ISSN 2449-8866
1(3) 2015

Volume 1
Number 3
October-December 2015

# Current Life Sciences

http://www.journals.tmkarpinski.com/index.php/cls
cls@interia.eu

# Current Life Sciences

**ISSN 2449-8866**



**List of Peer-Reviewers**
http://www.journals.tmkarpinski.com/index.php/cls/pages/view/reviewers

**Author Guidelines**
http://www.journals.tmkarpinski.com/index.php/cls/about/submissions

**More information**
www.journals.tmkarpinski.com/index.php/cls



**Publisher and Editor's office:** Tomasz M. Karpiński, Szkółkarska 88B, 62-002 Suchy Las, Poland, e-mail: cls@interia.eu

# Contents

ISSN 2449-8866

Current Life Sciences

Research Article

# Taxonomic novelties of the genus *Lactuca* L. in Jammu and Kashmir (India): diversity, phenology and distribution

**B. L. Bhellum[1], Bikarma Singh[2,3]***

[1]Department of Botany, Govt. College for Women, Parade, Jammu, Jammu and Kashmir State, India
[2]Biodiversity and Applied Botany Division, CSIR-Indian Institute of Integrative Medicine, Jammu-Tawi, Jammu and Kashmir State, India
[3]Academy of Scientific and Innovative Research, Anusandhan Bhawan, New Delhi, India
*Corresponding author: Bikarma Singh; E-mail: drbikarma@iiim.ac.in

**Received:** 20 July 2015; **Revised submission:** 21 September 2015; **Accepted:** 25 September 2015


## ABSTRACT

The genus *Lactuca* L. (tribe Cichorieae, Asteraceae) is revised taxonomically from the state of Jammu and Kashmir. The present investigation is based on field collection from natural habitat and scrutiny of a large number of herbarium specimens deposited at different Indian herbaria. A total of 15 species critically studied, revised as per latest nomenclature and authenticated for the state of Jammu and Kashmir. All valid taxa have been studied with the help of type specimens and literatures. A key to the species prepared along with detailed morphological description, chromosome number, phenological period, and regional as well as global distribution of each species is presented for easy identification.

**Keywords:** Diversity, Taxonomy, Cytology, *Lactuca*, Jammu and Kashmir, India.

## 1. INTRODUCTION

The genus *Lactuca* L., members of the tribe Cichorieae, was established by Carl Linnaeus [1] under the family Compositae (currently known as family Asteraceae). According to TPL [2], 147 species are currently accepted and reported distribution from Asia, Europe and Northern America. The greatest diversity of this genus called "Lac" in Latin meaning "milk" is chiefly confined to Mediterranean Basin and South-West Asia [3, 4]. In India 24 species have been reported so far from plains and hilly regions occupying different habitat in Himalayan belts, comprising Arunachal Pradesh, Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir [5, 6]. Review of literature reveals that the taxonomic treatment of this genus was carried out by various botanists of India and elsewhere in the world [7-17]. However, there is no published treatment of this genus from state of Jammu and Kashmir available, and the only known treatment referred so far is that of Hooker's Flora of British India of 1881 which is more than 134 years old. Since then a lot of ICBN nomenclatural changes have taken place and a large numbers of species which were previously reported under the genus *Lactuca* have now been shifted to other genera such as *Dubaeya*, *Ixeris*, *Xeridium*, *Cicubita*, *Launaea*, *Sonchus*, *Mulgedium* and vice versa.

From economic point of view, different spe-

cies under this genus, as for example, *Lactuca serriola* L., are used for multiple purposes in traditional medicines (like antiseptic, antispasmodic, cough suppressant, diuretic, expectorant, hypnotic, purgative and sedative), and used to cure bronchitis, asthma, gastrointestinal, and various other ailments [18]. Several other species used as vegetable (e.g. *Lactuca sativa* L.), cattle feeds (e.g. *Lactuca lessertiana* (Wall. ex DC.) Wall. ex C.B. Clarke) and different species bears a variety of flower colour such as blue, white, yellow, orange and purple which is often maintained in garden as ornamental plants.

Considering this fact, an effort have been made to provide first time taxonomic treatment of the genus *Lactuca* occurring in different regions of Jammu and Kashmir state. The present communication describes the updated nomenclature, morphological enumeration, cytology, phenology, and regional as well as global distribution of 15 species of Jammu and Kashmir. A key to species is provided for easy identification.

## 2. MATERIALS AND METHODS

The taxonomic investigations are based on the study of several herbarium specimens belonging to RRLH, JU and DD. Most of the specimens were studied in their natural habitats, collected as voucher and herbarium specimens prepared following standard technique [19]. The plants were carefully identified with the help of various floras and published literatures [20-28]. For the confirmation of identification, the specimens were cross-checked with the housed sample lodged at herbaria of Indian Institute of Integrative Medicine (RRLH), and Herbarium of Jammu University (JU). Valid botanical names along with the author citations were verified from www.theplantlist.org version 1.1 [2], www.ipni.org [29], and www.tropicos.org [30]. Voucher specimens of the plants were deposited at Janaki Ammal Herbarium Jammu (acronym RRLH).

## 3. RESULTS

Critical investigations of the Genus *Lactuca* L. in current scenario specify 15 species in Jammu and Kashmir, and these species were categorized into five sections (viz., *Lactuca* L., *Phoenixopus* Benth., *Lactucopsis* (Schultz Bip. ex Vis. et Pančič) Rony, *Mulgedium* (Cass.) C.B. Clarke, *Micranthae* Boiss.). Salient characters of these five sections are given below:

(1) **Section Lactuca**: this section is further divided into Lactuca and Cyanicae as subsection which is mainly based on life cycle. The former subsection comprises of annual or biennial herbs; capitula is composed from 10-30 yellow florets; achenes are obovate with many ribs, slender pale beak usually at least as long as the body (e.g. *L. benthamii, L. dissecta, L. dolichophylla, L. pygmaea, L. sativa, L. serriola*); however, the later, subsection are perennial herbs with capitula composed of not more than 22 blue or lilac florets and 1-3 ribbed achenes and non of the Jammu and Kashmir species falls under this group.

(2) **Section Phaenixopus**: Plant of this section are perennial, marked by decurrent leaves; capitula composed from 5-6 florets, densely branched panicle; achenes are 5-11 ribbed, oblong to elliptic, contracted into beak not longer than the body (e.g. *L. orientalis*).

(3) **Section Mulgedium**: Most of the species are perennial; inflorescence composed from few capitula; florets are numerous, blue, lilac, rarely white in colour; achenes are compressed, marked by very short beak of same colour as the plant body (e.g. *L. decipiens, L. kashmiriana, L. rapunculoides, L. rostrata, L. tatarica*).

(4) **Section Lactucopsis**: Species under this section are mostly biennial in nature; inflorescence is usually corymbose with capitula of 6-15 florets; achenes are oblong-elliptic with 2-10 ribs and beak extending 1/4 to 1/2 as long as body (e.g. *L. quercina*).

(5) **Section Micranthae**: This section includes annual or biennial species with violet or purple florets and elliptic 1-3 ribbed achenes, marked by beak 2-4 times longer than the body (e.g. *L. undulata*)

A key is prepared with reference to fifteen species for their easy identification and presented below.

| | | | |
|---|---|---|---|
| 1a. | Undershrubs; branches intricate or divaricate, spinescent | ..... | *L. orientalis* |
| 1b. | Annual or perennial herbs; branches not as above but usually paniculate, without spines (except *L. serriola*) | ..... | 2 |
| 2a. | Plants without rootstocks | ..... | 3 |
| 2b. | Plants with root stock | ..... | 9 |
| 3a. | Stem 25-150 cm tall, branches paniculate or corymbose | ..... | 4 |
| 3b. | Stem 3-50 cm tall, erect or suberect, dichotomously branched | ..... | 6 |
| 4a. | Leaves usually entire, sparingly half pinnatifid or lobed | ..... | *L. dolichophylla* |
| 4b. | Leaves usually runcinate, pinnatifid, margin spinously toothed | ..... | 5 |
| 5a. | Stem leaves undivided, abaxially with smooth midrib; leaves succulent, midrib smooth, beak of achene as long as body; phyllaries usually erect in fruit; achene with 5-7 ribs on each surface. | ..... | *L. sativa* |
| 5b. | Stem leaves pinnately lobed, abaxially usually with prickly setose midrib; leaves non-succulent, midrib spinous, beak of achene as long as or slightly longer than body; phyllaries usually reflexed in fruit; achene with 7-9 ribs on each surface. | ..... | *L. serriola* |
| 6a. | Head 12-14 mm long including beak; achenes flattened; base with rodlike appendages; achene body with 1 rib on either side | ..... | *L. undulata* |
| 6b. | Heads 6-7 mm long including beak; achenes elliptic or oblanceolate; base without rodlike appendages; achene body with 3-9 rib on either side | ..... | 7 |
| 7a. | Stem usually 15-45 cm long; leaves always dissected; achenes with white beak | ..... | *L. dissecta* |
| 7b. | Stem usually 3-12 cm long; leaves entire; achenes otherwise | ..... | 8 |
| 8a. | Heads 6-7.5 mm across | ..... | *L. pygmaea* |
| 8b. | Heads 2.5-3 cm across | ..... | *L. benthamii* |
| 9a. | Leaves petiolate | ..... | 10 |
| 9b. | Leaves sessile or nearly so | ..... | 11 |
| 10a. | Achenes black, beak nearly half the length of body | ..... | *L. quercina* |
| 10b. | Achenes not black; beak shortly constricted | ..... | *L. rostrata* |
| 11a. | Petioles winged | ..... | 12 |
| 11b. | Petioles not winged | ..... | *L. tatarica* |
| 12a. | Leaves margin incurved | ..... | *L. rapunculoides* |
| 12b. | Leaves margin not as above | ..... | 13 |
| 13a. | Outer involucre bracts 4-6 mm long; achenes sparsely hairy | ..... | *L. decipiens* |
| 13b. | Outer involucre bracts 1-2 mm long; achnes glabrous | ..... | *L. kashmiriana* |

### 3.1. Enumeration, morphological description, cytology, phenology and distribution

**1. *Lactuca benthamii*** C.B. Clarke, Comp. Ind. 273. 1876.

Annual or biennial, 10-15 cm tall, glabrous or puberulous herbs; stem stout branched; radical leaves spathulate, oblong, margin entire or obscurely dentate, glabrous above, glacous beneath; heads cylindric, on short stout branched corybose, blackish; involucres bracts few seriate, outer ovate inner oblong; ligules purplish; achenes smooth; pappus copius, uniseriate, dirty white.

Chromosome number: NA

Phenological period: July-August

Regional occurrence: Grows on slopes between 3000-5000 m MSL in Jammu & Kashmir

Global distribution: Endemic to Kashmir in Western Himalaya, India.

**2. *Lactuca decipiens*** Hook.f. & Thomson ex C.B. Clarke, Compos. Ind. 266. 1876.

Annual or biennial, 10-30 cm tall herbs; stem erect, branched above; leaves entire or lobed or bipinnatifid, glabrous or pubescent; lower leaves much lobed, lobes pointing backwards; upper leaves sessile, with winged auricles, upper oblanceolate; heads in terminal slender, drooping panicles; ligules whitish pink; achenes compressed, brown, hairy towards margins; pappus dirty white.

Chromosome number: n = 8 [31]

Phenological period: July-November

Regional occurrence: Yarika in Jammu and Kashmir

Global distribution: India (Jammu and Kashmir, and Himachal Pradesh in Western Himalaya, Uttar Pradesh), Pakistan, Afghanistan, Nepal

Voucher: Jammu and Kashmir - Kashmir, Ballra, Kapoor 6402 (RRLH)

Previous records:

*Cicerbita decipiens* (Hook.f. & Thomson ex C.B. Clarke) Beauverd, *Kovalevskiella decipiens* (Hook. f. & Thomson ex C.B.Clarke) Kamelin., *Mulgedium decipiens* Hook.f. & Thomson ex C.B.Clarke.

Note: Two varieties of *L. decipiens* (var. *decipens* and var. *multifida*) reported from Jammu and Kashmir. the former is widely distributed in Drass, Ladakhand Gumri, however, the later ones is reported from Suru to Sirimarg and endemic to Kashmir belt. A key is given below to differentiate the two varieties:

1a. Leaves entire or lobed; achenes beaked, not white .....var. *decipens*

1b. Leaves all pinnitifid, achnes beaked white .....var, *multifida.*

**3. *Lactuca dissecta*** D.Don, Prodr. Fl. Nepal. 164.1825.

Erect annual herbs, 15-45 cm tall, glabrous or pubescent; stems often tufted, dichotomously branched from the base; leaves entire, lyrate, runcinate, pinnatisect, radical leaves many, sessile, cauline leaves alternate, uppermost linear, amplexicaule; head ligulates, corymbose, blue; achenes blackish-brown, compressed, 3-ribbed on entire side; pappus vary, white hairy.

Chromosome number: n = 8 [32, 33]

Phenological period: March-May

Regional occurrence: Ramban, Jammu, Udhampur, Rajouri, Poonch, Kashmir, Ladakh, Batote, Lidder Valley and Yarika in Jammu and Kashmir between 300-3000 m MSL.

Global distribution: India (Jammu and Kashmir, Uttaranchal, Sikkim, Darjeeling and Himachal Pradesh in Himalaya, Uttar Pradesh, Madhya Pradesh), Bangladesh, Bhutan, Pakistan, Afghanistan, Nepal, China, Kazakhstan, Kyrgyzstan, Tajikistan, United Arab Emirates

Voucher: Jammu and Kashmir - Upper Lidder Valley, Gha Shangan, B.M. Sharma 20714; Maggarkote (1400m), Bhellum 12448.

Previous records: *Chondrilla auriculata* Wall., *Lactuca arvensis* Edgew., *Lactuca auriculata* DC., *Lactuca stocksii* Boiss.

**4. *Lactuca dolichophylla*** Kitam., Fl. E. Himalaya 341. 1966.

Annual erect herbs, stems simple, slender, 1-1.5 m tall, glabrous except hispid base; leaves sessile long, linear lanceolate, base stem clasping, apex acuminate, heads held in panicles, ligule blue; achnes elliptic or oblanceolate, 3-5 ribbed, beak equal or shorter than body of achenes

Chromosome number: n= 8 [34, 35]

Phenological period: July-November

Regional occurrence: Abundant along roadside or nearby forest nursery. Commonly reported in literature from Batote, Poonch and Udhampur area.

Global distribution: India (Jammu and Kashmir, Himachal Pradesh, Sikkim, and Assam in Himalaya, West Bengal, Uttar Pradesh, Tamil Nadu), Afghanistan, Bhutan, Myanmar, China, Nepal and Pakistan

Voucher: Jammu and Kashmir - Batote, 1500 m, Bhellum 1449; Udhampur, way to Gudalu, Srivastava 2752; Sissoo, Srivastava and Kapahi 17717.

Previous records: *Chondrilla longifolia* Wall., *Lactuca handeliana* S.Y.Hu, *Lactuca longifolia* (Wall.) DC., *Lactuca wallichiana* Tuisl, *Mulgedium sagittatum* Royle.

5. ***Lactuca kashmiriana*** Mamgain & R.R. Rao, J. Bombay Nat. Hist. Soc. 83: 406. 1986.

Annual or biennial herbs, 50-90 cm tall herbs; stem erect, glabrous, branched above, basal and middle leaves cordate or deltoid, membranous with winged petioles; upper ones ovate, hastate margin, sharpely serrate heads in terminal paniculately branched, ligule purple or blue; achenes oblanceolate, many ribbed, yellowish brown; pappus white.

Chromosome number: NA

Phenological period: August-October

Regional occurrence: Grows on moist slopes between 2500-4000 m MSL

Global distribution: Endemic to Kashmir in Western Himalaya, India.

**6. *Lactuca lessertiana*** (Wall. ex DC.) Wall. ex C.B. Clarke, Comp. Ind. 270. 1876.

Annual or perennial herbs; stem erect, glabrous or laxly villous; leaves highly variable, usually oblanceolate, margin entire or slightly toothed or lyrate pinnatifid; heads in hispid elongate panicles; involucral bracts hirsute; ligules blue or violet; achenes oblanceolate, elliptic, compressed, 6-14 mm long; pappus simple, white or yellowish white.

Chromosome number: 2n=16 [35]

Phenological period: July-October

Regional occurrence: Grows on dry slopes between the elevation of 2500-5000 m MSL in Dudhsar, Ladakh and Drass in Jammu and Kashmir

Global distribution: India (Himachal Pradesh, Jammu and Kashmir, Sikkim in Himalaya, Punjab, Uttar Pradesh), Bhutan, China, Nepal, Pakistan

Voucher: Jammu and Kashmir - Dudhsar, Jamwal 20719; Pahalgam (2600-4000 m), Tulian s.n.

Previous records: *Cicerbita lessertiana* (DC.) Mamgain and Rao, *Cicerbita lessertiana* (Wall. ex DC.) Mamgain and R.R. Rao, *Hieracium lessertianum* Wall., *Melanoseris lessertiana* (DC.) Decne., *Melanoseris lyrata* Decne., *Mulgedium lessertianum* (Wall. ex C.B.Clarke) Wall. ex DC., *Mulgedium lessertianum* var. *dentatum* DC., *Mulgedium lessertianum var. lessertianum*.

Note: During the study, the authors come across three varieties of this species. A key for easy identification for this subsp is given below:

1a. Leaves entire .....subsps. *lessertiana*
1b. Leaves lyrate, pinnatifid or dentate ..... 2
2a. Leaves shallowly lyrate-pinnatifid ..... subsps. *lyrata*
2b. Leaves dentate, mucronate .....subsps. *dentata*

**7. *Lactuca orientalis*** (Boiss.) Boiss., Fl. Orient. 3:819. 1875.

Annual or perennial, 15-50 cm tall herbs; stem branched, glabrous, branches often slender, silvery, spinescent, partly covered with decurrent leaf-bases; basal leaves pinnatifid, spreading, or incurved, triangular, acute, margin entire or toothed, upper leaves elliptic or oblanceolate, entire; heads solitary or 2-3 in fascicle; achenes fusiform, narrow at both ends, 6-8 ribbed on each face; pappus simple, pale or silvery.

Chromosome number: n=9 [36]

Phenological period: July-October

Regional occurrence: Grows on dry and open slopes between an elevations of 2000-4600 m MSL in Jammu and Kashmir.

Global distribution: India (Jammu and Kashmir), China, Pakistan, Kazakhstan, Kyrgyzstan, Pakistan and Tajikistan

Voucher: Jammu and Kashmir - Ladakh (2000-4600 m), Sapru s.n; Kistwar, Sharma s.n.

Previous records: *Lactuca orientalis* subsp. *orientalis*, *Lactuca viminea* var. *erostris* Regel, *Mulgedium orientale* (Boiss.) Popov, *Phaenixopus orientalis* (Boiss.) Sosn., *Phaenopus orientalis* Boiss., *Scariola orientalis* (Boiss.) Soják.

**8. *Lactuca pygmaea*** Bhellum, Curr. Lif. Sci. 1(1):1-5. 2015.

Annual, slender 3-12 cm tall herbs; juice milky, stem usually solitary, hairy at base; leaves thin, basal obovate, oblanceolate, oblong spathulate, margin entire or remotely dentate, apex rounded; heads pedunculate, solitary or a few, 7-10 mm long; involucral bracts 2-3 seriate, outer shorter than the inner; ligules blue; achenes obovate, compressed, 3-ribbed on either side; pappus simple, white.

Chromosome number: Not yet studied

Phenological period: March-April

Regional occurrence: Jammu province

Global distribution: Endemic to Kashmir in Western Himalaya, India

Voucher: Jammu and Kashmir - Jammu, East of Sainik Colony, Bhellum 15323 (RRLH).

**9. *Lactuca quercina*** L., Sp. Pl. 2: 795. 1753.

Annual or biennual 30-100 cm tall herbs; root tuberous; stem erect; leaves lyrate pinnatified with large terminal segiment ovate; upper oblong, elliptic or lanceolate, margin entire pinnatified or pinnatisect, segiment dentate; heads in corymbose panicles, achenes oblong- elliptic 8-10 mm about 5-ribbed, apex selose, beak nearly half the length of body of achenes

Chromosome number: 2n = 18 [36, 37]

Phenological period: August-October

Regional occurrence: Grows on dry slopes between 1500-2500 m MSL in Jammu and Kashmir. Other known areas in Gulmarg (3000 m), Zogila, Kishtwar, Kashmir, minimarg and Kangan

Global distribution: India (Jammu and Kashmir), Turkey, Armenia, Azerbaijan, Georgia, Russian Federation, Sweden, Austria, Czech Republic, Germany, Hungary, Slovakia, Belarus, Moldova, Russian Federation, Albania, Bosnia, Herzegovina, Bulgaria, Croatia, Greece, Italy, Macedonia, Montenegro, Romania, Serbia, Slovenia, France and Ukraine.

Voucher: J & K-Zojila, Nath & Kaw s.n.

Previous records: *Cicerbita corymbosa* Wallr. [Illegitimate], *Cicerbita quercina* (L.) Wallr., *Lactuca altissima* M.Bieb., *Lactuca chaixii* Vill., *Lactuca lipskyi* Grossh., *Lactuca quercina* subsp. *chaixii* (Vill.) Čelak., *Lactuca quercina* subsp. *sagittata* (Waldst. & Kit.) Soó & Jáv., *Lactuca quercina* subsp. *stricta* (Waldst. & Kit.) Hegi, *Lactuca sagittata* Waldst. & Kit., *Lactuca stanekii* Domin, *Lactuca stricta* Waldst. & Kit., *Lactucopsis altissima* (M.Bieb.) Vis. & Pančić, *Lactucopsis chaixii* (Vill.) Vis. & Pančić, *Lactucopsis quercina* (L.) Vis. & Pančić, *Melgedium quercinum* (L.) C.Jeffrey.

**10. *Lactuca rapunculoides*** (DC.) C.B. Clarke, Comp. Ind. 268. 1876.

Annual or biennual 50-100 cm tall, herb; stem erect branched above; basal leaves cordate or deltoid with margins incurved, hastate, middle stalked and upper nearly sessile, ovate, lanceolate, petiole winged; heads in drooping panicles, terminal; ligule white or purple; achenes fusiform compressed, narrow at both the ends, beak narrow brown; pappus dirty white.

Chromosome number: 2n=16 [36]

Phenological period: August-October

Regional 0ccurrence: Grows on Shady slopes adjacent to area of Gulmarg, Zojila, Kamri between the elevations of 3000-4500 m MSL in Jammu and Kashmir. Native to North-West Himalaya

Global distribution: India (Jammu and Kashmir, Himachal Pradesh in Western Himalaya, Maharashtra, Goa, Madhya Pradesh, Bihar), Afghanistan, China, Pakistan, Nepal

Voucher: Jammu and Kashmir - Gulmarg, RRS s.n.

Previous records: *Cicerbita rapunculoides* (DC.) Beauverd, *Kovalevskiella rapunculoides* (DC.) Kamelin, *Mulgedium rapunculoides* DC.

**11. *Lactuca rostrata*** (Blume) Boerl., Handl. Fl. Ned. Ind. 1: 245. 1892.

Annual or biennial erect herbs; stem 80-50 cm tall glabrous or pubrulous; lower leaves deltoid or triangular, pinnate or pinnatifid, upper ones sessile ovate or lanceolate; heads in paniculate racemes; ligule pink or pinkish purple; achenes oblanceolate or narrowly oblong; pappus pale white

Chromosome number: 2n = 18 [36]

Phenological period: August-October

Regional occurrence: Grows on moist Forest slopes between 2000-3500 m MSL in Jammu and Kashmir

Global distribution: India (Jammu and Kashmir), Malesia, Pakistan

Previous records: *Mulgedium rostratum* (Blume) Sch., *Youngia affinis* (Jungh.) Zoll. & Mor.

**12. *Lactuca sativa*** L., Sp. Pl. 2: 795. 1753.

Annual or biennual 25-75 cm tall herbs; stem erect glabrous succulent, leafy; leaves sessile, ovate, oblong, minutely spinulose toothed, base auriculate; heads in leafy branched glabrous, paniculates; peducles erect, white; ligules yellow; achenes oblanceolate, 6-8 ribbed, glabrous or sparsely hairy towards margin; pappus simple white.

Chromosome number: 2n= 18 [36, 38]

Phenological period: March-November

Regional occurrence: Commonly cultivated through all regions on moist hills between elevation of 1500-2600 m MSL in Jammu and Kashmir.

Global distribution: India (Jammu and Kashmir),

Argentina, Australia, Belize, Bolivia, Brazil, Canada, Caribbean, Chile, China, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru, New Zealand, South Africa, Tanzania, United States, Venezuala and Zaire

Previous records: *Lactuca capitata* (L.) DC., *Lactuca crispa* (L.) Roth, *Lactuca dregeana* DC., *Lactuca laciniata* Roth, *Lactuca palmata* Willd.

**13. *Lactuca serriola*** L., Cent. Pl. 2: 29. 1756.

Annual or biennial, erect herbs, 50-150 cm tall; stem branched, glabrescent, leafy; leaves sessile pinnatifid or runcinate, pinnatifid, segments toothed prickly underneath on midrib and nerves, cauline; head erect in panicles, yellow; achenes compressed, many ribbed, brown beak very slender about as long as main body of achene.

Chromosome number: 2n= 18 [36, 39]

Phenological period: July-September

Regional occurrence: Common on Moist situations in Bhadarwah. Other reported sites includes Jammu, Udhampur, Kathua, Kishtwar, Poonch and Wastelands in area of Talab Tillo between elevation of 300-4000 m MSL.

Global distribution: India (Jammu and Kashmir), Afghanistan, Argentina, Australia, Brazil, Canada, Chile, Ethiopia, Kazakhstan, Kyrgyzstan, Mongolia, New Zealand, Russia Federation, South Africa, Sudan, Tajikistan, United States and Uzbekistan

Voucher: Jammu and Kashmir - Ladakh, FJKH 840; Beggar (900 m), Bhellum 1450; Pir Panjal, Sanasar (2000m), Rao 7482.

Previous records: *Lactuca albicaulis* Boiss., *Lactuca altaica* Fisch. & C.A.Mey., *Lactuca altaica* Fisch. & Mey., *Lactuca augustana* All., *Lactuca coriacea* Sch.Bip., *Lactuca dubia* Jord., *Lactuca integrata* (Gren. & Godr.) A.Nelson, *Lactuca latifolia* Gilib., *Lactuca saligna* var. *robusta* Fisch. & C.A.Mey., *Lactuca scariola* L., *Lactuca sylvestris* Lam., *Lactuca tephrocarpa* K.Koch, *Lactuca verticalis* Gaterau.

**14. *Lactuca tatarica*** (L.) C.A. Mey., Verz. Pfl. Casp. Meer. 56. 1831.

Annual or biennual 15-40 cm tall, herbs; stem erect, glabrous or subglabrescent; leaves sessile sparsly radical leaves runcinate, spinous, toothed, base amplexicaul, heads many flowered, bractiolate panicles; achenes narrowly oblong, 4-5 ribbed, pale or dark brown, Pappus white.

Chromosome number: 2n= 18 [36,40]

Phenological period: July - September

Regional occurrence: Grows on open and moist slopes of meadows 2500-5000 m MSL in Jammu and Kashmir. Commonly reported areas are Rupsu, Nubra, Ladakh, Khalri, and Zanskar (2800-5000 m)

Global distribution: India (Jammu and Kashmir), Afghanistan, China, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Russia Federation, Tajikistan, United States and Uzbekistan

Voucher: Jammu and Kashmir - Ladakh, Gauglis, B.K. Abrol 6398 (RRLH)

Previous records: *Agathyrsus pulchellus* D. Don, *Agathyrsus tataricus* (L.) D.Don, *Cicerbita tatarica* (L.) Sosn., *Crepis charbonnelii* H.Lév., *Galathenium integrifolium* (Bigelow) Nutt., *Lactuca clarkei* Hook.f., *Lactuca integrifolia* Nutt., *Lactuca multipes* H.Lév. & Vaniot, *Lactuca oblongifolia* Nutt. [Invalid], *Lactuca pulchella* (Pursh) DC., *Lactuca sylvatica* A. Nelson, *Lagedium tataricum* (L.) Soják, *Mulgedium heterophyllum* Nutt., *Mulgedium oblongifolium* (Nutt.) Reveal, *Melgedium pulchellum* (Pursh) G.Don, *Melgedium roborovskii* Tzvelev, *Mulgedium runcinatum* Cass., *Melgedium tataricum* (L.) DC., *Sonchus lactucoides* Bunge, *Sonchus pulchellus* Pursh, *Sonchus sibiricus* Richardson, *Sonchus tataricus* L., *Sonchus volhynicus* Besser ex Nyman, *Wiestia tatarica* (L.) Sch.Bip.

Note: *L. tatarica* occurs in Kashmir Himalaya is a variety called '*L. tatarica* var. *tibetica* Hook.f., Fl. Brit. India 3: 406. 1881, and the above described species is for this variety.

**15. *Lactuca undulata*** Ledeb., Icon. Pl. 2: 12. 1830.

Annual 15-40 cm tall and glabrous or glaucous herb stem dichotomously branched from the base; leaves radical sessile, pinnately, lobed, lobes entire or sparingly toothed; cauline sessile auricled; heads in terminal clustered or panicled; ligule white, pink or bluish; achenes compressed oblanceolate, 3-4 ribbed;, tip clefted, beak elongated, cleft embrasing the base of achene; pappus white.

Chromosome number: 2n= 18 [30]

Phenological period: Grows on hilly areas such as Nubra, Zanskar, Rupshu and Ladakh between 2800-5000 m in Jammu and Kashmir.

Regional occurrence: Grows on open and moist

slopes of meadows 1500-4000 m MSL in Jammu and Kashmir. Commonly reported areas are Ladakh and Zanskar

Global distribution: India (Jammu and Kashmir), Afghanistan, China, Iraq, Pakistan, Russia, Tajikistan, Tazakhstan, and Uzbekistan.

Previous records: *Lactuca undulata* var. *albicaulis* Z.X. An., *Lactuca undulata* var. *pinnatipartita* Trautv.

## 4. DISCUSSION

Family Asteraceae (Compositae) is placed high in the Angiosperm Phylogeny, and represented the largest number of taxonomically described, accepted ca. 24,000 species, of any plant group family, distributed between approximately 1,700 genera around the globe [41]. The family is monophyletic, and has never been in question [42, 43]. However, several genera placed in the family have always been a source of disagreement among the botanist working in the field of taxonomy across the world [44-45]. Similar is the case of *Lactuca* [46], but Stebbins [47] for the first time studied seriously this genus particularly with reference to the knowledge pertaining on Indian species, and settled the dispute related to the status of this genus.

As there is no comprehensive treatment of the genus *Lactuca* from Jammu and Kashmir state and the only available treatment is that of Hooker's Flora of British India published in 1881, which is about 135 years old. Authors first time attempted to study this genus, and come up with the occurrence of fifteen species, viz., *L. benthamii*, *L. decipiens*, *L. dissecta*, *L. dolichophylla*, *L. kashmiriana*, *L. lessertiana*, *L. orientalis*, *L. pygmaea*, *L. quercina*, *L. rapunculoides*, *L. rostrata*, *L. sativa*, *L. serriola*, *L. tatarica*, and *L. undulata*. The presented work is the results of inventorization, frequent surveys and collections combined with the scrutiny of literatures and housed herbarium samples particularly related to diversity and taxonomy of *Lactuca*. While studying, the authors come to know that three species, viz., *L. benthamii*, *L. kashmiriana*, and *L. pygmaea* are endemic to the Western Himalaya, and rest of them found abode in different climatic zones of India. This study also concluded that the distribution of all the species under this genus ranges from 250 to 5,000 m above mean sea level. Most of the plant communities are annual and biennial, but *L. orientalis* recorded as perennial in nature. The height of the plant varies depending on the ecology and the climatic factors which influence their growth.

While gathering information related to the ethnobotany of *Lactuca* from people of Jammu and Kashmir, authors come to know that *Lactuca sativa* is eaten as a popular salad. The seeds of *Lactuca serriola* is used in powder form for the treatment of chronic cough, and also given as a decoction power for curing insomnia disease. This study is also supported by the previous published work of Bano and Qaiser [48]. Literatures also supported that *Lactucarium*, a drug used as hypnotic in the treatment of bronchitis and asthma reported from *Lactuca sativa* and *Lactuca serriola* [49]. *Lactuca tatarica* is used as fodder plant for cows and buffaloes, and this is also supported by work of Kirpicznikov [50]. Therefore, the genus is important from medicinal point of view, and all species within the group needs proper conservation and protection.

## ACKNOWLEDGEMENTS

The authors are grateful to Director IIIM, Dr Ram A. Vishwakarma for necessary herbarium facilities.

## AUTHOR'S CONTRIBUTION

Both the authors equally contributed in field work, collection, and identification, scrutiny of literatures, manuscript preparation and editing, associated with this research article. The final manuscript has been read and approved by both authors.

## TRANSPARENCY DECLARATION

The authors declare no conflicts of interest.

## REFERENCES

1. Linnaeus C. Species Plantarum. The Ray Society, London 1753.
2. TPL. The Plant List-A Working List of All Known Plant Species. Version1.1, released in September 2013. www.theplantlist.org (accessed 24.11.2014).
3. Lebeda A, Dolezalová I, Feráková V, Astley D. Geographical distribution of wild *Lactuca* species (Asteraceae, Lactuceae). Bot Rev. 2004; 70: 328-356.

4. Kitamura S. Plants of West Pakistan and Afghanistan. The committee of the Kyoto University Scientific Expedition to the Karakorum and Hindukush, Kyoto, Japan, 1964.
5. Mamgain SK, Rao RR. Asteraceae (tribe Cichorieae). In: Hajra PK, Rao RR, Singh DK, Uniyal BP (eds.), Flora of India. Botanical Survey of India, Kolkata, India, 1995; 12: 267-303.
6. Meena KL. *Lactuca serriola* L. (Asteraceae): an extended distribution to the states of Rajasthan. J Indian Bot Soc. 2014; 93(1): 132-134.
7. De Candolle AP. Prodomous Systematic. Naturalis Regni Vegetabilis, Paris (7), 1836.
8. Boissier PE. Flora Orientalis. Basileae, Genevae and Lugduni (3), 1875.
9. Clarke CB. Compositae Indicae. Thacker, Spink and Company, Calcutta, India 1876.
10. Hooker JD. The Flora of British India. L. Reeve and Co., London (3), 1881.
11. Rechinger KH. Compositae II. In: Koeie M, Rechinger KH. Det Kongelige Danske Videnskabernes Selskab Biologiske Skrifter. Symbolae Afghanicae, Afghanistan, 1955; 204-211.
12. Jeffrey C. Flora of Turkey and East Aegean Isles. University Press, Edinburgh, 1975.
13. Rechinger KH. Flora Iranica, Compositae II - Lactuceae No. 122. Akademische Druck Verlagsanstall, Graz, Austria, 1977.
14. Chaudhary SA. Flora of the Kingdom of Saudi Arabia. National Agriculture and Water Research Center, Riyadh, 2000.
15. Thulin M. Flora of Somalia. Royal Botanic Gardens, Kew, London (3), 2006.
16. Mabberley DJ. Mabberley's Plant-Book. A portable dictionary of plants their classification and uses. 3rd Edition. Cambridge University Press, Cambridge, New York, 2008.
17. Kilian N, Gemeinholzer B, Lack HW. Cichorieae. In: Funk VA, Susanna A, Stussey TF, Bayer RJ, Systematic, evolution and biogeography of Compositae. California Botanical Society, Vienna 2009: 344-383.
18. Janbaz KH, Latif MF, Saqib F, Imran I, Haq MZ, Feo VD. Pharmacological effects of *Lactuca serriola* L. in experimental model of gastrointestinal, respiratory and vascular ailments. J Evid Based Complement Altern Med. 2013; 9.
19. Jain SK, Rao RR. A handbook of Field and Herbarium Methods. Today and Tomorrow's Printer Publisher, New Delhi, India, 1977.
20. Hooker JD. The Flora of British India. L. Reeve and Co., London, 1872-1897.
21. Stewart RR. Flora of Ladakh, Western Tibet. Bull Torrey Bot Club 1916-1917; 43: 625-650.
22. Kachroo P. Flora of Ladaka: An ecological and taxonomical appraisal. Bishen Singh Mahendra Pal Singh, Dehra Dun, India, 1977.
23. Sharma BM, Kachroo P. Flora of Jammu and plants of neighbourhood (Vol. I.). Bishen Sing Mahendra Pal Singh, Dehra Dun, India (1), 1981.
24. Kachroo P, Sapru BL, Dhar U. Flora of Ladakh. Daya Publishing House, New Delhi, India, 1983.
25. Dhar U, Kachroo P. Alpine Flora of Kashmir Himalaya. Scientific Publishers, Jodhpur, India, 1983.
26. Sharma BM, Jamwal PS. Flora of Upper Lidder Valleys of Kashmir Himalaya. Scientific Publishers, Jodhpur, India (1 & 2), 1988.
27. Chaurasia OP, Singh B. Cold Desert plants. Field Research Laboratory, Leh Ladakh, India, 1996-2001.
28. Swamy A, Gupta BK. Flora of Udhampur district. Bishen Singh Mahendra Pal Singh, Dehra Dun, India, 1998.
29. IPNI. The International Plant Name Index. Online: www.ipni.org (accessed 24.11.2014).
30. TROPICOS. Missouri Botanical Garden. Online: www.tropicos.org (accessed 24.11.2014).
31. Malik RA, Gupta RD. Meiotic studies in some selected members of Gamopetalae from Kashmir Himalaya. Pl Syst Evol. 2013; 299(8): 1549-1560.
32. Gupta RC, Gill BS. Cytopalynology of North and Central Indian Compositae. J Cytol Genet. 1989; 24: 96-105.
33. Razaq ZA, Vahidy AA, Ali SI. Chromosome numbers in Compositae from Pakistan. Ann Missouri Bot Gard. 1994; 81: 800-808.
34. Kaul MLH. Genecology and evolutionary dynamics of Mecardonia dianthera. In: Kachroo P, Advancing Frontiers in Cytogenetics. Hindustan Publication Co., Delhi, India, 1974; 327-343.
35. CCDB. The Chromosome Counts Database-a community resource of plant chromosome numbers. CCDB chromosome counts database, version 1.19. http://ccdb.tau.ac.il/home.
36. Patricia MA, Julio RD, Ana IH. IAPT/IOPB chromosome data 13. Taxon. 2012; 61 (4): 889-902.
37. Feráková V. Chromosome study in *Lactuca quercina* L. and *Lactuca chaixii* Vill. Folia Geobot Phytotax. 1968; 3(1): 111-116
38. Yan GX, Zhang SZ, Xue FH, Wang LY, Yun JF, Fu XQ. The chromosome numbers and natural distribution of 38 forage plants in north China. Grassl China. 2000; (5): 1-5.
39. Krasnikov AA, Zhirova OS, Lomonosova MN, Smirnov S. Chromosome numbers of Asteraceae from the southern Siberia and Kazakhstan. Bot Žhurn. 2003; 88(9): 151-153

40. Stepanov NV, Muratova EN. Chromosome numbers of some taxa of higher plants of Krasnoyarsk territory. Bot Žhurn. 1995; 80(6): 114-116.
41. Funk VA, Susanna A, Stuessy TF, Robinson H. Classification of Compositae. 2015; 171-189. www.compositae.org/pdf/CB_Classification.pdf
42. Tournefort JP de. Institutiones Rei Herbariae. Typo graphia Regia, Paris (3), 1700.
43. Lundberg J, Bremer K. A phylogenetic study of the order Asterales using one morphological and three molecular data sets. Intern J Pl Sci. 2003; 164: 553-578.
44. Bhellum BL. *Lactuca pygmaea* (Asteraceae, Cichorieae) - a new species from India. Curr Life Sci. 2015; 1(1): 1-5.
45. Kilian N. *Lactuca stebbinsii* (Lactuceae, Compositae), a puzzling new species from Angola. Willdenowia. 2001; 31: 71-78.
46. Kilian N, Djavadi SB, Eskandari M. Two new mountainous species of *Lactuca* (Cichorieae, Asteraceae) from Iran, one presenting a new, possibly myrmecochorous achene variant. PhytoKeys. 2012; 11: 61-77.
47. Stebbins GL. Notes on some Indian species of Lactuca. Indian Forest Bot. 1939; 1: 237-245.
48. Bano R, Qaiser M. A taxonomic revision of the genus *Lactuca* L. (Cichorieae-Asteraceae) from Pakistan. Pak J Bot. 2011; 43(5): 2259-2268.
49. Ambasta SP, Ramachandra K, Kashyapa K, Chand R. The useful plants of India. CSIR New Delhi, 1986.
50. Kirpicznikov ME. In: Flora of the USSRi. Bobrov EG, Tzevlev NN. Compositae, Leningrad, 1964; 29: 7-9.

ISSN 2449-8866

Current Life Sciences

Research Article

# Vegetation patterns and floristic composition of Yemen

**Othman Saad Saeed Al-Hawshabi[1]*, Salah Mohammed Ibrahim El-Naggar[2]**

[1]Biology Department, Faculty of Education, Aden University, Aden, Yemen

[2]Botany Department, Faculty of Science, Assiut University, Assiut, Egypt

*Corresponding author: Othman Saad Saeed Al-Hawshabi, e-mail: othmanhamood773@yahoo.com

**Received:** 25 August 2015; **Revised submission:** 31 October 2015; **Accepted:** 05 November 2015



## ABSTRACT

In Yemen five main phytogeographical regions have been recognized: coastal plain, mountains, inland plains, desert and islands in the Red Sea and Indian Ocean. The floristic composition and affinities of the floristic elements in of each region has been discussed in the light of the climatic and edaphic factors. In addition to the floristic composition, vegetation patterns in each region has been described and discussed. On the coastal plain regions are several plant species associated to plant communities such as: *Euphorbia qarad*, *Odyssa mucronata*, *Senna holosericea*, and also *Dobra glabra*, *Euphorbia fractiflexa*, *E. inarticulata*, *E. triaculata*. On the flat sand (plain) and sand dunes are xerophytic elements such as: *Fagonia indica*, *Gloriosa revoilii*, *Panicum turgidum* and *Salvadora persica*. *Pluchea indica* subsp. *yemenensis* is found in Abyan and Lahej plains. The natural vegetation of mountainous regions is composed of undershrubs, shrubs and dwarf trees. On the mountain tops are found several taxa of ferns such as: *Adiantum capillus-veneris*, *A. incisum* and *Selaginella yemensis*. Floristic diversity is very restricted in the desert. The vegetation of Socotra is characterized by the richness in the tree elements and endemits such as *Dracaena cinnabari*, *Commiphora socotrana* and *Euphorbia socotrana.*

**Keywords:** Yemen, Vegetation, Floristic composition, Climate, Phytogeography.

## 1. INTRODUCTION

Recently, there is a global interest in the biodiversity in the world, since the natural resources, particularly the wild plants, are widely regarded as a vital component of many countries natural wealth. The floristic study of an area is considered as a cornerstone for any other biological ones particularly those of biodiversity [1, 2]. Vegetation and flora of any area are not fixed up. They change from time to time. Various ecological factors, mostly biotic, change the floristic components and the vegetation type. The total number of species may be changed; dominant species may be replaced with other species; the floristic composition, i.e. family : genus, species ratio may be changed [3]. Vegetation is not equivalent to flora. Vegetation refers to the plants or plant communities covering the land surface of a particular place. It is important to know the plant habits (e.g. trees, shrubs, herbs and epiphytes), but not absolutely necessary to know the plant names. While a flora of a particular place refers to all the plants of that place. It constitutes the plant diversity and resources of that place.

The Republic of Yemen lies in the southwestern corner of the Arabian Peninsula. It extends between latitudes 12°40´ to 19°00´N, and longitudes

42° 30´ to 53° 05´ E, and it is bordered by Kingdom of Saudi Arabia in the north, the Arabian Sea and the Gulf of Aden in the south, Sultanate of Oman in the east, and the Red Sea in the west. It comprises about 527.970 km$^2$, However, due to the topographic differences and variations in soil characters, Yemen contains one of the diverse floras and complicated vegetation of the Arabian Peninsula region [4-7].

Generally, Yemen is a mountainous country, the altitudinal ranges from sea level up to 3760 m. a.s.l. (e.g. Jabal Al-Nabi Shauib, the highest point in the Arabian Peninsula as whole). Such altitudinal variation results a great diversity in climates and landscapes [8]. Common vegetation types found in Yemen include: grasslands, scrublands, woodlands, desert plants and coastal vegetation [4, 9]. The flora of Yemen is characterized by its high diversity and density, particularly in the southwest mountains, which makes it a complicated flora. This flora is having affinities with the floras of the tropical African, Sudanese region, the Saharo-Arabian region, the Mediterranean countries and the Irano-Turanian region [10-12].

The objectives of these series are to give general glance on the vegetation types in Yemen, to give an annotated check list of the floristic composition of each phytogeographical region in Yemen, to revise taxonomically some critical taxa in the flora of Yemen, to enumerate the endemic taxa to the flora of Yemen, to update the nomenclature of some taxa and to added the new recorded taxa which are recently reported in the flora of Yemen.

## 2. MATERIALS AND METHODS

The authors made the present study through several trips during the different seasons between 2007 and 2014 for selected areas from Yemen, also on based of the literatures about flora and vegetation in whole Yemen.

## 3. RESULTS AND DISCUSSION

In terms of ecology Yemen can be subdivided to five major zones, varying significantly from each other in total climatic and edaphic factors. These zones are:

1. Coastal plains regions:
    a. Western coastal plain (Tihama plain).
    b. Southern coastal plain.
2. Mountainous regions:
    a. Low altitude mountains.
    b. Medium altitude Mountains.
    c. High altitude mountains.
3. Highland plains.
4. Eastern desert.
5. Islands in the Red Sea and Indian Ocean.

### 3.1. Coastal plains regions

The coastal plains lie between the Red Sea and the western mountains (western plain) and between the Arabian Sea and the Gulf of Aden, and the southern and eastern mountains (Southern plain) with a length of 1920 km. These can be recognized to following:

#### *3.1.1. Western coastal plain (Tihama plain)*

This coastal plain lies between the Red Sea and the Western escarpment. It extends From Bab Al-Mandab in the south to the northern borders of Yemen of about 420 km long with a width of 20-40 km. This plain extends towards the north in the Saudi Arabian Land. The plain covers a total area of about 16000 km$^2$ in Yemen. The altitudes of this coastal plain range between the sea level and 300 m a.s.l. The climate of this region is arid or humid arid. In the Red Sea Coast, winter may extend from mid of October to mid of April with summer in the rest of the year. In January (winter), mean daily temperature ranges from about 20˚C in the far north to about 29˚C in the far south, in July (summer) these are 35˚C and 40˚C respectively. The main daily minimum and maximum temperatures range between 24.7˚C and 41.1˚C in summer (July) and 18.3˚C and 30.1˚C in winter (January) [13]. Rainfall over the Red sea coast is scanty and sporadic and vary localized. Mainly, this does not reach more than 300 mm per year. On the Red Sea coast, the relative humidity increases from north to south and are seasonally and daily changeable. It ranges from 83% to 90% in maximum and between 41% and 57% in minimum. Soils are mainly sands, but gravels, boulders, rock fragments also can be found particularly at the foothills and on the beds of the

shallow rivers (Wadis). Soils at the salt marshes (Sabkhat) are rich in salts which are resulted from the evaporation of the soil humidity and scanty of the rain [14]. This plain is dissected by some shallow and wide Wadis which are daring the water into the Red Sea, of these Wadis are: Mor, Rima, Siham, Rusyan, Surdud and Zabid. Based on the water of these Wadis, in addition to a few mount of the rain, several crops are being cultivated in this area. In addition to the cultivated crops there is natural vegetation varies from region to region. Dubaie & Al-Khulaidi [15] reported 264 wild species from this region, these taxa may be distributed as the following: Directly on the sea shore or a few meters away of the sea shore the communities of the mangrove of *Avicenna marina*, which are recorded at Medi, Alluhya, Al-Hodyda and Al-Makha and *Rhizophora mucronata* which are recorded at Al-Hodyda. Follow these communities several depressions on the sea shore, salt marshes (Sabkhat) are distributed. Halophytes of different families inhabiting these salt marshes, of these are: *Salsola spinescens, Suaeda monoica, Atriplex sp.* (Chenopodiaceae*), Aeluropus lagopoides* (Poaceae*), Limonium axillare* (Plumbaginaceae). On the flat sandy plain, several plant species associate to form plant communities of these are: *Senna italica, Senna holosericea, Aerva javanica, Aerva lanata, Dipterygium glaucum, Blepharis ciliaris, Tephrosia purpurea, Euphorbia qarad, Odyssa mucronata* and *Jatropha spinosa*. The growth of some plants on the sand soils help in building up sand dunes of these plants you can found *Leptadenia pyrotechnica, Panicum turgidum, Salvadora persica and Tamarix aphylla*. On the banks of the shallow and wide Wadis which running in this area some shrubs and trees as: *Tamarix aphylla, Tamarix nilotica, Salix sp., Acacia mellifera, Balanites aegyptiaca* are growing. Towards to the east to the foothill of Tihama, the soil changes, boulders gravels and rock fragments become the main dominant of the soil elements so, the vegetation changes and floristic composition is changed. In this area you can found *Dobra glabra, Acacia asak, Adenium obesum, Euphorbia* cactus, *E. fractiflexa, E. inarticulata* and *E. triaculaeta* [4, 14-16].

### *3.1.2. Southern coastal plain*

This plain lies between the Arabian Sea and the Gulf of Aden and the Southern escarpment with altitude ranges from sea level to 200 m a.s.l. It stretches from Bab Al-Mandab on the Red Sea in the west to the Yemen - Oman borders in the East for about 1500 km long and a width from 10-60 km and cover about 44240 $km^2$. This belt, in some localities, is intersected by rocky slopes or vertical cliffs ascending almost immediately behind the beach results a very narrow coastal plain. The climate of this plain is arid or hyper arid. The main temperature ranges from 19º C in January (winter) to 37º C in July (summer). Rainfall in that area is scanty and changeable daily and seasonally. The total annual rain fall ranges between 39 mm and 63 mm. The main annual relative humidity ranges between 56% and 58% (minimum) and 73% and 75% (maximum). Soils are mainly sands but in some places rocks are found. Some depressions of salt marshes and salt crests can also be noted on the surface of some places. Chemically, the soil of this plain is alkaline.

The Southern coastal plain is dissected by several Wadis, of these are: Tuban, Bana, Hassan, Ahwar, Hajer and Mayfa'a. These wades daring their water into the Arabian Sea and the Gulf of Aden. Based on the water of these Wadis and the little amount of the rain, many crops have been cultivated in this region. Besides the cultivated crops some native species are growing naturally. On the muddy localities on the shore of Arabian Sea and the Gulf of Aden, the mangroves of Avicennia marina are recorded at Al-Makha and Bir Ali. Halophytes plants are growing in the depressions of the salt marshes of these are: *Suaeda monoica, S. vermiculata, Tamarix nilotica, Halopeplis perfoliata, Aeluropus lagopoides, Sporobolus spicatus, Salicornia fruticosa* and *Arthrocnemum macrostachyum* [14, 17]. On the flat sand (plain) and sand dunes, xerophytic elements such as: *Crotalaria microphylla, Fagonia indica, Gloriosa revoilii, Panicum turgidum, Salvadora persica and Tamarix aphylla* are found. *Pluchea indica* subsp. *yemenensis* is found in Abyan plain Wadi Hassan E of Zingibar and Lahej plain Wadi Arraja Toor Al-Baha district, where it grows on the wadi beds, near streams or on sand flat near the sea [18, 19].

*Euphorbia dracunculoides* Lam. is reported as a new record for the flora of Yemen from Al-Kaud village, Abyan governorate, at distance about 55 km east of Aden, where it grows as a weed of irrigated fields in clay soil and around cultivation at alt. 20 m a.s.l. [20].

### 3.2. Mountainous regions

As it is known that, Yemen is a mountainous country. These mountains can be classified according to its elevations and locations into the following:

#### *3.2.1. Low altitude mountains*

The low altitude of mountains rise from 300 to 1000 m a.s.l. These mountains located in the west are known as Tihama foothills, while those found in the south and east are: Jabal Al Urays, Lodar, Mudia, Hadhramout hills and Jabal Assaqmi (Toor Al- Baha). The climate of these regions is arid. This region receives about 200-400 mm rain per year, temperatures range from 25ºC to 30ºC, while the relative humidity is very high. The natural vegetation of this region is particularly on the slopes of the hills and on the banks of the Wadis. This vegetation is composed of undershrubs, shrubs and dwarf trees such as: *Dobra glabra, Acacia asak, Acacia tortilis, Anisotes trisulcus, Commiphora myrrha, C. gileadensis, Grewia sp., Crotalaria saltiana, Indigofera spinosa, Acalypha fruticosa, Achyranthus aspera and Aristolochia bracteolata* or/and succulent plants such as, *Adenium obesum, Duvalia sulcata, Euphorbia cactus, E. greuteri, E. inarticulata, Huernia rubra, Kalancho bentii, Monolluma quadrangula, Orbea chrysostephana* and *O. deflersiana* [5, 14, 16, 18, 21, 22].

#### *3.2.2. Medium altitude mountains*

The mountains which have elevations ranging between 1000 and 1800 m a.s.l. are usually known as the medium altitude mountains in Yemen. These mountains located in the west such as: Hajjah, Al-Mahweet, Taiz Mountains, Jabal Buraa, Jabal Melhaan, Jabal Eraf, around Madinet Al-Sharq, west Huth, west Al-Makhdeer, west Maarib, east Saada and north Al Bayda or located in the south as, Mukairas, Yafea Al-Sufla, Al-Awaleq Al-Sufla, Bayhan, north Attaq and (Jabal Athumah, Jabal Khulaakah; Jabal Al-Kharaf at Toor Al-Baha). Climate in this region is wet arid. Temperature is ranging from 20-25ºC, while rainfall ranges from 600 to 800 mm. The natural vegetation in these regions is composed of the high trees which are belonging to the Sudano-Zambezian elements. This type of vegetation is called the tropical forest in Arabia, particularly on the canal banks of the Wadis and the lower parts of the slopes of these mountains [9, 23, 24]. These shrubs and trees are *Tamarindus indica, Combretum molle, Grewia schweinfurthii, G. tembensis G. vill*osa, *Maytenus parviflora, M. senegalensis, Olea europaea subsp. cuspidate, Premna resinosa, Rhus flexicaulis, Teclea nobilis*, and *Trichilia emetic.* Some of other large trees to be found throughout the area are common riparian species such as *Ficus ingens, Ficus vasta, Ficus sycomorus* and *Breonadia salicina, Terminalia brownii and Mimusops laurifolia*. Some of these trees may reach over 25 m in height and are frequent along the wadi channel. These form a dense canopy of trees in the valley bottom and are invariably covered in an equally dense tangle of climbing species such as: *Carissa spinarum, Ipomoea nil, Cissus quadrangularis, Cissus rotundifolia, Momordica balsamina, Coccina grandis, Zehneria anomala, Leptadenia arborea* and *Pergularia* daemia [25]. In recent time there were two new records added to Yemeni flora are; *Allium subhirsutum* and *Justicia ladanoides* [26].

#### *3.2.3. High altitude mountains*

In Yemen, it is usually known that, all mountains with elevations above 1800 m high, are known as the high altitude mountains. Most of these mountains are located in the West or/and in the center of Yemen. Of these are: Alturba, Saber, Ibb, Dhamar, around Sana'a (Jabal Al Nabi Shauib), Reyma, Jabal Abran, Al-Dhalaa, High Yafea and Hajjah. These mountains are considered to be the most diverse regions floristically in Yemen. Climate at these regions are wetted arid. According to location, orientation and elevation, temperature varies seasonally and daily. These temperatures range from 10 ºC to 11ºC in winter and from 26ºC to 30ºC in summer. In the mid-day it reaches to 30ºC

in summer and decrease to below the 0ºC in the night in winter. The rainfall in these mountains ranges from 250 to 800 mm in the rainy sessions (March-May) and (August-September). The relative humidity is with wide range. The edaphic factors, orientation, degree of the slopping create the wide range of the diversity scales between these mountains in different localities in the country. These mountains are dissected by narrow and deep Wadis, which daring their water westerly into the Red Sea or southerly into the Arabian Sea and the Gulf of Aden. The vegetation of these high altitude mountains are composed of undershrubs as: *Rosa abyssinica, Otostegia fruticosa, Salvia aegyptiaca, Lavandula pubescens* or herbs of different families such as *Geranium arabicum, G. trilophum, Erodium cicutarium, E. malacoides, Sisymbrium irio, Oxalis corniculata, Trichodesma africanum, Scabiosa columbaria* and *Campanula edulis.* Some remaining forest of *Juniperus procera* (Gymnosperm) are found on the top of these high mountains as in Jabal Saber. Several taxa of ferns such as: *Adiantum capillus-veneris, A. incisum* and *Selaginella yemensis*, can be also found.

### 3.3. Highland plains

The high, wide and flat area, located between the western mountains and the eastern mountains are known as the highland plains. These plains are of granites and metamorphic rocks, including plains with elevation above 1800 m a.s.l., such as the plains of Sa'adah, Sana'a, Dhamar, Rada'a and Qa Bakil, or others with elevation less than 1800 m a.s.l. as Qa Haql, Qa Shaharah and Al-Qaeda. These are flat plain, its soils of alluvial clay and sands accumulated from the surrounding mountains. On the other hand, these areas received a considerable amount of water as a rainfall ranging from 250 mm to 450 mm per year. Temperature in these region decreasing and ranges from 15 ºC to 31 ºC. The above two characters are bases on which most of the cultivated crops dominate in them. The cultivated crops are in these regions include corn, wheat, tomato, potato, vegetables and fruits. Besides the cultivated crops there are natural vegetation grow in the waste area, this vegetation is composed of dwarf trees and shrubs such as: *Acacia asak, Acacia tortilis, Acacia mellifera, Jatropha curcas, Acalypha fruticosa, Cadia purpurea, Cordia africana, Combretum molle, Terminalia brownii, Ziziphus spina-christi.* Some other perennials and annuals are dominant in this region of these are: *Peganum harmala, Brassica tournefortii, Indigofera spinosa, Heliotropium longiflorum, H. bacciferum, Solanum villosum, S. incanum, Datura stramonium, Datura innoxia, Ruellia patula, Barleria bispinosa, B. proxima, Blepharis ciliaris, Portulaca oleracea, Indigofera articulata, Indigofera oblongifolia, Flaveria trinervia, Hibiscus deflersii, H. vitifolius, Pulicaria jaubertii, P. undulata, P. petiolaris* and *Verbesina encelioides.*

### 3.4. Eastern desert

A desert is an area of land that is marked by very sparse vegetation due to extreme climatic conditions and extremely low levels of precipitation (seldom exceeds more than 30 mm per year). In desert the amount of water which is lost in evaporation - transpiration is much more than that gained by precipitation. In Yemen the Eastern desert is a sandy region, located at the northern and eastern boundaries of Yemen (east north of Marib and Ramlet Al-Sabaateen). Topographically, this desert is raised in the south and west and drop gradually towards the north and east from 1000 m to less than 500 m a.s.l. [27, 28]. This region is classified as "hyper-arid", with typical annual rainfall of less than 30 mm. Daily maximum temperatures range from 47°C to 50°C and can reach as high as 56°C.

The hyper arid climate of the Rub' al-Khali (eastern desert of Yemen) strongly controlled plant life in this subtropical hot desert. Today rain may not occur for years in some parts, yet the extensive sands provide more scope for plant growth than do some rock and gravel tracts. Floristic diversity is very restricted in the desert. The sand plain vegetation is characterised by very sparsely shrub communities such as *Calligonum comosum, Panicum turgidum, Cornulaca arabica, Haloxylon persicum, Dipterygium glaucum, Limeum arabicum, Zygophyllum coccineum and Fagonia indica.* Sand-free gravel floors are nearly or entirely sterile. Sand dunes on the desert may be inhabited by *Leptadenia pyrotechnica, Salvadora persica* and *Panicum turgidum.* The shallow Wadis between these dunes some shrub such as (*Acacia tortilis* and *Tamarix*

*nilotica*) and some undershrubs such as (*Senna italica* and *Aerva javanica*) may be found. Tree forms are absent except for rare individuals on some borderlands such as *Balanites aegyptiaca.* Annual plants are virtually absent, a situation contrasting sharply with that in Arabia to the North where more than half the desert species are Therophytes. After the scanty rain, some ephemerals such as: *Diplotaxis harra, Anastatica hieriochuntica, Zygophyllum simplex* and *Stipagrostis ciliata* grow and form a dense stands or green patches in the desert for a few days.

### 3.5. Islands

Yemen is rich in islands which lie in the Red Sea, the Arabian Sea and Indian Ocean. These islands are estimated as about 200 islands. The large ones in the Red Sea are Kamaran, Great Hunnish, Small Hunnish, Maiun and Jabal Al-Tear, while those located in Indian Ocean are Socotra, Abd El-Kuri and Semha. Most of the largest ones of these islands are inhabiting since a long time ago, while others are not. Botanically, only islands of Indian Ocean have been studied such as: Socotra, Abd El-Kuri and Semha, while those of the Red sea are still virgin except some of them belonging to Saudi Arabian e.g. Farasan [29]. The climate of these islands is more or less similar to that of coastal plains. Soils in these islands are mainly of sands or rocks. The vegetation of Islands in the Red Sea is mainly composed of halophytes in the salt marshes and the xerophytes elements on the sea shore and desert. These plants are belonging to Sudano-Zambezian region [29, 30]. The vegetation of these Islands is similar to that of Tihama plain, this vegetation is composed of xerophytic and halophytic of tropical elements. The distribution of this vegetation can be as the following: mangroves of *Avicennia marina* and *Rhizophora mucronata* may be found on the shore as which are found in Farasan Island [29]. Halophytes plants are growing on the salt marshes, of these halophytes are: *Salsola spinescens, Suaeda, monoica and Limonium axillare*. On the flat land of sands, xerophytes plants such as: *Zygophyllum coccineum, Panicum turgidum, Senna holosericea, Senna italica* and *Aerva javanica* or shrubs as *Tamarix nilotica, Salvadora persica* and *Acacia spp.* may be found. Most of the islands in the Indian Ocean are tropical climatically. The vegetation of these Islands is characterized by the richness in the tree elements and endemics such as *Dracaena cinnabari*, *Commiphora socotrana* and *Euphorbia socotrana.* It is known that islands are rich in endemics particularly those of Archipelago of Socotra. Most of the endemics in these islands are belonging to Acanthaceae, Boraginaceae, Asteraceae, Euphorbiaceae and Burseraceae. The endemism in Socotra Archipelago ca. 240 species, 9 genera, one near-endemic family (Dirachmaceae). The number of the endemic species in Socotra is constituted about 30% of the whole flora of Socotra Archipelago (790 species) [16, 31, 32].

## AUTHOR'S CONTRIBUTION

Both authors have equally contribution in fields of work, collection, identification, scrutiny of literature, manuscript preparation and editing, associated with this research article. The final manuscript has been read and approved by both authors.

## TRANSPARENCY DECLARATION

The authors declare no conflicts of interest.

## REFERENCES

1. Nicholes GE. Methods in floristic study of vegetation. Ecol. 1930; 11: 127-135.
2. Yavari A, Shahgolzari SM. Floristic study of Khan-Gormaz protected area in Hamadan province, Cairo University Press Cairo, Egypt. Iran Int J Agric Biol. 2010; 12: 271-275.
3. Nair R. Floristic study of Dadra and Nagar Haveli. Life Sci Leaflets. 2011; 20: 898-903.
4. Al-Hubaishi AA, Muller-Hohenstein K. An introduction to the vegetation of Yemen: ecological basis, floristic composition and human influence. Deutsche Gesellschaft Technische Zusammenarbeit (GTZ), Eschborn, West Germany, 1984.
5. Boulos L. A contribution to the flora of South Yemen (PDRY). Candollea. 1988; 43: 549-585.
6. El-Gouri M, Sailan A, Bahmish H, Al-Mualem A, Bazarah M, Al-Khulaidi A. Yemen: country report to the FAO International Technical Conference on Plant Genetic Resources. (Leipzig). 1996: 32.
7. Ministry of Water and Environment. Fourth national report, Assessing progress towards target. Environ-

ment Protection Authority, Ministry of water and environment, Republic of Yemen, 2010.

8. El-Anbaawy MI. Geology of Yemen Republic. Dar El-Kotob and El-Wathaiq El-Kawmiah, Sana'a Yemen, 1985.
9. Wood JRI. A handbook of the Yemen flora. Royal Botanic Gardens, Kew, UK, 1997.
10. Akhan H. Diversity biogeography and photo-synthetic pathways of *Argusia* and *Heliotropium* (Boraginaceae) in South-West Asia with an analysis of phytogeographical units. Bot J Linn Soc. 2007; 155: 401-425.
11. White F, Léonard J. Phytogeographical links between Africa and Southwest Asia. Flora Veget Muhndi. 1991; 9: 229-246.
12. Zohary M. Geobotanical foundations of the Middle East. 2 Vols. Gustav Fischer Verlag, Stuttgart, 1973.
13. Zahran MA, Al-Kaf HF. Introduction to the ecology of littoral halophytes of Yemen. Arab Gulf J Sci Res. 1996; 14: 691-703.
14. Al-Gifri AN, Gabali SA. The coastal Sabkhat of Yemen. Kluwer Academic Publishers, 2002: 141-146.
15. Dubaie AS, Al-Khulaidi AA. Studies on the flora of Yemen on the flora of Tihama plain with one figure. Feddes Repert. 1993; 104(3-4): 259-265.
16. Al-Khulaidi AA. Flora of Yemen. Sustainable Natural Resource Management Project (SNRMP) II, Sana'a, Yemen, 2013.
17. Kürschner H. Biogeography and Introduction to Vegetation. In: Ghazanfar SA, Fisher M, eds. Vegetation of the Arabian Peninsula. Kluwer Academic Publishers, London, UK, 1998: 76-78.
18. Hamood OSS. Flora of Toor Al-Baha District Lahej governorate, Republic of Yemen and its phyto-geographical affinities. Ph. D. Sc. Thesis, Fac. Sci. Sana'a Univ., 2012.
19. King-Jones S. Studies in the Compositae of the Arabian Peninsula and Socotra - 4. The Arabian species of *Pluchea* (Compositae, Plucheeae). Willdenowia. 1999; 29: 203-220.
20. Al-Hawshabi OSS. *Euphorbia dracunculoides* Lam. (Euphorbiaceae): a new record to the flora of Yemen. Assiut Univ Bull Environ Res. 2015; 18(1): 11-18.
21. Gabali SA, Al-Gifri AN. Flora of South Yemen angiospermae - a provisional checklist. Feddes Repert. 1990; 101(7-8): 373-383.
22. Kilian N, Kürschner H, Hein P. *Euphorbia greuteri* (Euphorbiaceae), a new single-spined succulent from the foothills of Jabal Urays, Abyan, Yemen. Willdenowia. 2006; 36: 441-446.
23. Hepper FN. Outline of the vegetation of the Yemen Arab Republic. Publ. Cairo Univ Herb. 1977; 7&8: 307-322.
24. Hepper FN, Wood JRI. Where there forests in Yemen? Proc Semin Arab Stud. 1979; 9: 65-71.
25. Hall M, Al-Khulaidi AW, Miller AG, Scholte P, Al-Qadasi AH. Arabia's last forests under threat: plant biodiversity and conservation in the valley forest of Jabal Bura (Yemen). Edinburgh J Bot. 2008; 65(1): 113-135.
26. Al-Hawshabi OSS. Two new records to the flora of the Arabian Peninsula from Yemen. J Biol Earth Sci. 2014; 4(2): B179-B184.
27. Dubaie AS. Vegetation degradation and desertifi-cation in Yemen. Taiz Univ Res J. 1998; 1: 44-59.
28. FAO. The state of plant genetic resources for food and agriculture in Yemen (1996-2006). Second national report, FAO, 2009.
29. El-Demerdash MA. The vegetation of the Farasan Islands, Red Sea, Saudi Arabia. J Veget Sci. 1996; 7: 81-88.
30. Wickens GE. Studies in the flora of Arabia: III. A biographical index of plant collectors in the Arabian Peninsula (including Socotra). Notes Royal Botan Garden Edinburgh. 1982; 40: 301-330.
31. Fisher M, Ghazanfar SA, Chaudhary SA, Seddon PJ, Robertson EF, Omar S, et al. Diversity and Conservation. In: Ghazanfar SA, Fisher M, eds. Vegetation of the Arabian Peninsula. Kluwer Academic Publishers, London, UK, 1998.
32. Miller AG, Cope TA. Flora of the Arabian Peninsula and Socotra. Vol. 1, Edinburgh Univ. Press in Association with Royal Botanic Garden Edinburgh, UK, 1996.

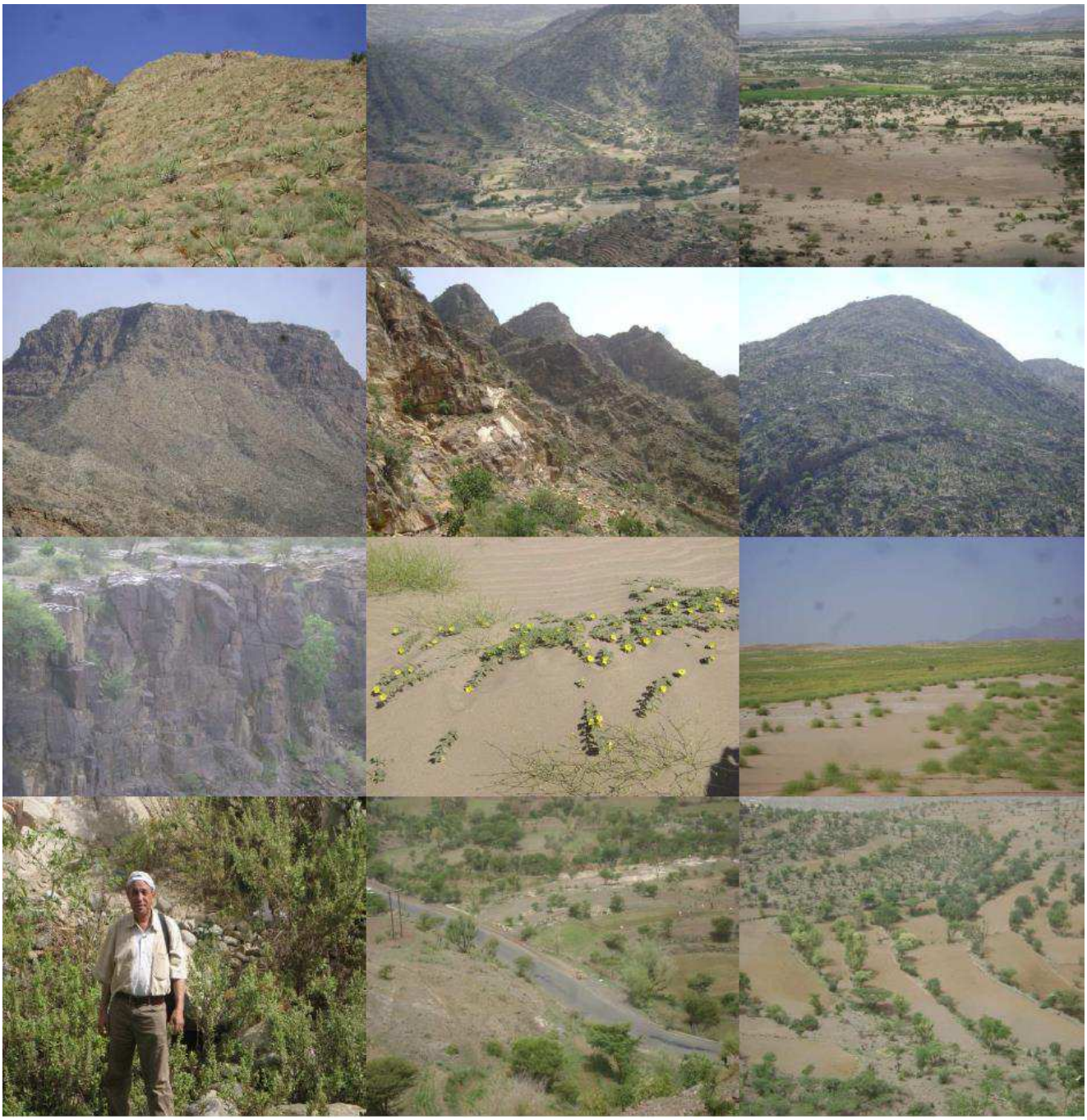

**Plate 1.** Different habitats in the study area.

**Plate 2.** Different habitats in the study area.

ISSN 2449-8866

Current Life Sciences

Research Article

# Preliminary study of butterfly species variation in FRI campus in accordance to its micro climatic condition

**Jayashree Das[1], Siba Prasad Parida[2]***

[1]Forest Research Institute, Dehradun, Uttarakhand, India

[2]Regional Museum of Natural History, Acharya Vihar, Bhubaneswar, India

*Corresponding author: Dr. Siba Prasad Parida; email: paridasp@gmail.com

**Received:** 14 September 2015; **Revised submission:** 26 October 2015; **Accepted:** 10 November 2015



## ABSTRACT

Within a period of three months study in the Forest Research Institute Campus, total 42 numbers of butterflies species were identified belonging to five families of the order lepidoptera. The maximum species were from the family Nymphalidae (19) followed by the family Pieridae (9). A large number of species were observed when the humidity was near the maximum and the temperature was neither more than 40°C nor less than 10°C. Five endangered species Common Mime, Danid Eggfly, Ringed Argus, Common Hedge Blue and Common Perriot are protected under Schedule-I of the Wildlife (Protection) Act, 1972. Further there were changes in population count of few species (25%). The variation is related with the change of the climatic conditions of the Campus. Furthermore it can be due to presence of host plant populations, availability of food source.

**Keywords:** Butterflies, Host plant, Climatic conditions, Diversity, Variations.

## 1. INTRODUCTION

India is home to about 1504 species of butterflies [1] which is about 8.74% of total butterfly species in the world and constitute 65% of total Indian fauna. India comes mainly under the Oriental Region and partly under the Palaearctic Region [2]. Different species of butterfly are supported by different ecosystems of our country. Butterflies are sensitive biota, which get severely affected by environmental variations and changes in forest structure [3]. About 15-20% of these are endemic to the Indian region, which makes this an especially important region for butterfly diversity and conservation [4].

Biogeographically, the Dehradun area is in the West Himalayan zone of India, which covers the Palearctic realm [5]. The Western Himalaya is the region from west Nepal through Uttaranchal to Kashmir and beyond, in Pakistan. The vegetation includes subtropical evergreen and coniferous forest as well as alpine steppes [2].

Appropriate abiotic and biotic factors such as climate condition, temperature and wind exposure, availability of host and larval plants [6], food and vegetation [7-11], topographic features [12], habitat quality [6] are some of the most important parameters to determine butterfly composition in a community. Butterflies are also strongly influenced by local weather and highly sensitive to environmental changes besides being charismatic insects that could fascinate the public attention [13]. Butterflies are extremely sensitive to changes in vegetation composition and structure, and different

types of vegetation show different butterfly species composition [14].

## 2. MATERIALS AND METHODS

### 2.1. Study Site

The Forest Research Institute established in the year 1906 has area coverage of 450 hectares of lush green estate. The area has a vast diversity of flora and fauna. The dominating tree species are: *Pinus rouxburghii, Dendrocalamus strictus, Cedrus deodar, Eucalyptus* species, many other rare and endangered species, species with ethno-botanical importance and few exotic species. Flowering shrub and climber species like *Dahlia* sp., *Passiflora vitifolia, Eschscholzia californica, Hibiscus rosa-sinensis, Lantana camara var. aculeata, Rosa* sp., *Helianthus annuus, Dorotheanthus bellidiformis* etc.

### 2.2. Methods

The study was carried with the main aim of identifying the variety of species found with the campus and also to observe their variation in species as well as the population with respect to local temperature and humidity change. The study was conducted for a period of 3 months from the mid of August to the mid of November, 2014. The dense forest way between the New Rosewood Girls Hostel to the FRI (Deemed) University building was covered. The butterfly species were observed on every $7^{th}$ day of the previous observation taken, for 2 hrs within 1:00 pm to 3:00 pm and 9:00 am to 11:00 am alternately. The minimum temperature, maximum temperature and humidity data were collected from the meterological station of FRI campus.

The species were identified from the photographs taken in the field and later compared to the Butterfly of India website, also from the help of my guide Dr. Siba Prasad Parida. Species identity was confirmed with the help of the field guides by [2, 15], taxonomy and nomenclature have been updated after [16]. The data sheet was prepared of the species observed, along with the concerned day temperature and humidity recoded.

## 3. RESULTS

A total of 42 species were observed during the 3 months study period. The most common species were: *Papilio polytes, Catopsilia pyranthe, Eurema brigitta, Eurema hecabe, Pieris canidia, Acraea violae, Ypthima huebneri* and *Zizula hylax*

The total species observed in the study area 45% of the species i.e. 19 species belong to the family Nymphalidae and least from the Hesperiidae family i.e. 2 species (4.76%). The large difference may be due the presence of host plant, smaller body size, site specific, etc.

The status of the observed species in the IUCN and the WPA was observed from the concerned list and recorded. Most of the butterfly species are not listed in the threatened list of IUCN. Only 2 species are placed in the LC (least concern) status: *Eurema brigitta, Euploea core*. Though the species are not considered in the IUCN, but few are listed in the WPA [17] under Schedule-I: *Papilio clytia, Callerebia annada, Hypolimnas misippus, Acytolepis puspa, Castalius rosimon*; Schedule-II: *Hypolimnas misippus;* Schedule-IV: *Euploea core*.

Most species of the families Nymphalidae, Lycaenidae and Hesperiidae were not observed in the initial phase of the study work. The 5 butterfly species of Papilionidae family were present from the initial phase of the study but by the end of the study 4 species were not observed. Other than 2-3 species of Pieridae family rest are found in the whole phase of study. The highest numbers of species were recorded during the study period of after the commencement of the first 4 week and before the last 3 week. The minimum temp was ranging from 13.8 to 22.3°C, maximum temp ranging from 29.2 to 33.1°C with mean temp ranging from 17.95 to 24°C and humidity scale was ranging from 90-98%.

Of the 42 species recorded, the numbers of individual remain constant for more than 85% of the species. From the Pieridae family while the number of individuals observed became half towards the end of the study of *Catopsilia pyranthe*, the number increased in *Eurema blanda* and *Eurema brigitta.* Similarly in the Nymphalidae family the number of individuals also increased in *Phalanta phalantha, Ypthima asterope, Ypthima huebneri* and *Ypthima baldus.*

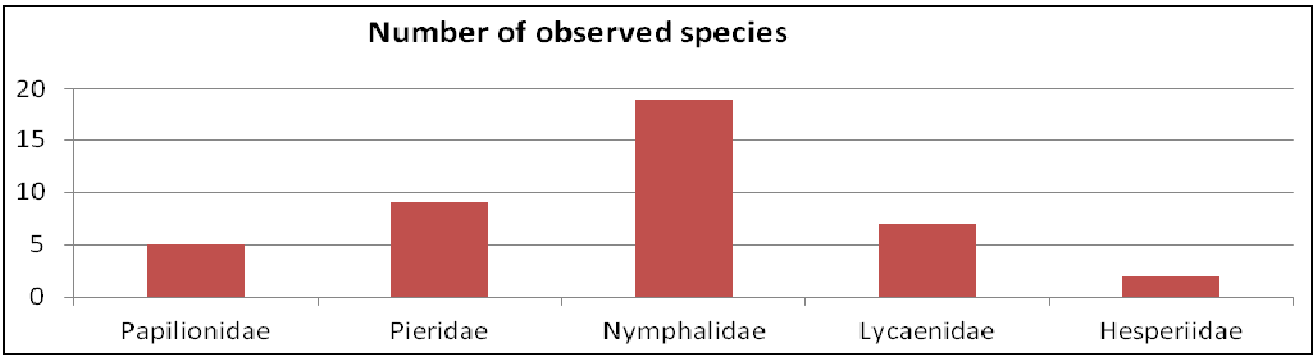


**Figure 1**. Number of observed butterfly species in different families.

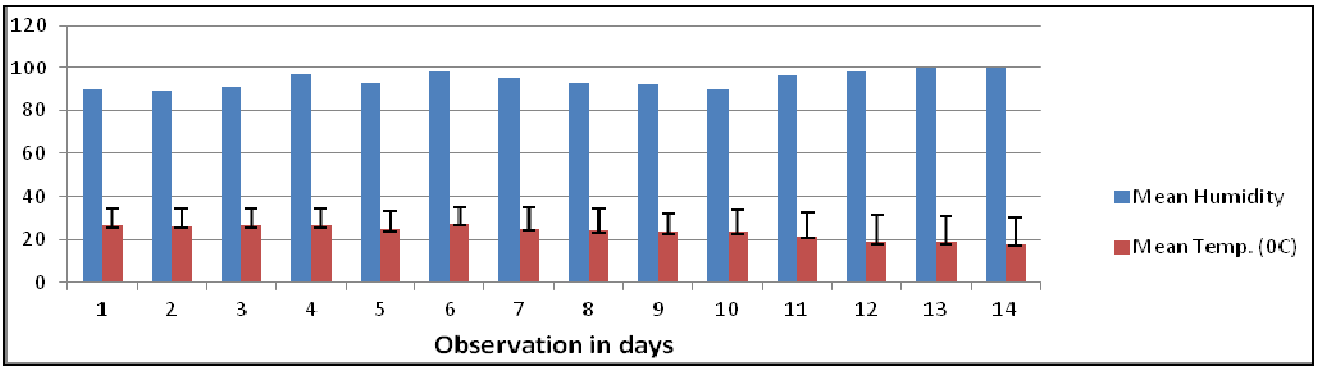


**Figure 2**. Humidity and mean temperature ± SD of the days in which butterflies were observed.

## 4. DISCUSSION

Though many species were observed all are not listed as they were not identified due to inaccessibility, restless and fast movements, smaller body size and not distinguishable body pattern, away from naked eye range. During the 3 months of study there was a variation in the number of species observed. The butterflies are considered as the good indicator of the environment quality. The highest number of species was observed from mid of September to the end of October. It was the period before the onset of winter in the area having high temperature and humidity. This variation indicates that, the abiotic factors of rainfall, temperature and humidity played a vital role in influencing the distribution and abundance [1, 16]. The variation in species is also due to the dependence of the species on the host plant, flowering season. The butterflies are host plant specific species and can survive in a environment with good population of its host plant. Butterflies and their caterpillars are dependent on specific host plants for food, thus the diversity of butterflies indirectly reflects overall plant diversity especially that of shrubs and herbs in the given area [18]. Most of them are strictly seasonal and prefer only particular set of habitats [19]. They depend for completion of the most phases of their life cycle: reproduce, lay egg, feeding. Differences in phenology across the seasons and among the species could be a mechanism to reduce competition [20, 21]. The present findings suggest that short-term assessments that do not take account of seasonality will be misleading and so reliable rapid assessment technique may prove elusive [22].

The vast expansion of forest and no use of heavy vehicles maintain the silence of the area and regulate the weather condition of the campus. The management of wilderness areas as well as their food plants may help to maintain and increase the butterfly diversity of the campus [23]. The area is not randomly allowed to the outsiders, helps to protect the environment from destruction due to human interference. Increased human activities have already been associated with decreased butterfly species [24].

**Table 1.** Following butterflies sighted during the study.

| Common name | Scientific name | IUCN Status | WPA Status |
|---|---|---|---|
| **Family Papilionidae** | | | |
| Common rose | *Atrophaneura aristolochiae* (Fabricius) | x | x |
| Tailed jay | *Graphium agamemnon* (Linnaeus) | x | x |
| Common jay | *Graphium doson* (Felder) | x | x |
| Common mime | *Papilio clytia* (Fruhstorfer) | x | I |
| Common mormon | *Papilio polytes* (Linnaeus) | x | x |
| **Family Pieridae** | | | |
| Common emigrant | *Catopsilia pomona* (Fabricius) | x | x |
| Motled emigrant | *Catopsilia pyranthe* (Linnaeus) | x | x |
| Three spot grass yellow | *Eurema blanda* (Boisduval) | x | x |
| Small grass yellow | *Eurema brigitta* (Cramer) | x | x |
| Common grass yellow | *Eurema hecabe* (Linnaeus) | x | x |
| Oriental psyche | *Leptosia nina* (Fabricius) | x | x |
| Indian wanderer | *Pareronia hippia* | x | x |
| Large cabbage white | *Pieris brassicae* (Linnaeus) | x | x |
| Indian cabbage white | *Pieris canidia* (Sparman) | x | x |
| **Family Nymphalidae** | | | |
| Twany coster | *Acraea violae* (Fabricius) | x | x |
| Common castor | *Ariadne merione* (Cramer) | x | x |
| Ringed argus | *Callerebia annada* (Moore) | x | I |
| Plain tiger | *Danaus chrysippus* (Linnaeus) | x | x |
| Striped tiger | *Danaus genutia* (Cramer) | x | x |
| Common crow | *Euploea core* (Cramer) | x | IV |
| Great eggfly | *Hypolimnas bolina* (Linnaeus) | x | x |
| Danaid eggfly | *Hypolimnas misippus* (Linnaeus) | x | I |
| Chocolate pansy | *Junonia iphita* (Cramer) | x | x |
| Lemon pansy | *Junonia lemonias* (Linnaeus) | x | x |
| Common evening brown | *Melanitis leda* (Linnaeus) | x | x |
| Common sailer | *Neptis hylas* (Linnaeus) | x | x |
| Common lascar | *Pantoporia hordonia* (Stoll) | x | x |
| Glassy tiger | *Parantic aglea* (Stoll) | x | x |
| Common leopard | *Phalanta phalantha* (Drury) | x | x |
| Blue tiger | *Tirumala limniace* (Cramer) | x | x |
| Common three ring | *Ypthima asterope* (Klug) | x | x |
| Common five ring | *Ypthima baldus* (Fabricius) | x | x |
| Common four ring | *Ypthima huebneri* (Kirby) | x | x |
| **Family Lycaenidae** | | | |
| Common hedge blue | *Acytolepis puspa* (Horsfield) | x | I |
| Large oak blue | *Arhopala amantes* (Hewitson) | x | x |

| Common name | Scientific name | IUCN Status | WPA Status |
|---|---|---|---|
| Common perriot | *Castalius rosimon* (Fabricius) | x | I |
| Pale grass blue | *Pseudozizeeria maha* (Kollar) | x | x |
| Red perriot | *Talicada nyseus* (Guerin-Meneville) | x | x |
| Forest pierrot | *Taraka hamada* (Druce) | x | x |
| Tiny grass blue | *Zizula hylax* (Fabricius) | x | x |
| **Family Hesperiidae** | | | |
| Common dartlet | *Oriens gola* (Moore) | x | x |
| Himalayan Grass dart | *Tatrocera danna* | x | x |

The highest number of species recorded belongs to family Nymphalidae as the study was done along the main path from the New Rosewood Girls Hostel to the FRI University building. The site is mostly of open forest or shrub and grassland type. Many studies have documented the dominance shown by members of the Nymphalidae family in tropical region owing to its polyphagous nature which helps to inhabit all the habitats [25]. They are also comparatively more strong, good and active fliers that can search a large area for resources [20, 26-28]. It avoids shade and dense vegetation but frequents openings in all vegetation types, including clearing in evergreen forest [29].

As the study time was after the sun rise so species belonging to the Pieridae family was commonly observed one. All Pieridae are attracted to sunlight and they quickly move inside foliage in a cloudy weather that obscures the sun [30]. This family has great affinity to flowers [31].

The species belonging to the Lycaenidae family was commonly sites in hostel campus or near the bushy vegetation of University gate as the area has flowering plants and receive a very good amount of sunlight. As far as Lycaenidae are concerned, owing to their preference for open deciduous forest and scrub land grasslands near the human habitations [30].

## 5. CONCLUSION

The current study was restricted to a limited period of time period and it was suggested that the preliminary study of butterfly species variation in FRI campus in accordance to its micro climatic condition gives the baseline information for the future study.

## AUTHOR'S CONTRIBUTION

JD: Field data collection, compilation of data, collection of references and manuscript preparation. SPP: Collection of references, final editing and checking of manuscript. The final manuscript has been read and approved by both authors.

## TRANSPARENCY DECLARATION

The authors declare no conflicts of interest

## REFERENCES

1. Tiple AD. Butterflies of Vidarbha region, Maharashtra State, central India. J Threat Taxa. 2011; 3(1): 1469-1477.
2. Kehimkar I. The book of Indian butterflies. Bombay Natural History Society, 2008.
3. Pollard E. Monitoring butterfly numbers. In: Goldsmith FB, ed. Monitoring for Conservation and Ecology. Chapman and Hall, London. 1991; 275: 87-111.
4. http://www.ifoundbutterflies.org
5. Rodgers WA, Panwar HS. Planning a Wildlife Protected Area Network in India. A report prepared for the Ministry of Environment and Forests and Wildlife, Government of India, 1988.
6. Barlow J, Overal WL, Araujo IS, Gardner TA, Carlos AP. The value of primary, secondary and plantation forests for fruit-feeding butterflies in the Brazilian Amazon. J Appl Ecol. 2007; 44: 1001-1012.
7. Jain N, Jain A. Butterfly diversity of Hadoti Region, Rajasthan, India. Flora Fauna. 2012; 18(2): 274-276.

8. Khan MR, Khurshid A, Ikram B, Malik AI, Mir A. Biodiversity of butterflies from district Pooch and Sudhnoti, Azad Kashmir. Asian J Plant Sci. 2004; 3(5): 556-560.
9. Kharat A, Nikam S, Gurule S. Pattern of butterfly diversity from Nashik and Dhule Districts, Maharashtra. Flora Fauna. 2012; 18(2): 243-252.
10. Kumaraswamy S, Kunte K. Intergrating biodiversity and conservation with modern agricultural landscapes. Biodivers Conserv. 2013; 22: 2735-2750.
11. Ravindra M, Viswanathan S, Ram GM. Checklist of butterfly species of Osmania University Campus, Hyderabad. Zoo Print J. 1996; 11(10): 5.
12. Amala S, Rajkumar M, Anuradha V. Species richness of butterflies in the selected areas of Siumalai Hills. Int J Pure Appl Sci Technol. 2011; 6(2): 89-92.
13. Perveen F, Fazal F. Biology and distribution of butterfly fauna of Hazara University, Garden Campus, Mansehra, Pakistan. Open J Animal Sci. 2013; 3(2A): 28-36.
14. Sawchik J, Dufrêne M, Lebrun P. Distribution patterns and indicator species of butterfly assemblages of wet meadows in Southern Belgium. Belgian J Zool. 2005; 135: 43-52.
15. Kunte K. Butterflies of Peninsular India. Universities Press (Hyderabad) and Indian Academy of Sciences (Bengaluru), 2000.
16. Kunte K, Roy P, Kalesh S, Kodandaramaiah U. eds. Butterflies of India, v. 2.10. Indian Foundation for Butterflies, 2015.
17. The Wildlife (Protection) Act 1972. Dehradun. Natraj Publishers, 2006.
18. Hill JK, Hamer KC, Dawood MM, Tangah J, Chey VK. Rainfall but not selective logging affects changes in abundance of a tropical forest butterfly in Sabah, Borneo. J Trop Ecol. 2003; 19: 35-42.
19. Padhye AD, Dahanukar N, Paingankar M, Deshpande M, Deshpande D. Season and Landscape wise distribution of butterflies in Tamhini, Northern, Western Ghats, India. Zoo Print J. 2006; 21(3): 2175-2181.
20. Kunte K. Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. J Biosci. 1997; 22: 593-603.
21. Clench HK. Temporal association and population regulation in eastern Hesperiine butterflies. Ecology. 1967; 48: 1000-1006.
22. Wolda H, Fisk FW. Seasonality of tropical insects. II. Blattaria in Panama. J Animal Ecol. 1981; 50: 827-838.
23. Hamer KC, Hill JK, Mustaffa N, Benedick S, Sherratt TN, Chey VK, Maryatis M. Temporal variation in abundance and diversity of butterflies in Bornean Rainforests: opposite impacts of logging recorded in different seasons. J Trop Ecol. 2005; 21(40): 417-425.
24. Mohapatra RK, Mishra AK, Mishra S, Parida SP. A preliminary assessment of butterfly diversity in Utkal University Campus, Odisha. Zoo Print J. 2013; 28(9): 28-31.
25. Clark PJ, Reed JM, Chew FS. Effect of urbanization on butterfly species richness, guild structure and rarity. Urban Ecosystem. 2007; 10: 321-337.
26. Parasharya BM. Butterflies of Gujarat. Anand Agricultural University, India, 2007.
27. Eswaran R, Pramod P. Structure of butterfly community of Anaikatty hills, Western Ghats. Zoo Print J. 2005; 20(8): 1939-1942.
28. Krishnakumar N, Kumaraguru A, Thiyagesan K, Asokan S. Diversity of papilionid butterflies in the Indira Gandhi Wildlife Sanctuary, Western Ghats, Southern India. Tiger Paper. 2008; 35: 1-8.
29. Raut NB, Pendharkar A. Butterfly (Rhopalocera) fauna of Maharashtra Nature Park, Mumbai, Maharashtra, India. J Species Lists Distrib. 2010; 6(1): 22-25.
30. Mali MS, Khokhariya BP, Dabgar YB. Biotic interrelationship of plants and butterflies in surrounding of Gandhinagar, Gujarat. Int J Scient Res. 2014; 3(4): 420-422.
31. Gay T, Punetha IK. Common butterflies of India. WWF, Oxfords University Press, 1992.

ISSN 2449-8866

Current Life Sciences

Research Article

# Unrecorded macrofungi from the Narpuh Reserve Forest of Meghalaya, India

**Rajesh Kumar*, Shailesh Pandey, Krishna Giri, Gaurav Mishra, Raja R. Rishi**

Rain Forest Research Institute, Jorhat, Assam, 785001 India

*Corresponding author: Rajesh Kumar, Tel. +9-9706632479, e-mail: rajesh@icfre.org

**Received:** 22 September 2015; **Revised submission:** 26 October 2015; **Accepted:** 08 November 2015



## ABSTRACT

Surveys were conducted in Narpuh Reserve Forest, Meghalaya, India to unveil the macrofungal diversity. A variety of macrofungi was collected and identified on the basis of macro- and microscopic characteristics. The microscopic characterization revealed that the collected wild mushrooms belong to 11 orders, 20 families, and 24 genera. Six species of genus *Russula*, 4 species of *Amanita*, *Boletus* and *Suillus*, 3 species of *Inocybe*, *Lactarius*, and 2 species of *Coltricia* and *Laccaria* were identified. However, only one species of each genus *Armillaria*, *Clitocybe*, *Lepista*, *Cuphophyllus*, *Hypholoma*, *Leccinum*, *Xerocomus*, *Scleroderma*, *Ramaria*, *Clathrus*, *Auricularia*, *Thelephora*, *Xylaria*, *Sarcoscypha*, *Cantharellus* and *Gomphus* were found. Among the collected mushrooms 23 macrofungi were identified for the first time from this region.

**Keywords:** Macrofungi, Microscopy, Diversity, Narpuh Reserve Forest, Meghalaya.

## 1. INTRODUCTION

The present communication is based on the mycological survey and exploration study at Narpuh Reserve Forest of Meghalaya, India. Meghalaya forests owing to enormous variation in climatic conditions and peculiar physiography, harbour rich and diverse macrofungi. These forests have not been surveyed extensively for macrofungal diversity. The number of fungi recorded in India exceeds 27000 species [1]. Mushroom species are the indicators of the forest life support system [2]. The presence or absence of fungal species is an useful indicator to assess the damage or the maturity of an ecosystem. Data on their diversity in different vegetation types is important for planning and managing ecosystem biodiversity [3]. Food values of *Lentinula edodes* (Berk) Pegler, *Agaricus bisporus* (Emil J. Imbach), *Pleurotus sajor-caju* (Fries) Sing., and *Volvariella volvacea* (Bull. ex Fries) has been reported [4]. Earlier, forty nine mushroom species have been reported from Meghalaya state of Northeast India [5-9]. But the taxonomic studies of Indian macrofungi have recently been in decline [10] and there is urgent need to thoroughly explore these forests for macrofungi emanating in different seasons under varied environments and conserve the biodiversity prevailing in the state. The present communication, as a part of continuing investigation, describes some newly reported macrofungi from Meghalaya state of Northeast India.

## 2. MATERIALS AND METHODS

### 2.1. Study area

Meghalaya (25°5'-26°10' N latitudes, 89°47'-92°47' E longitudes), covering an area of 22,429 km$^2$ is located in the North Eastern region of India. In the Meghalaya State, Narpuh Reserve Forest (Block-I) (25°5'54" N latitudes, 92°24'03" E longitudes) occupied an area of 62.42 km$^2$ and situated in the Jaintia Hills, India. It rests in the Indo-Bangla border and covers either sides of Lubha Bridge, one of the longest span bridges in India. The vegetation of this protected forest is semi evergreen and the top canopy consists of *Tetrameles nudiflora, Toona ciliata, Michelia champaca, Mesua ferrea, Gmelina arborea, Ficus* spp., *Amoora, Schima wallichii, Sterculia* spp., *Aesculus assamica Duabhanga grandiflora, Artocarpus chaplasha.* The middle canopy comprises of *Alstonia scholaris, Calicarpa arborea* and *Dillenia indica*. *Symplocos paniculata, Psychotria erratica, Adenia trilobata, Acronychia pedunculata* and *Ardisa griffthii* are abundant shrub species. Many orchids, bamboo, cane, fern, lichen, grasses are also present in the forest as epiphytic and/or under story vegetation.

**Table 1.** List of identified wild mushrooms of Narpuh Reserve Forest Meghalaya, India.

| Order | Family | Genus | Species |
|---|---|---|---|
| Agaricales | Amanitaceae | *Amanita* | *fulva* |
| | | | *pantherina* |
| | | | *vaginata* |
| | Physalacriaceae | *Armillaria* | *mellea* |
| | Tricholomataceae | *Clitocybe* | *fragans* |
| | | *Lepista* | *irina* |
| | Hygrophoraceae | *Cuphophyllus* | *pratenis* |
| | Strophariaceae | *Hypholoma* | *sublateritium* |
| | Cortinariaceae | *Inocybe* | *erubescens* |
| | | | *geophylla* |
| | | | *perlata* |
| | Hydnangiaceae | *Laccaria* | *amethystine* |
| | | | *laccata* |
| Boletales | Boletaceae | *Boletus* | *bicolor* |
| | | | *luridiformis* |
| | | | *permagnificus* |
| | | | *subtomentosus* |
| | | *Leccinum* | *holopus* |
| | | *Xerocomus* | *subtomentosus* |
| | Sclerodermataceae | *Scleroderma* | *citrinum* |
| | Suillaceae | *Suillus* | *bovines* |
| | | | *cavipes* |
| | | | *decipiens* |
| | | | *granulatus* |

### 2.2. Collection of mushrooms

Systematic and periodical surveys of Narpuh Reserve Forest (Block-I) were undertaken during June 2014 to November 2014. The methods developed by Natrajan et al. [11-13] were followed for field survey and mushroom collection. Prevailing habitat conditions of the sampling site were also recorded along with the collection of mushrooms samples.

The specimens were dried in hot air oven at 40-50$^{o}$C and stored in air tight plastic containers with some naphthalene balls. The soft textured specimens were preserved in 2% formaldehyde. However, the leathery textured samples were preserved in 4% formaldehyde and kept in Forest Protection Division, Rain Forest Research Institute, Jorhat, Assam. Identification numbers were assigned to each specimen for further studies. Simultaneously a spore print was prepared by placing the pileus downwards where a black and white paper (half white and half black) was covered with bell jar [14, 15].

## 3. RESULTS

A total of 77 mushroom samples were collected from Narpuh Reserve Forest (Block-I). Out of which, only 44 mushroom samples were identified up to the species level. Remaining samples were identified only up to the genus level. The mushrooms identified up to the species level belongs to 11 orders, 20 families, and 24 genera. They are: *Russula* (6 species), *Amanita, Boletus, Suillus (*4 species each), *Inocybe, Lactarius* (3 species each), *Coltricia, Laccaria* (2 species each) and genus *Armillaria, Clitocybe, Lepista, Cuphophyllus, Hypholoma, Leccinum, Xerocomus, Scleroderma, Ramaria, Clathrus, Auricularia, Thelephora, Xylaria, Sarcoscypha, Cantharellus* and *Gomphus* with only one species. The diversity of mushrooms revealed that *Thelephora penicillata, Xylaria polymorpha, Clathrus ruber, Sarcoscypha coccinea, Lactarius indigo, Boletus bicolor, B. luridiformis, B. permagnificus, Amanita pantherina, A. vaginata, Lepista irina, Inocybe erubescens, I. geophylla, I. perlata, Laccaria amethystine, Xerocomus subtomentosus, Suillus decipiens, Lactarius indigo, Russula decipiens, Lactarius indigo, Russula parvovirescens, R. virescens, R. xerampelina* and *Cantharellus californicus* were recorded for the first time from this region (Table 1). The morphological characterization of the identified mushrooms was also carried out (Table 2). The photographs of some mushroom species are given in the Plate 1.

## 4. DISCUSSION

Different researchers have contributed to the study of mushroom flora of Meghalaya. Eleven wild mushroom species from East Khasi district of Meghalaya have been recorded through local market survey [5]. Wild edible mushrooms such as *Cantharllus floccosus, Clavaria Cinerea, Clavaria aurea, Clavaria* spp., *Lentinus edodes* and *Boletus edulis* have been reported from Meghalaya which are consumed by local people for time immemorial [6]. *Agaricus biosporus, Cantharellus cibarius, Clavaria flava, Gomphus floccossus, Lactarious volemus* and *Ramaria boyrytis* with local names have been recorded from wild forest of Khasi Hills Meghalaya [7].

Some of the macrofungi have been reported from Northeast India are known to possess varying degrees of nutritional and medicinal values [9]. A total of 13 species of mushrooms under 9 genera and 6 families were earlier documented by Tanti [16] from Kohima district of Nagaland, North east India. Similarly, 26 different species of mushrooms under 14 genera and 13 families were documented from Western Assam of Northeast region of India [8]. However, the ecological data available on some of the genera is still not enough.

## 5. CONCLUSIONS

Research and monitoring are the important factors in developing strategies which protect and promote the edible macrofungi of a particular ecosystem. Knowledge about the edibility of wild macrofungi is diminishing especially among young generation; therefore awareness generation about the edibility of the wild mushrooms is an imperative need of the hour. The wild macro fungi play an important role to maintain the health and impart the biodiversity of the forest ecosystems. Besides, the ecological values of macrofungi, medicinal and nutritional importance should also be taken in to

the consideration. Therefore, it becomes quite necessary to explore, document and conserve this natural wealth.

## AUTHORS CONTRIBUTION

Conception and design: RK; Development of methodology: RK, GM and KG; Acquisition of data: RRR, SP; Analysis and interpretation of data writing, review and/or revision of the manuscript, administrative, technical or material support: RK; Study supervision: SP. The final manuscript has been read and approved by all authors.

## TRANSPARENCY DECLARATION

The authors declare no conflicts of interest.

**Table 2.** Characteristics of some identified mushrooms.

| Name of the species | Macroscopic and microscopic characteristics |
|---|---|
| *Ramaria formosa* (Pers.) Quél | Fruiting body was 6-20 x 4-18 cm, vertically oriented, wrinkled, whitish orange, much-branched. Base was well developed whitish below and pink above. Spore size was 8-4 x 4-6 µm, elliptical, roughened. |
| *Auricularia delicate* (Mont.) Henn. | Fruit bodies was soft rubbery gelatinous, transluscent reddish to pinkish brown, sessile to substipitate, semicircular, up to 60 mm diameter and 1-2.5 mm thick. Pileus glabrous, with fine hyaline hairs; hymenium reticulate, with veins a pale hyaline cream colour, surface pale pinkish cream to pale reddish brown. Spores size was 10-12.5 x 5.4-5.5 µm. |
| *Thelephora penicillata* (Pers.) Fr. | Fruiting body was 4 to 15 cm across. Short-lived rosette-like fans lying low on the forest floor, purple at the base and white or cream towards the branched and pointed tips. Spore size was 6-9.5 x 5.5-7 µm, angularly ellipsoidal, ornamented with irregular warts. |
| *Xylaria polymorpha* (Pers.) Grev. | Fruit body was 2-7 x1-3 cm, irregularly club-shaped passing into a short cylindrical stalk below, black or yellowish with a finely roughened surface. Spore size was 18-30 x 5-8 µm, blackish, fusiform. |
| *Clathrus ruber* P. Micheli ex Pers. | Eggs were spheroidal, diameter upto 5 cm, white with rhizomorphs at the base. Carpophore globose, 5-10 x 5 cm, red with netlike lacunose arms delimiting, polygonal holes, spores grayish, elliptical, smooth, 5-6 x 1.8-2 µm. |
| *Sarcoscypha coccinea* (Scop.) Sacc. | Carpophore was 1-5 cm in diameter, cup shaped, fairly open, orange inside, pinkish and downy outside, margin slightly incurved. Stipe was absent, villose at the base. Spore size was 28-40 x 8-12 µm, whitish, elliptical and smooth. |
| *Gomphus floccosus* (Schw.) Singer | Cap was 5-8 cm wide funnel shaped, yellow to pale orange, margin curved down ward or rolled in ward. Gills were 8-12 cm x 1-2 mm wide and1 mm thick. Stem 3-6 cm long in diameter, solid, pale yellow. Spore size was 10-18.5 x 5-9.5 µm, warted and elliptical. |
| *Lactarius indigo* (Schwein.) Fr. | Cap was 4-13 cm, convex becoming flat and shiny blue. Gills were attached to the stem, close and colored like the cap. Stem was 2-6 x 1-1.5 cm thick and tapering towards the base. Spore size was 6.5-9 x 3.5-7 µm, ellipsoid to subglobose, ornamentation about 0.4 µm high. |
| *Boletus bicolor* Peck. | Cap was 4-14 cm, convex, dry and look like soft leather. Pore surface 1-1.5 angular pores per mm, tubes 3-8 mm deep. Stem was 5-12 x 1.5-3 cm, club-shaped, red to purplish red. Spore size was 9-10 x 3.5-5 µm, subfusiform and smooth. |
| *Amanita pantherina* (DC. ex Fr.) Krombh. | Cap was 3-15 cm, broadly convex, sticky, yellowish brown with numerous cottony whitish warts. Gills were free from the stem. Stem 4-18 x 2 cm, with a swollen basal bulb, scaly with a whitish ring. Spore size was 8-12 x 6-10 µm, smooth, ellipsoid. Basidia 4-spored. |


**Plate 1.** Some mushroom samples: **A.** *Ramaria formosa,* **B.** *Auricularia delicata,* **C.** *Thelephora penicillata,* **D.** *Xylaria polymorpha,* **E.** *Clathrus ruber,* **F.** *Sarcoscypha coccinea,* **G.** *Gomphus floccosus,* **H.** *Lactarius indigo,* **I.** *Boletus bicolor,* **J.** *Amanita pantherina,* **K.** *Scleroderma citrinum,* **L.** *Russula parvovirescens.*

## ACKNOWLEDGEMENTS

Authors gratefully acknowledge the assistance and information received from Meghalaya State Forest Department, particularly about the Narpuh Reserve Forest and financial assistance from Indian Council of Forestry Research and Education (ICFRE), Dehradun for funding the research project: No-RFRI-/2014-15/FP-2.

## REFERENCES

1. Sarbhoy AK, Agarwal DK, Varshne JL. Fungi of India 1982-1992. CBS Publishers and Distributors, New Delhi. 1996.
2. Stamets P. The role of mushroom in nature, culturing mushroom mycelium on agar media. In: Growing gourmet and medicinal mushrooms. Ten Speed Press, Hong Kong. 2000.

3. Engola APO, Eilu G, Kabasa JD, Kisovi L, Munishi PKT, Olila D. Ecology of edible indigenous mushrooms of the Lake Victoria basin (Uganda). Res J Biol Sci. 2007; 2(1): 62-68.
4. Singh HB, Adhikari RK, Sharma RK, Sharma TC, Rao PG. Cultivation of Shiitake mushroom - a potential agro-industry for hilly areas of Northeastern India. Nat Prod Rad. 2008; 7: 74-78.
5. Khaund P, Joshi SR. Wild edible macrofungal species consumed by the Khasi tribe of Meghalaya India. Indian J Nat Prod Resour. 2013; 4(2): 197-204.
6. Barua P, Adhikary RK, Kalita P, Bordoloi D, Gogol P, Singh RS, Ghosh AC. Wild edible mushrooms of Meghalaya. Anc Sci Life. 1998; 17(3): 190-193.
7. Kabita D, Albinus L, Dibyendu P, Lalit J. Ethnomycological knowledge on wild edible mushroom of Khasi Tribes of Meghalaya, Northeastern India. Eur Acad Res. 2014; 2(3): 3433-3442.
8. Sarma TC, Sarma I, Patiri BN. Wild edible mushrooms used by some ethnic tribes of Western Assam. Bioscan Int J Life Sci. 2010; 3: 613-625.
9. Kumar R, Pandey S, Tapwal A, Rishi RR, Giri K, Mishra G. Ethnomycological knowledge on wild mushrooms by tribes of Mokokchung, Nagaland, North East India. J Ethnobiol Trad Med Photon. 2014; 122: 890-899.
10. Hyde KD. Mycology and its future in the Asia region. Fungal Divers. 2003; 13: 59-68.
11. Natrajan KC, Naryanan C, Ravindran C, Kumaresan V. Biodiversity of agarics from Nilgri Biosphere Reserve, Western Gharts, India. Curr Sci. 2005; 12: 1890-1892.
12. Metzler S, Metzler V. Texas mushrooms. University of Texas Press. 1992.
13. Lodge DJ, Ammirati JF, O'Dell TE, Mueller GM. Collecting and 19 describing macrofungi. In: Mueller GM, Bills GF, Foster MS (eds.) Biodiversity of fungi, inventory and monitoring. Elsevier, London. 2004.
14. Singer R. The Agaricales in Modern Taxonomy. 4th ed. J. Cramer, Weinheim. 1989.
15. Grimes GL. Principle of mushroom identification. In: Spoerke DG, Rumack BH (eds.) Handbook of mushroom posioning diagnosis and treatment. CRC Press, London. 1994.
16. Tanti B, Gurung L, Sharma GC. Wild edible fungal resources used by ethnic tribes of Nagaland India. Ind J Trad Knowl. 2011; 10(3): 512-515.

ISSN 2449-8866

Current Life Sciences

Research Article

# Comparative studies on physico-chemical variations of two major mangrove wetlands in East coast of Tamilnadu, India

**A. Arunprasath, M. Gomathinayagam**

Department of Botany, Annamalai University, Chidambaram, 608 002, India
*Corresponding author: M. Gomathinayagam, e-mail: gomsnayagam@yahoo.com

**Received:** 05 October 2015; **Revised submission:** 30 November 2015; **Accepted:** 10 December 2015


## ABSTRACT

For the present investigation, two study areas were identified as Pichavaram in Cuddalore district and Muthupet in Thiruvarur district of Tamilnadu, India. The physico-chemical variation studies of two mangrove wetlands were conducted, encompassing physical and chemical aspects. Ecological study includes the study of both abiotic and biotic components of mangrove ecosystem. Abiotic components include mainly water and soil which support the mangroves. Water quality analysis involved both physical and chemical parameters. Physical parameter is mainly temperature of water. Chemical parameters assayed are pH, electrical conductivity (EC), salinity, dissolved oxygen (DO), biological oxygen demand (BOD) and mineral composition like sodium, potassium, calcium, magnesium and chloride. Soil analysis comprises physical parameters like moisture content of the soil. Chemical parameters studied are pH, EC, salinity, organic carbon and minerals like sodium, potassium, calcium, magnesium and chloride. All the studies were conducted in three seasons - monsoon, pre-monsoon and post-monsoon.

**Keywords:** Pichavaram; Muthupet; Mangrove; Physico-chemical parameters; Salinity; BOD.

## 1. INTRODUCTION

The word mangrove is formed by two words: in Portuguese “Mangue” (meaning tree bush) and the English “Grove”. Macnae [1] coined a new name “mangal” for mangrove community and retained the term mangrove” for individual species. Mangroves consist of a complex of plant communities, fringing sheltered tropical shores and estuaries. Such communities usually comprise of trees, mostly species of the family Rhizophoraceae [2]. Despite the extreme conditions prevailing, mangroves have successfully colonized their habitats by developing morphological, reproductive and physiological adaptations like pneumatophores, stilt roots, prop roots, knee roots and viviparous germination which facilitate their growth in aquatic environment [3]. Within this ecosystem, individual plants, animals, soil microbial populations and the physical environment are linked by processes by which a continuous exchange and assimilation of energy occurs [4]. Moreover, the frequent tidal inundation can induce water logging of the soil and cause salinity fluctuations [5]. These complex ecosystems are found between the latitudes of 300 North and 380 South, along the tropical coast of Africa, Australia, Asia and America. Mangroves include approximately 16 to 24 families and 54 to 75 species. Mangroves are well distributed in Asia, North America, Africa, Australia and New Zealand.

The greatest diversity of mangrove species exists in South-East Asia and has been reported by Chapman [6]. Mangroves are mostly evergreen and are the only known woody halophytes [7]. In India, the total area of mangroves is estimated to be 6740 sq.km [8], which is about 7% of the world's mangrove area. The extent of mangroves along the East coast of India is larger than those along the West coast [9, 10] studied the mangroves in India and provided detailed manuals. West Bengal has the biggest mangrove formation and about 4200 sq.km support mangroves [11]. The mangrove ecosystem of the Sundarbans (West Bengal) comprises about 65% and the remaining 35% mangals are distributed in the bay islands (Andaman and Nicobar islands) and coast lines of eight states of India. A detailed account of mangroves in India was provided by Blasco [12]. Kathiresan and Rajendiran [13] estimated Mangrove plants of Tamil Nadu. Tamil Nadu has a coastline of about 950 km. Along the coastline major mangrove wetlands are present in two areas like Pichavaram in Cuddalore District and the other in the Muthupet region in Thiruvarur District. Small patches of mangroves are also present along the Palk Bay, particularly in the Devipattinam region and also in some of the islands of the Gulf of Mannar in Ramanathapuram District. In the Pichavaram mangrove wetland, are 12 species currently present [14, 15].

Ecophysiological aspects of some salt marsh halophytes' included analysis of soil samples collected during different seasons and showed that pH of saturation extracts varies from 7.4 to 8.3. The salinity of the habitat was at a minimum during monsoon but increased during the dry period i.e. summer through winter. Exchangeable sodium percentage and sodium absorption ratio, important factors affecting swelling and dispersion of clay particles were found to be extremely high in all the cases. These observations suggest that the soils have saline - alkaline characteristics [16]. The limit of tolerance of each species is determined by its specific environmental requirements such as salinity, temperature, soil feature, pH, electrical conductivity, etc. The present investigation intends to analyze the physico-chemical parameters of the Pichavaram and Muthupet mangrove forests in different seasons. Seasonal variations in Tamilnadu due to monsoons - South West monsoon during June-September and North East monsoon during October-December are well marked. The seasonal variations affect the physiological and biochemical status of the mangroves. So the present study was conducted to get proper knowledge regarding the Physico-chemical aspects of Pichavaram and Muthupet mangroves forests will help us to know more about the nature of mangrove wetlands.

## 2. MATERIALS AND METHODS

### 2.1. Study Area I

For the present study, a specific area were identified namely Pichavaram. Pichavaram is situated latitude: 11°27'N and longitude: 79°47' E. It is about 250 km south of the city of Chennai, on the south east coast of India. It is located in the Vellar - Coleroon estuarine complex and has many islands separated by intricate water ways.

### 2.2. Study area II

Muthupet mangrove forest is located in latitude of 10.4°N and longitude of 79.5°E at the southern end of the Cauvery delta, covering an area of approximately 6,803.01 ha of which only 4% is occupied by well-grown mangroves. The rivers Paminiyar, Koraiyar, Kilaithankiyar, Marakkakoraiyar and other tributaries of the river Cauvery flow through Muthupet and adjacent villages.

All the studies were conducted in three seasons: monsoon, pre-monsoon and post-monsoon (Fig. 1).

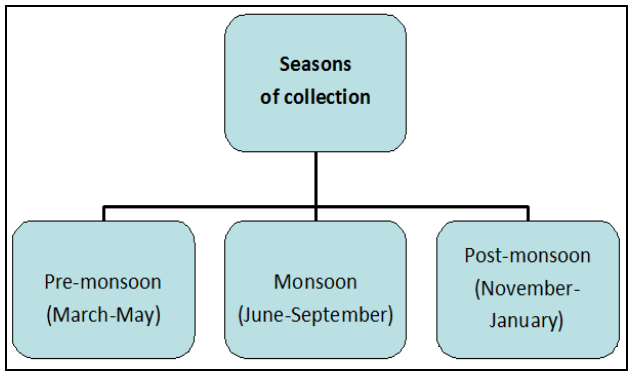


**Fig. 1**. Seasons of conducted studies.

### 2.3. Water qualify analysis

Temperature of water was measured directly at the sampling sites itself. For further analyses, water samples were collected in sterilized airtight bottles and brought to the laboratory. Electrical conductivity of water was measured using conductivity meter (Elico 180) and expressed in mhos $cm^{-1}$. Salinity of water was measured using salinity meter (YSI 85). Biological oxygen demand (BOD) Dissolved Oxygen (DO) was calculated using Winkler's Azide Modification formula. Chemical parameters like chloride, sodium, calcium, magnesium and potassium were analyzed using standard method [17].

### 2.4. Soil analysis

The collected soil sample was air dried at room temperature (37°C) for 1-3 days. Physical parameters like moisture, pH, electrical conductivity (EC), salinity, organic carbon and chemical parameters like chloride, sodium, calcium, magnesium and potassium were analyzed [24]. It can be determined by various titration methods. The pH of the suspension was determined using pH meter (Equiptronics, India). Electrical conductivity of soil was determined in the filtrate of the water extract using conductivity meter. Chemical parameters like chloride, sodium, calcium, magnesium and potassium were analyzed using standard method [17]. The soil samples were determined in accordance with standard analytical methods. The statistical analysis was carried out with the SPSS ver 21.0 software.

## 3. RESULTS

### 3.1. Physico-chemical parameters

The sampling and analysis of soil and water were conducted in three seasons during the period from 2013-2014. As there was seasonal as well as year wise variations the average values have been computed for all the parameters. A number of parameters were employed for both physical and chemical analysis in the case of water as well as soil.

#### *3.1.1. Physical parameters of water samples*

*3.1.1.1. Temperature*

Temperature of water bodies generally varies with sites and seasons. High temperature was recorded during post-monsoon season in Muthupet and pre-monsoon season in Pichavaram. Low temperature was recorded during monsoon season in both study sites (Fig. 2).

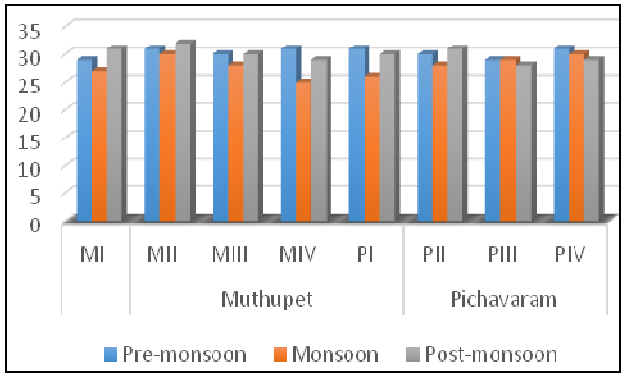


**Fig. 2.** Seasonal variations in temperature (°C).

*3.1.1.2. Hydrogen ion concentration (pH)*

High pH value was noticed during monsoon and pre-monsoon and low pH was observed during post-monsoon seasons in Muthupet. But in Pichavaram high pH value was noticed during pre-monsoon and low during monsoon (Fig. 3).

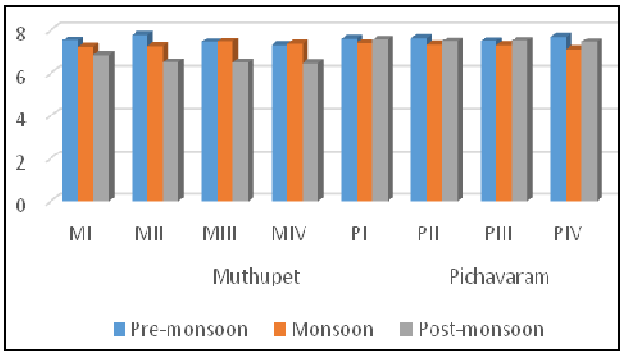


**Fig. 3.** Seasonal variations in pH.

*3.1.1.3. Electrical conductivity (EC)*

Electrical conductivity was maximum during pre-monsoon followed by post-monsoon seasons in both study sites which showed higher concentration of dissolved salts in water. Low value of EC during monsoon showed that the water was almost pure with lesser amount of dissolved salts (Fig. 4).

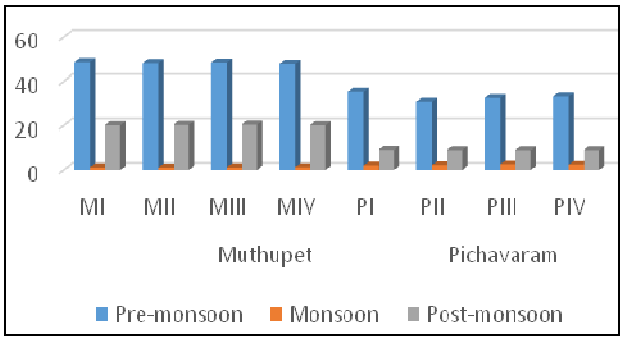


**Fig. 4.** Seasonal variations in electrical conductivity EC (mhoscm$^{-1}$).

*3.1.1.4. Salinity*

Highest salinity was recorded in pre-monsoon followed by post-monsoon in both study sites. Lowest salinity, was noted during monsoon season (Fig. 5).

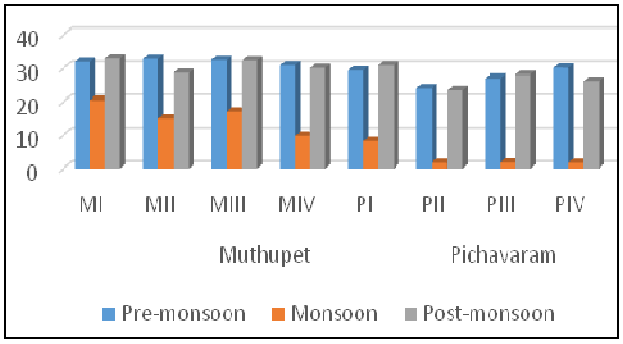


**Fig. 5.** Seasonal variations in salinity (ppt).

*3.1.1.5. Dissolved Oxygen (DO)*

Dissolved oxygen was high during monsoon season. DO values were less during pre-monsoon and post-monsoon seasons. Among the two sites, water collected from Pichavaram composed of high DO during all the seasons (Fig. 6).

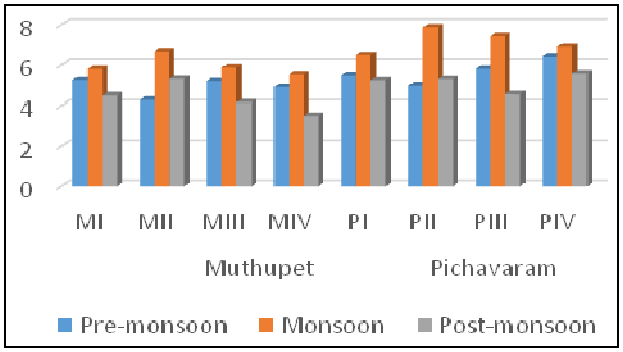


**Fig. 6.** Seasonal variations in dissolved oxygen DO (mg/l).

*3.1.1.6. Biological Oxygen Demand (BOD)*

BOD value was highest in post-monsoon season in both the study sites. In mangrove area high BOD was noticed. During monsoon season BOD was minimum in water collected from Muthupet (Fig. 7).

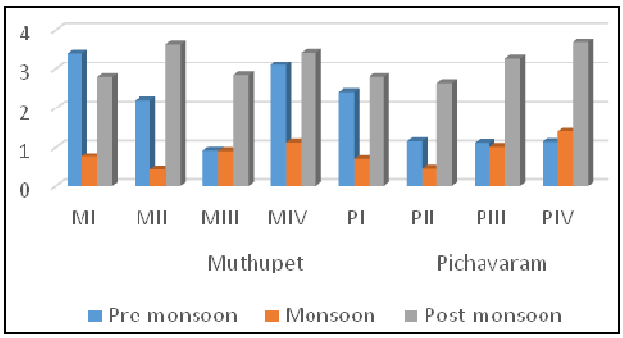


**Fig. 7.** Seasonal variations in BOD (mg/l).

***3.1.2. Chemical parameters of water samples***

*3.1.2.1. Chloride*

Among the seasons studied, the pre-monsoon recorded high chloride concentration in Muthupet and Pichavaram. Minimum concentration of chloride was recorded during monsoon season. When mangrove and non-mangrove areas were compared, non-mangrove areas showed higher chloride concentration than the mangrove sites (Fig. 8).

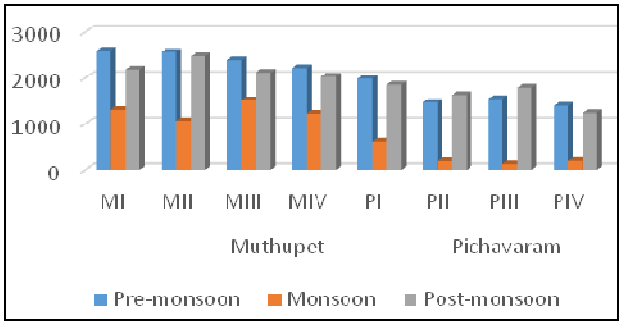


**Fig. 8.** Seasonal variations in chloride (mg/l).

*3.1.2.2. Sodium*

Well marked variations in sodium concentration were recorded in all seasons. Maximum concentration was recorded during the post-monsoon season followed by the pre-monsoon one. During monsoon season, low values of Na were recorded which was attributed to dilution by rain water in both study sites (Fig. 9).

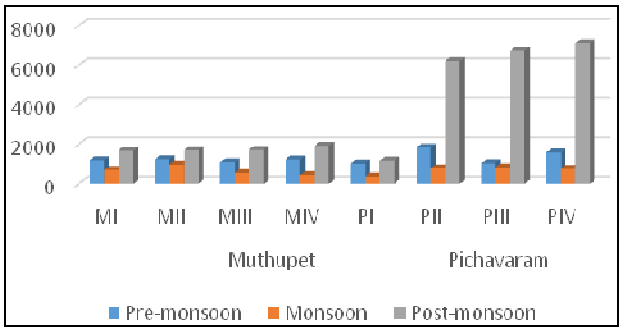


**Fig. 9.** Seasonal variations in sodium (mg/l).

*3.1.2.3. Potassium*

Higher concentration of potassium was recorded during pre-monsoon followed by post-monsoon season in both study sites. Lowest value of potassium was recorded in the monsoon season (Fig. 10).

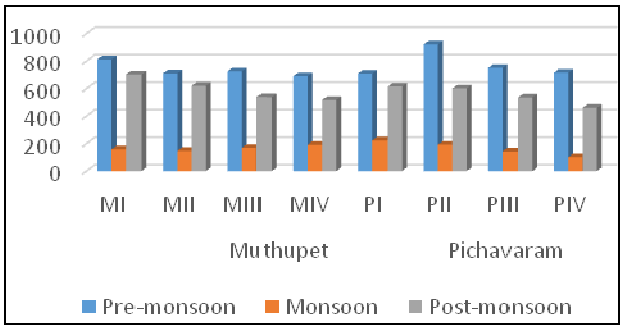


**Fig. 10.** Seasonal variations in potassium (mg/l).

*3.1.2.4. Calcium*

Maximum concentration of calcium was recorded during pre-monsoon followed by post-monsoon season. Low value of Ca was recorded during monsoon season in both the study sites (Fig. 11).

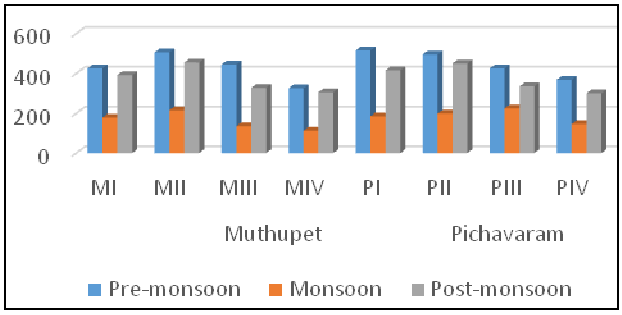


**Fig. 11.** Seasonal variations in calcium (mg/l).

*3.1.2.5. Magnesium*

Maximum concentration of magnesium was recorded during the pre-monsoon followed by post-monsoon season. Minimum value was recorded during monsoon season in both study sites. Higher concentration of Mg in the mangrove site was due to the contribution of Mg by the decomposed mangrove litter (Fig. 12).

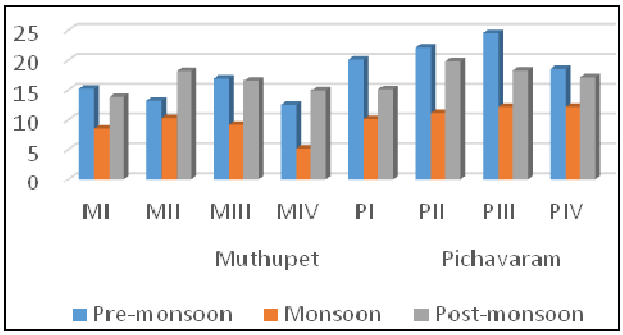


**Fig. 12.** Seasonal variations in magnesium (mg/l).

### *3.1.3. Physical parameters of soil samples*

*3.1.3.1. Moisture content of the soil*

Among the various seasons studied, the monsoon season recorded higher moisture content than the pre and post-monsoon seasons. The mangrove sites recorded high moisture content than the non-mangrove sites. This is due to the sandy-loam texture of the soil of these sites. It has high moisture holding capacity. Mangrove sites contained high organic matter, leading to high moisture content (Fig. 13).

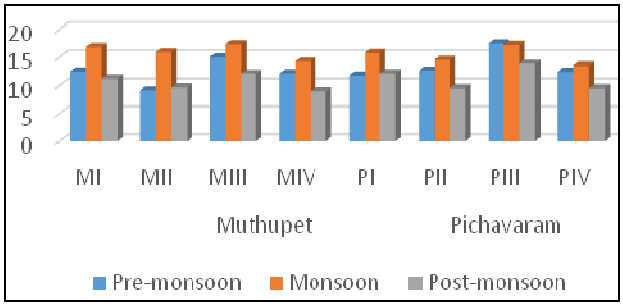


**Fig. 13.** Seasonal variations in moisture content (%).

*3.1.3.2. Hydrogen ion concentration (pH)*

pH was found to be low during the monsoon season than the pre and post-monsoon seasons in Pichavaram. Low pH was observed in Muthupet during pre and post-monsoon seasons indicating the acidity of the soil. Pichavaram soil recorded a higher pH than the estuarine soil. This alkaline pH was due to the dominance of sea water (Fig. 14).

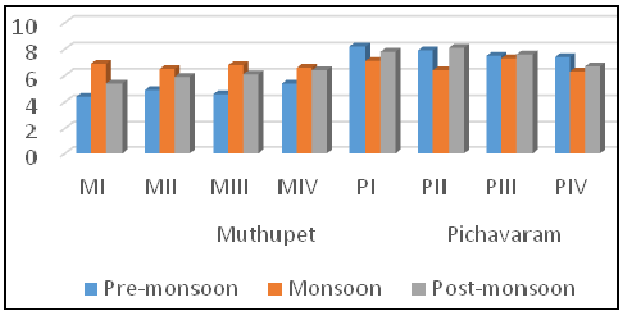


**Fig. 14.** Seasonal variations in pH.

*3.1.3.3. Electrical conductivity (EC)*

High electrical conductivity (EC) values were recorded during pre and post-monsoon seasons in both study sites. The monsoon season recorded the lowest EC values which may be due to dilution by rain water. High EC values were observed in mangrove sites when compared to non-mangrove sites. The sediments of mangrove sites containing high organic matter and acidic pH attain specific conductivity values (Fig. 15).

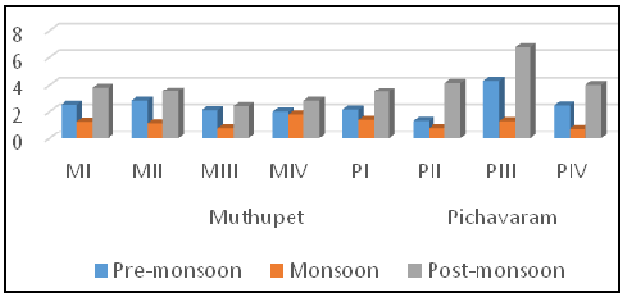


**Fig. 15.** Seasonal variations in electrical conductivity EC (mhos/cm).

*3.1.3.4. Salinity*

The monsoon season recorded the lowest salinity. Post-monsoon recorded highest salinity followed by pre-monsoon season in both study sites (Fig. 16).

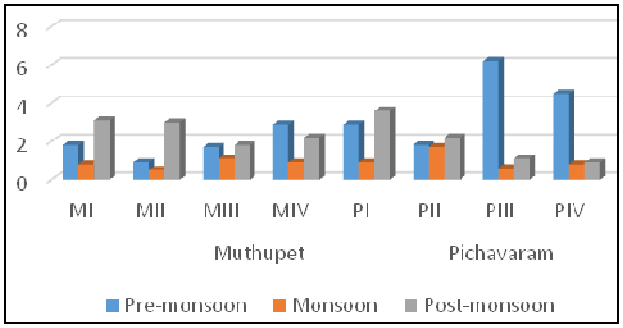


**Fig. 16.** Seasonal variations in salinity (ppt).

*3.1.3.5. Organic carbon*

The mangrove sites recorded higher values of organic carbon. It is due to plant and animal debris deposited in the soil. Increased organic carbon in the mangrove soil is due to microbial degradation of mangrove litter. Pre-monsoon and post-monsoon seasons recorded higher values for organic percentage than monsoon season in both study sites (Fig. 17).

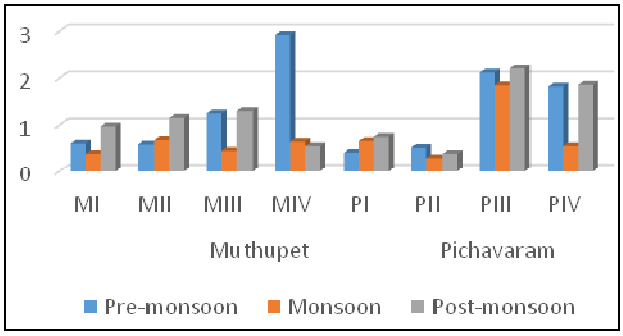


**Fig. 17.** Seasonal variations in organic carbon (%).

***3.1.4. Chemical parameters***

*3.1.4.1. Chloride*

Post-monsoon season recorded the highest concentration of chloride followed by pre-monsoon season. Higher concentration of $Cl^-$ was noticed at the mangrove sites. Monsoon season recorded lowest $Cl^-$ value because of the influx of rainwater (Fig. 18).

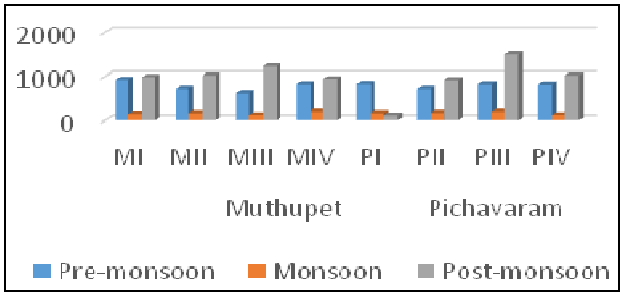


**Fig. 18.** Seasonal variations in chloride (mg/100 g).

*3.1.4.2. Sodium*

Higher concentration of sodium during pre-monsoon followed by postmonsoon season in both study sites. Lowest concentration of Na during monsoon season may be because of dilution by rainwater. In the mangrove sites, higher concentration of Na was recorded (Fig. 19).

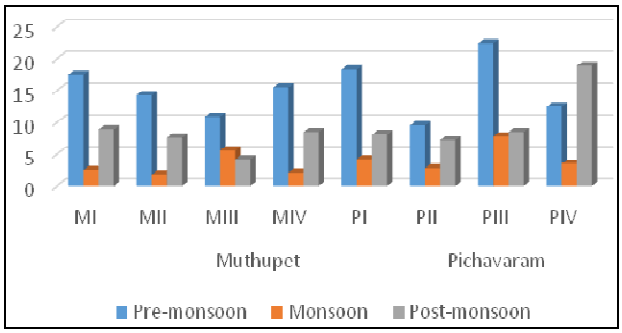


**Fig. 19.** Seasonal variations in sodium (mg/100 g).

*3.1.4.3. Potassium*

Potassium concentration was maximum during pre and post-monsoon seasons. Decay of mangrove leaves liberates K, contributing to high values of K in the sediment. Low value of K was recorded during the monsoon season. It may be due to dilution by rain water (Fig. 20).

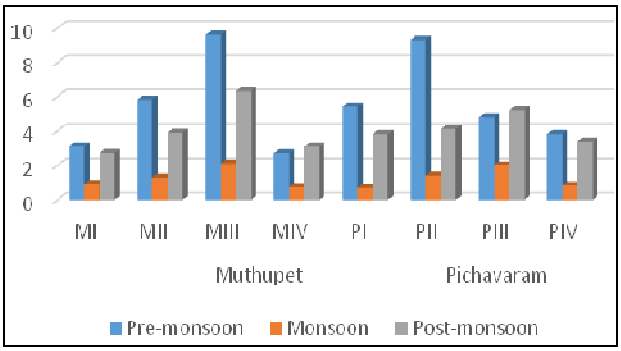


**Fig. 20.** Seasonal variations in potassium (mg/100 g).

*3.1.4.4. Calcium*

Higher concentration of Calcium during the pre and post-monsoon seasons. Lower value of Ca was recorded during monsoon season in both study sites (Fig. 21).

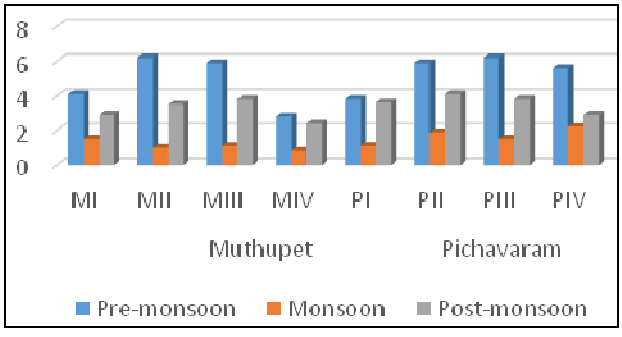


**Fig. 21.** Seasonal variations in calcium (mg/100 g).

*3.1.4.5. Magnesium*

Higher value of magnesium was recorded during pre and post-monsoon seasons. Lower concentration of Mg during monsoon season in both study sites. Ecological study included analysis of water and soil of two study areas (Fig. 22).

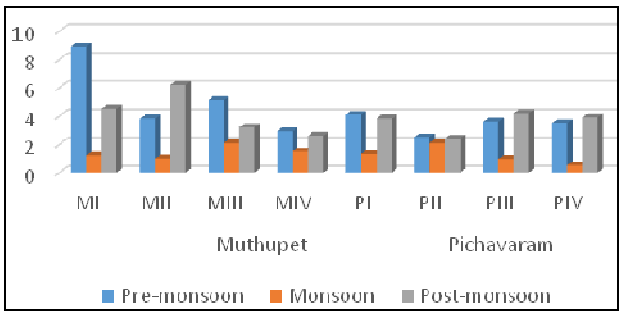


**Fig. 22.** Seasonal variations in magnesium (mg/100 g).

## 4. DISCUSSION

### 4.1. Water quality analysis

Physical parameters of water include mainly temperature. Water temperature is crucial to aquatic life. Temperature is of importance to physiological processes such as photosynthesis and respiration. Physiological stress may be experienced when high temperatures are combined with full sunlight. Pre-monsoon and post-monsoon seasons recorded high values for temperatures in both study sites, evidently exerting maximum stress on mangrove flora. High pH values during monsoon and pre-monsoon seasons in Muthupet indicate that water is alkaline. It may be due to mixing of fresh and brackish waters during tides in the estuary. But in Pichavaram high pH value during post-monsoon season indicates that water is alkaline. It may be due to decomposition of mangrove litter. Electrical conductivity (EC) of water is a measure of ability of the water sample to conduct electric current, which is the reciprocal of resistance. It provides a very rapid means of obtaining a good estimate of the total dissolved solid concentration and salinity of water samples. Most of the dissolved inorganic substances in water are in an ionized state which contributes to conductance. A number of salts are found dissolved in natural water, the common ones being carbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, etc. which contribute

to electrical conductivity in water samples analyzed [18]. Maximum value for EC during pre and post-monsoon seasons is due to higher concentration of dissolved salts in water. During monsoon, the water is almost pure with lesser amount of dissolved salts. Salinity was considered the most significant parameter controlling the distribution of mangroves. Salinity of mangrove areas was greatly affected by seasonal rainfall and evaporation [19]. The salinity of water may be mainly due to the presence of NaCl. A very high salinity was observed in pre-monsoon when compared to monsoon season. Very low salinity during monsoon may be due to high flushing during the monsoon season. The high values during the pre-monsoon season were found to be related to the lean summer flows and increase in evaporation [18]. Dissolved oxygen (DO) is an important parameter of water quality, which is an index of physical and biological processes taking place in water. Dissolved oxygen in water maintains the higher form of life and keep the proper balance of various populations, thus making the water body healthy. Dissolved oxygen concentrations in mangroves vary according to areas and zonation of plants [19]. The results indicate that dissolved oxygen is maximum in monsoon season 6.69 mg/l and 7.89 mg/l in Muthupet estuary and Pichavaram, respectively. Lowest values are recorded in post-monsoon season with values 3.52 mg/l and 4.56 mg/l in Muthupet and Pichavaram, respectively. This showed that dissolved oxygen concentration varies according to season, richness of plants and aquatic organisms in mangroves. The higher values in the monsoon period may be due to the intrusion of fresh DO rich water into the study sites. Mangrove rich sites MI, MII and MIII recorded high DO values which are an indication of productive water body. In Pichavaram PII, PIII and PIV are mangrove rich site with higher values of DO. The rate of removal of oxygen by micro-organisms through the anaerobic degradation of dissolved organic matter is reflected as Biological Oxygen Demand (BOD). It is an index of organic pollution in water. The BOD of tidal waters and estuaries is affected by salinity and only low values were obtained. The BOD values for Muthupet estuary during pre-monsoon ranges from 2.80 to 3.42 mg/l and 0.43 to 1.12 mg/l during monsoon. In Pichavaram, the value for BOD was 2.65 to 3.68 mg/l and 0.45 to 1.4 mg/l in pre-monsoon and monsoon seasons, respectively.

Chloride is the common anion found in water. Its concentration in natural waters varies from a few milligrams to several thousand milligrams per litre. In coastal region and estuary, seawater intrusion may contribute to the chloride content of inland water. Chloride is a major constituent in seawater. High chloride content was noted during pre-monsoon in Muthupet and Pichavaram. During pre-monsoon high electrical conductivity (EC) was also noted. It is due to high chloride content during pre-monsoon. Low chloride concentration in mangrove sites may be due to special tolerance mechanism shown by mangroves. They have the unique capacity for salt accumulation, which may reduce the chloride content in water. The fine grained sediments in the mangrove sites may bind chloride from the overlying water. Sodium is one of the important, naturally occurring alkali metals whose concentration is remarkably high in saline and brackish waters. Sodium limits biological diversity due to osmotic stress [18]. In both study sites, high concentration of sodium is reported during post-monsoon season. Sodium concentration in Muthupet was in a range of 414 mg/l and 1081 mg/l during monsoon and pre-monsoon, respectively. In Pichavaram sodium concentration was in a range of 356 mg/l and 1822 mg/l during monsoon and pre-monsoon, respectively. Very low concentration during monsoon season may be due to dilution by rain water.

Potassium is a naturally occurring element whose concentration remains quite lower than sodium. Higher concentration of potassium was recorded during pre-monsoon season 812 mg/l and 921 mg/l in Muthupet and Pichavaram, respectively. Monsoon season recorded lowest value for potassium, 146 mg/l and 101 mg/l in Muthupet and Pichavaram, respectively. The lowest value in monsoon season may be due to influx of freshwater. Calcium is an important macronutrient in the aquatic environment and it is the fifth element in the order of abundance. It is a predominant cation in river water. High concentration of calcium is recorded during the premonsoon season in both study areas 1445 mg/l and 515 mg/l in Muthupetand Pichavaram, respectively. Monsoon season recorded lowest value for calcium concentration. It

may be due to dilution by rainwater and influx of freshwater. Magnesium is an important constituent of seawater and estuarine water. It is an essential constituent of chlorophyll molecule without which no ecosystem could operate. High values of magnesium concentration were recorded during pre-monsoon in both Muthupet and Pichavaram 16.90 mg/l and 24.51 mg/l, respectively. Lower value for magnesium during monsoon season may be due to dilution of water by rain. Mangrove sites with high concentration of magnesium are due to the contribution by decomposed mangrove litter.

**4.2. Soil analysis**

Soil is a natural medium for plant growth and it supplies the required nutrients to growing plants. Water in the soil is an important solvent and transporting agent. It maintains the texture and compactness of soil and makes it habitable for microbes, plants and animals. The moisture content in soil is mainly from infiltration of precipitated water. Its content in soil depends upon the water holding capacity of soil, evaporation, soil texture, porosity, etc. [18]. The percentage of moisture content in Muthupet and Pichavaram was maximum during monsoon season. It is due to the soil texture. Muthupet estuary soil is rich in sand, silt and clay and hence has maximum water holding capacity. In Pichavaram, silt and clay was abundant in the substratum. Muthupet soil is with higher moisture content percentage than Pichavaram soil. In Muthupet the estuarine soil is permanently water satuarated whereas in Pichavaram the soil is only moist. pH of the soil is a good measure of the indication of acidity or alkalinity of soil. Muthupet estuary soil showed pH value close to neutral value 6.5 to 6.9 during monsoon season and low pH during pre-monsoon and post-monsoon seasons. This indicates acidity of the soil. In Pichavaram higher values for pH were recorded during pre-monsoon and post-monsoon seasons, indicating alkalinity of the soil. The mangrove sediments were found to be acidic. Mangroves prefer low pH i.e. the sediments may become acidic due to the reduction of sulphides to sulphate with consequent formation of sulphuric acid in annoxic conditions [18]. Electrical conductivity (EC) gives a clear idea of the soluble salts present in the soil. Conductivity of soil is usually lower than that of water. In both study areas, the monsoon season recorded the lowest EC values which may be due to dilution of soil water by rain water. The increase in salt content in mangrove sites may be due to estuarine water and the decaying mangrove litter. Decreased salinity in the monsoon season may be due to the leaching of salt ions as a result of precipitation [20]. The increase in salinity level during pre and post monsoon seasons may be due to decreased water contents in both soils of the study sites. The salinity of the habitat is at a minimum during monsoon but increased during the dry period ie. pre-monsoon and post-monsoon seasons. Lowest salinity was recorded in the monsoon season in both study areas and it ranged between 0.5 ppt to 1.1 ppt in Muthupet and 0.8 ppt to 1.7 ppt in Pichavaram. Salinity observed in the pre-monsoon season was 0.9 ppt to 2.9 ppt and 1.8 ppt to 6.2 ppt in Muthupet and Pichavaram, respectively. In the post-monsoon, the values were 1.8 ppt to 3.1 ppt and 0.9 ppt to 3.6 ppt in Muthupet and Pichavaram, respectively. The high salinity values were recorded for coastal soils in all the months compared to interior soils. The salinity was lowest in January and highest in March for both the soils. There was a gradual increase in salinity from January to March and a subsequent decrease in both the cases. The increase in salinity level up to March may be due to decreased water content in the soil of both the study areas.

Mangrove soils showed high values for organic carbon. It is due to the microbial degradation of mangrove litter. The organic carbon percentage in Muthupet and Pichavaram soil varied from 0.38% to 0.65% and 0.55% to 1.85%, respectively during monsoon season. But pre-monsoon and post-monsoon seasons recorded higher values for organic carbon percentage. During pre-monsoon season, organic carbon percentage varies between 0.59% to 2.92% in Muthupet and 0.41% to 2.12% in Pichavaram. Post-monsoon values for organic carbon percentage are 0.55% to 1.15% and 0.38% to 2.21% in Muthupet and Pichavaram respectively. This shows that the estuarine soil in Muthupet is rich in organic carbon than Pichavaram soil. The chloride content in Muthupet and Pichavaram during monsoon ranged between 150 mg/100 g to 205 mg/100 g and 122 mg/100 g to 205 mg/100 g respectively. Higher values were recorded during

premonsoon and post-monsoon seasons. This may be due to the decomposition of mangrove litter in both the study areas. Lowest value in the monsoon may be due to the influx of freshwater. The Sodium content was maximum during the pre-monsoon season in both the study areas. The values ranged between 10.9 mg/100 g and 17.5 mg/100 g in Muthupet and 9.5 mg/100 g and 22.4 mg/100 g in Pichavaram. Lowest value was recorded during the monsoon season because of the influx of rainwater. The pre-monsoon period recorded higher values for Potassium content in both the study areas. The values ranged between 2.70 mg/100 g and 9.61 mg/100 g and 3.81 mg/100 g to 9.31 mg/100 g in Muthupet and Pichavaram respectively. Lesser value in post-monsoon season was recorded in both study sites. Lowest value was recorded during the monsoon season. It may be due to dilution by rainwater. Higher values during pre-monsoon and post-monsoon seasons are due to decay of mangrove leaves, liberating potassium. Both the study areas recorded high values for calcium content during pre-monsoon season. The values ranged between 2.8 mg/100 g to 6.2 mg/100 g and 3.8 mg/100 g to 6.2 mg/100 g in Muthupet and Pichavaram respectively. Monsoon season recorded minimum values in both the study areas. This may be due to influx of freshwater. Magnesium content was maximum during the pre-monsoon season in both the study areas. The value ranged between 2.9 mg/100 g and 8.9 mg/100 g in Muthupet and 2.5 mg/100 g and 4.1 mg/100 g in Pichavaram. The monsoon season recorded lowest value due to the influx of freshwater. The increase in magnesium contents during the pre-monsoon may be due to the decay of mangrove litter.

## 5. CONCLUSIONS

In conclusion, it may be noted that mangrove ecosystem must be protected. Intensive aforestation would certainly ensure formation of rich mangrove forests. Awareness programmes should be conducted by the Government for conserving the biodiversity of mangrove ecosystem.

## AUTHORS CONTRIBUTION

Both authors have equally contribution in conducted studies and manuscript preparation. The final manuscript has been read and approved by both authors.

## TRANSPARENCY DECLARATION

The authors declare no conflicts of interest.

## ACKNOWLEDGEMENTS

The authors are extremely grateful to the Professor and Head, Department of Botany, Annamalai University and Authorities of Annamalai University for the basic facilities provided during the study period.

## REFERENCES

1. Macnae W. A general account of the fauna and flora of mangrove swamps and forests in Indo-west pacific region. Adv Mar Biol. 1968; 6: 73-270.
2. Aksornkoae S. The pertinent, physical, chemical and biological characteristics of the input of sedimentary source materials entering the estuarine zone. In: Proceedings of UNESCO Biochemistry of Estuarine Sediments. 1978: 128-130.
3. Tomlinson PB. The botany of mangroves. The Cambridge University Press, Cambridge; 1986.
4. Singh VP, Odaki K. Mangrove ecosystem: structure and function. Scientific Publishers (India), New Delhi. 2004: 14-17.
5. Parida J. Salt tolerance mechanisms in mangroves: a review. Trees-Struct Funct. 2010; 24: 199-217.
6. Chapman VJ. Mangrove vegetation. Vaduz Cramer; 1976.
7. Komiyama O, Poungparn K. Allometry, biomass, and productivity of mangrove forests: a review. Aquat Bot. 2008; 89: 128-137.
8. MoEF. Mangroves in India - Status Report. Ministry of Environment of Forests, Government of India, New Delhi; 1987.
9. Banerjee LK, Sastry ARK, Nayar MP. Mangroves in India - identification manual. Botanical Survey of India, Calcutta; 1983.
10. Naskar KR. Manual of Indian mangroves. Daya Publishing House, Delhi; 2004.
11. Chand Basha S. Mangroves of Kerala - a fast disappearing asset. Ind For. 1992; 118: 175-190.
12. Blasco F. Mangroves of India. Sec Sci Tech. 1975; 14(1): 154-156.
13. Kathiresan K, Rajendiran H. Fishery resources and

economic gain in three mangrove areas on the south east-coast of India. Fish Manag Ecol. 2002; 9: 277-283.

14. Tissot C. Recent evolution of mangrove vegetation in the Cauvery Delta. A palynological study. J Mar Biol Ass India. 1987; 29: 16-22.
15. Selvam V, Gnanappazham L, Navamuniyammal M, Ravichandran KK, Karunagaram VM. Atlas of mangrove wetlands of India. M.S. Swaminathan Research Foundation, Chennai, India; 2002.
16. APHA. Standard Methods for the Examination of Water and Wastewater. 16th edn. American Public Health Association, Washington, D.C.; 1995.
17. Vogel AI. A text book of quantitative inorganic analysis. The ELBS edn, London; 1984.
18. Lakshmi K. Ecological studies on the mangrove ecosystems of Valapattanam and Thalassery River Basin. Ph.D. Thesis, University of Calicut; 2002.
19. Aksornkoae S. Ecology and management of mangroves. IUCN Bangkok; 1993.
20. Chandrashekar KR, Sandhyarani S. Salinity induced chemical changes in *Crotalaria striata* DC. plants. Indian J Plant Physiol. 1996; 1: 44-48.
21. Malik GM, Joshi MP, Zadafiya SK, Raval VH. Study on physico-chemical characterization of some lotic system of South Gujarat, India. Res J Chem Sci. 2012; 2(1): 83-85.