

## IDENTITY AND STATUS OF RECENTLY DESCRIBED CYCAS PSCHANNAE (CYCADACEAE) IN THE ANDAMAN AND NICOBAR ISLANDS, INDIA

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### ABSTRACT

After examining the diagnostic taxonomic characters on a cultivated plant in AJC Bose Indian Botanic Garden, Howrah, W.B., India a new cycad *Cycas pschannae* R.C. Srivast. & L.J. Singh (Cycadaceae) has been recently described. The authors also mentioned occurrence of this species as wild in Andaman Islands of India without exsiccata and any other supporting evidence. Detailed population assessment of the species and its distribution has not been carried out so far. Therefore, in the present paper the species is described and illustrated along with its distribution, structure of natural population, habitat ecology, biogeography morpho-anatomical characters along with its comparison to closely related species like *C. dharmrajii* L.J. Singh and *C. Zeylanica* (Schust.) A. Lindstrom & Hill in detail for the first time. A key to the species of *Cycas* from Andaman and Nicobar Islands is also provided.

Keywords: Andaman and nicobar islands, conservation status, cycads, *Cycas pschannae*, India.

### INTRODUCTION

*Cycas* is the well-recognized largest genus amongst the Oriental Cycads, widely distributed in the tropical and subtropical lowlands of South East Asia, Madagascar, East Africa, North and North east Australia and South west pacific (De Laubenfels & Adema 1998, Jones 2002, Pant 2002, Lindstrom & Hill 2002, 2007, Hill *et al.* 2007, Osborne *et al.* 2012, Su *et al.* 2014). It was originally described by Linnaeus (1737: 482, 1753: 1188, 1754: 495) and subsequently provided the type of generic name in the family Cycadaceae. Although, the first botanical description of cycads had been given by a pre Linnean author Van Rheede (1678) and called *Cycas circinalis* as 'Todda Panna' a Malayalam name from India. It is an illegitimate name of the genus. Thereafter, the genus *Cycas* has been revised and studied from time to time by various cycadologists but till date the species diversity is unresolved and complex. The genus therefore remains very much in need of world revision. Due to conflicting

reports prevailing about the diversity at species level, it has generated a lot of interest amongst cycadologists, morphologists, anatomists and taxonomists.

In India the Cycad flora is represented by a single genus *Cycas* which occurs naturally in Andaman and Nicobar Islands, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, West Bengal, Bihar, Jharkhand, Odisha, N E India (Old Assam) and Sikkim (Thiselton-Dyer 1881, 1888, Hill 1995, Singh 2017). Andaman and Nicobar Islands, a landmass of 572 islands, located about 1200 km away from the mainland India is located between the latitude of 6-14'N and longitude of 92-14' E. It is well recognized one of the hot spot of plant diversity. These islands are geographically disjunctive and separated by sea. The Nicobar groups of Islands are separated from Andaman group by 10° channels with heavy tidal flows making sea difficult for transportation. The geographical isolation of these Islands and also from the major land masses of South and South-East Asia over millions of years encouraged the

insular plants to have as much of diversity and variability. The Andaman and Nicobar Islands with excellent *Cycas* population with three species (Singh 2017) but natural disasters like tsunami, cyclones and human induced pressures are major threats to cycads habitat. Currently three species of the genus occurs naturally in these Islands (Singh 2017). In these islands most of the population of extant Cycads occurs in protected areas as reserve forest but many populations also grows in unprotected and in unreserved beach forests. Based on diagnostic morphological characters on megasporophyll of a *Cycas* plant which was cultivated in Indian Botanic Garden, a new species *Cycas pschannae* was described (Srivastava and Singh 2015). They stated that populations of this species are also found in Andaman Islands without exsiccata and any other supporting evidence. However, one of the authors (LJS) has collected several plant specimens of this species from nine different localities of Andaman and Nicobar Islands and the present work is the outcome of study of Cycads over several years in the Andaman and Nicobar Islands since 2011. Furthermore, during the study of herbarium specimens at CAL, PBL, BSD and DD, the author came across several herbarium specimens collection made from the Andaman and Nicobar Islands: Thothathri (08.02.1959, 9201 CAL!), N.P. Balakrishnan (18.07.1976, 3872 PBL!) resemble this species and contain the diagnostic characters of recently described species therefore they were re-identified as *C. pschannae*. After critical examination of herbarium specimens deposited at CAL & PBL, authors found that *C. pschannae* appears to have first been collected by K. Thothathri in 1959 from Taralait Bay Beach Forest, North Andaman, however, this Herbarium specimen (9201 CAL) has been identified as *C. rumphii* Miq. followed by N.P. Balakrishnan in 1976 from Coastal

Forest of Galathea to Pygmalion Point, Nicobar Islands (3872, PBL). While during the present studies of the genus *Cycas* in these Islands, specimens of *C. pschannae* have been collected from Curt Burt Bay Wild Life Sanctuary, Middle Andaman by senior author for the first time in 2012 and based on morphological characters observed from original habitat the details on taxonomy and anatomy are being presented in present publication in detail along with conservation status for the first time which were not included in the original publication of this species (Srivastava and Singh 2015).

## MATERIALS AND METHODS

During study of *Cycads* in the Andaman and Nicobar Islands 19 field trips were conducted and specimens were vouched from various natural populations during the period 2011–2016. Herbarium collections held by CAL, PBL were also examined. Terminology is followed same as in previous paper (Srivastava and Singh 2015). Many of the measurements were made with fresh material at natural population, which were not described in the previous paper because they were described only based on diagnostic morphological characters on megasporophyll of a *Cycas* plant which was introduced in Indian Botanic Garden. The study of external morphology was done by the technique adapted by Misra & Singh (2000a). For the anatomical studies both hand and microtome sections were prepared by the technique adapted by Johansen (1940). Presence of cutin was tested with Sudan IV and other microchemical tests like lignin and starch were made by phloroglucinol and iodine solutions respectively. The natural populations were observed in various localities of these Islands. Among them, 4 are in Middle Andaman, 4 in North Andaman and 1 is in Nicobar Islands as mentioned in Table 1.

Randomly located nine natural populations were surveyed and studied. All the living trees were identified and their girth & height were measured along with formation of megasporophyll, male cone and seed. All the natural populations were observed every year from April, 2011 to

April, 2016. To achieve a total track length of 1-2.5 km at each survey site, track lines were established on 6 sub-sites per site, a sub-site consisted of parallel track lines of variable length with a distance between them of 50 m. Track lines consisted of track segments of 50 m each.



Plate 1. Holotype of *Cycas pschannae*, 10<sup>th</sup> December, 2001, RCS, Cy 19(CAL)



Plate 2. *Cycas pschannae*, 8<sup>th</sup> February, 1959, K. Thothari, 9201(CAL)

**Key to the species of *Cycas* in the Andaman and Nicobar Islands**

1. Stem less than 9 m; megasporophyll lamina lanceolate, obscurely dentate.....*C. zeylanica*
- Stem more than 9 m; megasporophyll lamina semiorbicular to orbicular .....2
2. Trunk with not swollen at base; male cone cylindrical, megasporophyll with 2 lateral, unequal horn-like curved structure, abruptly long acuminate apices, .....*C. pschannae*
- Trunk with swollen at base; male cone lanceolate, megasporophyll with well-defined 10-28 paired lateral hook like structure, .....*C. dharmrajii*

***Cycas pschannae* R. C. Srivast. & L.J. Singh** *Int. J. Curr. Res. Biosci. Plant. Biol.* 2(8): 35-37(August, 2015)

**DESCRIPTION (PLATE 1-7, FIG. 1- 4):**

*Plants* arborescent, up to 12 m high, 25-35 cm diam. not swollen at the base, covered with persistent orange brown leaf scars, rough bark and polymorphic roots (terrestrial, coralloid and non-coralloid aerial roots). Leafscars rhomboidal: large leaf scars ca 6.5 x 3 cm; small leaf scars ca 4 x 1.8 cm. Cataphylls ca 10.5-17.5 cm long, ca 1.8-2.1 cm broad at base, persistent, narrowly triangular, abaxially glabrous, lemon colour, adaxially orange brown, woolly or floccose, densely tomentose. Petioles 45- 65 cm long, glabrous, spinescent, pinnacanth 26-28 pairs, 3-5 mm long. Leaves dark to light green, glossy, 157-205 cm long, flat with 82-115 pair of leaflets, with rachis section flat, margins slightly recurved, and the acute tip consistently terminated by paired leaflets; the first three pairs of basal and apical leaflets smaller in size. First three basal pairs of leaflets 15.5 - 16 x 1-1.5 cm, 1.4 cm apart inserted at 95-100° to the rachis, Rest leaving three basal leaflets 26.5 - 27 x 1.2-1.6 cm, 1.2-1.6 cm apart, inserted at 75- 80° to the rachis; median leaflets 23.5-24 x 1.2-1.4 cm, 1.2-1.4 cm apart inserted at 60° to the rachis; top leaflets 18.5-19.5 x 1-1.3 cm, 1.2-1.4 cm apart, inserted at 55° inserted to the rachis; mid vein raised above and below, leaflet in cross-section with midrib without mesophyll cells (palisade and spongy parenchyma), diploxylic vascular bundle surrounded by dimorphic bundle sheath: sclerenchymatous towards abaxial side and centrifugal xylem, parenchymatous towards metaxylem of centripetal xylem which give rise to semi-circular shape, v- shaped centrifugal xylem, intra or extra vascular xylem parenchyma and lower; epidermis of margin is not supported by hypodermis and epidermis cells with a characteristic pitting on the periclinal walls. Male cone cylindrical, orange, 25 cm long. Cone axis 3-5 cm long. Microsporophyll 6.7- 7 cm long, fertile zone 4

cm long, 1.3 cm wide, sterile apex 1.5- 1.8 cm. Pollen grains oval & elliptical, monocolpate; colpus or sulcus present on distal side. Megasporophyll 35-45 cm long with 2-3 pairs of ovule, golden brown woolly or densely tomentose, abaxially green, glabrous at the top, semi-orbicular to orbicular at base, triangular above with abruptly long acuminate apices and 2-lateral, unequal horn like curved structure ca 0.4-0.7 cm long. Sterile apex 5-8 cm long, margin entire, folded inwardly. Ovule orthotropous, shortly stalked, ovoid, bright green turning greenish brown on maturity, abortive ovule retuse at apex. Seeds ovoid, 5.5 -6.5 cm long, 3.5-4.0 cm wide; sarcotesta lemon colour, fleshy, 0.9 cm thick, fibrous layer absent; sclerotesta smooth; ca 0.3 cm, thick, endotesta ca. 0.2 cm thick.

**Habitat, ecology and distribution:**

Abundant in littoral forest near the sea in sandy soil and also in periphery and low elevation evergreen beach forests. It is reported here as an endemic to Andaman and Nicobar Islands.

**Conservation status:**

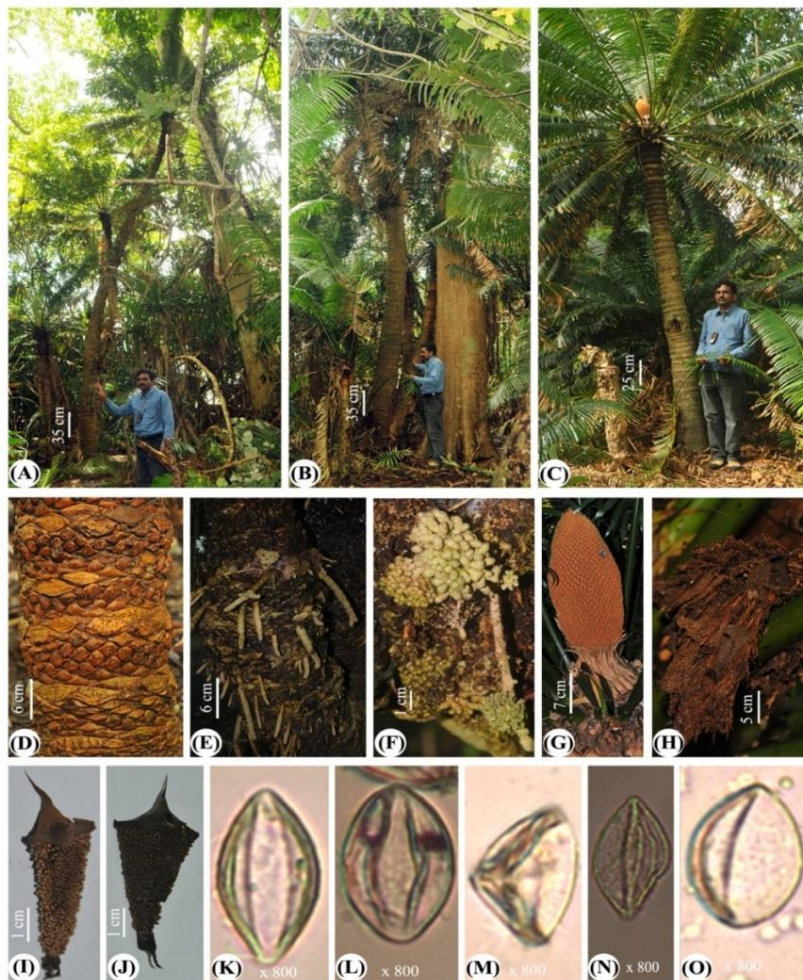
The species occurs throughout the Andaman and Nicobar Islands with sporadic populations but faces a number of significant threats. Natural disasters like tsunami, cyclone leads to habitat loss. Besides, the human induced pressure like over exploitation by local people for manifold usages like beautiful appearance of foliage crowns of leaves used as decorative materials during religious and ceremonial rituals etc. and settlements are also leading to threats. Therefore, the species can be scored using the IUCN Categories and Criteria (IUCN, 2015) as vulnerable (VU).

**Note:**

The plants also show occurrence of polymorphic roots; terrestrial, coralloid and non-coralloid aerial roots. The non-coralloid aerial roots are positively geotropic, light brown in colour, delicate as well as woody in nature and originate from damaged part of the trunk. Coralloid roots are densely branched with swollen tips and greenish brown in colour, and develop near the

ground surface from normal root and grow horizontally in the soil with apogeotropic, aerotropic and phototropic in nature while terrestrial roots (normal) are underground, light brown in colour.

During field survey the authors also observed occasionally parthenospermy or parthenocarpy in female plant growing in the private Areca plot at Shippighat, South Andaman. Areca grower (Local Farmer)



**Plate 3. *Cycas pschannae*. (A)- (B ) Giant female tree with multi- branching, (C) male tree with cone, (D) Rhomboidal leaf bases, (E) trunk base with aerial roots, (F) coralloid roots, (G) top of male plant with cone, (H)Top of male plant with dahisced cone, (I)-(J) Microsporophyll (Lower and side view), (K) – (O), Pollen grains x ca 800.**

stated that this plant was taken from Middle Andaman (Natural habitat) by his grandfather and planted for ornamental value. The single female plants growing with mature ovule and no male species within their proximity.

**Similar species:**

This taxon appears apparently close to the species of *Cycas dharmrajii* L. J. Singh and *Cycas zeylanica* (Schust.) A. Lindstrom. & Hill but markedly distinct by a combination of characters as mentioned in Table 2.

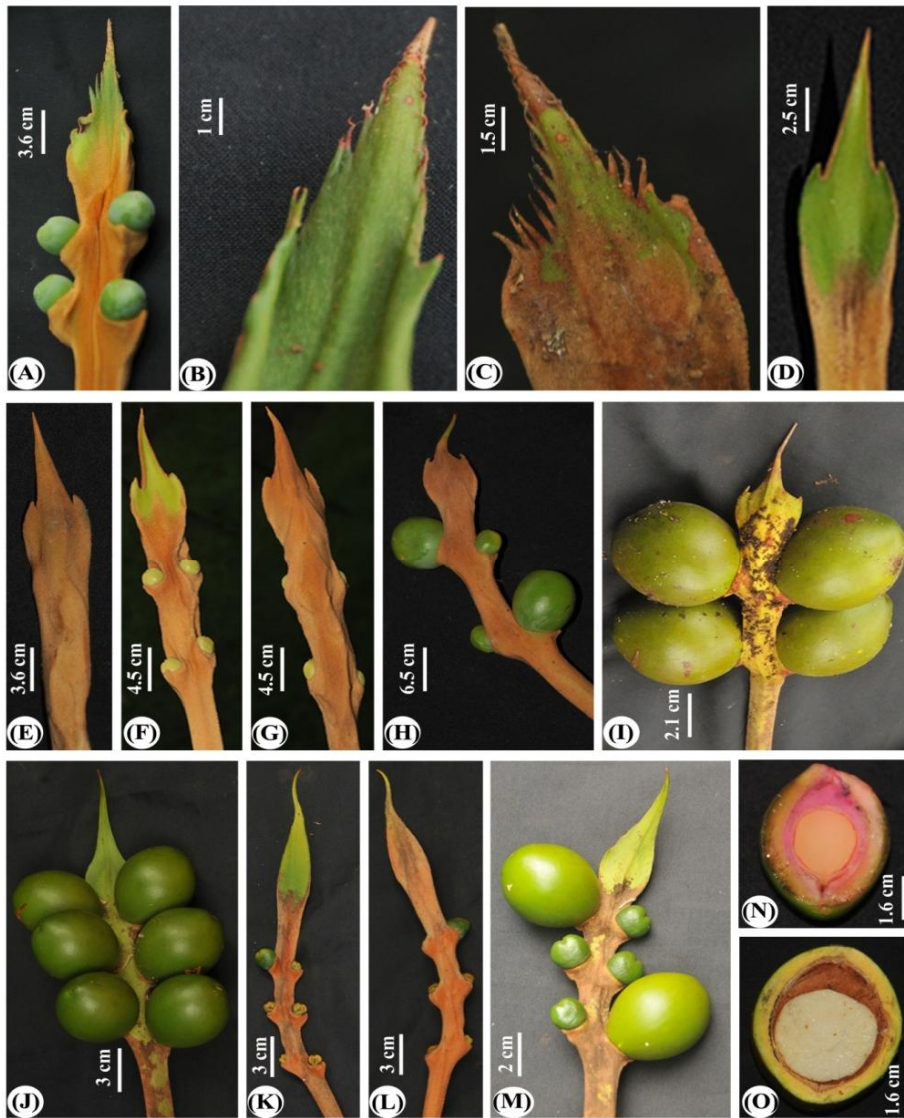


Plate 4. Comparison of female sporophylls (A) –(C) *Cycas dharmrajii*, (D)- (I) *C. pschannae*, (J)-(M) *C. zeylanica*, (N)-(O) Ovule and Seed of *C. pschannae* in L.S.

**Specimens examined:****Holotype and Isotype-**

India, West Bengal, Howrah, Dr. AJCBIBG, 10 December, 2001, RCS Cy, 19(CAL).

**Additional specimens-**

India, Andaman and Nicobar Islands, North Andaman, Taralait Bay Beach, 8<sup>th</sup> February, 1959. K. Thothathri 9201 (CAL!), INDIA, Andaman and Nicobar Islands, Great Nicobar, Galathea to Pygmalion Point Coastal Forest, 18 July, 1976. N.P. Balakrishnan 3872 (PBL), India, Andaman and Nicobar Islands, North Andaman, Lamia Bay between Chota Thambu Nallah and Ram Nagar Sea Shore 13°35'32.1"N, 092°57'51.1"E, 7 m alt., 12 May 1982, M.K. Vasudeva Rao 9005 (PBL), India, Andaman and Nicobar Islands, Middle Andaman, Curt Burt Bay Wild Life Sanctuary, 12°36'48.2"N, 092° 48'57.2"E, 14 m alt., 26 October 2012, Lal Ji Singh 29509 (PBL), INDIA, Andaman and Nicobar Islands, Middle Andaman, Panchawati, 13°35'32.1" N, 092°57'51.3" E, 7 m alt., 26 October 2012, Lal Ji Singh 29512 (PBL), India, Andaman and Nicobar Islands, Middle Andaman, Morce Dera, 12°33'14.5" N, 092° 57'05.0"E, 27 m alt., 28 October 2012, Lal Ji Singh 29513 (PBL!), INDIA, Andaman and Nicobar Islands, Middle Andaman, Tikka Dera, 12°31'10.8" N, 092° 48'47.4" E, 13 m alt., 28 October 2012, Lal Ji Singh 29514 (PBL), India, Andaman and Nicobar Islands, Great Nicobar, Galathea to Pygmalion Point Coastal Forest, 06°55'22.0" N, 093° 49'59.0" E, 30 m alt., 10 February 2013, Lal Ji Singh 29537 (PBL), India, Andaman and Nicobar Islands, South Andaman, Port Blair, Sippighat (cultivated/planted), 11°36'42.8"N, 092°40'54.6"E, 47 m alt., 16 February 2013, Lal Ji Singh 29607(PBL), India, Andaman and Nicobar Islands, North Andaman, Lamia Bay 13°10'9.8.1"N, 093°01'91.0"E, 10 m alt., 21 August, 2014. Lal Ji Singh 29607(PBL), India, Andaman and Nicobar Islands, North

Andaman, Taralait Bay Beach, 21 August 2014. Lal Ji Singh 29610(PBL), India, Andaman and Nicobar Islands, North Andaman, Smith Island, 13°18'43.0"N, 093°04'13.5"E, 11 m alt., 26 August, 2014. Lal Ji Singh 29636(PBL), India, Andaman and Nicobar Islands, North Andaman, Ross Island, 13°18'08.1"N, 093° 04'31.7"E, 21 m alt., 26 August, 2014, Lal Ji Singh 29638 (PBL).

**Anatomy:**

The anatomical study of leaflets, ovule and seeds of *Cycas pschannae* was also taken up which will be helpful in taxonomy. The morpho-anatomical features of body parts resemble fundamentally to the other species of *Cycas*. However, much variation exists in the internal structure especially in leaflets.

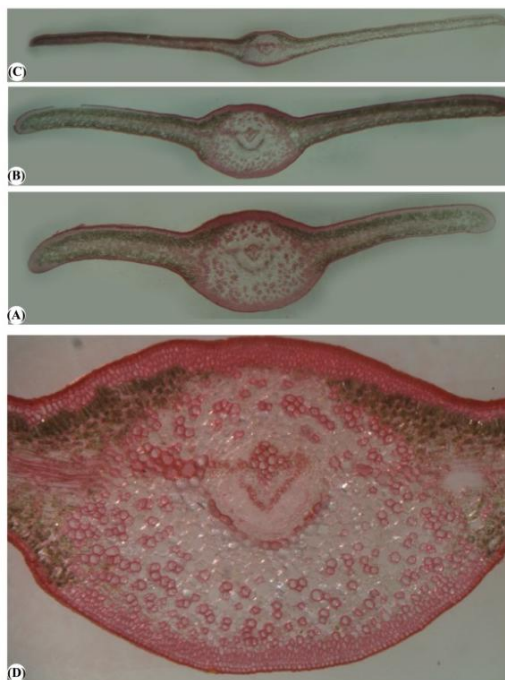


Plate 5. *Cycas pschannae*. (A)-(C) Transsections of leaflet from base to apex x 12, (D) Transsection of leaflet through midrib showing cellular details x 400.

**Leaflets:**

The leaflets are dorsiventral and they have flat margin or recurved. The lamina is dorsiventral and usually hypostomatic. The epidermis has thick walled cells, characteristic pitting on the periclinal walls and their outer surface is covered by thick, laminated cuticle. The walls of the hypodermal cells are themselves highly cutinized and lignified. The hypodermis is single layered below the upper epidermis is except for the midrib and the margins where it becomes 3-4 layered. The lower epidermis is interrupted with stomata. Stomata are of gymnospermous type with monocyclic, haplocheilic in nature. Subsidiary cells are 6 to 9 in numbers and epidermal cells are irregular with pits. Portions of the walls of guard cells are composed mainly of lignin and the dorsal walls of the guard cells are covered with a thick cuticle.

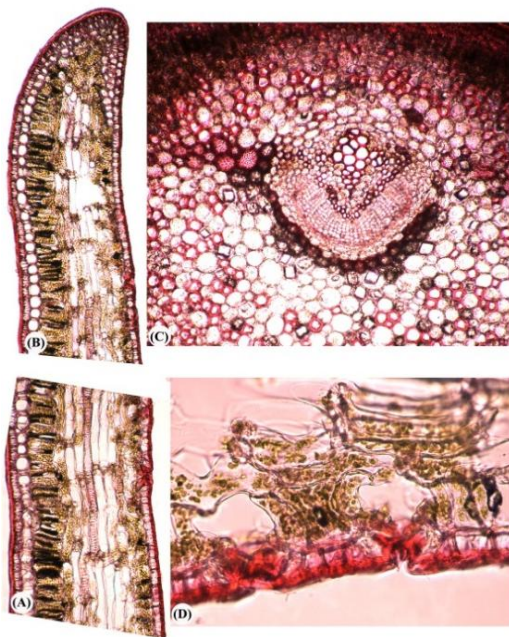


Plate 6. *Cycas pschannae*. (A)-(B) Trans section of leaflet through margins showing cellular details x 1200, (C) Vascular bundle of leaflet showing cellular details in T.S. x 600, (D) Portion of lower epidermis showing stomata x 7200.

The mesophyll is differentiated into palisade and spongy tissue except midrib region. The spongy tissue is more compact with shorter vertically elongated palisade like cells. Both palisade and spongy cells contain numerous chloroplasts. In midrib region upper and lower side occupies by thin walled, polygonal parenchymatous cells intermixed with thick walled polygonal lignified cells below hypodermis to over the vascular bundle. The primary accessory and the transfusion tissue cells are connected with the xylem of the midrib bundle. The vascular bundle is diploxylic in nature, made up of a broad triangular centripetal exarch xylem and v-shaped centrifugal xylem. The centrifugal xylem elements develop continuous arc on both lateral side of the centripetal xylem and forms v-shaped structure. An arc of cambium lies on its outer side below 2-3 cells thick phloem which is present just below semicircular bundle sheath. The cambium produces multi-layered xylem parenchyma on its inner side, towards v-shaped centrifugal xylem.

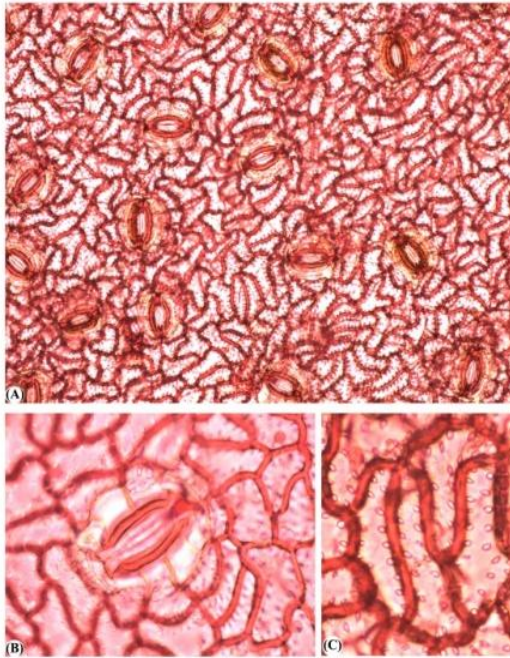
The vascular bundle is surrounded by dimorphic bundle sheath: sclerenchymatous towards abaxial side, and centrifugal xylem and parenchymatous towards metaxylem of centripetal xylem which give rise to semi-circular shape. These thin walled parenchymatous cells of bundle sheath may be helping in conduction of water and minerals.

**Ovule:**

The integument is differentiated into three layers: the outer fleshy (Sarcotesta), middle stony (Sclerotesta) and the inner fleshy layer (Endotesta). The ovule is supplied with three vascular traces. The median vascular strand supplies to the base of the integument, which extends up to the chalazal end of the nucellus and further ramifies abruptly. The two side strands pass to the integument which again divide- one



branch supplies to the ovule pulpy layer and other to the inner soft layer.



**Plate 7. *Cycas pschannae*. (A) Surface view of stomatiferous region of lower epidermis, (B) Stoma showing magnified view of guard cells, (C) Cells of epidermis showing characteristic pitting of the periclinal walls.**

#### Seed:

Mature seeds are large, egg shaped, fleshy and remain covered with a greenish brown or lemon coloured thick seed coat. Integument is differentiated in to sarcotesta as a thick outer fleshy layer, sclerotesta as a middle stony layer and endotesta as an inner fleshy layer. The seeds are dispersed by snails due to their attractive edible fleshy outer pulp. The natural sclerification probably helps in germination.

#### Population Status (Table 1):

During the course of studies of Cycads over several years since 2011, authors observed that Cycad populations are

sparsely scattered throughout the Andaman and Nicobar Islands and are confined to limited localities. *C.pschannae* is an endemic to Andaman and Nicobar Islands and restricted in distribution (Table 1). Many populations are small and greatly fragmented with only a handful of adult plants. All the sub-sites were similar with respect to the ecological conditions. These islands have a tropical climate which is warm, moist and equable. The temperature ranges from 18°C to 34°C. The proximity of the sea and the abundant rainfall prevent extremes of heat. An average of 3000 mm rainfall per year is received from south west and north east monsoons which extend over a period of eight months. The extent of rainfall may vary with island. The humidity is high varying from 66 to 85%. In normal conditions the wind speed is fairly constant (5 knots per hour) but during cyclonic weather it may go as high as 120 to 130 knots per hour. The soil is mostly sandy clay to sandy loam. These soils are medium to heavy textured and moderately well drained and subjected to seasonal fluctuations in ground water. Most of the soils of these islands have medium to high organic matter status indicating that the organic carbon is >0.5%. Parts of south and middle Andaman has low organic carbon status mainly because of severe erosion of the surface soil caused due to extensive deforestation and complete neglect of the deforested area. In general, soil fertility analysis indicates medium in available N, low in both available P and K.

Data for this study were collected from April, 2011 to April, 2015. The areas sampled in the populations were variable: 12400 m<sup>2</sup> at Middle Andaman, Curt Burt Bay Wild Life Sanctuary, 12200 m<sup>2</sup> at Middle Andaman, Morce Dera, 16200 m<sup>2</sup> at Middle Andaman, Tikka Dera; 10500 m<sup>2</sup> at Middle Andaman, Panchawati; 12400 m<sup>2</sup> at 'North Andaman, Taralait Bay Beach Forest; 1100

m<sup>2</sup> at North Andaman, Lamiya Bay Beach Forest; 12100 m<sup>2</sup> at North Andaman, Smith Island; 10100 m<sup>2</sup> at North Andaman, Ross Island and Nicobar Islands (Galathea to Pygmalion Point) even although individuals were not distributed uniformly. The proportion of reproductive adults with respect to total number of individuals is not proportional to the area sampled. Plant density is highest in at Taralait Bay Beach Forest, Ross Island of North Andaman, Curt Burt Bay Wild Life Sanctuary of Middle Andaman and Galathea to Pygmalion Point of Nicobar Islands and lowest in Lamiya Bay, Smith Island of North Andaman,

Panchawati, Morce Dera, Tikka Dera of Middle Andaman. However, seedlings and juveniles plants showed a random distribution whilst the adults were found to be contagious. On the other hand, the seed production in all populations varied: 103 ± 34 (Curt Burt Bay Wild Life Sanctuary), 98 ± 54 (Taralait Bay Beach Forest) 63 ± 24 (Ross Island), 53 ± 14 (Galathea to Pygmalion Point), seeds per cone while Panchawati, Morce Dera, Tikka Dera and Smith Island no seed production and male cone observed. Only megasporophylls with young or abortive ovule have been observed.

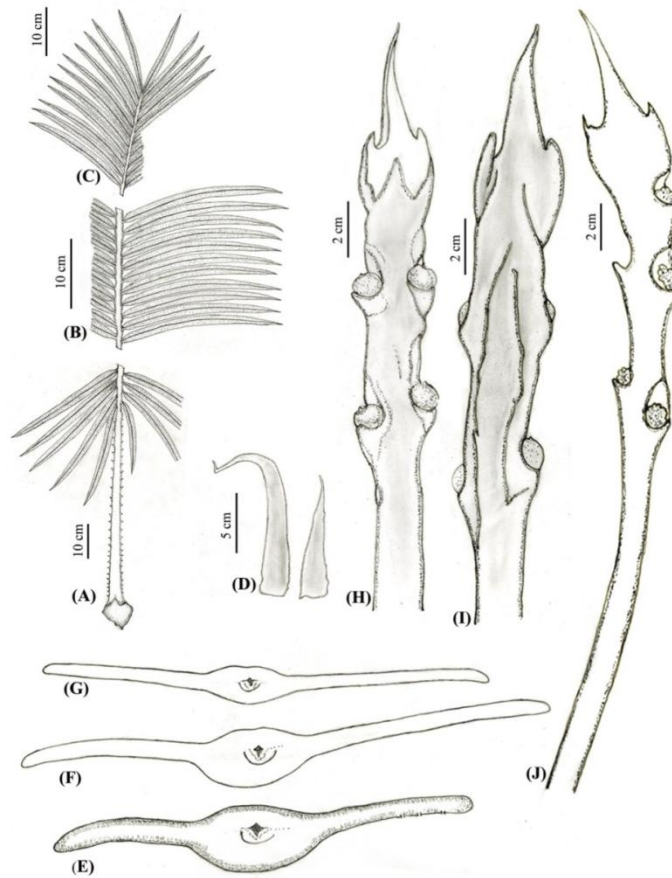


Fig. 1. *Cycas pschannae*. (A)-(C) Leaf with petiole, (D) Scale leaf, (E) – (G). Topography sketches of transverse sections of leaflet from base to apex x 12, (H)-(J) Megasporophyll (ventral & dorsal view).

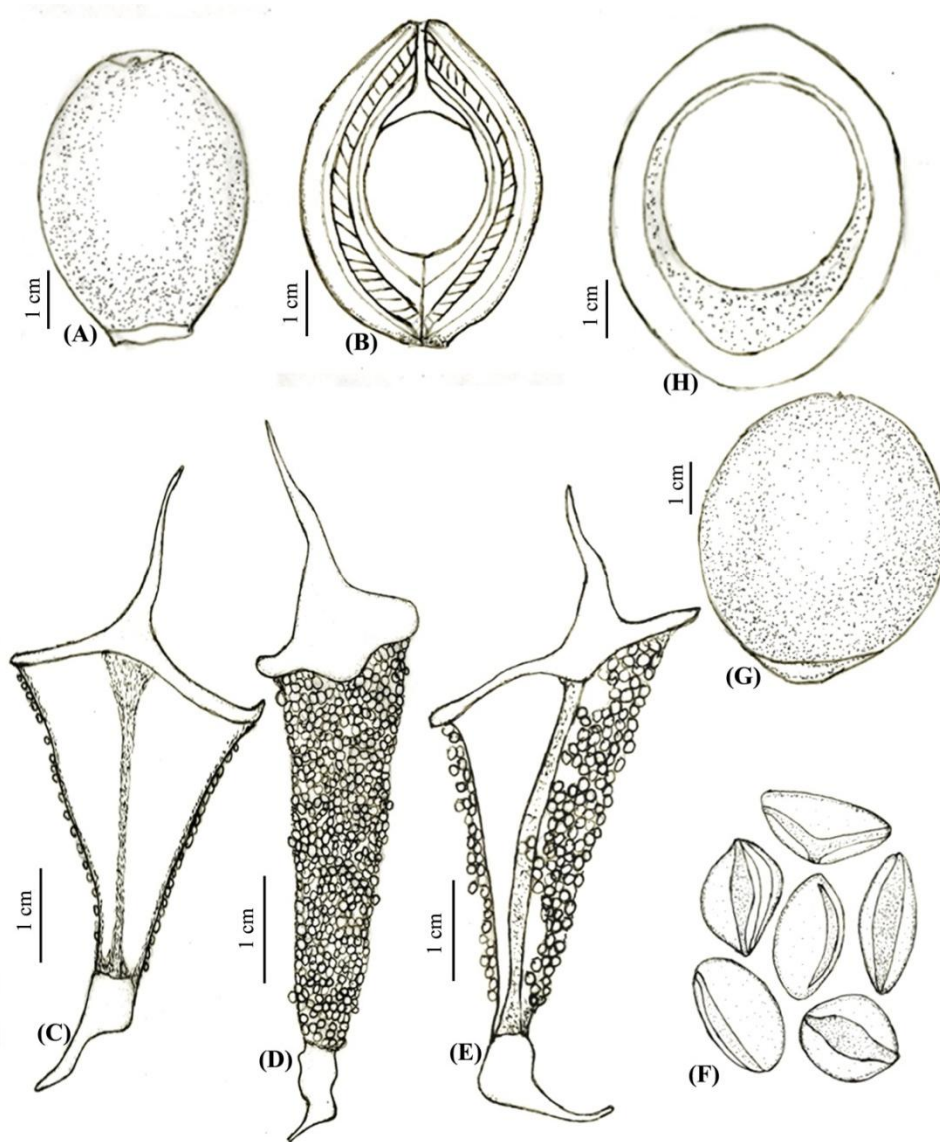


Fig. 2. *Cycas pschannae*. (A) Ovule, (B) Ovule in L.S., (C)-(E) Microsporophyll (upper, lower & side view), (F) Pollen grains x ca 600, (G) Seed, (H) Seed in L.S.

Numbers of semi adults were significantly greater than that of adults in all habitats. Recruitment of seedlings and juveniles were significantly greater in Middle Andaman than in Middle and Nicobar Islands. No juveniles were found during the survey in coastal

forest of Middle Andaman, Morce Dera, Tikka Dera, Panchawati, North Andaman, Lamiya Bay. Percentage of mortality of juveniles and adult trees were significantly greater in coastal forest of North than in coastal forests of middle Andaman and

Nicobar Islands. Authors also observed that the Middle Andaman and group of Nicobar Islands have experienced massive loss of natural habitats in the past and facing risk of extinction mainly because of natural calamities such as tsunami, cyclones and

anthropogenic pressure like heavy exploitation. Hence the most of the populations have become very small and greatly fragmented in beach forests and reflect reduction in the maximum number of mature, reproductive trees.

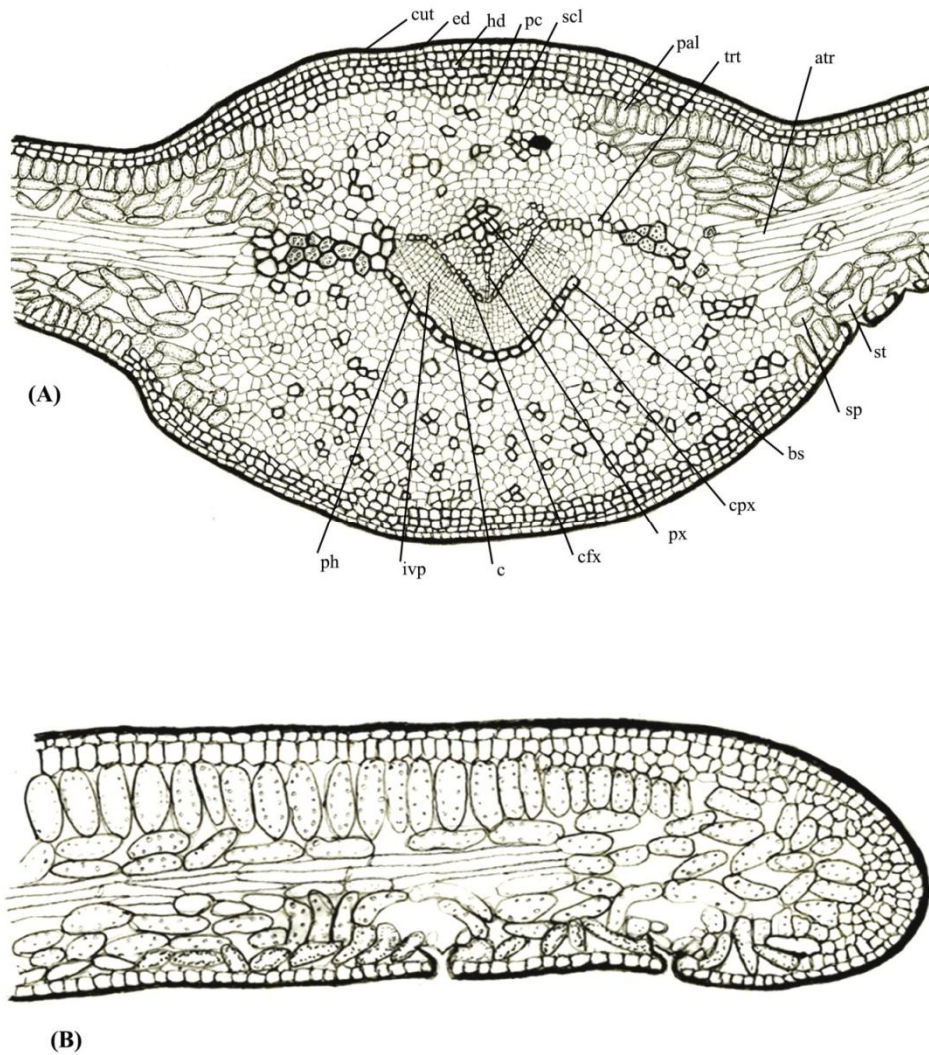


Fig. 3. *Cycas pschannae* (A) Transection of leaflet through midrib showing cellular details x 100, (B) Trans section of leaflet through margins showing cellular details x 200, (atr- accessory transfusion tissue; bs- bundle sheath; c- cambium; cfx- centrifugal xylem; cpx- centripetal xylem; cut- cuticle; ed- epidermis; hd- hypodermis; ivp- intravascular parenchyma; pal- palisade; pc- parenchyma; ph- phloem; px- protoxylem; scl- sclerenchyma; sp- spongy parenchyma; st- stomata; trt- transfusion tissue).

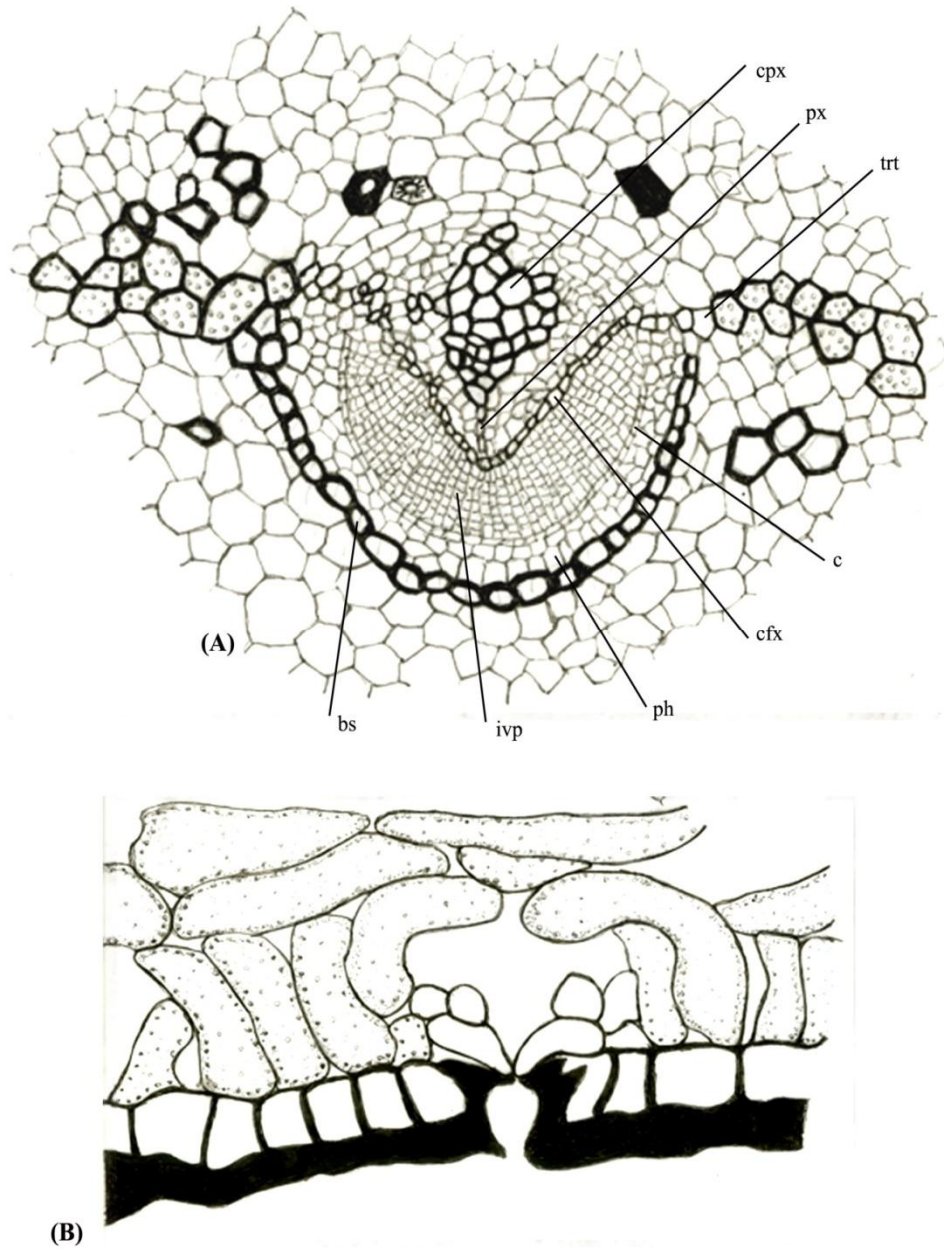


Fig. 4. *Cycas pschannae*. (A) Vascular bundle of leaflet showing cellular details in T.S. x 400, (B) Portion of lower epidermis showing stomata x 600, (C) A stoma in surface view, (bs- bundle sheath; c- cambium; cfx- centrifugal xylem; cpx- centripetal xylem; ed- epidermis; ivp- intravascular parenchyma; ll- lateral lignin lamella; p- pit; ph- phloem; pl- polar lignin lamella; px- protoxylem; su- subsidiary cell; trt- transfusion tissue).

**Table 1. *Cycas pschannae* observed in various locations of natural population in the Andaman and Nicobar Islands**

| S. No | Locality/<br>population                                      | Pattern of<br>population | Estimated<br>No. of<br>plants in<br>population | No. of<br>plants<br>per ha | No. of<br>plants<br>in 50 x<br>50<br>metres | No. of<br>Seedlings<br>present<br>/absent in<br>50 x 50<br>metre plot | No. of<br>semi-<br>adult<br>plants in<br>50 x 50<br>metres | No. of<br>adult<br>plants in<br>50 x 50<br>metres |
|-------|--|--------------------------|--|----------------------------|---|---|--|---|
| 1.    | Middle<br>Andaman<br>Curt Burt<br>Bay Wild Life<br>Sanctuary | Congregate               | 1200   | 300                        | 65  | +156  | 52   | 13<br>(Male-02,<br>Female-11)                     |
| 2.    | Middle<br>Andaman,<br>Morce Dera                             | Scattered                | 30   | 9                          | 2   | -   | 1  | 1<br>(Male-0,<br>Female-1)                        |
| 3.    | Middle<br>Andaman,<br>Tikka Dera                             | Scattered                | 50   | 14                         | 3   | -   | 2  | 1<br>(Male-0,<br>Female-1)                        |
| 4.    | Middle<br>Andaman,<br>Panchawati                             | Scattered                | 70   | 20                         | 5   | -   | 3  | 1<br>(Male-0,<br>Female-1)                        |
| 5.    | North<br>Andaman,<br>Lamia Bay                               | Scattered                | 65   | 20                         | 10  | -   | 9  | 1<br>(Male-0,<br>Female-1)                        |
| 6.    | North<br>Andama,<br>Smith Island                             | Scattered                | 200  | 25                         | 9   | +37   | 7  | 2<br>(Male-1,<br>Female-1)                        |
| 7.    | North<br>Andamann,<br>Ross Island                            | Congregate               | 500  | 109                        | 28  | +57   | 15   | 13<br>(Male-2,<br>Female-11)                      |
| 8.    | North<br>Andaman<br>Taralait Bay<br>Beach Forest             | Scattered                | 115  | 20                         | 11  | -35   | 9  | 2<br>(Male-0,<br>Female-2)                        |
| 9.    | Nicobar<br>Islands<br>(Galathea to<br>Pygmalion<br>Point).   | Scattered                | 150  | 35                         | 12  | -   | 8  | 4<br>(Male-0,<br>Female-4)                        |

In Andaman and Nicobar Islands most of the populations occur in protected areas as reserve forests. In the present studies population structure is determined by the height of individuals. Large adults are those between 5–12 m tall; reproductive aged plants were observed >5 m tall with branched or broken trunk and juveniles <60 cm in height. The present study identified 06 populations which existed in reserve situations, Populations within these islands

are still at risk of being over exploitation by local people.

The authors also observed that populations also have an aggregated spatial distribution pattern, excepting seedlings and juvenile plants. Based on the field surveys and interviews with experienced local harvesters, it is believed that over exploitation has taken place in the most of areas in these Islands

Table 2. Characters evaluated in comparison between *Cycas zeylanica*, *C. pschannae* and *C. dharmrajii*

| Characters                      | <i>C. zeylanica</i>  | <i>C. pschannae</i>   | <i>C. dharmrajii</i>   |
|---------------------------------|--|---|--|
| <b>Distribution and habitat</b> | Sri Lanka, southern coastal regions, and the Andaman and Nicobar groups  | North & Middle Andaman, Nicobar Island  | Table Excelsiar Island (North Andaman Groups), Little Andaman  |
| <b>Plant trunk</b>              |  |   |  |
| Height                          | 2.3- 3.1 m long  | up to 12 m long   | up to 11 m long  |
| Branching                       | abnormal branching not reported  | branched ( di, tri and tetrachotomous branching )   | dichotomously branched   |
| Diameter of trunk               | 13-20 cm, base not swollen;  | 25-30 cm, base not swollen  | 50-62cm, base swollen  |
| Bark                            | thin and smooth  | thick and rough   | thick and rough  |
| Leaf bases                      | not persistent.  | persistent  | Persistent   |
| Aerial Roots                    | not reported   | present   | present  |
| Cataphylls                      | 10-12 cm long, not persistent  | 10.5-17.5cm long, persistent  | 8.0-15.0 cm long, persistent   |
| <b>Leaves</b>                   |  |   |  |
| Length                          | 140-190 cm long.   | 157-205 cm long   | 150-180 cm long.   |
| Petiole                         | 50-70 cm long  | 45-65 cm long   | 40-45 cm long  |
| Leaflet number per side         | 70-100   | 82-115  | 74-85  |
| <b>Anatomy of leaflet</b>       |  |   |  |
| Bundle Sheath                   | circular and sclerenchymatous  | dimorphic and semicircular: made up of sclerenchyma and parenchyma both.  | circular and parenchymatous  |
| Centrifugal xylem               | breakup in to small patches  | forms v- shaped structure.  | breakup in to small patches  |
| Mucilage Canal                  | not reported   | absent  | 2 mucilage canals towards the abaxial (phloem side) of the vascular bundle   |
| <b>Male cone</b>                |  |   |  |
| Shape & Colour                  | fusiform, orange-brown   | cylindrical, orange   | lanceolate orange  |
| Length                          | 30-40 cm long,   | 25 cm long  | 20-25 cm long  |
| Microsporophyll                 | 3.5-4.5 mm long, fertile zone 3.0-4.0 cm long, 1.7-1.9 cm wide, sterile apex 0.3-0.5 cm long.                              | 6.7- 7 cm long, fertile zone 4 cm long, 1.3 cm wide, sterile apex 1.5- 1.8 cm.  | 3.5-4.5cm long, fertile zone 1.5-2.5 cm long, 0.5-1.5 cm wide, sterile apex 1.0-1.5 cm.                            |
| Pollen grains                   | not reported   | oval & elliptical   | boat shaped  |
| <b>Megasporophyll</b>           |  |   |  |
| Length                          | 17-30 cm long.   | 35-45cm long.   | 19-40 cm long  |
| Shape                           | lamina lanceolate, obscurely dentate margin, 6-12 lateral bumps or short spines, apical spine distinct from lateral spines | lamina semi-orbicular to orbicular, smooth, top triangular with 2-lateral, unequal horn like curved structure and abruptly long acuminate apex with inwardly folded entire margin.. | semi-orbicular to orbicular at the base, top triangular with well-defined 10-28 paired lateral hook like structure |
| <b>Ovule</b>                    | 2-4  | 2-6   | 2-6  |
| (per megasporophyll)            |  |   |  |
| <b>Seed</b>                     |  |   |  |
| Shape                           | flattened- ovoid   | ovoid   | ovate  |
| Length                          | 60-70 mm long.   | 5.5-6.5cm long.   | 4.8-5.5 cm long,   |
| Diameter                        | 4.5-5.5 cm in diameter.  | 3.5-4.0 cm in diameter.   | 3-3.8 cm diameter.   |

since last decades. Although the felling of large trees had been extensive at the periphery sites of forests, evidence from this study suggests that natural calamities and anthropogenic pressures are major threats to may cause extinction. Saplings and small trees do not seem to be the object of harvesters. There were also indications of active regeneration in the form of seedling growth and possibly regrowth following felling. A limited amount of seed dispersal was observed only by snails.

#### **Role of the species in its ecosystem**

During survey authors observed the interaction with various animals in their natural habitats

**Bees-** Small bees were observed collecting resinous sap from the tender leaves of the plant.

**Ants-** The species of ants were also observed collecting the resinous sap from the young unfurling leaves of the cycad and collecting secretions from the bodies of plains cupid butterfly larva.

**Snails-**Snails were observed collecting the resinous sap from the young unfurling leaves and fleshy mesocarp from seeds and a limited amount of dispersal may be carried out.

#### **Conclusions:**

Cycads are indeed the most ancient and archaic plants and have been referred to as “living fossils”, they evolved during the Carbo-Permo-times, some 280-300 Million years ago, and reached to their climax in to Jurassic times coinciding with Dinosaurs of animal world. The group achieved its maximum diversity in the Jurassic and Cretaceous periods, when it was distributed almost worldwide. At the end of the

Cretaceous, when the non-avian dinosaurs became extinct, so did most of the *Cycas* in the Northern Hemisphere (Hill 1998, Pant 2002, Su *et al.* 2014). Pant (1996) stated that Cycad habitats in Asia have suffered severe reduction and degradation over the centuries and these pressures will inevitably continue and even increase in the near future. According to Donaldson (2003) the reasons for the decline in cycad numbers are many and varied. Almost certainly, there are some species that are dying out naturally and, ideally, these should be left alone to allow the natural process of extinction to proceed. However, there is no doubt that human activities have significantly affected cycad populations and these factors are shaping the future survival or extinction of cycad populations far more than natural processes. The destruction and alteration of natural habitat, as well as the removal of plants from the wild in massive numbers for landscaping and plant collections, are frequently cited as the main reasons for the decline and disappearance of cycad populations. Other factors, such as the influence of alien plants and animals, and use in traditional practices are also possible threats that need to be evaluated. The Andaman and Nicobar Islands presents excellent Cycads population in protected areas as reserve forest in comparison to unreserved beach forests. In spite of excellent population, cycads suffer by various natural disasters and human induced pressures. Percentage of mortality of juveniles and adult trees were significantly greater in reserve forest than in non-reserve beach forests.

The present study revealed that natural populations of *C. pschannae* are found not only in Andaman Islands but also in various other localities of beach forests of Nicobar Islands (Galathea to Pygmalion Point). This taxon found in periphery of disturbed lowland evergreen beach forests and



exhibits the presence of tall branched trunk (upto 12 m in height) with coralloid and non-coralloid aerial roots, characteristic pitting on the periclinal walls of epidermal cells of leaflets like more recently described Cycads, *C. dharmrajii* L.J. Singh from these Islands (Singh 2017). Although, occurrence of aerial roots is considered as a characteristic feature of monocots and there are relatively scanty reports on occurrence of aerial roots in Cycads and dicotyledonous plants (Gill & Tomlinson 1975, Pant & Das 1989, Misra & Singh 2000a, 2004a, b, Singh 2002, Singh & Misra 2012, 2015, Singh 2016). Recently Misra & Singh (2004a) stated that the aerial roots in general have not been subjected to their study. Besides this affinity, *C. pschannae* is highly differentiated from *C. dharmrajii* by its giant trunk with a swollen base, often branched, medium sized leaves, megasporophyll with well-defined 10-28 paired lateral hook like structure and 1-3 pairs of ovule, 2-schizo-lysigenous mucilage canals in leaflets (Singh 2017). *C. pschannae* can be distinguished from other species by the presence of abnormal branching habit of giant female trunk, megasporophyll with 2- lateral, unequal horn like curved structures leaflets possessing midrib without mesophyll cells (palisade and spongy parenchyma), diploxylic vascular bundle surrounded by dimorphic bundle sheath: sclerenchymatous towards abaxial side and centrifugal xylem, parenchymatous towards metaxylem of centripetal xylem which give rise to semi-circular shape, v-shaped centrifugal xylem, intra or extra vascular xylem parenchyma and lower; epidermis of margin is not supported by hypodermis.

During the course of studies of population status the authors concluded that older and reproductive stems can be branched or broken several times with fertile part; megasporophyll and male cone. The maximum diameter is the only measurement

for age with little systematic significance. This taxon also shows a limited amount of seed dispersal by snails. However, seeds of Cycads are toxic and relatively large because of this seeds generally do not disperse far from the parent plant. A limited amount of dispersal may be carried out by mammals, rodents and fruit bats are also observed in some Cycads (The Queensland Herbarium 2007). The present authors noticed occasionally parthenospermy or parthenocarpy in single female plant of this species as in case of *C. revoluta* and *C. rumphii* (Le Goc 1971, Pant 2002).

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