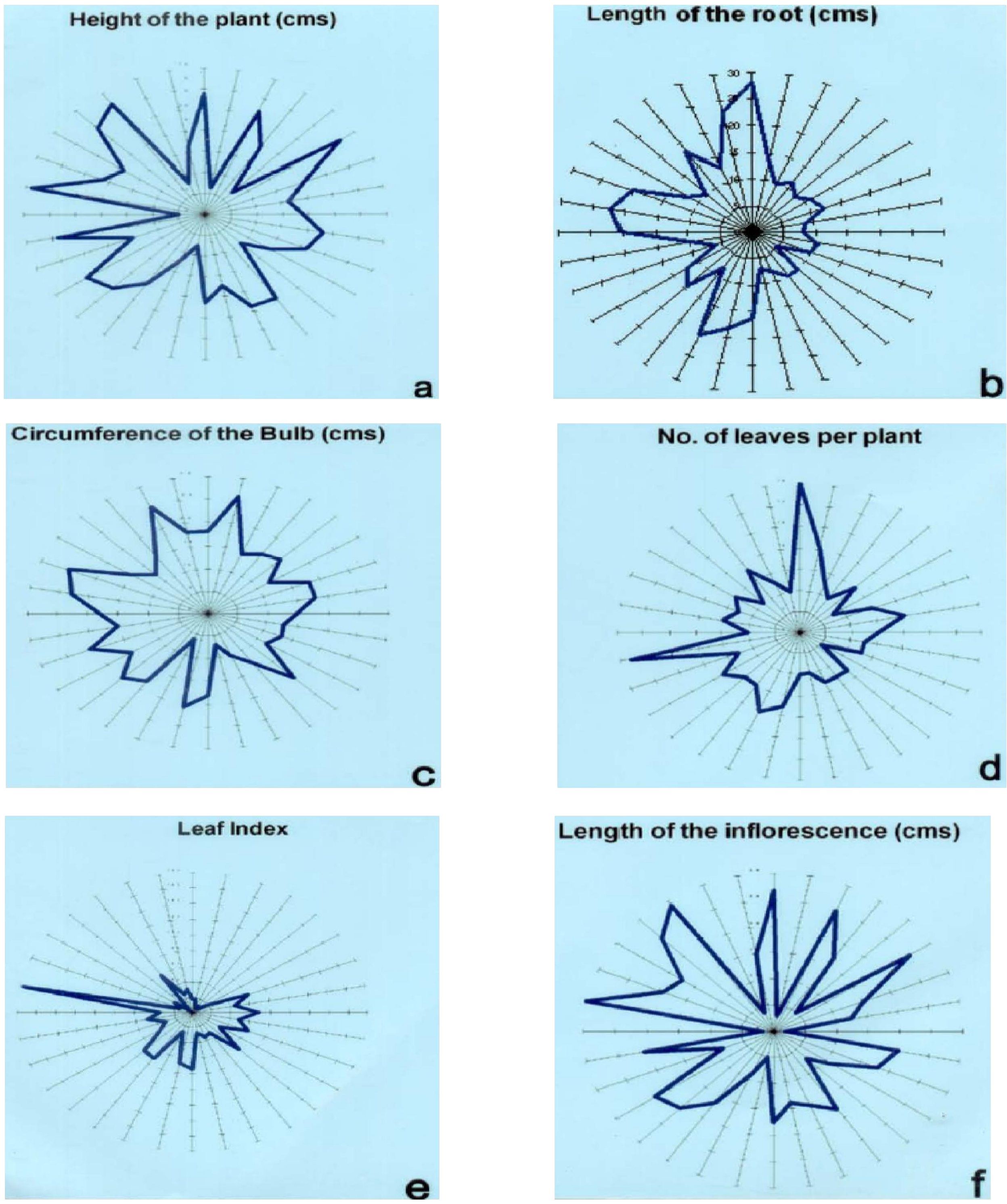

Fig. 4. (a – f) *Polygraphs of Urginea indica populations.*

variations and similarities are considered the basis responsible for designating them as cytotypes. Thus, on the basis of the above variations 32 cytomorphotypes have been recognized.

Effect of isolation in the evolution of new populations and species in the geographically isolated riverine islands is less studied. Ranganathittu is a river in island. The parameters (attributes) contributing most to separate the populations were pedicel length, leaf index, flower colour and blooming time drooping and erect flowers, no. of leaves, inflorescence length, circumference of bulb, root length etc. Few populations show similarity but they grow in geographically separate areas.

These populations deserve more detailed examination. More over these morphological difference have a genetic

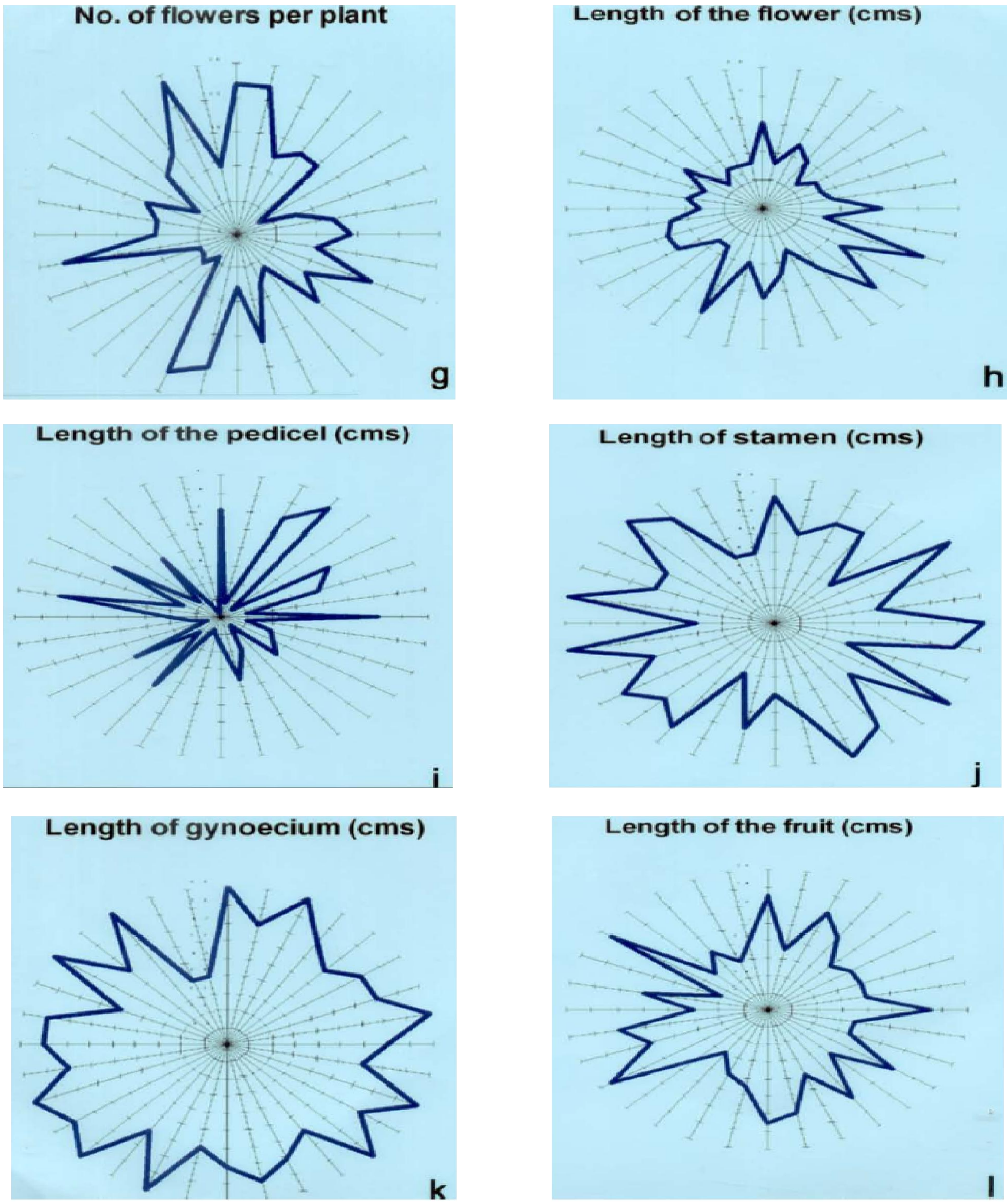

Fig. 5 (g-l). *Polygraphs of Urginea indica populations.*

basis i.e., cytological variations Shiva Kameshwari and Muniyamma (2004). These populations would be worthy of recognition as a separate subspecific taxon.

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