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ORIGINAL RESEARCH ARTICLE

QUASI-COMPLEMENTED 0-DISTRIBUTIVE SEMILATTICES

S. S. Khopade

Author affiliation:

Department of
Mathematics,
Karmaveer Hire Arts,
Science, Commerce and
Education College, Gargoti,
Dist – Kolhapur, M.S., India
E-mail:
santajikhopade@gmail.com

ABSTRACT:

Some new properties of α -ideals in a 0- distributive semilattice are derived. Characterizations of quasi-complemented semilattices using α -ideals are furnished. A necessary and sufficient condition for a quasi-complemented semilattice to be pseudo complemented is given.

KEYWORDS: 0-distributive semilattice, quasi-complemented semilattice, pseudo complemented semilattice, α -ideals, 0-ideals, homomorphism.

MATHEMATICS SUBJECT CLASSIFICATION: 06B99

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1. INTRODUCTION:

As a generalization of the concept of distributive lattices on one hand and pseudo-complemented lattices on the other, 0- distributive lattices are introduced by Varlet [7]. Following Varlet, a lattice L with the least element 0 is called 0- distributive, if it satisfies the condition: $a \wedge b = 0 = a \wedge c$ imply $a \wedge (b \vee c) = 0$ for any $a, b, c \in L$ and a lattice with 0 is quasi-complemented if, for each $a \in L$ there exists $b \in L$ such that $a \wedge b = 0$ and $a \vee b$ is a dense element in L . Of course an element $a \in L$ is dense if $\{b \in L / a \wedge b = 0\} = \{0\}$. Cornish [1] introduced the concept of α -ideals in a distributive lattice and studied their properties. C. Jayaram [4] introduced and studied α -ideals in a 0- distributive lattice. Additional properties of α -ideals in 0- distributive lattices are obtained by Pawar et.al. in [5] and [6]. Cornish in [2] has given various characterisations of quasi-complemented 0-distributive lattices using minimal prime ideals. 0- distributive semilattices arise as a natural generalisation of distributive semilattices with 0, 0- distributive lattices and pseudo-complemented semilattices. In this paper we first derive some properties of α -ideals in a 0- distributive semilattice and use them to characterise quasi-complemented semilattices. A necessary and sufficient condition for a quasi-complemented semilattice to be pseudo complemented is given. The concept of annihilator preserving homomorphism for 0- distributive semi- lattices is introduced and it is observed that image and inverse image of an α -ideal is an α -ideal under annihilator preserving homomorphism for 0- distributive semi- lattices.

2. PRELIMINARIES:

Following are some basic concepts and results that we need in sequel. For other non-explicitly stated elementary notions please refer to [3]. By a semilattice S we mean meet semilattice (S, \wedge) . The smallest (largest) element in S if exists is denoted by 0 (1). If both 0 and 1 exist in S , we say S is bounded. A semilattice S is said to be directed above, if for any $a, b \in S$, there exists $c \in S$ such that $c \geq a, b$. S with 0 is called 0- distributive, if for $a, b \in S$, with $a \wedge b = 0 = a \wedge c$, there exists $d \in S$ such that $d \geq a, c$ and $a \wedge d = 0$. Obviously, every 0- distributive semilattice is directed above. Now onwards throughout this paper S will denote a bounded 0- distributive semilattice unless otherwise stated. A non-empty subset A of S is a sub semilattice of S if $a \wedge b \in A$ for all $a, b \in A$. A non-empty subset A of S is a down set of S , if for $a, b \in S$, $a \leq b$ and $b \in A$ imply $a \in A$. A down set I of S is an ideal if for $a, b \in I$, there exists $c \in I$ such that $c \geq a, b$. An ideal P in S is called prime if $a \wedge b \in P$ implies $a \in P$ or $b \in P$ for $a, b \in S$. A minimal element in the set of all prime ideals of S is called a minimal prime ideal. An ideal $I \neq S$ is a maximal ideal if it is not contained in any ideal except S . For a non-empty subset A of S , $A^* = \{x \in S / x \wedge a = 0, \text{ for all } a \in A\}$. If $A = \{a\}$, then $\{a\}^* = (a)^*$, where $(a) = \{x \in S / x \leq a\}$. S is said to be quasi-complemented if for

each $a \in S$ there exists $b \in S$ such that $\{a\}^{**} = \{b\}^*$. An ideal I in S is an α -ideal if $\{a\}^{**} \subseteq I$ for each $a \in I$. An ideal I in S is called an annihilator ideal if $I = A^*$, for a non-empty subset A of S . A non-empty subset F of S is a up set of S , if for $a, b \in S$, $a \leq b$, $a \in F$ imply $b \in F$. A up set F of S is a filter of S , if $a \wedge b \in F$ for all $a, b \in F$. A filter F of S is prime if $S \setminus F$ is a prime ideal in S . A filter $F \neq S$ is a maximal filter if it is not contained in any filter except S . Let S and S' be bounded semilattices with bounds $\{0, 1\}$ and $\{0', 1'\}$ respectively. A mapping $f: S \rightarrow S'$ is a homomorphism, if it satisfies the conditions: (i) $f(a \wedge b) = f(a) \wedge f(b)$ for all $a, b \in S$ and (ii) $f(0) = 0'$ and $f(1) = 1'$.

Following results are easy to verify, which we use in the subsequent sections.

Result1: Let S be a directed above semilattice with 0 . A prime ideal M in S is minimal prime if and only if for each $x \in M$, there exists $y \notin M$ such that $x \wedge y = 0$.

Result2: Let S be a directed above semilattice with 0 . The following statements are equivalent.

- (i) S is a 0 - distributive semilattice.
- (ii) $\{a\}^*$ is an ideal in S for any $a \in S$.
- (iii) A^* is an ideal in S , for any non-empty sub set A of S .
- (iv) Every maximal filter in S is prime.

Result3: Every annihilator ideal in S is an α -ideal.

Result4: Let S and S' be bounded semilattices and $f: S \rightarrow S'$ be an epimorphism. Then (i) if I is an ideal in S , then $f(I)$ is an ideal in S' .

(ii) if I' is an ideal in S' , then $f^{-1}(I')$ is an ideal in S .

3. α – ideals

We begin with a theorem which is crucial for further development.

Theorem 3.1: For any sub semilattice A of S , the set $A^0 = \{x \in S / x \wedge a = 0 \text{ for some } a \in A\}$ is an α -ideal in S .

Proof:- A^0 is non-empty, as $0 \in A^0$. Obviously, A^0 is a down set.

Let $x, y \in A^0$. Then $x \wedge a = 0$ and $y \wedge b = 0$ for some $a, b \in A$. As S is 0 - distributive, there exists $d \in S$ such that $d \geq x, y$ and $d \wedge a \wedge b = 0$. As $a \wedge b \in A$, $d \in A^0$. Hence A^0 is an ideal in S . Let $x \in A^0$ and $t \in \{x\}^{**}$. Thus $x \in A^0 \Rightarrow x \wedge t = 0$ for some $a \in A \Rightarrow x \wedge a = 0 \Rightarrow t \wedge a = 0 \Rightarrow t \in A^0$. This shows that $\{x\}^{**} \subseteq A^0$ for any $x \in A^0$. Hence A^0 is an α -ideal in S . ■

We know that any filter in S is a sub semilattice of S . Hence we have

Corollary 3.2:- For any filter F in S , F^0 is an α -ideal in S . An ideal I in S is called a 0 - ideal if $I = F^0$, for some filter F of S .

Therefore we have

Corollary3.3:- Any 0- ideal in S is an α -ideal in S .

Corollary3.4:- Any minimal prime ideal in S is an α -ideal in S .

Proof:- Let M be any minimal prime ideal in S . Then by Result 1, $M = (S \setminus M)^0$ and $(S \setminus M)$ is a sub semilattice of S . Hence M is an α -ideal in S . ■

For any prime ideal P in S , define $O(P) = \{x \in S / x \wedge a = 0 \text{ for some } a \notin P\}$. Then we have

Corollary3.5:- For any prime ideal P in S , the set $O(P)$ is an α -ideal in S .

Proof:- Let P be any prime ideal in S . Then $O(P) = (S \setminus P)^0$ and $(S \setminus P)$ is a sub semilattice of S . Hence by Theorem 3.1, $O(P)$ is an α -ideal in S . ■

An ideal I in S is said to be dense in S if $I^* = \{0\}$. For non-dense prime ideals in S , we have **Theorem 3.6:-** Any non-dense prime ideal in S is an α -ideal in S .

Proof:- Let P be a non-dense prime ideal in S . Then $P^* \neq \{0\}$. Select $0 \neq x \in P^*$. Then $P \subseteq P^{**} \subseteq \{x\}^*$. Now $t \in \{x\}^* \Rightarrow t \wedge x = 0 \Rightarrow t \in P$ (since $x \in P^* \Rightarrow x \notin P$). Hence $\{x\}^* \subseteq P$. Combining both the inclusions we get $P = \{x\}^*$.

As every annihilator ideal in S is an α -ideal (by Result 3), P is an α -ideal in S . ■

In the following theorem we give some necessary and sufficient conditions for an ideal in S to be an α -ideal in S .

Theorem 3.7:- For an ideal I in S , following statements are equivalent.

(i) I is an α -ideal in S .

(ii) $I = \bigcup \{i\}^{**} / i \in I$.

(iii) For $x, y \in S$, $\{x\}^* = \{y\}^*$, $x \in I \Rightarrow y \in I$.

(iv) For $x, y \in S$, $h(x) = h(y)$, $x \in I \Rightarrow y \in I$, where $h(x) = \{M / M \text{ is a minimal prime ideal containing } x\}$.

(v) $I = \{x \in S / (x) \cap \{i\}^* = \{0\} \text{ for some } i \in I\}$.

(vi) $I = \{x \in S / (x) \subseteq \{i\}^{**}, \text{ for some } i \in I\}$.

Proof:- (i) \Leftrightarrow (ii). Follows by the definition of an α -ideal in S .

(ii) \Leftrightarrow (vi). Obviously, true.

(iii) \Leftrightarrow (iv). Follows from the fact that $h(x) = h(y) \Leftrightarrow \{x\}^* = \{y\}^*$, for $x, y \in S$.

(iv) \Leftrightarrow (v). Follows from the fact that $(x) \cap \{y\}^* = \{0\} \Leftrightarrow (x) \subseteq \{y\}^{**}$, for $x, y \in S$.

(ii) \Rightarrow (iii) Assume that there exist $x, y \in S$, $\{x\}^* = \{y\}^*$, $x \in I$ but $y \notin I$. Hence by (ii),

$y \notin \bigcup \{i\}^{**} / i \in I$. Therefore $y \notin \{x\}^{**}$ and hence $t \wedge y \neq 0$ for some $t \in \{x\}^*$. As $\{x\}^* = \{y\}^*$, we get $t \wedge y = 0$; which is not true. Hence $y \in I$ and the implication follows.

(iii) \Rightarrow (ii) Obviously, $I \subseteq \bigcup \{i\}^{**} / i \in I$ (since $i \in \{i\}^{**}$). Let $t \in \bigcup \{i\}^{**} / i \in I$. Then $t \in \{x\}^{**}$ for some $x \in I$.

Thus $t \wedge x \in I$ (since I is a down set) and $\{t\}^* \subseteq \{t \wedge x\}^*$. Again $y \in \{t \wedge x\}^* \Rightarrow t \wedge x \wedge y = 0 \Rightarrow t \wedge y \in \{x\}^* \Rightarrow t \wedge y \in \{t\}^*$ (since $t \in \{x\}^{**} \Rightarrow \{x\}^* \subseteq \{t\}^*$) $\Rightarrow t \wedge y = 0 \Rightarrow y \in \{t\}^*$. Hence $\{t \wedge x\}^* \subseteq \{0\}^*$. Combining both the

inclusions we get $\{t \wedge x\}^* = \{x\}^* \wedge t$, by assumption, $t \in I$. This shows that $\cup\{\{i\}^{**} / i \in I\} \subseteq I$. Obviously, as $I \subseteq \cup\{\{i\}^{**} / i \in I\}$ (since $i \in \{i\}^{**}$, for every $i \in I$), we get $I = \cup\{\{i\}^{**} / i \in I\}$ and the implication follows. Thus we have (ii) \Leftarrow (iii) and the result follows. ■

We know that S is disjunctive iff for $a < b$ in S , there exists $c \in S$ such that $a \wedge c = 0$, but $b \wedge c \neq 0$. Thus S is disjunctive if and only if $\{a\}^* = \{b\}^*$ implies $a = b$ for $a, b \in S$. By Theorem 3.7(iii) we have

Corollary 3.8:- Every ideal in a disjunctive 0- distributive semilattice is an α -ideal. Let S and S' be bounded 0- distributive semilattices. A homomorphism $f: S \rightarrow S'$ is said to be annihilator preserving if $f(A^*) = (f(A))^*$ for any non-empty subset A of S .

Theorem 3.9:- Let S and S' be bounded 0- distributive semilattices and $f: S \rightarrow S'$ is an annihilator preserving, onto homomorphism. Then

- (i) If I is an α - ideal in S , then $f(I)$ is an α - ideal in S' .
- (ii) If I' is an α - ideal in S' , then $f^{-1}(I')$ is an α - ideal in S .

Proof:- (i) Let I be an α - ideal in S . Then $f(I)$ is an ideal in S' (by Result 4 (i)). Let $x \in f(I)$. Then $x = f(a)$ for some $a \in I$. As I is an α -ideal in S , $\{a\}^{**} \subseteq I$. Hence $f(\{a\}^{**}) \subseteq f(I) \Rightarrow \{f(a)\}^{**} \subseteq f(I)$ (since f is an annihilator preserving) $\Rightarrow \{x\}^{**} \subseteq f(I)$. Hence $f(I)$ is an α - ideal in S' .

(ii) Let I' be an ideal in S' . Then $f^{-1}(I')$ is an ideal in S (by Result 4(ii)). Let $x, y \in S$ such that $\{x\}^* = \{y\}^*$ and $x \in f^{-1}(I')$. But then $f(\{x\}^*) = f(\{y\}^*)$ will imply $\{f(x)\}^* = \{f(y)\}^*$ (since f is an annihilator preserving). As $f(x) \in I'$ and I' is an α -ideal in S' , $f(x) \in I'$. i.e. $y \in f^{-1}(I')$. Hence $f^{-1}(I')$ is an α - ideal in S . ■

Theorem 3.10:- Let S and S' be bounded 0- distributive semilattices and $f: S \rightarrow S'$ is an onto homomorphism. Then for an α - ideal I' in S' , $f^{-1}(I')$ is an α - ideal in S provided $f^{-1}(\{x\}^*)$ is an α - ideal in S for any x in S' .

Proof:- Let I' be an α - ideal in S' . Then $f^{-1}(I')$ is an ideal in S (by Result 4(ii)). Let $x, y \in S$ such that $\{x\}^* = \{y\}^*$ and $x \in f^{-1}(I')$. But then $f(\{x\}^*) = f(\{y\}^*)$. Let $f(t) \in \{f(x)\}^*$ for some $t \in S$. Hence $f(x) \in \{f(t)\}^* \Rightarrow x \in f^{-1}(\{f(t)\}^*)$. By assumption $f^{-1}(\{f(t)\}^*)$ is an α -ideal in S . Therefore $\{x\}^* = \{y\}^*$ and $x \in f^{-1}(\{f(t)\}^*)$ imply $y \in f^{-1}(\{f(t)\}^*)$ (see Theorem 3.7(iii)). Thus $f(t) \wedge f(y) = 0 \Rightarrow f(t) \in \{f(y)\}^*$. This shows that $\{f(x)\}^* \subseteq \{f(y)\}^*$. Similarly we can show $\{f(y)\}^* \subseteq \{f(x)\}^*$. Hence $\{f(x)\}^* = \{f(y)\}^*$. As $f(x) \in I'$ (since $x \in f^{-1}(I')$ and I' is an α - ideal in S' , $f(y) \in I'$ (see Theorem 3.7 (iii)). Thus $y \in f^{-1}(I')$ and the result follows by Theorem 3.7 (iii). ■

4. Quasi-complemented semilattices

It was established by Varlet [7], a 0- distributive lattice is quasi-complemented if and only if for each $a \in S$ there exists $b \in S$ such that $\{a\}^{**} = \{b\}^*$. Using this Characteristic property we define

Definition 4.1:-A 0- distributive semilattice S is quasi-complemented if for each $a \in S$ there exists $b \in S$ such that $\{a\}^{**} = \{b\}^*$.

Let $I_\alpha(S)$ denote the set of all α - ideals in S . By Theorem 3.1, we have $\{A^0/A$ is a sub semilattice of $S\} \subseteq I_\alpha(S)$. The equality of these two sets holds if and only if S is quasi-complemented. This we prove in the following theorem.

Theorem 4.2:- S is quasi-complemented if and only if $I_\alpha(S) = \{A^0/A$ is a subsemilattice of $S\}$.

Proof:-Let $I_\alpha(S) = \{A^0/A$ is a sub semilattice of $S\}$. Let $x \in S$. Then $\{x\}^{**} \in I_\alpha(S)$ (by Result 3) $\Rightarrow \{x\}^{**} \in \{A^0/A$ is a sub semilattice of $S\} \Rightarrow \{x\}^{**} = A^0$ for sub semilattice A of S . As $x \in A^0$, $a \wedge x = 0$ for some $a \in A$. Thus $x \in \{a\}^* \Rightarrow \{x\}^{**} \subseteq \{a\}^*$. Now $a \in A \Rightarrow \{a\}^* \subseteq A^0 = \{x\}^{**}$. From both the inclusions we get $\{x\}^{**} = \{a\}^*$. Hence S is quasi-complemented. Conversely, let S be quasi-complemented and $I \in I_\alpha(S)$. Define $S(I) = \{x \in S / \{a\}^* \subseteq \{x\}^{**}, \text{ for some } a \in I\}$. $S(I) \neq \emptyset$ as $1 \in S(I)$. Let $x, y \in S(I)$. Then $\{a\}^* \subseteq \{x\}^{**}$ and $\{b\}^* \subseteq \{y\}^{**}$ for some $a, b \in I$. Being an ideal in S , there exists $t \in I$ such that $t \geq a, b$. Hence $\{t\}^* \subseteq \{a\}^* \cap \{b\}^* \subseteq \{x\}^{**} \cap \{y\}^{**} = \{x \wedge y\}^{**}$. This shows that $x \wedge y \in S(I)$ (since $t \in I$). Hence $S(I)$ is a sub semilattice of S . Claim that $I = (S(I))^0$. Let $a \in I$. As S is quasi-complemented, there exists $b \in S$ such that $\{a\}^{**} = \{b\}^*$. Hence $a \in (S(I))^0$. Thus $I \subseteq (S(I))^0$ (since $a \wedge b = 0$). Select $a \in (S(I))^0$. Then $a \wedge b = 0$, for some $b \in S(I)$. But then $\{c\}^* \subseteq \{b\}^{**}$, for some $c \in I$. Therefore $\{b\}^* \subseteq \{c\}^{**} \subseteq I$ (since I is an α -ideal) implies that $a \in I$ (since $a \in \{b\}^*$). This shows $(S(I))^0 \subseteq I$. Combining both the inclusions we get $I = (S(I))^0$. Hence $I \in \{A^0/A$ is a sub semilattice of $S\}$. Thus we get $I_\alpha(S) \subseteq \{A^0/A$ is a sub semilattice of $S\}$. As the reverse inclusion holds by Theorem 3.1, we get $I_\alpha(S) = \{A^0/A$ is a sub semilattice of $S\}$. ■

In the following theorem we give some more necessary and sufficient conditions for S to be quasi-complemented.

Theorem 4.3:- Following statements are equivalent.

- (i) S is quasi-complemented.
- (ii) For each α -ideal I in S , there exists a sub semilattice A of S such that $I = A^0$.
- (iii) Each α -ideal in S is a 0-ideal.
- (iv) For each α -ideal I in S there exists a sub semilattice A of S such that $I = \bigcup \{\{a\}^* / a \in A\}$.

Proof:- (i) \Leftrightarrow (ii). Follows by Theorem 4.2.

(ii) \Rightarrow (iii) Let I be an α -ideal in S . As S is quasi-complemented, $I = (S(I))^0$ where $S(I) = \{x \in S / \{a\}^* \subseteq \{x\}^{**}, \text{ for some } a \in I\}$ is a sub semilattice of S (see the proof of Theorem 4.2 (if part)). Let $x, y \in S$ such that

$x \leq \mathbb{Q}$ and $x \in \mathbb{Q}(\mathbb{Q})$. Then $\{a\}^* \subseteq \{x\}^{**}$, for some $a \in I$ and $\{x\}^{**} \subseteq \{y\}^{**}$ imply $y \in \mathbb{Q}(\mathbb{Q})$. Hence $S(I)$ is an up set of S .

Thus $S(I)$ is a filter in S and hence I is a 0-ideal in S .

(iii) \Rightarrow (ii) Let I be an α -ideal in S . As I is a 0-ideal, $I = F^0$, for some filter F of S . We know that any filter in S is a sub semilattice of S , the implication follows.

(ii) \Leftarrow (iv) Let A be a sub semilattice of S . Then $A^0 = \{x \in \mathbb{Q} / x \wedge a = 0 \text{ for some } a \in A\} = \{x \in \mathbb{Q} / x \in \{a\}^* = 0 \text{ for some } a \in A\} = \cup\{\{a\}^* / a \in A\}$.

Hence $I = A^0$ if and only if $I = \cup\{\{a\}^* / a \in A\}$.

Thus all the statements are equivalent. ■

For any ideal I in S , define $\mathbb{Q}^{\mathbb{Q}} = \{x \in S / \{a\}^* \subseteq (x), \text{ for some } a \in I\}$. Then we have **Theorem 4.4:-** For any ideal I in S , $\mathbb{Q}^{\mathbb{Q}}$ is a filter in S and if $I \subseteq O(P)$ for some prime ideal P in S , then $\mathbb{Q}^{\mathbb{Q}} \subseteq (S \setminus P)$.

Proof:- $\mathbb{Q}^{\mathbb{Q}} \neq \emptyset$ as $1 \in \mathbb{Q}^{\mathbb{Q}}$. Let $x, y \in \mathbb{Q}^{\mathbb{Q}}$. Then $\{a\}^* \subseteq (x)$ and $\{b\}^* \subseteq (y)$, for some $a, b \in I$. I being an ideal in S , there exists $t \in I$ such that $t \geq a, b$. Hence $\{t\}^* \subseteq \{a\}^* \cap \{b\}^* \subseteq (x) \cap (y) = (x \wedge y)$. This shows that $x \wedge y \in \mathbb{Q}^{\mathbb{Q}}$ as $t \in I$. Hence $\mathbb{Q}^{\mathbb{Q}}$ is a sub semilattice of S . Obviously, $\mathbb{Q}^{\mathbb{Q}}$ is an up set of S . Hence $\mathbb{Q}^{\mathbb{Q}}$ is a filter in S . Assume that $I \subseteq O(P)$ for some prime ideal P in S . Then $x \in \mathbb{Q}^{\mathbb{Q}} \Rightarrow \{a\}^* \subseteq (x)$ for some $a \in I \Rightarrow \{a\}^* \subseteq (x)$, for some $a \in O(P)$ (since $I \subseteq O(\mathbb{Q})$). As $a \in O(\mathbb{Q})$, $a \wedge \mathbb{Q} = 0$ for some $b \notin P$. Thus $b \in \{a\}^* \Rightarrow b \leq x$ (since $\{a\}^* \subseteq (x)$). Hence $x \notin P$ (since $b \notin P$ and P is a down set) implies $x \in (S \setminus P)$ and the result follows. ■

Thus we have proved that $I \subseteq O(P) \Rightarrow \mathbb{Q}^{\mathbb{Q}} \subseteq (S \setminus P)$ for any ideal I and any prime ideal P in S . In the direction of reverse implication we prove

Theorem 4.5:- If S is pseudo complemented, then $\mathbb{Q}^{\mathbb{Q}} \subseteq (S \setminus P) \Rightarrow I \subseteq O(\mathbb{Q})$ provided I is an α -ideal and P is a prime ideal in S .

Proof:- Let I be an α -ideal and P is a prime ideal in S such that $\mathbb{Q}^{\mathbb{Q}} \subseteq (S \setminus P)$. Let $x \in I$. As S is pseudo complemented, $\mathbb{Q}^{\mathbb{Q}} = \{x \in S / a^* \leq x, \text{ for some } a \in I\}$. Hence $x \in I \Rightarrow x^* \in \mathbb{Q}^{\mathbb{Q}} \Rightarrow x^* \in (S \setminus P)$ (since $\mathbb{Q}^{\mathbb{Q}} \subseteq (S \setminus P) \Rightarrow x^* \notin P \Rightarrow x \in O(P)$ (since $x \wedge x^* = 0$). This shows that $I \subseteq O(\mathbb{Q})$. ■

As every pseudo complemented semilattice is 0- distributive, from Theorem 4.4 and Theorem 4.5 we get

Corollary 4.6:- Let S be a pseudo complemented semilattice and I be an α -ideal in S . Then $I \subseteq O(P) \Leftrightarrow \mathbb{Q}^{\mathbb{Q}} \subseteq (S \setminus P)$ for any prime ideal P in S .

We know that every pseudo complemented semilattice is quasi-complemented but not conversely. In the following theorem we give a necessary and sufficient condition for a quasi-complemented lattice to be pseudo complemented.

Theorem 4.7:- Let S be a quasi-complemented lattice. Then S is pseudo complemented if and only if $I = (\alpha I)^0$, for each α -ideal I in S .

Proof:- Assume that $I = (\alpha I)^0$, for any α -ideal I in S . Let $x \in S$. As S is quasi-complemented, there exists $y \in S$ such that $\{x\}^{**} = \{y\}^*$. Thus $x \in \{y\}^*$ and $\{y\}^*$ is an α -ideal I in S (by Result 3) imply $x \in ((\alpha I)^0)^0$, by assumption. Hence $x \wedge z = 0$, for some $z \in (\alpha I)^0$. But then $\{a\}^* \subseteq \{z\}$, for some $a \in \{y\}^*$. Thus $\{x\}^* = \{y\}^{**}$ and $\{y\}^{**} \subseteq \{a\}^*$ imply $\{x\}^* \subseteq \{z\}$. Again $x \wedge \alpha = 0 \Rightarrow x \in \{x\}^* \Rightarrow \{z\} \subseteq \{x\}^*$. From both the inclusions we get $\{x\}^* = \{z\}$. This proves that the pseudo complement of x exists and equal to z . Hence S is pseudo complemented. Conversely, assume that S is pseudo complemented. Let I be an α -ideal in S . To prove that $I = (\alpha I)^0$. Note that αI is a filter in S (see Theorem 4.6). For any $x \in I, x^* \in \alpha I$ (since $\{x\}^* = (x^*)$) and hence $x \in (\alpha I)^0$ as $x \wedge x^* = 0$. Thus $I \subseteq (\alpha I)^0$. Conversely, let $x \in (\alpha I)^0$. Then $x \wedge \alpha = 0$ for some $y \in \alpha I$. Hence $a^* \leq y$, for some $a \in I$. As I is an α -ideal, $a \in I \Rightarrow a^{**} \in I$. Again $x \wedge \alpha = 0 \Rightarrow x \leq y^*$ and $a^* \leq y \Rightarrow y^* \leq a^{**}$ give $x \leq a^{**}$. I being a down set, $a^{**} \in I \Rightarrow x \in I$. This shows that $(\alpha I)^0 \subseteq I$. Combining both the inclusions we get $I = (\alpha I)^0$. ■

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ORIGINAL RESEARCH ARTICLE

PROTECTIVE ROLE OF *CURCUMA LONGA* EXTRACT SUPPLEMENTATION IN STZ INDUCED DIABETIC RATS

R. Lakshmidevi, Obaiah Jamakala, S. Mannur Ismail, B. Sujatha and M. Bhaskar*

Author affiliation:

Division of Animal
Biotechnology,
Department of Zoology,
S. V. University, Tirupati
– 517 502, A. P., India

E-mail:

matchabhaskar@yahoo.com,
matchabhaskar@gmail.com

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ABSTRACT:

Diabetes mellitus is a chronic metabolic disorder that prevents the body to utilize glucose completely or partially. It is characterized by raised glucose concentration in the blood and alterations in carbohydrate, protein and fat metabolism. *Curcuma longa* has several biological properties, including antidiabetic and antioxidant activity. The present study was designed to investigate the antidiabetic effect of *Curcuma longa* extract against streptozotocin (STZ) induced perturbations in blood glucose, body weights and hematological alterations in albino rats. Adult male albino Wister rats, weighing 180 ± 20 g was made diabetic by injecting STZ (40mg/kg body weight) intraperitoneally. Diabetic rats were supplemented with ethanolic extract of *Curcuma longa* rhizomes (250 mg/kg body weight) for a period of three weeks. After this period, rats were decapitated and blood was collected from control and experimental rats. Blood glucose levels, WBC, RBC, serum total proteins, albumin, globulin, creatinine, urea and cholesterol were significantly elevated in diabetic rats with decreased hemoglobin and body weight levels when compared with control. The above mentioned parameters were significantly restored to near normal by oral administration of *Curcuma longa* extract once daily for three weeks as compared to untreated rats. The results obtained indicated that *Curcuma longa* extract to be beneficial in preventing diabetes induced alterations in blood glucose, body weights and hematology in rats.

KEYWORDS: Diabetes; Streptozotocin; *Curcuma longa*; Blood glucose; Body weight; hematology; Rats.

INTRODUCTION:

Diabetes mellitus, is a chronic metabolic disorder commonly known as diabetes, is a disorder of carbohydrate metabolism characterized by high blood sugar level (hyperglycemia) and high level of sugar in urine (glycosuria), Insulin lowers the blood glucose level. Insulin is released from the pancreas to normalize the glucose level. In patients with diabetes, the absence or insufficient production of insulin causes hyperglycemia.

This can be due to failure in the formation of insulin or liberation or action [1]. Since insulin is produced by the β -cells of the islets of langerhans, any alterations in the number of functioning cells will decrease the amount of insulin synthesis. Many diabetics can produce sufficient insulin but some stimulus to the islets tissue is needed for its secretion.

This study is a part of the national non-communicable diseases (NCD) risk factor surveillance conducted in different geographical locations in India, This nation-wide NCD risk factor surveillance study showed that the prevalence of self reported Diabetes is higher in urban, intermediate in Peri-urban and lowest in rural areas.

Table 1. Top countries for estimated number of people with Diabetes, 2000-2030

Ranking	2000		2030	
	Country	People with Diabetes (Millions)	Country	People with Diabetes (Millions)
1	India	31.7	India	79.4
2	China	20.8	China	42.3
3	U.S.	17.7	U.S.	30.3
4	Indonesia	8.4	Indonesia	21.3
5	Japan	6.8	Japan	8.9
6	Pakistan	5.2	Pakistan	11.9
7	Brazil	4.6	Brazil	11.3
8	Bangladesh	3.2	Bangladesh	11.1

Ayurvedic Approach in Diabetes treatment:

Ayurvedic physicians have treated diabetes for thousands of years using a combination of regulated lifestyle and herbal formulations. The physicians also prescribed specific herbal formulations for the treatment of diabetes. In recent times, the safety and efficacy of these herbs have been validated by laboratory experiments and clinical trials. A large variety of compounds obtained from several plant families were found to hypoglycemic effect. The glycosides, glycans,

certain triterpenes, various types of sulfide molecules, polysaccharides, oils, vitamins, alkaloids, saponins, glycoproteins, peptides, amino acids and proteins isolated from various plant families showed beneficial effects in reducing the blood sugar. Many Indian medicinal plants are reported to be useful in diabetes [2, 3, 4, 5] and [6]. Medicinal plants used to treat hypoglycemic or hyperglycemic conditions are of considerable interest for ethno-botanical community as they are recognized to contain valuable medicinal properties in different parts of the plant and a number of plants have shown varying degree of hypoglycemic and anti-hyperglycemic activity. The active principles of many plant species are isolated for direct use as drugs, lead compounds or pharmacological agents. Several species of medicinal plants are used in the treatment of *Diabetes mellitus*. Traditional plant medicines or herbal formulations might offer a natural key to unlock diabetic complications.

Antioxidants play an important role to protect against damage by reactive oxygen species and their role in diabetes has been evaluated. Many plant extracts and products were shown to possess significant antioxidant activity. In the present study two of such plants were selected for evaluation of their antioxidant potential mediated antidiabetic activity.

Curcuma longa:

In Ayurvedic medicine, turmeric is thought to have many medicinal properties and in India many people use it as a readily available antiseptic for cuts, burns and bruises. Practitioners of Ayurvedic medicine say that it has fluoride which is thought to be essential for teeth. It is also used as an antibacterial agent. It is taken in some Asian countries as a dietary supplement, which allegedly helps with stomach problems and other ailments. It is popular as a tea in Okinawa, Japan. The active ingredient in turmeric is curcumin. U.S. National Institutes of Health had four clinical trials to study curcumin treatment for pancreatic cancer, multiple myeloma, Alzheimer's, and colorectal cancer. Curcumin has been used for thousands of years as a safe anti-inflammatory agent in a variety of ailments as part of Indian traditional medicine". A recent study involving mice has shown that turmeric slows the spread of breast cancer into lungs and other body parts. Turmeric also enhances the effect of taxol in reducing metastasis of breast cancer.

Researchers had discovered that turmeric-treated mice were less susceptible to developing type-II diabetes, based on their blood glucose levels, and glucose and insulin tolerance tests. They also discovered that turmeric-fed obese mice showed significantly reduced inflammation in fat tissue and liver compared to controls. They speculated that curcumin in the turmeric lessens insulin resistance and prevents type-II diabetes in these mouse models by dampening the inflammatory response provoked by obesity. Curcumin and its analogues have a variety of physiological and

pharmacological activities such as antiinflammatory, anticarcinogenic and antioxidant properties [4, 5, 6, 7 and 8].

The present research work was carried out to evaluate the beneficial effects and Protective role of Plant Extract of *Curcuma longa* against Streptozotocin induced Diabetes. Other objective of the study was to determine the role of plant extract on hematological and serum biochemical parameters.

MATERIAL AND METHODS:

Procurement and Maintenance of Animals:

Healthy female albino wistar rats (180±20g) were procured from Sri Venkateswara Enterprises, Bangalore, Karnataka, India (Reg. No: 237/99/CPCSEA), Animals were maintained in the animal house of Sri Venkateswara University, Dept of Zoology, Tirupati. Rats were kept in sterilized polypropylene cages lined with paddy husk (18"x10"x8"), The animals were maintained under a regulated 12 h light: 12 h dark scheduled at 24±1°C and relative humidity of 55±15%. Rats were provided standard rat chow (Sai Durga Feeds and Foods, Bangalore, India) and water *ad libitum*.

Procurement of chemicals:

All the chemicals used in the present study were Analar Grade (AR) and were obtained from Sigma (St. Louis, MO, USA), Fisher (Pittsburg, PA, USA), Merck (Mumbai, India), Ranbaxy (NEW Delhi, India), Qualigens (Mumbai, India) scientific companies.

For the present work Barnstead Thermoline water purification plant was used for Nano pure water, Kubota KR 200000T centrifuge for centrifugation of the homogenates and Hitachi UV -2000 Spectrophotometer for measuring the optical density values were used for high –quality results.

Streptozotocin:

Systematic (IUPAC) name: - 2-deoxy-2-([methyl (nitroso) amino] carbonyl) amino)- β -Dglucopyranose

Streptozotocin is a mixture of α - and β -stereoisomers. It occurs as pale yellow or off-white crystals, powder, or platelets, while the research grade may be off-white to tan solid. It is very soluble in water, ketones, and lower alcohols, slightly soluble in polar organic solvents, and insoluble in monopolar organic solvents. The pure compound is sensitive to humidity and light. Streptozotocin decomposes to diazomethane in alkaline solutions at 0°C. When heated to decomposition, it emits toxic fumes of nitrogen oxides (IARC 1978, HSDB 2001),

Preparation of *Curcuma longa* extract:

The fine powder of *Curcuma longa* rhizome powder were purchased (AGMARK symbol) in Tirupati. The powder is extracted by cold percolation with 95% ethanol for 24h. The extract was

recovered and 95% ethanol was further added to the plant material and the extraction was continued. The process was repeated three times. The three extractions were pooled together, combined, filtered and the filtrate was concentrated to dryness under reduced pressure in rotary evaporator. The resulting ethanol extract was air-dried. Finally light yellow powdery, crude ethanol extract of *Curcuma longa* was obtained. Without any further purification the plant crude ethanol extract was used in the study. Dose equivalent to 250mg/kg/body was calculated and suspended in 2% v/v Tween 80 solution for the experiment [4].

Induction of Diabetes:

Streptozotocin (STZ, 2-deoxy-2-({[methyl (nitroso) amino] carbonyl} amino)- β -Dglucopyranose) frequently used dosage is 40mg/kg BW [9] Single injection of STZ given intravenously or intraperitoneally to the adult rats to induce diabetes. After fasting for 18hrs, rats were injected intraperitoneally with a single dose of 40mg STZ (Sigma, St. Louis, Mo., USA) freshly dissolved in 0.1 M cold sodium citrate buffer, (pH 4.5), After injection, they had a free access to food and water was given 5% glucose solution to drink overnight to counter hypoglycemic shock. Diabetes in rats was identified by moderate polydipsia and marked polyuria. From the second day onwards fasting blood samples were collected from the rats by tail vein and blood glucose was measured by Accu chek Sensor comfort glucometer (Manufacture-Johnson and Johnson) to know the induction of diabetes. If the blood glucose levels were more than 300mg/dL, insulin (IIU Protamine Zinc Insulin) is given to the diabetic rats for diabetic condition for one week. After one week the rats with hyperglycemia (blood glucose level 250mg/dL) were selected and used for the experiment [10].

Grouping of animals:

- Group -1 : Normal Control rats.
- Group- 2 : Diabetic rats (Streptozotocin)
- Group -3 : Diabetic rats treated with 250 mg/Kg b.w. of *Curcuma longa*.

The blood samples were collected after completion of treatment i.e. on 22nd day of the treatment. The blood was used for the hematological parameters and separated serum was used for the serum biochemical parameters.

Estimation of Blood glucose:

Estimation of Blood glucose levels was carried out by using Accu Chek glucometer (Sensor Comfort),

Body Weight Changes:

Body weights of all groups of (eight) rats were recorded before and after treatments. The body weights of all groups were recorded at an interval of one week till the completion of the experiential period (21 days),

Hematology:

Blood samples were collected at the end of experimentation period immediately after sacrifice the blood was collected from the jugular vein and the blood was allowed into a graduated centrifuge tubes containing 10% EDTA, a common anticoagulant used for routine hematological work. The blood parameters like total erythrocytic count, total leucocyte count, hemoglobin and hematocrit (PCV) were estimated by using standard procedures.

Biochemical Parameters:

With out adding anticoagulant, the blood was collected into separate tubes and subject for centrifugation and serum collected was used for biochemical analysis. The parameters such as of glucose, total proteins, albumin, globulin, total cholesterol, creatinine, blood urea nitrogen, and bilirubin were estimated by using diagnostic kits supplied by SD fine, Ranbaxy, span diagnostics Ltd., India, and the procedures mentioned in the kit.

RESULTS AND DISCUSSION:**Blood Glucose:**

Blood glucose levels were measured using glucometer (Accu Chek) in control, diabetic, diabetic treated with *Curcuma longa* extract groups before and after treatment. In group II, the blood glucose levels were significantly increased after induction with STZ when compared with control.

Table1. Showing Blood glucose levels in the control and experimental animals:

Days	Group-I	Group-II	Group-III
1 st Day	89.33 ±8.38	282.16 ±37.92	280.16 ±34.62
10 th Day	106.50 ±9.35	306.66 ±30.32	208.67 ±24.41
21 st Day	119.52 ±12.56	271.33 ±42.78	137.16 ±23.92

Values are mean ± S.D. of 6 individual rats

Blood glucose levels were significantly decreased in the group III, where the rats were subjected to *Curcuma longa* extract. The various blood glucose values of alterations are as shown in Table-1 and Figure-1.

Most of the body cells use the sugar called glucose as their major source of energy. Glucose molecules are broken down within cells in order to produce adenosine triphosphate (ATP) molecules, energy-rich molecules that power numerous cellular processes. Glucose molecules are delivered to cells by the circulating blood and therefore, to ensure a constant supply of glucose to cells, it is essential that blood glucose levels be maintained at relatively constant levels. Level

constancy is accomplished primarily through negative feedback systems, which ensure that blood glucose concentration is maintained within the normal range of 70-110 mg/dl.

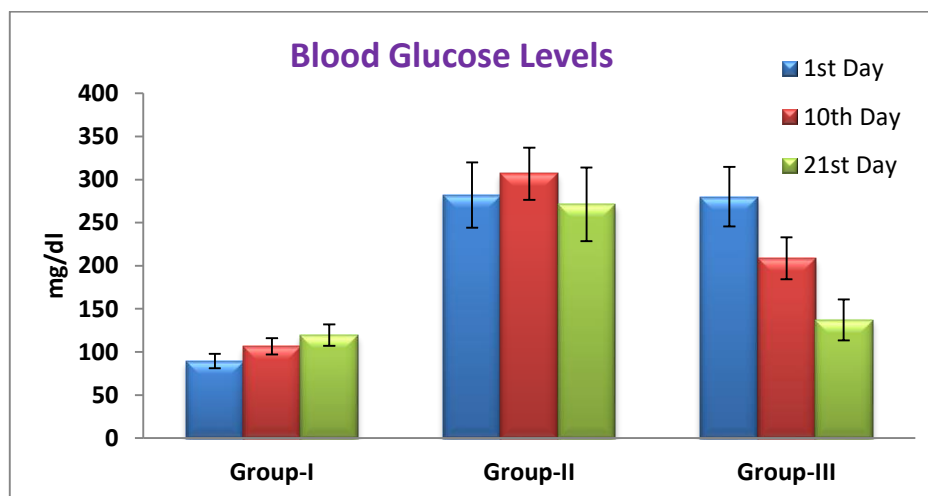


Figure 1. Blood glucose levels in control and experimental animals

The levels of glucose in the blood are monitored by the cells in the pancreas. If the blood glucose level falls to dangerous levels (as in very heavy exercise or lack of food for extended periods), the Alpha cells of the pancreas release glucagon, a hormone which alerts the liver to increase blood glucose levels and converts stored glycogen into glucose (Glycogenesis), Thus glucose is released into the blood stream, increasing blood sugar levels. There are several other causes for an increase in blood sugar levels. Among them diabetic stress due to the accumulation of reactive oxygen species is a major cause.

In the present study blood glucose levels were maintained at normal levels in control rats. A significant increase in glucose levels found in STZ treated rats could be due to the destruction of pancreatic beta-cells by STZ induced oxidative stress. The elevation of glucose in STZ treated rats was due to an oxidative stress produced in the pancreas, due to a single strand break in pancreatic islets DNA [11]. In experimental diabetes, enzymes of glucose and fatty acid metabolism are markedly altered; hence blood glucose levels were increased [12]. An increased hyperglycemia has been reported to induce oxidative stress due to glycation of proteins and accumulation of polyols [13]. One of the consequences of hyperglycemia is increased metabolism of glucose by sorbitol pathway. Besides this, other path ways, such as fatty acid and cholesterol biosynthesis favor hyperglycemia [14]. Hyperglycemia is currently considered to be primarily responsible for the auto-oxidative glycosylation, formation of hydro peroxides and free radicals, in particular the hydroxyl radical and low density lipoprotein oxidation [15].

The action of STZ in the pancreas is preceded by its rapid uptake by the B cells [16]. Rapid uptake by insulin-secreting cells has been proposed to be one of the important features determining

STZ diabetogenicity. Another aspect concerns the formation of reactive oxygen species [17]. A similar uptake of STZ also takes place in the liver. However, the liver and other tissues are more resistant to reactive oxygen species in comparison to pancreatic β cells and this resistance protects them against STZ toxicity [18, 19]. The formation of reactive oxygen species is preceded by STZ reduction. In beta cells of the pancreas its reduction occurs in the presence of different reducing agents. Since STZ exhibits a high affinity to the SH-containing cellular compounds, reduced glutathione (GSH), cysteine and protein-bound sulfhydryl groups (including SH containing enzymes) are very susceptible to its action [20]. However, other reducing agents such as ascorbate may also participate in this reduction [21, 22] proposed that one of the SH-containing compounds essential for proper glucose-induced insulin secretion is glucokinase (EC 2.7.1.2), being very vulnerable to STZ. STZ reacts with two -SH groups in the sugarbinding side of glucokinase resulting in the formation of the disulfide bond and inactivation of the enzyme. Glucose can protect glucokinase against the inactivation hindering the access of alloxan to the -SH groups of the enzyme [22].

In case of rats which were subjected to both STZ and plant extracts, the decrease in blood glucose was due to the hypoglycemic activity of the extracts. Changes of blood glucose levels in the group III where diabetic rats were treated with plant extract is due to the flavonoid and triterpenoid compounds in them. A number of investigations had reported that 6-gingerol, tannins, polyphenolic compound, flavonoids, triterpenoids possess analgesic, hypoglycemic and other pharmacological actions in various experimental animal models [23, 24]. The plant favorably affected glycolytic, gluconeogenic, and lipogenic enzymes to restore glucose homeostasis in STZ-induced diabetic rats [25]. The administration of *Curcuma longa* powder to diabetic animals has been shown to lower blood glucose levels and partially restore the activities of key enzymes of carbohydrate and lipid metabolism close to normal values in animal model systems [25, 26]. Oxidant induced alterations in the glucose utilizing system during diabetic manifestation is partially reversed by the administration of herbal extracts (Methanol extracts (75%) of *Aegle marmelos*, *Momordica charantia*, *Trigonella foenum-graecum*, *curcuma longa*, *Eclipta prostrata*, *Salacia oblonga*, *Coriandrum sativum*, *Vernonia anthelmintica* and *Murraya koenigii*) having antioxidant activity. Various reports demonstrated that the *Curcuma longa* have hypoglycemic, hypocholesterolemic and hyperinsulinemic effects on type 1 and type 2 *Diabetes mellitus* patients and experimental diabetic animals [27, 28]. Oral administration of extract from *Curcuma longa* lowers blood glucose and attenuates STZ-induced hyperlipidemia in diabetic rabbits. [29]. *Curcuma longa* rhizomes have been reported to possess active constituents showing blood glucose lowering activity in STZ induced diabetic rats [30]. Curumin has been shown to lower blood glucose levels in typ-2 diabetic KK-ay mice [31] and STZ treated rats [32]. The

administration of an aqueous extract of turmeric and abromine powder resulted in a significant reduction in blood glucose.

Body Weights:

Body weights of rats were measured using a digital balance at an interval of 10 days during the experimental period. The initial average weight of animals was in the range of 180 ± 200 g. In group II, the body weights were significantly decreased after induction with STZ when compared with the control rats. In the group III, the body weights were significant increased when compared with the diabetic (group II) rats. The changes of body weights are as shown in Table-2 and figure-2.

Table 2. Body Weight levels in the control and experimental animals:

Days	Group-I	Group-II	Group-III
1 st Day	242.53±28.41	229.66±31.38	227.64±15.73
10 th Day	260.43±24.31	188.42±13.76	220.88±25.57
21 st Day	276.17±19.28	140.19±14.71	237.33±19.02

Values are mean \pm S.D. of 6 individual rats

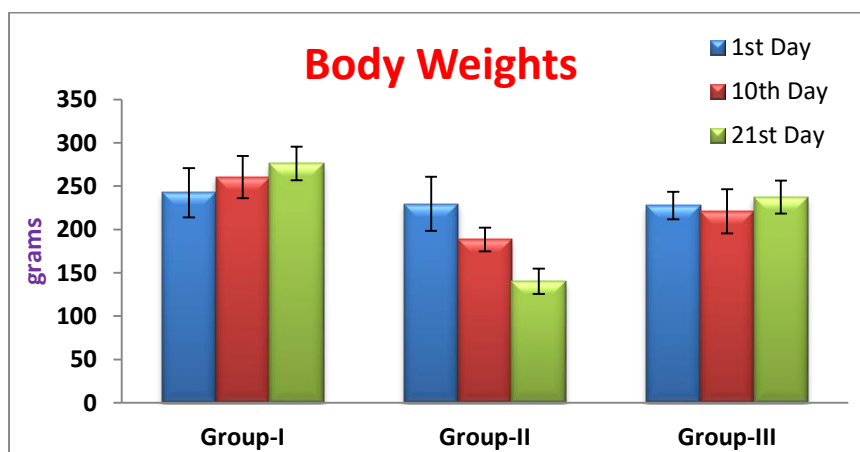


Figure 2. Body weights levels in control and experimental animals

Body weight is determined by energy intake on one hand and energy expenditure on the other. Imbalance between energy intake and expenditure results in a change in body weight. Organisms expend energy to perform daily work required for survival, such as finding food or evading predators. Metabolic efficiency refers to the amount of energy an organism has to exert to perform a given amount of work.

Metabolic efficiency varies among different species of organisms and among different individuals within a species. An individual with high metabolic efficiency will expend less energy to perform a specific task, such as climbing a set of stairs, than an individual with low metabolic efficiency. Compared with an individual with low metabolic efficiency, an individual with high metabolic efficiency is better able to preserve body weight during negative daily energy balance (expenditure exceeding intake), but likely to gain more weight during positive energy balance (intake exceeding expenditure). The ability of an organism to minimize reduction in body weight during long periods of starvation is likely associated with its survival. As a result, millions of years of evolution may have favored organisms with high metabolic efficiency [33, 34, 35, 36].

A constellation of clinical studies has established the close link between obesity and type 2 diabetes [37, 38]. This correlation, however, is not perfect; many diabetic patients are not obese, and many obese individuals are perfectly responsive to insulin. Regardless of whether a causal relationship exists between obesity and the body's response to insulin, beneficial effects of weight loss on the metabolic parameters of many diabetic patients are well documented [39, 40]. Thus, it is not surprising that a combination of weight loss and exercise is an effective treatment for many diabetic patients [41].

In the present study, STZ induced diabetic rats showed decreased level of body weights. The decrease in body weight in diabetic rats clearly shows a loss or degradation of structural proteins. Weight loss which is one of the clinical features of *Diabetes mellitus* may be due to the degeneration of the adipocytes and muscle tissues to make up for the energy lost from the body due to frequent urination and over conversion of glycogen to glucose. Weight loss is a very serious issue in the management of *Diabetes mellitus* [42].

Due to diabetes the structural proteins are known to contribute for the body weight [43]. STZ induced diabetes is characterized by a severe loss in body weight. The control diabetic animals showed a significant decrease in body weight compared with normal rats [44]. Changes in body weight in adult and non adult diabetic rats varied. Since the non adult diabetic rats are in the growing age, diabetic loss of weight is not seen in them and they even show a slight weight gain. In adult rats, however diabetes is accompanied by loss of weight [45]. Weight loss during diabetes is mainly related to urinary glucose excretion because cells become to use glucose. Another factor could be also the osmotic diuresis resulting in hyper osmotic dehydration.

In the case of diabetic rats treated with *Curcuma long* extract (group III) increased levels in body weights were observed. They showed almost same response as that of control rats. This shows that *Curcuma long* plant extract opposes degeneration of the adipocytes and muscle tissues which

occurs during diabetic stress in order to make up for the energy lost from the body due to frequent urination and over conversion of glycogen to glucose.

Hematological Parameters:

Significant decreased levels of hemoglobin, during diabetes when compared with corresponding control group. But WBC and RBC was increased in diabetes rats.

Table 3. Blood Parameters levels in the control and experimental animals:

Parameters	Group I	Group II	Group III
Haemoglobin (gm/dl)	12.8± 0.7	9.2± 0.86	12.4± 0.98
RBC (millions/ μ l)	4.5± 0.32	3.8± 0.37	4.8± 0.43
WBC (cells/ μ l)	5600± 348.23	5800± 316.23	6400± 361.24

Values are mean \pm S.D. of 6 individual rats

Administration of *Curcuma longa* extract tended to bring the values to near to normal range and the effect was more pronounced in the group of rats treated with plant extract.

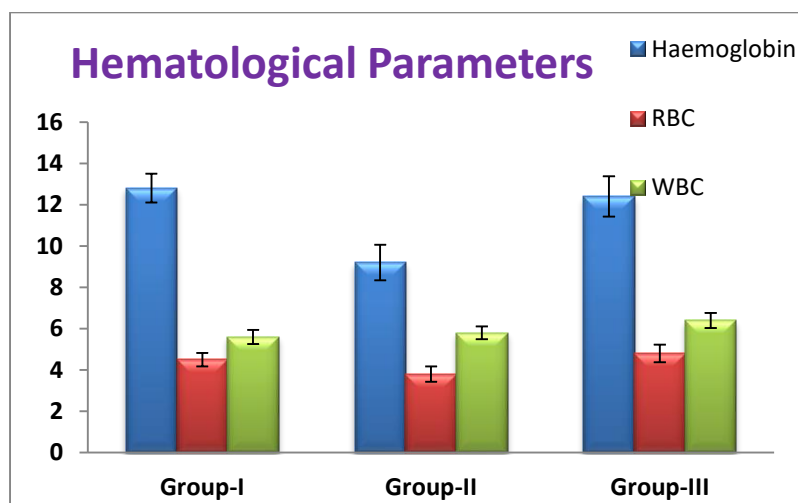


Figure 3. Blood Parameters levels in the control and experimental animals

In diabetic rat haemoglobin (Hb) levels were found to be low when compared to normal rats, as the Hb synthesis might also be depressed. Thus *Curcuma longa* treated rats showed improved levels of Hb because of its glucose lowering effect. The various proteins including hemoglobin undergo an enzymatic glycation in diabetes. Glycosylated hemoglobin was found to be increased in diabetes condition and the amount of increase is directly proportional to that of fasting blood

glucose level [46]. Lowered levels of hemoglobin were observed in diabetic rats which might be due to the increased formation of HbA1c. Hyperglycemia is the clinical hallmark of poorly controlled diabetes, which is known to cause glycation, and also known as nonenzymatic glycosylation. HbA1c was found to increase in patients with *Diabetes mellitus* and the increase was directly proportional to the fasting blood glucose levels. Previous studies reported that the active components present in *Curcuma longa* were effective in raising the hemoglobin levels in rats.

The link between chronic diseases and anemia is well characterized [47]. The occurrence of anaemia in *Diabetes mellitus* has been reported due to the increased non-enzymatic glycosylation of RBC membrane proteins, which correlates with hyperglycemia. Oxidation of these proteins and hyperglycaemia in *Diabetes mellitus* causes an increase in the production of lipid peroxides that lead to haemolysis of RBC. The major pathological consequences of free radical induced membrane lipid peroxidation include increased membrane rigidity, decreased cellular deformability, reduced erythrocyte survival, and lipid fluidity [48]. In this study, the RBC membrane lipid peroxide levels in diabetic rats were not measured. The reversal effect shown by the *Curcuma longa* were effective in reduce the RBC levels in rats.

Peripheral WBC count has been shown to be associated with insulin resistance, type 2 diabetes, coronary artery disease, stroke, and diabetes micro- and macrovascular complications [49, 50]. Peripheral blood leukocytes are composed of polymorphonuclear cells, including monocytes as well as lymphocytes. Polymorpho- and mononuclear leukocytes can be activated by advanced glycation end products, oxidative stress, angiotensin II [51, 52], and cytokines in a state of hyperglycemia. Leukocytes may be activated through the release of cytokines, such as TNF- α , transforming growth factor-1, superoxide, nuclear factor κ B (NF- κ B), monocyte chemoattractant protein 1, interleukin-1 β , and others [53] to participate in the pathogenesis of diabetic micro- and macrovascular complications. The profile of the WBC count reflects the balance between the rate of granulocyte production and that of WBC. [54] reported that diabetes in mice was accompanied by moderate neutrophilic leukocytosis and prolonged circulation times of neutrophils and monocytes, and a shortened circulation time of lymphocytes, which increases the susceptibility to infection. The active components present in *Curcuma longa* decreases the WBC count.

Serum Biochemical Parameters:

A significant increase in serum total proteins (5.42), albumin (2.52) and globulin (3.86) was recorded in diabetic untreated rats when compared to the normal control rats (Group-I), *Curcuma longa* treated diabetic rats showed significant decrease in serum total proteins (4.72), albumin (2.24) and globulin (2.68) levels compared to the diabetic rats and also nearly levels of the control rats.

Table 4. Serum Biochemical Parameters levels in the control and experimental animals:

Parameters	Group I	Group II	Group III
Total Proteins (g/dl)	4.68± 0.53	5.42± 0.92	4.72± 0.34
Albumin (g/dl)	2.12± 0.32	2.52± 0.48	2.24± 0.36
Globulin (g/dl)	2.44± 0.38	3.86± 0.97	2.68± 0.82

Values are mean ± S.D. of 6 individual rats

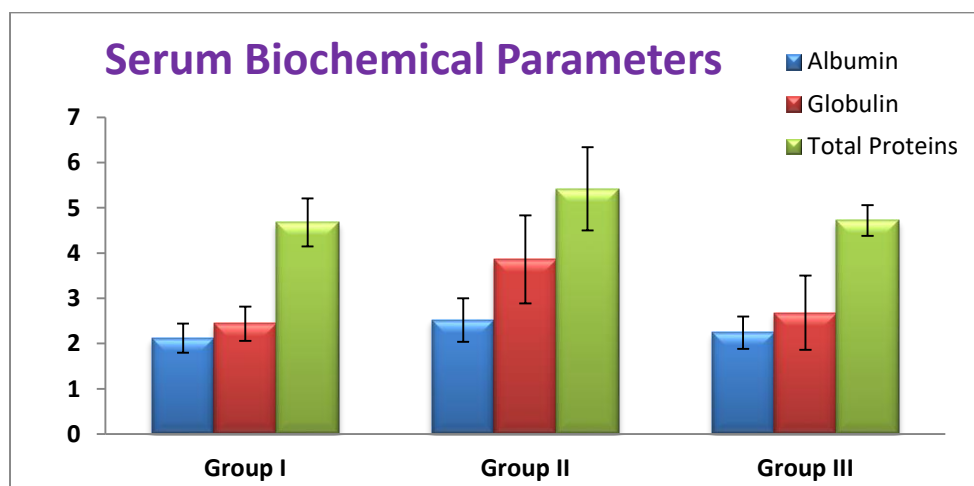


Figure 4. Serum Biochemical Parameters levels in the control and experimental animals

Hyperlipidemia is a known complication of *Diabetes mellitus* and coexists with it and is characterized by increased levels of cholesterol and also changes in lipoprotein patterns. Interest in the study of plasma lipids in diabetes arises from the widely acknowledged higher incidence of atherosclerotic disease which is a major cause of premature death in diabetic patients whether it is type-I or type-II [55].

In the present investigation, results show a significant in plasma albumin, globulin, total protein levels in diabetic rats which are in agreement with many earlier reports. These alterations in diabetes are due to enhanced catabolism of proteins [46, 56]. It is well known that in insulin deficiency (diabetes) decreased protein synthesis and increased protein degradation lead to release of amino acids which are directed for gluconeogenesis. Lowered albumin and globulin in diabetic rats might be due to increased degradation and/or decreased production and/or increased urinary excretion of these substrates. Microalbuminuria in STZ-diabetic rats and humans is well documented with increased albumin excretion range (AER) [57] and formation of advanced glycation and products (AGEs) leading to kidney damage and diabetic glomerulopathy [58]. *Curcuma longa* supplementation appears to have rectified this abnormality in diabetic rats as evidenced by significantly elevated serum albumin levels in rats receiving *Curcuma longa* observed that the risk of

progression to over proteinuria can be reduced by improved glycemic control. In the present study also, the glycemic control exerted by *Curcuma longa* might have contributed to the restored plasma albumin levels. Moreover, supplementation of *Curcuma longa* might have induced protein synthesis by effective utilization of the available amino acids and also by reducing protein catabolism and/or by regulating certain signal transduction mechanisms and enzymes. Phytochemicals of *Curcuma longa* extract appear to have mitigated the metabolic abnormalities and restored the urea and creatinine levels.

Insulin is the principal regulatory hormone involved in the tight regulation of fuel metabolism. In response to blood glucose levels, it is secreted by the β -cell of the pancreas and exerts its effects by binding to cell surface receptors that are present on virtually all cell types and tissues [59]. In the present study, normal rats treated with *Curcuma longa* extract showed normal levels of insulin while diabetic rats had shown very low levels of insulin as a consequence of pancreatic β -cell damage indicating low pancreatic β -cell activity followed by Streptozotocin.

The serum biochemical parameter of control rats are Creatinine (2.16), Urea (26.945) and (95.74) was tabulated in Table-1. Increased levels of the creatinine (2.83), urea (35.36) and cholesterol (135.38) was recorded in the diabetic untreated rats (group-II), *Curcuma longa* treated rats shows significantly decreased levels of creatinine (2.34), urea (28.28) and cholesterol (102.68) when compared to the diabetic rats and also near to the normal rats (Table-5 and Figure-5),

Table 5. Serum Biochemical Parameters levels in the control and experimental animals

Parameters	Group I	Group II	Group III
Creatinine (mg/dl)	2.16± 0.16	2.83± 0.42	2.34± 0.68
Urea (mg/dl)	26.94± 3.94	35.36± 6.46	28.28± 5.98
Cholesterol (mg/dl)	95.74± 10.92	135.38± 23.6	102.68± 18.74

Values are mean \pm S.D. of 6 individual rats

Hyperlipidemia is a known complication of *Diabetes mellitus* and coexists with it and is characterized by increased levels of cholesterol and also changes in lipoprotein patterns [60]. Interest in the study of plasma lipids in diabetes arises from the widely acknowledged higher incidence of atherosclerotic disease which is a major cause of premature death in diabetic patients whether it is type-I or type-II [51, 55].

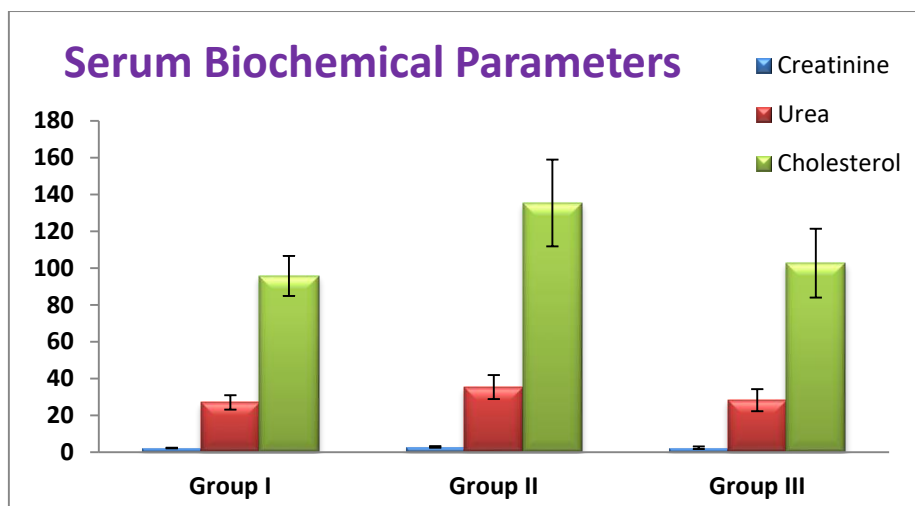


Figure 5. Serum Biochemical Parameters levels in the control and experimental animals

In the present investigation, results show a significant increase in urea and creatinine levels in diabetic rats which are in agreement with many earlier reports. These alterations in diabetes are due to enhanced catabolism of proteins [56]. It is well known that in insulin deficiency (diabetes) decreased protein synthesis and increased protein degradation lead to release of amino acids which are directed for gluconeogenesis. Due to increased catabolism of proteins and amino acids, hepatic ureagenesis and creatinine production are elevated in diabetic rats [46]. As a consequence, increments in urea and creatinine levels occur in plasma. Microalbuminuria in STZ-diabetic rats and humans is well documented with increased albumin excretion range (AER) [57] and formation of advanced glycation and products (AGEs) leading to kidney damage and diabetic glomerulopathy [58]. *Curcuma longa* supplementation appears to have rectified this abnormality in diabetic rats as evidenced by significantly elevated serum albumin levels in rats receiving *Curcuma longa* observed that the risk of progression to over proteinuria can be reduced by improved glycemic control. In the present study also, the glycemic control exerted by *Curcuma longa* might have contributed to the restored plasma albumin levels. Moreover, supplementation of *Curcuma longa* might have induced protein synthesis by effective utilization of the available amino acids and also by reducing protein catabolism and/or by regulating certain signal transduction mechanisms and enzymes. Phytochemicals of *Curcuma longa* extract appear to have mitigated the metabolic abnormalities and restored the urea and creatinine levels.

Insulin is the principal regulatory hormone involved in the tight regulation of fuel metabolism. In response to blood glucose levels, it is secreted by the β -cell of the pancreas and exerts its effects by binding to cell surface receptors that are present on virtually all cell types and tissues [59]. In the present study, normal rats treated with *Curcuma longa* extract showed normal

levels of insulin while diabetic rats had shown very low levels of insulin as a consequence of pancreatic β -cell damage indicating low pancreatic β -cell activity followed by Streptozotocin.

SUMMARY AND CONCLUSION:

In present investigation, anti-diabetic properties of *Curcuma longa* in STZ induced diabetic rat hematological parameters and serum biochemical parameters were studied with the blood glucose and body weight levels. Wistar stain male albino rats of 3 months age were used in the present study. They were maintained in the animal house at $24\pm 2^\circ$ C, humidity of 45-64% with photoperiod of 12 hours light and 12 hours darkness. Regarding selection of age and grouping of animals as mentioned in "Material and methods" was taken in to consideration to select 3 months old rats as adult age in this experimental design for expected results. They were maintained in clean poly propylene cages and fed with standard rat pellet diet (Hindustan lever Ltd., Mumbai) and water *ad libitum*. The animals of same age group were divided in to 3 groups, each group consists of six animals and the division of groups is as follows.

- Group -1 : Normal Control rats.
Group- 2 : Diabetic rats (Streptozotocin)
Group -3 : Diabetic rats treated with 250 mg/Kg b.w. of *Curcuma longa*.

The blood samples were collected after completion of treatment i.e. on 22nd day of the treatment. The blood was used for the hematological parameters and separated serum was used for the serum biochemical parameters.

The summary of the results from this study is presented as follows:

1. No significant blood glucose level changes were observed in control rats. In diabetic rats blood glucose levels were increased. *Curcuma longa* rats, which were subjected to *Curcuma longa* extract supplementation showed decreased levels of blood glucose. This may be due to the antidiabetic compounds present in *Curcuma longa*.
2. We observed body weight changes in the current investigation in all experimental rats. In diabetic rats, the body weights were significantly decreased after induction of STZ. The decrease in body weight in diabetic rats clearly showed a loss or degradation of structural proteins. Weight loss which is one of the clinical features of *Diabetes mellitus* may be due to the degeneration of the adipocytes and muscle tissues to make up for the energy loss from the body due to frequent urination and over conversion of glycogen to glucose. In the *Curcuma longa* treated rats, body weights were gained near to control levels after treatment with *Curcuma longa* plant extract.
3. The blood parameters revealed significant alterations in all experimental groups. In group-II (Diabetic rats) the blood parameters such as Hemoglobin, RBC, WBC counts were highly decreased

which suggest the anemic condition in the body, and increased count was observed in group-III (Diabetic + *Curcuma lona*) treated rats.

4. Increased levels were observed in Albumin, Globulin, Total proteins, Creatinine, Urea and Cholesterol in group-II (Diabetic) rats indicating its impact on Soluble proteins, disturbance on immune mechanism etc, whereas the same were decreased in group-III treated with *Curcuma longa* plant extract of diabetic rats.

To conclude the present findings reveals that treatment with selected dosage of *Curcuma longa* extract is beneficial in countering the alterations in various blood and serum biochemical parameters. This study drawn a conclusion, stating that *Curcuma longa* treatment to diabetic rats may be beneficial to improve the metabolic efficiency and thereby improve the health status. Thus *Curcuma longa* may be useful in the formulation of herbal drugs which can be used in the treatment of diabetes.

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ORIGINAL RESEARCH ARTICLE**POLLINATION AND BIODIVERSITY****Pollobi Duara****Author affiliation:**

Department of Zoology,
Gauhati University,
Guwahati and Jorhat
College, Jorhat, Assam,
INDIA

E-mail:

pallu111.111@gmail.com

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ABSTRACT:

The procedure of transportation of dusts from stamens to the ovary in a similar blossom or starting with one bloom then onto the next in similar species is called fertilization. Plants must depend on dust vectors, from twist to bugs to feathered creatures, to transport their dust to another person. The investigation of fertilization unites many controls, for example, organic science, cultivation, entomology, and environment. Fertilization by bugs regularly happens on plants that have created hued petals and a solid aroma to draw in creepy crawlies, for example, honey bees, wasps and once in a while ants (Hymenoptera), insects (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). Fertilization is basic for nourishment generation and human employments, and straightforwardly interfaces wild biological communities with horticultural creation frameworks. Tropical timberlands are notable focuses of biodiversity. At the point when the quantity of blooming plant builds, pollinator creepy crawly assorted variety going to blossom likewise increments.

KEYWORDS: Pollination, Biodiversity, benefit.

INTRODUCTION:

Creepy crawly plant collaboration alludes to the exercises of two sorts of creatures: bugs that search out and use plants for sustenance, shield, egg-laying destinations, and the plants that give those assets. The collaborations can be gainful to both the plant and the creepy crawly, as outlined by pollination. The procedure of transportation of dusts from stamens to the ovary in a similar blossom or starting with one bloom then onto the next in similar species is called fertilization. Plants must depend on dust vectors, from twist to bugs to feathered creatures, to transport their dust starting with onto the next individual blossom or starting with one bloom then onto the next in similar species is called fertilization. Fertilization is the procedure by which plants sexually repeat.

Plants and creatures have a nearby interrelationship for their survival, spread and control. [1] States that "Sexual generation is similarly as critical for plants as it is for creatures with regards to sex they can't simply get up and get themselves a mate.". Most organic product crops expect fertilization to guarantee that natural product sets. Dust grains get got on the sticky surface of the stigma, germinate and create a tube that becomes down the style and joins with the female cell in the ovary. This union is called preparation. After preparation occurs, seeds create and the organic product develops. The procedure is somewhat extraordinary in angiosperms (blossoming plants) from what it is in gymnosperms (other seed plants). In angiosperms, after the pollen grain has landed on the stigma, it creates a pollen tube which grows down the style until it reaches the ovary. Sperm cells from the pollen grain then move along the pollen tube and enter the egg cell through the micropyle and fertilise it, resulting in the production of a seed.

In gymnosperms, the ovule is not contained in a carpel, but exposed on the surface of a dedicated support organ, such as the scale of a cone, so that the penetration of carpel tissue is unnecessary. Flowers can attract pollinators by providing ample nectar of the right composition, and by advertising this nectar by deep shape and recognizable floral patterns, by providing excess pollen as food, or by providing shelter or a place to raise young [2]. The study of pollination brings together many disciplines, such as botany, horticulture, entomology, and ecology. The pollination process as an interaction between flower and pollen vector was first addressed in the 18th century by Christian Konrad Sprengel.

Types of Pollination:

Cross-pollination: The transfer of pollen between two different species or varieties

Self-pollination: The transfer of pollen within a single plant or among several plants of the same variety .

Abiotic: Abiotic pollination refers to situations where pollination is mediated without the involvement of other organisms. The most common form of abiotic pollination, anemophily is pollination by wind. Hydrophily is pollination by water

Biotic: More commonly, the process of pollination requires pollinators: organisms that carry or move the pollen grains from the anther of one flower to the receptive part of the carpel or pistil (stigma) of another. This is biotic pollination. The majority of these pollinators are insects, but about 1,500 species of birds and mammals have been reported to visit flowers and may transfer pollen between them. Entomophily, pollination by insects, often occurs on plants that have developed colored petals and a strong scent to attract insects such as, bees, wasps and occasionally ants (Hymenoptera), beetles (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). In zoophily, pollination

is performed by vertebrates. Ornithophily or bird pollination is the pollination of flowering plants by birds. Chiropterophily or bat pollination is the pollination of flowering plants by bats.

POLLINATING INSECTS:

Bees and wasps:

They have a place with arrange Hymenoptera. Bumble bees fly out from bloom to blossom, gathering nectar (later changed over to nectar), and dust grains. The honey bee gathers the dust by rubbing against the anthers. The dust gathers on the rear legs, in a structure alluded to as a "dust wicker container". As the honey bee flies from blossom to bloom, a portion of the dust grains are exchanged onto the disgrace of different blooms.

Butterflies and Moths:

Lepidoptera (butterflies and moths) likewise fertilize plants to different degrees. They are not real pollinators of nourishment crops, but rather different moths are imperative pollinators of other business harvests, for example, tobacco. Moth fertilizes night-time blooms.

Beetles:

Scarabs of species that spend significant time in eating dust, nectar, or blooms themselves, are imperative cross-pollinators of a few plants, for example, individuals from the Araceae and Zamiaceae that deliver massive measures of dust.

Thrips and Ants:

Various thrips are comparatively minor opportunist pollinators. Ants also pollinate some kinds of flowers, but for the most part they are parasites, robbing nectar without conveying useful amounts of pollen to a stigma. Ants have traditionally been considered as poor or ineffective pollinators [2, 3].

Hoverflies:

Hoverflies are important pollinators of flowering plants worldwide.

Diptera:

Some Diptera (flies) may be the main pollinators at higher elevations of mountains, whereas *Bombus* species are the only pollinators among Apoidea in alpine regions at timberline and beyond.

IMPORTANCE:

Pollination is a keystone process in both human managed and natural terrestrial ecosystems. Is an essential service that depends to a large extent on the symbiosis between species, the pollinated and the pollinator? Pollination is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems. Pollinators account for a major

share of global biodiversity in their own right. Wild bees and flies are two very diverse groups of species responsible for pollinating many flowering plants. Damaged plants are less attractive to pollinators as a result of changes in floral characters [4].

Pollinating insects are sensitive to the area and richness of floral resources in patches, even at relatively small scales. Therefore, larger wild flower plantings with more diverse flower species mixes are more suitable for the conservation of wild pollinators. Insect pollinators play a critical role in the population dynamics and evolution of floral traits in many plant species. Tropical forests are well known centres of biodiversity [5] and recently much interest has been focused on the ecological processes responsible for generating and maintaining the diversity [6]. All floral visitors to a plant species are important, as in the- documentation of all visitors spatially and temporally. The vast majority of insects visits a range of flowers of different plant species according to availability and the majority of plants are visited several or many insects species [7], although not all may be effective pollinators. Bees and most butterflies are able to tackle a broad range of flower species and are responsible for the pollination of many insect pollinated plants.

ANTHROPOGENIC EFFECT:

There is a growing recognition that plant – pollinator interactions can be drastically influenced by anthropogenic changes to ecosystems, climate change, habitat fragmentation, agricultural intensification, urbanization, pollution, pesticides and species invasions all have the potential to affect plant pollinator interactions directly or indirectly. Various studies indicate that higher the number of flowering plants greater the diversity of pollinating insects. Fragmentation and destruction of natural semicultural habitats may result in the loss of bee diversity and disruption of plant pollinator interactions

Ecology of pollinating insects:

The important biological inquiries emerge were-the means by which and why are creatures pulled in to bloom, by what method would animals be able to and blossoming plants go about as particular specialists upon each other, bringing about co-development of a mutualistic relationship. Creepy crawlies are pulled in to blossoms since its a lifestyle, the blooms help them to survive. The piece of the plant that really pulls in creepy crawlies is the vivid petals, once they have arrived on it, the dust appended to the stamens make them stay gather. When the quantity of blooming plant expands pollinator bug decent variety going by blossom likewise increments. In this way, there is an immediate connection between them. A huge number of years of co-advancement between blossoming plants and their pollinators, with each taking part species populace going about as a specific operator on the other, have brought about finished whelming biodiversity of the two creepy

crawlies and blooming plants. Scrounging pollinators ordinarily move short separations between blossoms, regularly going by neighbouring plants [8]. The shape and shades of the blooms, their fragrance, their area on the stalks, the season and day by day timetable of their dust and nectar offerings, are balanced absolutely to pull specifically types of creepy crawlies and those masters thus are hereditarily adjusted to react to specific sorts of blossoms [9].

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ORIGINAL RESEARCH ARTICLE

PATTERN OF DISTRIBUTION AND SUBSTRATE SPECIFICITY OF MACROLICHENS
IN SHIMOGA DISTRICT OF SOUTHERN INDIAVinayaka.K. S.^{1*} and Y. L. Krishnamurthy²**Author affiliation:**

¹Department of Botany,
Kumadvathi First Grade
College, Shikaripura,
Shimoga 577 427

²Biodiversity and Bio-
prospecting Laboratory,
Post Graduate
Department of Studies
and Research in Applied
Botany, Kuvempu
University,
Shankaraghatta,
Shimoga, Karnataka, India
-577 451

E-mail:

ks.vinayaka@gmail.com

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ABSTRACT:

The species richness is a fundamental measure of biodiversity and current trends of declining species richness in many regions of the world are major ecological, economical and cultural problem. Understanding the pattern of diversity and distribution of organisms is a key aspect in conservation and management. The study area is situated at 13°27' and 14°39' N latitude to 74°38' and 76°4' E longitude and represent 8465 sq. km with a forest cover of 3270 sq.km. The temperature varies from 19 to 32°C and the mean annual rainfall is 2800 mm. The study site was selected by random sampling method and the lichen species were collected from different substrates and identified. The area is harbored with different types of forests supports luxuriant growth of lichens. The present study investigates 944 individuals belong to 95 species and they represent 31 genera among 14 families. The corticolous lichens were abundant (71 species). The Parmeliaceae (41.6%) is dominated family followed by Physciaceae (33.5%). The pattern of distribution of lichens varies with forest type and altitude. The tree main trunk represents 44.4%, branches (27.7%), fallen twigs (16.6%) and others 11.2%. Out of 95 species 75 percent were foliose and 20 percent were fruticose lichens. The important host trees were *Terminalia paniculata*, *Ficus tsihela*, *Tectona grandis*, *Rhandia dumetorium* etc. Majority of the lichen species are found to favors the wood. This brings out the importance of woody microhabitats in promoting lichen species diversity. Some important macro lichen species of the study area are *Bulbothrix* spp, *Coccocarpia* spp, *Dirinaria* spp, *Heterodermia* spp, *Leptogium* spp, *Parmotrema* spp, *Usnea* spp, *Ramalina* spp etc. Out of these parmelioid lichens were highly diverse. *Ramalina pacifica* was high in abundance and *Pseudocyphelaria aurata* were low in number.

KEYWORDS: Macrolichens, Tropical lichens, Parmotrema, Western Ghats.

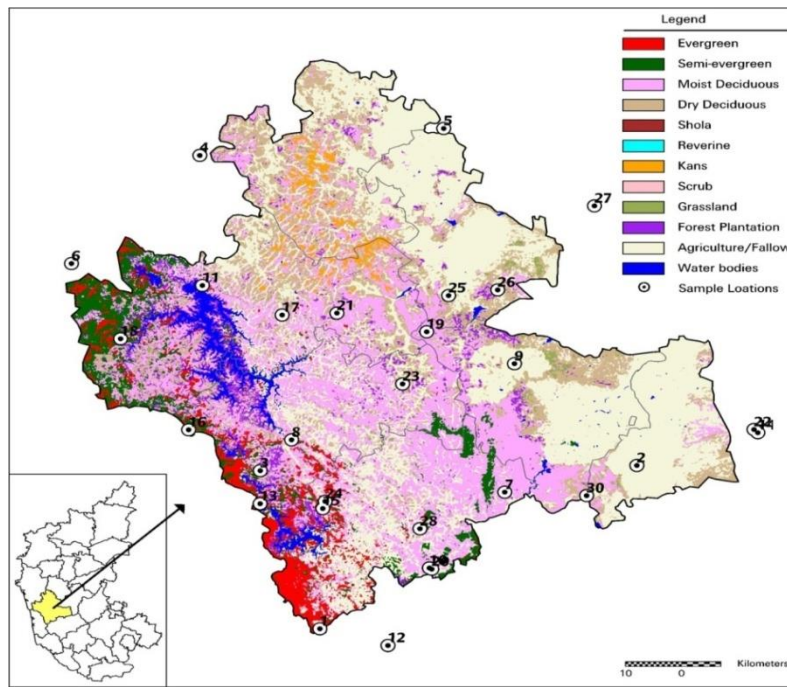
INTRODUCTION:

Lichens are among the most widely distributed and dominant groups of organisms in the world, and cover as much as eight per cent of the earth's surface [1]. These little plants are the most successful symbiotic organisms on earth and can grow on almost anything and anywhere. They are found colonizing on rocks, soil, trunks and branches of tree, animal shells, bones, insect's backs, humus, synthetic material, bricks, cement, concrete roofs and walls, glass and iron [2,3,4].

Although there are several publications available on the lichen-photophyte relationships from European and other countries, only scanty information [5,6] is available for Indian lichens. The aim of this paper is to elucidate the microhabitat and host specificity of macrolichens and to evaluate the important host species exploited by them. In a heterogeneous forest land the diversity of lichens is variable as the supporting host trees provide space for different types of lichens. Some lichens show preference for certain trees mostly based on the nature of bark and its microclimatic and chemical conditions. Understanding the host preference is an important aspect in lichen ecology as these organisms play an essential functional role in forest ecosystem. In addition knowledge of degree of host specificity of lichens serves as a useful purpose in the estimation of their diversity and conservation [5,7]. Microhabitat differences play an essential role in explaining patterns of species composition and diversity at the scale of individual trees. Microhabitats vary primarily along the height of the tree, from the base of the trunk to the tree crown [8,9]. Lichens are widely used as indicators of continuity and health of the forest [10,11,12,13]. Lichens have strongest correlation emerged between tree density and host tree diversity on lichen distribution. Lichens have efficient mechanisms for accumulation of nutrients from the environment and also given the brief account on lichen distribution and identification methods [14]. Studied Epiphytic lichens and bryophytes with their host specificity [15,16]. The difference in species diversity on different substrates and the effect of both substrate and site variation [17].

METHODOLOGY:

Survey had been carried out by using transect method. Each transects measuring 50x10 m laid in different forest locations of study site. Again each transects were divided into subquadrats of 20 x 20cm for collection and identification of lichens. Along with this we have also collected random samples as opportunistic collection which encounters other than quadrats. The representative lichen specimens were collected along with their substratum irrespectively of their growth form. The three major substrates rock, soil and wood were considered as the microhabitats. The woody substrates included tree trunks, branches, twigs, wood logs and stumps.



- | | | | | |
|-----------------|----------------|------------------|--------------------|-----------------|
| 1. Agumbe | 2. Bhadravathi | 3. Chakra | 4. Chandragutti | 5. Chikkerur |
| 6. Gerusoppa | 7. Hanagere | 8. Haniya | 9. Harnahalli | 10. Herambapura |
| 11. Honnemaradu | 12. Hosahalli | 13. Hulikal | 14. Idlumane | 15. Kavaledurga |
| 16. Kodachadri | 17. Kodluthota | 18. Kogar | 19. Konehosur | 20. Kuppalli |
| 21. Mupanne | 22. Nittur | 23. Rippenpet | 24. Shankaraghatta | 25. Shettihalli |
| 26. Shikaripura | 27. Sorba | 28. Thirthahalli | 29. Ullur | 30. Umblebilu |

Figure 1: Map of Shimoga district in Karnataka showing sampling sites

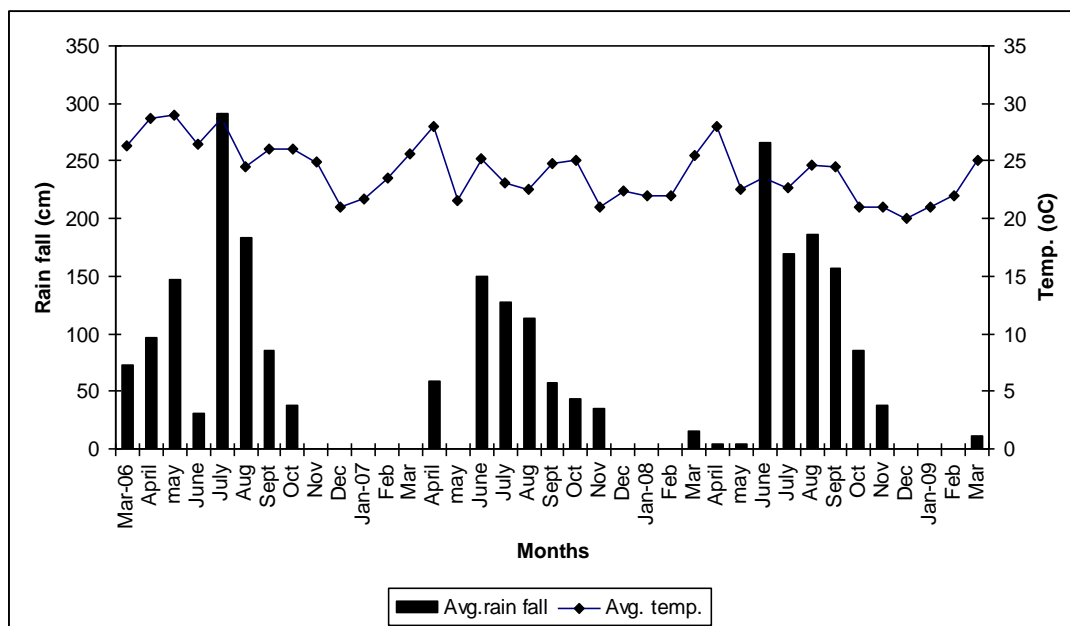


Fig. 2 : Graph representing Avg. rainfall & temperature in study sites

To study the tree host-lichen association a total of 35 tree species were selected each from deciduous and semi-evergreen forests of three districts. All the host trees which were above 10 cm GBH (Girth at Breast Height) were noted and collected lichens from them and the host tree species were identified with the help of published floras [18,19]. Canopy cover was noted down by observation and light intensity was recorded by using LUX meter. Approximate 10 cm² size of bark was separated carefully from stem of tree at 1.5 m level from ground and collected. The wound of the trees was treated with plaster of paris to avoid microbial and insect damage. About 0.5g of bark sample weighed and soaked with 0.25M KCl solution. Later they were kept in oven for one hour at 80°C and then P^H was determined by using pH meter. The pH of the tree bark was estimated by the procedure of [20] using digital pH meter (Multi-Parameter PTTestr™ 35 Oakton, USA) and also recorded the texture. The barks were grouped as rough, smooth and moderate based on their texture to correlate association of lichens.

RESULTS:

The present study investigates 944 individuals belong to 95 species and they represent 31 genera among 14 families. The corticolous lichens were abundant (71 species). The Parmeliaceae (41.6%) is dominated family followed by Physciaceae (33.5%). The pattern of distribution of lichens varies with forest type and altitude. The tree main trunk represents 44.4%, branches (27.7%), fallen twigs (16.6%) and others 11.2%. Out of 95 species 75 percent were foliose and 20 percent were fruticose lichens. The lichens growth is influenced by substrates and microclimate. In the study area distribution pattern of lichen varies with the availability of substrates like bark, wood, rock, twig and soil. Most species of lichens were dominated on the main stem (49%) followed by twig (25%) and leaves supported for less number of lichens. Among the terricolous lichens *Cladonia* and *Cetraria* were represented. Saxicolous lichens *Dirinaria applanata*, *Endocarpon* sp., *Parmotrema grayanum*, *Leptogium pichneum* were found here. Some macrolichen species showed specificity to a particular host tree which could be attributed to various ecological conditions. *Physma byrsaeum* is specific to host *Mangifera indica* and bamboo in semi-evergreen forest, *Rocella montagnei* reported only from *Mangifera indica* tree in deciduous forest. *Punctelia* sp., *Usnea undulata* were corticolous species reported from deciduous forests only. *Coccocarpia erythroxyli* and *Heterodermia speciosa* hosted by *Litsea floribunda* and some *Usnea* species were supported by branches of *Tectona grandis* and *Syzygium* species. *Leptogium chloromelum*, *Coccocarpia palmicola*, *C. erythroxyli* and *Collema* sp. were distributed in evergreen forest of Agumbe, Kodachadri and Hulikal of Shimoga district. *Bulbothrix isidiza*, *Phyllopsora* sp. *Heterodermia incana* and *Parmotrema stuppeum* were occurred in semi-evergreen forests of Hosanagar, Rippenpet, Kuppali, Kogar, Sigandur and Jog of Shimoga

district. Association of the algal partner in the distribution of lichen is *Trebouxia* (61%) which is the dominant algal partner followed by *Nostoc* (19%) and *Trentepohllia* (8%). In Shimoga district, *Parmotrema cristiferum* and *P. tinctorum* is having high importance value (IVI) i.e., 5.29 and 5.19 respectively and it is followed by *Dirinaria applanata* (5.13).

The indicator species analysis with respect to forest types indicates that several species were strongly co-relate with a particular forest type (Table 1). Diversity and distribution of epiphytic macrolichens on tree trunk in rain forest of Gran Piedra was studied by [21]. They reported that 21 species of macrolichens species composition is varies with slopes, but frequency of lichen change with cardinal orientation. The proportion of foliose and fruticose lichens increase with altitude [22]. Our study also reveals similar results indicate the *Usnea* and *Ramalina* species occurred at higher altitudes. Microhabitat differences play an essential role in explaining patterns of species composition and diversity at the scale of individual trees.

Diversity of epiphytic lichens in boreo-nemoral forest was studied by [23]. They reported 74 species of lichens from 13 study sites, most of them were crustose and most frequent species is *Graphis*. The DCA analysis found that 36 percent variation between compositions of lichen communities. The CCA ordination of the lichen species and environmental variables revealed more specifically the influence of the measured environmental factors on the composition of lichen species. When compared with other study sites, the malnad area of Karnataka is having high diversity with 106 species from three main sites. DCA analysis results indicate variation of 40 per cent with lichen composition in different forests.

Lichens constitute a significant portion of the biodiversity of forests worldwide. In many forests, lichen diversity exceeds that of the trees and shrubs, and often that of all vascular species in a forest stand [24]. Our study sought to quantify differences in lichen communities and lichen diversity among three sites with common forest vegetation types. Distinctive lichen communities that appears to be enhanced by the structural diversity within these stands. Species richness of lichens differed with respect to vegetation type, with sand pine scrub plots being the most diverse. The tropics are supposed to host the biologically richest land ecosystems in the world. In terms of lichen diversity, however, they seem to be so far the least-explored regions, as many new species are still being described every year [25,26,27,28,29]. For most organism groups, both local, alpha diversity and regional, beta diversity is higher in tropical than in temperate areas [30,31,32]. Similar results were occurring in the present study. Few studies are available in which lichen species diversity, specifically microlichens, has been assessed for tropical vegetation. Also, the available studies all used somewhat different sampling techniques, included different forest strata and identified the lichens to various taxonomic levels depending on growth form.

Table 1. Study sites of Shimoga with species richness:

Study sites	Latitude	Longitude	Altitude	Species richness	Corti colous	Terri colous	Saxi colous	Cort/ Sax	Sax/ Ter
Agumbe	13 28.194	75 7.718	643	46	36	1	5	4	0
Bhadravathi	13 50.146	75 41.533	630	24	20	0	2	2	0
Chakra	13 47.59	75 0.179	632	34	25	0	6	3	0
Chandragutti	14 26.61	74 51.5	625	43	29	1	7	5	1
Chikkerur	14 31.27	75 18.26	628	19	17	0	1	1	0
Gerusoppa	14 12.40	74 38.06	530	28	25	1	2	0	0
Hanagere	13 46.17	75 27.17	643	21	18	0	3	0	0
Haniya	13 51.597	75 3.427	624	35	31	0	3	1	0
Harnahalli	14 02.25	75 27.48	673	17	15	0	0	2	0
Herambapura	13 36.339	75 19.351	705	26	23	0	3	0	0
Honnemaradu	14 10.386	74 52.629	580	45	42	0	1	2	0
Hosahalli	13 26.468	75 15.281	680	39	39	0	0	0	0
Hulikal	13 43.47	75 0.38	581	41	38	0	2	1	0
Hidlumane	13 54.811	75 54.653	647	26	22	0	4	0	0
Kavaledurga	13 43.193	75 07.29	847	34	16	2	12	4	0
Kodachadri	13 52.30	74 52.05	1230	34	29	1	3	1	0
Kodluthota	14 7.125	75 01.60	634	36	34	0	2	0	0
Kogar	14 3.28	74 43.97	712	29	26	0	1	2	0
Konehosur	14 5.786	75 17.627	642	58	55	0	0	3	0
Kuppalli	13 36.198	75 19.62	696	27	26	0	1	0	0
Mupanne	14 07.65	75 7.623	675	19	19	0	0	0	0
Nittur	13 55.19	75 54.21	623	21	21	0	0	0	0
Rippenpet	13 59.15	75 15.29	684	28	26	0	2	0	0
Shankaraghata	13 44.101	75 7.505	675	53	46	0	5	2	0
Shettihalli	14 10.42	75 19.815	730	38	34	0	0	4	0
Shikaripura	14 11.375	75 25.194	622	18	17	0	1	0	0
Sorba	14 22.35	75 35.36	650	23	22	1	0	0	0
Thirthahalli	13 41.18	75 18.08	635	28	25	0	3	0	0
Ullur	13 08.03	75 06.36	647	17	17	0	0	0	0
Umblebilu	13 46.145	75 36.187	650	37	33	0	1	3	0

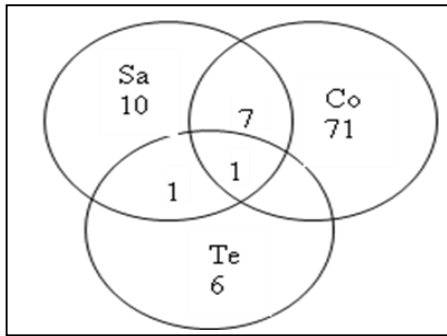


Figure 3: Venn diagram showing distribution of lichens on different substrates Shimoga district

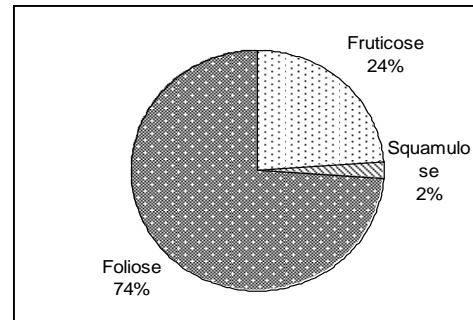


Figure 4: Growth forms of macrolichens recorded in Shimoga district

A transect of 47 mature trees was studied within an Atlantic rain-forest plot in northeastern Brazil to determinate effects of phorophyte specificity and environmental parameters vs. stochasticity on the structure of corticolous, crustose microlichen communities. A total of 150 lichen species was found, most being rare to extremely rare. Multivariate analysis of sample plots indicated subtle phorophyte preferences among certain lichen species, corresponding to differences in bark pH, degree of bark shedding, density and size of bark lenticels, and presence of milk sap. Individual and multiple regressions revealed correlations between lichen species richness.

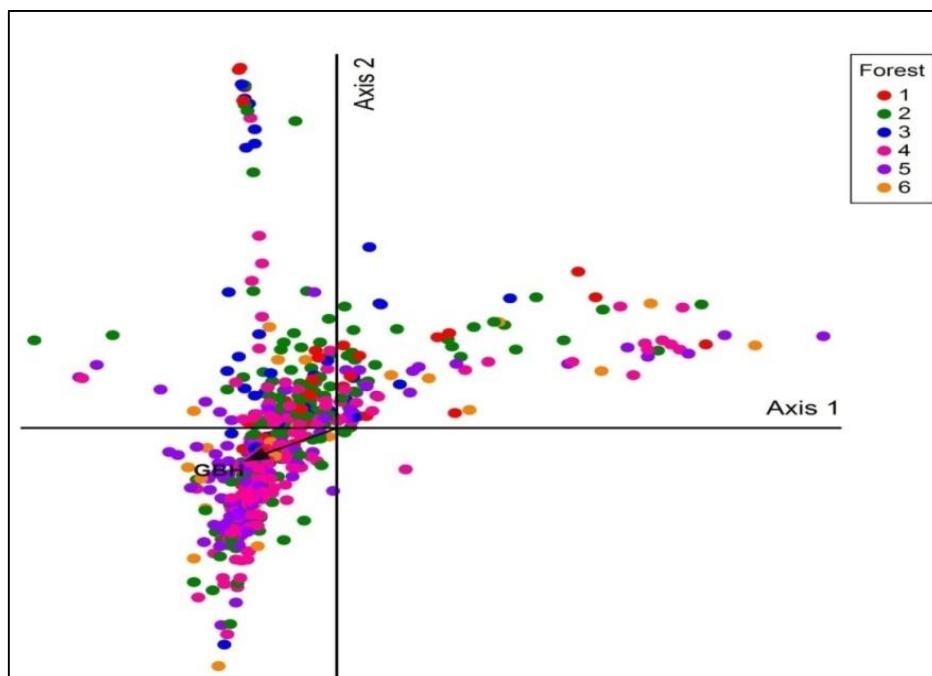


Figure 5: Ordination DCA analysis lichen diversity with different forest types (1= Evergreen, 2= Semi-evergreen, 3 = (Shola) Montane, 4 = Deciduous, 5 = Scrubby, 6 =open areas)

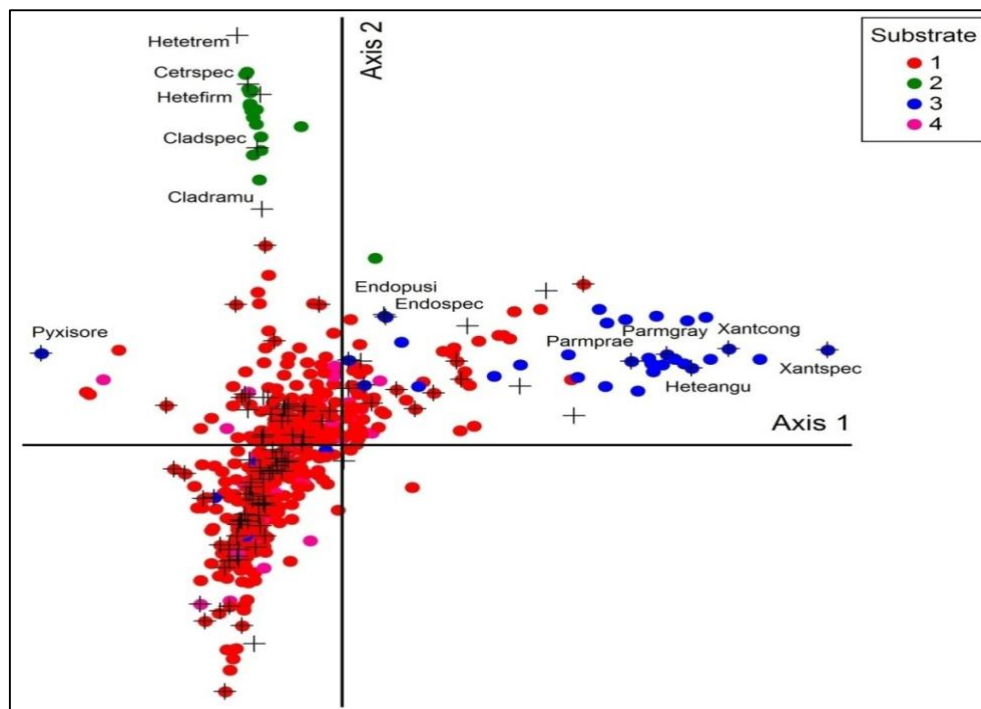


Figure 6: Ordination DCA analysis of lichen diversity in relation with different substrate (1= bark, 2= soil, 3= rock, 4= twig/wood/branch)

The lichen diversity of New Guinea is almost completely dependent upon primary forest. Some species appear to be able to maintain themselves on planted trees and in secondary vegetation [33]. In the present investigation it has been found that large number of lichens are corticolous, so it is very necessary care should be taken that not only the tree diversity is maintained, but also that the forest structure is preserved, including the presence of large hardwood trees. Selective logging of such valuable trees greatly reduces the lichenological value of the forest, as can be observed regrettably in nature reserves worldwide. While lichen species tend to have wide ranges, and are consequently of low protection priority, Western Ghats has an unusually high number of endemic species that are restricted to the region and therefore deserving of more attention.

We had carried out the quantitative estimation of lichens diversity in the three forests and six vegetation types a report of 106 species. Quantitative transect sampling yielded three times as many species as non-quantitative opportunistic sampling. Similar to our study support the 456 lichen species collected and identified across the 22 studied localities by quantitatively sampled transect [34].

Table 2. Macrolichens of Shimoga districts with their diversity indices:

Species	Family	S	GF	I	II	III	DEN	FRE	AB	RD	RF	IVI
<i>Bulbothrix isidiza</i> (Nyl.) Hale	Parmeliaceae	Cort	Fo	18	30	13	0.6	0.43	1.38	1.9	2.41	4.31
<i>Candelaria concolor</i> (Dicks.) Stein	Candeleriaceae	Cort	Fo	6	30	2	0.2	0.07	3	0.63	0.37	1.01
<i>Canoparmelia</i> sp. Elix and Hale	Parmeliaceae	Cort	Fo	12	30	7	0.4	0.23	1.71	1.27	1.3	2.57
<i>C. texana</i> (Tuck.) Elix and Hale	Parmeliaceae	Cort	Fo	5	30	3	0.17	0.1	1.67	0.53	0.56	1.08
<i>Cetraria</i> sp. Ach.	Parmeliaceae	Ter	Fr	4	30	1	0.13	0.03	4	0.42	0.19	0.61
<i>Cladonia</i> sp. P.Browne	Cladoniaceae	Ter	Fr	15	30	9	0.5	0.3	1.67	1.59	1.67	3.25
<i>C. ramulosa</i> (With.) J.R. Laundon	Cladoniaceae	Ter	Fr	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
<i>Coccocarpia palmicola</i> (Spreng.) Arvidss. & D.J.Galioway	Coccocarpiaceae	Cort	Sq	18	30	11	0.6	0.37	1.64	1.9	2.04	3.94
<i>C. erythroxyli</i> (Spreng.) Swinsc.& Krog	Coccocarpiaceae	Cort/Sax	Sq	17	30	10	0.57	0.33	1.7	1.8	1.85	3.65
<i>Collema</i> sp. G.H.Web. In Wigg.	Collemataceae	Cort	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
<i>C. leptaleum</i> (Mont.) Degel	Collemataceae	Cort	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
<i>Dirinaria aegialita</i> (Afz.in Ach.) Moore	Physciaceae	Cort	Fo	8	30	2	0.27	0.07	4	0.85	0.37	1.22
<i>D. applanata</i> (Fee) D.D. Awasthi	Physciaceae	Sax	Fo	24	30	14	0.8	0.47	1.71	2.54	2.59	5.13
<i>D. confluens</i> (Fr.) D.D. Awasthi	Physciaceae	Cort	Fo	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
<i>D. consimilis</i> (Stirton) D.D. Awasthi	Physciaceae	Cort	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
<i>D. papillulifera</i> (Nyl.) D.D. Awasthi	Physciaceae	Cort	Fo	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
<i>Endocarpon</i> sp. Hedw.	Verrucariaceae	Sax	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
<i>E. pusillum</i> Hedw.	Verrucariaceae	Sax	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9

<i>Everniastrum nepalense</i> (Taylor) Hale	Parmeliaceae	Ter	Fr	8	30	5	0.27	0.17	1.6	0.85	0.93	1.77
<i>Heterodermia incana</i> (Stirton) D.D. Awasthi	Physciaceae	Cor	Fo	13	30	8	0.43	0.27	1.63	1.38	1.48	2.86
<i>H. microphylla</i> (Kurok.) Skorepa	Physciaceae	Sax	Fo	17	30	8	0.57	0.27	2.13	1.8	1.48	3.28
<i>H. Leucomela</i> (L.) Poelt	Physciaceae	Cor	Fo	8	30	4	0.27	0.13	2	0.85	0.74	1.59
<i>H. albidiflava</i> (Kurok.) D.D. Awasthi	Physciaceae	Cor	Fo	18	30	11	0.6	0.37	1.64	1.9	2.04	3.94
<i>H. angustiloba</i> (Mull.Arg.) D.D.Awasthi	Physciaceae	Cor	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
<i>H. dendritica</i> (Pers.) Poelt	Physciaceae	Cort	Fo	18	30	10	0.6	0.33	1.8	1.9	1.85	3.76
<i>H. diademata</i> (Taylor) D.D.Awasthi	Physciaceae	Cort/ Sax	Fo	15	30	12	0.5	0.4	1.25	1.59	2.22	3.81
<i>H. dissecta</i> (Kurok.) D.D.Awasthi	Physciaceae	Cort	Fo	25	30	10	0.83	0.33	2.5	2.65	1.85	4.5
<i>H. firmula</i> (Nyl.) Trevis.	Physciaceae	Ter	Fo	9	30	4	0.3	0.13	2.25	0.95	0.74	1.69
<i>H. comosa</i> (Eschw.) Follman and Radon	Physciaceae	Cort	Fo	9	30	4	0.3	0.13	2.25	0.95	0.74	1.69
<i>H. obscurata</i> (Nyl.) Trevis.	Physciaceae	Cort	Fo	11	30	7	0.37	0.23	1.57	1.16	1.3	2.46
<i>H. speciosa</i> (Wulf.) Trevis.	Physciaceae	Cort	Fo	6	30	2	0.2	0.07	3	0.63	0.37	1.01
<i>H. tremulans</i> (Mull. Arg.) W. Culb	Physciaceae	Ter	Fo	11	30	4	0.37	0.13	2.75	1.16	0.74	1.9
<i>Hyperphyscia adglutinata</i> (Florke) Mayerh. and Poelt	Physciaceae	Cort	Fo	9	30	5	0.3	0.17	1.8	0.95	0.93	1.88
<i>Hypotrachyna infirma</i> (Kurok.) Hale	Parmeliaceae	Cort	Fo	8	30	2	0.27	0.07	4	0.85	0.37	1.22
<i>H. crenata</i> (Kurok.) Hale	Parmeliaceae	Cort	Fo	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
<i>Leptogium aurstroamericanum</i> (Malme) Dodge	Collembataceae	Cort	Fo	3	30	2	0.1	0.07	1.5	0.32	0.37	0.69

<i>L. burnetiae</i> Dodge	Collemtaceae	Cort/Sax	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
<i>L. cochleatum</i> (Dikson) P. M. Jorg. and James	Collemtaceae	Cort	Fo	5	30	4	0.17	0.13	1.25	0.53	0.74	1.27
<i>L. denticulatum</i> Nyl.	Collemtaceae	Cort	Fo	9	30	4	0.3	0.13	2.25	0.95	0.74	1.69
<i>L. indicum</i> D.D.Awasthi and Akhtar	Collemtaceae	Cort	Fo	5	30	3	0.17	0.1	1.67	0.53	0.56	1.08
<i>L. pichneum</i> (Ach.) Malme	Collemtaceae	Sax	Fo	3	30	3	0.1	0.1	1	0.32	0.56	0.87
<i>L. ulvaceum</i> (Pers.) Vain.	Collemtaceae	Cort	Fo	17	30	7	0.57	0.23	2.43	1.8	1.3	3.1
<i>L. chloromelum</i> (Sw.) Nyl.	Collemtaceae	Cort	Fo	16	30	10	0.53	0.33	1.6	1.69	1.85	3.54
<i>Myelochroa xantholepis</i> (Mont.&Bosch) Elix & Hale	Parmeliaceae	Cort/Sax	Fo	9	30	6	0.3	0.2	1.5	0.95	1.11	2.06
<i>Parmelia</i> sp. Ach.	Parmeliaceae	Cort	Fo	7	30	3	0.23	0.1	2.33	0.74	0.56	1.3
<i>Parmelinopsis</i> sp. Elix and Hale	Parmeliaceae	Cort	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
<i>Parmelinella wallichiana</i> (Taylor) Elix&Hale	Parmeliaceae	Cort/Sax	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
<i>Parmotrema austrosinense</i> (Zahlbr.) Hale	Parmeliaceae	Cort	Fo	8	30	5	0.27	0.17	1.6	0.85	0.93	1.77
<i>P. crinitum</i> (Ach.) Choisy	Parmeliaceae	Cort	Fo	15	30	6	0.5	0.2	2.5	1.59	1.11	2.7
<i>P. cristiferum</i> (Taylor) Hale	Parmeliaceae	Cort	Fo	22	30	16	0.73	0.53	1.38	2.33	2.96	5.29
<i>P. grayanum</i> (Hue) Hale	Parmeliaceae	Cort	Fo	11	30	10	0.37	0.33	1.1	1.16	1.85	3.02
<i>P.hababianum</i> (Gyeln.) Hale	Parmeliaceae	Cort	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
<i>P. mellisii</i> (C.W. Dodge) Hale	Parmeliaceae	Sax	Fo	4	30	4	0.13	0.13	1	0.42	0.74	1.16
<i>P. praesorediosum</i> (Nyl.) Hale	Parmeliaceae	Sax	Fo	7	30	5	0.23	0.17	1.4	0.74	0.93	1.67
<i>P. reticulatum</i> (Taylor) Choisy	Parmeliaceae	Cort	Fo	17	30	10	0.57	0.33	1.7	1.8	1.85	3.65
<i>P. stuppeum</i> (Taylor) Hale	Parmeliaceae	Cort/Sax	Fo	14	30	5	0.47	0.17	2.8	1.48	0.93	2.41
<i>P. tinctorum</i> (Despr.ex Nyl.)Hale	Parmeliaceae	Cort/Sax	Fo	21	30	16	0.7	0.53	1.31	2.22	2.96	5.19

<i>P. vartakii</i> Hale	Parmeliaceae	Cort	Fo	3	30	2	0.1	0.07	1.5	0.32	0.37	0.69
<i>Phaeophyscia orbicularis</i> (Neck.) Moberg	Physciaceae	Cort	Fo	4	30	4	0.13	0.13	1	0.42	0.74	1.16
<i>Phyllopsora buettneri</i> (Mull. Arg.) Zahlbr.	Biatoraceae	Cort	Fo	6	30	3	0.2	0.1	2	0.63	0.56	1.19
<i>P. corallina</i> (Eschw.) Mull.Arg.	Biatoraceae	Cort	Fo	6	30	3	0.2	0.1	2	0.63	0.56	1.19
<i>P. haemophaea</i> (Nyl.) Mull. Arg.	Biatoraceae	Cort	Fo	5	30	3	0.17	0.1	1.67	0.53	0.56	1.08
<i>P. parvifolia</i> (Pers.) Mull. Arg.	Biatoraceae	Cort	Fo	4	30	1	0.13	0.03	4	0.42	0.19	0.61
<i>Physcia dilatata</i> Nyl.	Physciaceae	Cort	Fo	4	30	2	0.13	0.07	2	0.42	0.37	0.79
<i>Physma byrsaeum</i> (Ach.) Tuck.	Collembataceae	Cort	Fo	15	30	6	0.5	0.2	2.5	1.59	1.11	2.7
<i>Pseudocyphellaria aurata</i> (Sm.ex Ach.)Vain.	Lobariaceae	Cort	Fo	15	30	7	0.5	0.23	2.14	1.59	1.3	2.88
<i>Punctelia</i> sp. Krog	Parmeliaceae	Cort	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
<i>Pyxine coccifera</i> (Fee) Nyl.	Physciaceae	Cort	Fo	16	30	10	0.53	0.33	1.6	1.69	1.85	3.54
<i>P. cocoes</i> (Sw.) Nyl.	Physciaceae	Cort	Fo	9	30	6	0.3	0.2	1.5	0.95	1.11	2.06
<i>P. minuta</i> Vain.	Physciaceae	Cort	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
<i>P. petricola</i> Nyl.	Physciaceae	Cort	Fo	6	30	3	0.2	0.1	2	0.63	0.56	1.19
<i>P. reticulata</i> (Vain.) Vain.	Physciaceae	Cort	Fo	7	30	3	0.23	0.1	2.33	0.74	0.56	1.3
<i>P. soledata</i> (Ach.) Mont.	Physciaceae	Cort	Fo	6	30	5	0.2	0.17	1.2	0.63	0.93	1.56
<i>Ramalina hossei</i> Vain.	Ramalinaceae	Cort	Fr	2	30	3	0.07	0.1	0.67	0.21	0.56	0.77
<i>R. pacifica</i> Asahina	Ramalinaceae	Cort	Fr	20	30	15	0.67	0.5	1.33	2.12	2.78	4.89
<i>Ramalina</i> sp. Ach.	Ramalinaceae	Cort	Fr	2	30	1	0.07	0.03	2	0.21	0.19	0.4
<i>R. conduplicans</i> Vain.	Ramalinaceae	Cort	Fr	12	30	6	0.4	0.2	2	1.27	1.11	2.38
<i>R. hossei</i> var. <i>divericata</i> H.Magn. & G. Awasthi	Ramalinaceae	Cort	Fr	14	30	7	0.47	0.23	2	1.48	1.3	2.78

<i>R. nervulosa</i> (Mull. Arg.) Abbayes	Ramalinaceae	Cort	Fr	17	30	9	0.57	0.3	1.89	1.8	1.67	3.47
<i>R. pollinaria</i> (Westr.) Ach.	Ramalinaceae	Cort	Fr	8	30	3	0.27	0.1	2.67	0.85	0.56	1.4
<i>R. taitensis</i> Nyl.	Ramalinaceae	Cort	Fr	10	30	6	0.33	0.2	1.67	1.06	1.11	2.17
<i>Relicina abstrusa</i> (Vain.) Hale	Parmeliaceae	Cort	Fo	8	30	4	0.27	0.13	2	0.85	0.74	1.59
<i>Rocella montagnei</i> Bel.em. D.D. Awasthi	Roccellaceae	Cort	Fr	19	30	8	0.63	0.27	2.38	2.01	1.48	3.49
<i>Teloschistes flavicans</i> (Sw.) Norm.	Teloschistaceae	Cort	Fr	13	30	10	0.43	0.33	1.3	1.38	1.85	3.23
<i>Usnea aciculifera</i> Vain.	Parmeliaceae	Cort	Fr	8	30	3	0.27	0.1	2.67	0.85	0.56	1.4
<i>U. eumitrioides</i> Mot.	Parmeliaceae	Cort	Fr	8	30	4	0.27	0.13	2	0.85	0.74	1.59
<i>U. galbinifera</i> Asahina.	Parmeliaceae	Cort	Fr	9	30	6	0.3	0.2	1.5	0.95	1.11	2.06
<i>U. ghattensis</i> G. Awasthi	Parmeliaceae	Cort	Fr	12	30	6	0.4	0.2	2	1.27	1.11	2.38
<i>U. picta</i> (J. Steiner) Mot.	Parmeliaceae	Cort	Fr	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
<i>U. pictoides</i> G. Awasthi	Parmeliaceae	Cort	Fr	10	30	3	0.33	0.1	3.33	1.06	0.56	1.61
<i>U. stigmatoides</i> G. Awasthi	Parmeliaceae	Cort	Fr	16	30	9	0.53	0.3	1.78	1.69	1.67	3.36
<i>U. undulata</i> Stirt.	Parmeliaceae	Cort	Fr	6	30	5	0.2	0.17	1.2	0.63	0.93	1.56
<i>U. vegae</i> Mot.	Parmeliaceae	Cort	Fr	12	30	8	0.4	0.27	1.5	1.27	1.48	2.75
<i>Xanthoparmelia</i> sp. (vain.) Hale	Parmeliaceae	Sax	Fo	12	30	6	0.4	0.2	2	1.27	1.11	2.38
<i>X. congensis</i> (B.Stein) Hale	Parmeliaceae	Sax	Fo	9	30	5	0.3	0.17	1.8	0.95	0.93	1.88

Abbreviations: S - Substrate, G - growth forms, I - Number of individuals, II - Number of transects studied, III - Number of transects occurred, Sax - Saxicolous, Ter -Terricolous, Cort - Corticolous, Fr - Fruticose, Fo - Foliose, Sq - Squamolouse, RD - Relative density, RF - Relative frequency, IVI - Importance value index, DEN - density, Fre - Frequency, AB - abundance.

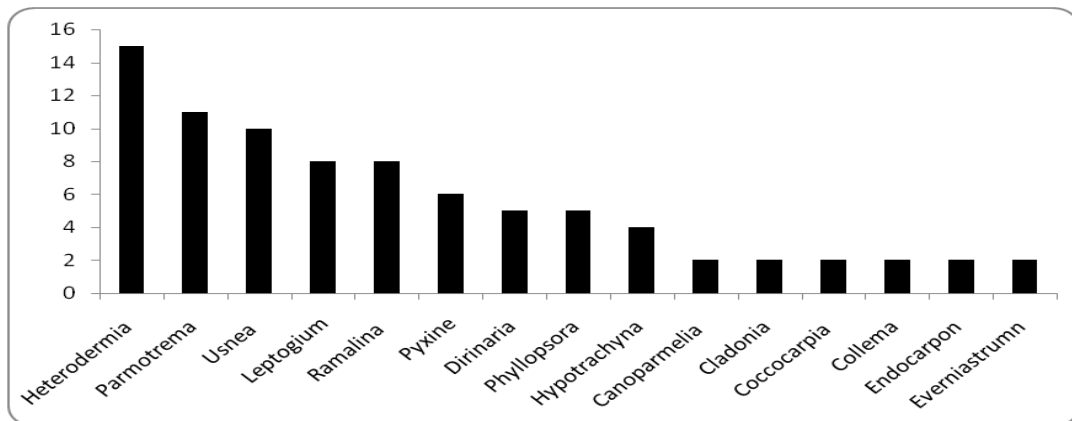


Figure 7: Genus level lichen diversity

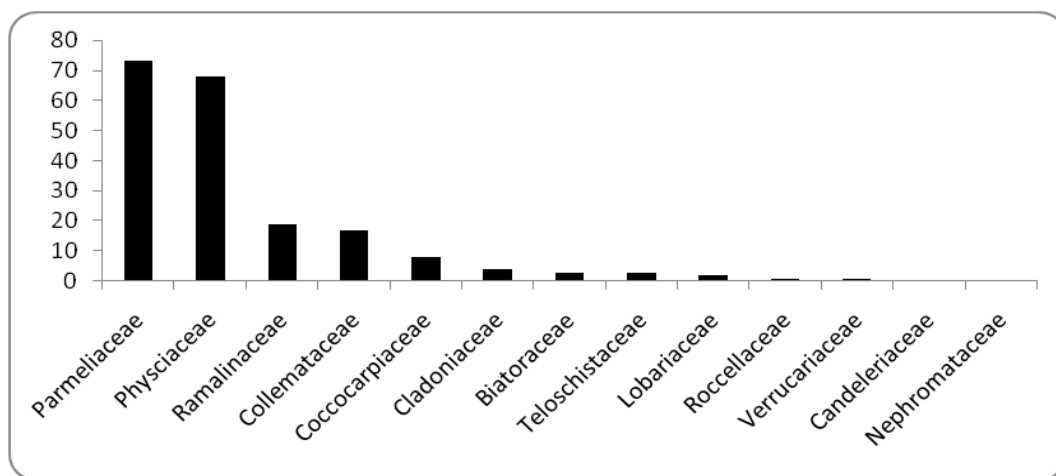


Figure 8: Number of individuals of macrolichens with their family importance value (FIV)

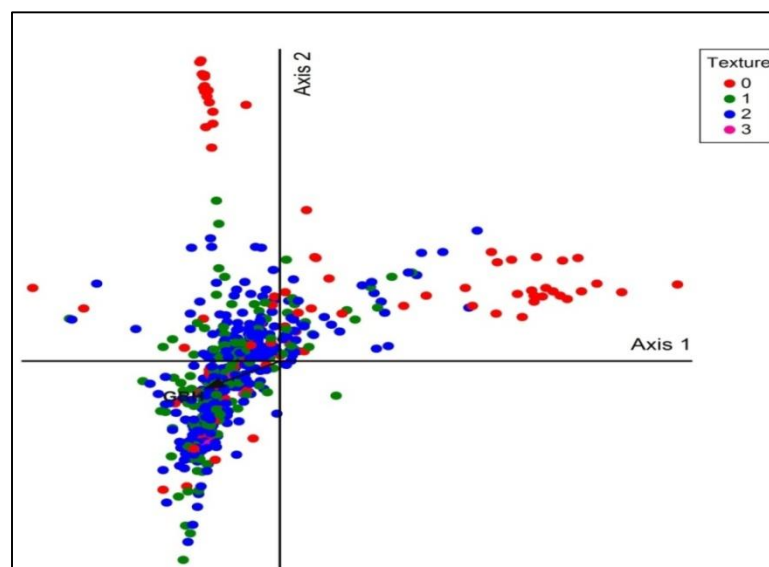


Figure 9: Ordination DCA analysis in relation to bark texture (0=smooth, 1=moderate, 2=hard, 3=extremely hard)

Species diversity tends to decrease with increasing elevation. The species at higher altitudes supports less number of lichens in Kodachadri and Kemmannugundi higher peaks, as evidenced by occurrence of *Usnea*, *Parmotrema* and *Leptogium* species only. It was emphasized that altitude and humidity play a significant role in the diversity and distribution of lichens [35].

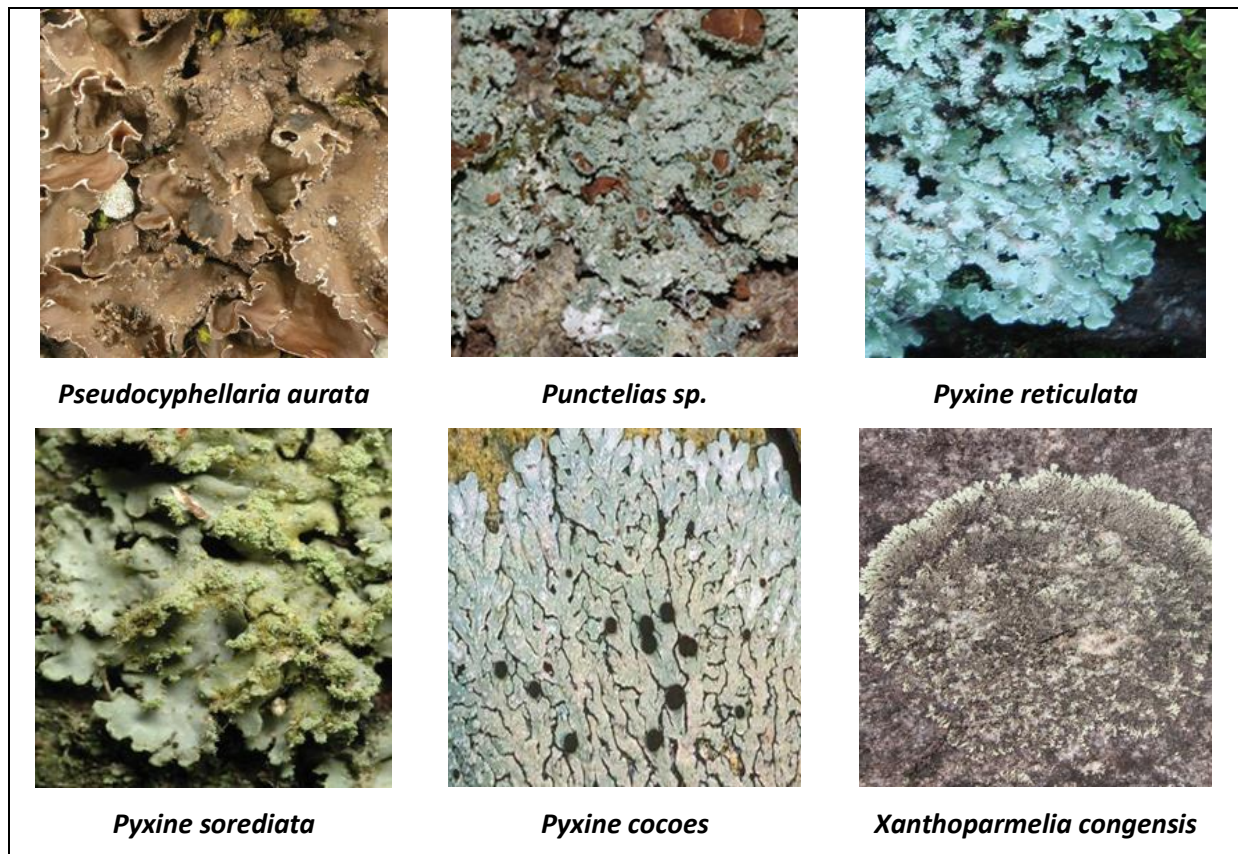


Plate 1: Pictorial representation of some foliose lichens occurring in the study area

Epiphytic lichens change hosts in different climatic regimes, even when the same host trees are present. Similar host specificity pattern of lichens in the upland forests of Wisconsin [36]. Macro and micro climatic conditions and bark characteristics of trees vary depending on the forest types and altitude. Although, light factor is important in the distribution of lichens, the availability of light is low inside evergreen forests when compare to deciduous forests. Bruiteg [37] observed that frequency, duration and form of precipitation are important for the distribution of lichens. In addition to precipitation, mist and fog may cause humid condition even where precipitation is low. This study is further useful for understanding distribution of bioresources of lower plants in the area. The baseline information on lichens in district will be useful for conservation policy making and biomonitoring studies keeping in view of global warming and climatic change.

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ORIGINAL RESEARCH ARTICLE

BRYODIVERSITY, DISTRIBUTION, THREATS AND CONSERVATION OF LIVERWORTS AND HORNWORTS FROM FORTS OF KOLHAPUR DISTRICT

Rajendra Ananda Lavate

Author affiliation:

Raje Ramrao
Mahavidhyalaya, Jath-416
404; Dist. Sangli (M.S.),
India.

E-mail:

bryoraj@gmail.com

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ABSTRACT:

Bryodiversity, including liverworts and hornworts strongly concentrated in the humid tropics is ecologically very significant. The present paper provides the first hand consolidated account 41 species of liverworts and hornworts belonging to 18 genera and 12 families from forts of Kolhapur District which includes detailed account of the bryodiversity and distribution. Also causes of threats and action plan for their conservation, monitoring and management has been suggested.

KEYWORDS: Brodiversity, distribution, conservation, liverworts, hornworts, forts, Kolhapur district.

INTRODUCTION:

Liverworts and hornworts are small terrestrial plants that grow closely packed together in mats or cushions found in all habitats and climatic conditions except marine environment. In India there are about 930 species of liverworts and hornworts belong to 140 genera and 59 families out of which 834 species, 16 subspecies, 39 varieties and 2 forma belong to 134 genera, 56 families of liverworts and 39 species belong to 6 genera in 3 families of hornworts. As far as Maharashtra is concerned 72 species of liverworts and hornworts belong to 25 genera and 18 families were reported of which 52 species are of liverworts, 20 species are of hornworts [1].

BRYODIVERSITY AND STATUS:

Kolhapur is the southernmost district of Maharashtra state with geographical area of about 7685 sq kms located between 17° 17' to 15° 43' North latitudes and 73° 40' to 74° 42' East longitudes at an average elevation from 390 to 900 meters entirely in the Panchganga basin. It includes the main range of Sahyadri running North-South on Western Side and large spurs which

stretch North-East and East from Sahyadris and valleys with about 16 forts of historical and botanical interest viz., Aajra, Bhudargad, Chandgad, Gagangad, Gandharvgad, Hanumantgad, Kalanidhigad, Mahipaalgad, Paargad, Paavangad, Panhala, Saamangad, Shivgad, Vallabhgad, Vilasgad and Vishalgad [2].

The present comprehensive survey from forts of Kolhapur District records 41 species belonging to 18 genera of liverworts and hornworts [2].

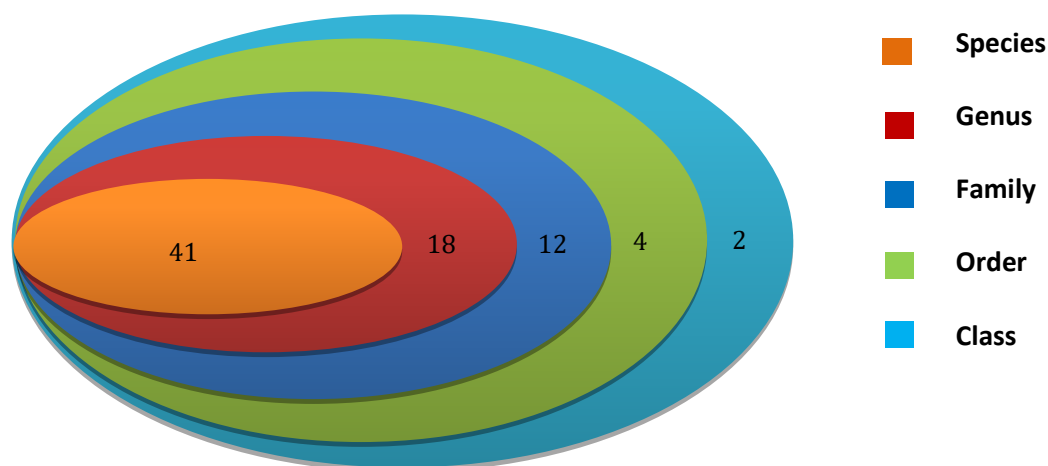


Figure 1. Diversity of Liverworts and Hornworts in from few forts of Kolhapur District

These 18 genera are spread over 10 families of 04 orders (**Fig. 1**). 14 genera and 31 species were belonging to the group Hepaticopsida while 04 genera and 10 species were belonging to the group Anthocerotopsida. Amongst these 07 species were reported as new distributional records for Maharashtra. Amongst the order Marchantiales had maximum number of genera (**Table 1 and 2**).

Table 1: Distribution of genera and species of Liverworts and Hornworts from forts of Kolhapur District

Sr. No.	Orders	Families	Genera	Species
1.	Jungermanniales	2	4	07
2.	Metzgeriales	4	5	07
3.	Marchantiales	4	5	17
4.	Anthocerotales	2	4	10
TOTAL		12	18	41

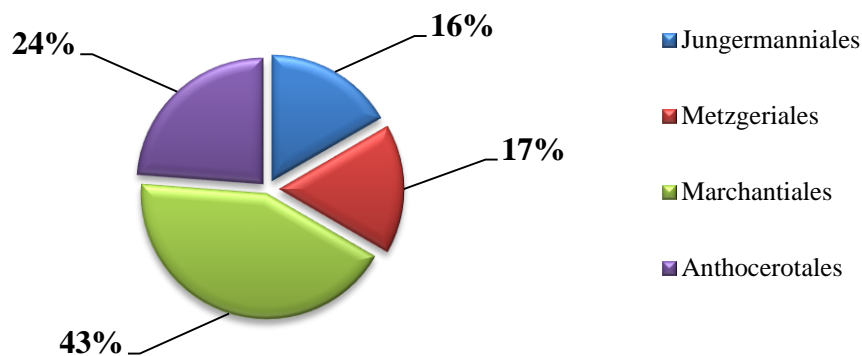


Fig. 2: Pie chart showing number (in %) of species in various orders of Liverworts and Hornworts from few forts of Kolhapur District

It was also the most specious order (**Fig. 2**). Marchantiales is the most dominant order in forts of Kolhapur District, followed by Anthocerotales, Metzgeriales and Jungermanniales.

The present study revealed the occurrence of 41 taxa (31 liverworts and 10 hornworts) belonging to 3 orders, 10 families and 14 genera of Hepaticae and 1 order, 2 families and 4 genera of Anthocerotae in the Kolhapur District of Maharashtra (Table 1.1 and 1.2). This accounts for 4.1 percent of total Indian liverworts and hornworts.

Marchantiales with 17 species belonging to 5 genera and 4 families is the largest order within the study area followed by Anthocerotales with 10 species belonging to 4 genera and 2 families. The order Jungermanniales and Metzgeriales are represented by 7 species each belonging to 4 genera and 2 families and 5 genera and 4 families respectively. Ricciaceae and Anthocerotaceae are the largest families each with 8 species followed by Lejeuneaceae (5 species), Aytoniaceae (4 species), Aneuraceae and Cyathodiaceae (each with 3 species) whereas Jungermanniaceae, Fossombroniaceae, Targionaceae and Notothyladaceae are represented by 2 species each. Two families viz., Metzgeriaceae and Pallaviciniaceae are represented by just a single species.

At lower taxonomic level, genus *Riccia* L. with 8 species is the largest genus followed by *Anthoceros* L. (4 species), *Cyathodium* Kunze, *Lejeunea* Lib., *Plagiochasma* Lehm. & Lindenb. and *Phaeoceros* Prosk. (3 species each) and *Fossombronia* Raddi, *Notothylas* Sull. *Riccardia* Gray, *Solenostoma* Mitt., *Targionia* L. (2 species). Seven genera viz., *Aneura* Dumort., *Archilejeunea* (Spruce) Schiffn., *Asterella* P. Beauv., *Cheilolejeunea* (Spruce) Schiffn., *Folioceros* D.C. Bharad., *Metzgeria* Raddi., and *Pallavicinia* Gray, are represented by just a single species.

Table 2: Number of genera and species in each family of Liverworts and hornworts on forts of Kolhapur District

Sr. No.	Name of order/ family	Number of	
		Genera	Species
I.	Jungermanniales		
1.	Jungermanniaceae	1	2
2.	Lejeuneaceae	3	5
II.	Metzgeriales		
3.	Aneuraceae	2	3
4.	Metzgeriaceae	1	1
5.	Fossombroniaceae	1	2
6.	Pallaviciniaceae	1	1
III.	Marchantiales		
7.	Aytoniaceae	2	4
8.	Cyathodiaceae	1	3
9.	Targioniaceae	1	2
10.	Ricciaceae	1	8
11.	Anthocerotales		
12.	Anthocerotaceae	3	8
13.	Notothyladaceae	1	2

DISTRIBUTION OF LIVERWORTS AND HORNWORTS:

DISTRIBUTION ON THE BASIS OF ALTITUDE:

The altitudinal gradient is a complex one and varied in climate, edaphic and biotic factors. With increasing elevation, there is decrease in temperature and an increase in precipitation, relative humidity and increases soil moisture [3]. The composition of liverworts and hornworts varies along the altitude. Some species are strictly growing at high altitude whereas some are growing at low altitude. The maximum composition of liverworts and hornworts was observed at high altitude. Therefore, it is one of the limiting factor on which distribution of liverworts and hornworts is greatly depends. The maximum height of Kolhapur district is 1000 m. The observed liverworts and hornworts at various altitudes are given below,

a. Foothills Zone (below the 500 m): The zone is occupied by following liverworts and hornworts: *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Riccia cavernosa*, *R. crystallina*, *R. discolor*, *Targionia hypophylla*, *Anthoceros erectus* etc.

b. Middle Hill Zone (between 500 –750 m): The zone occupied by the following liverworts and hornworts: *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Notothylas indica*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccia cavernosa*, *R. crystallina*, *R. discolor*, *R. frostii*, *R. plana* and *Targionia hypophylla*, etc.

c. High Elevation Zone (above 750 m): Here, the climate is very cool with high atmospheric moisture and high soil moisture which helps liverworts and hornworts to proliferate extensively. Maximum number of liverworts and hornworts found here e.g. *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cheilolejeunea intertexta*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Fossombronia himalayensis*, *Folioceros dixitianus*, *Lejeunea discreta*, *L. flava*, *L. tuberculosa*, *Metzgeria himalayensis*, *Notothylas indica*, *N. levieri*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *R. santapau*, *Riccia. crystallina*, *R. fluitans*, *R. melanospora*, *Pallavicinia lyellii*, *Solenostoma fossombronioides*, *S. tetragonum*, *Targionia hypophylla*, *T. hypophylla* var. *sinhgarhii* etc.

DISTRIBUTION ON THE BASIS OF RAINFALL:

The average rainfall of Kolhapur district is 1645 mm per year. Eastern part of the district like Shirol, Haatkangle and part of Kagal tehsils experiences very low rain (500 mm per year) while, the Western part of a district like Chandgad, Ajara, Bhudargad, Radhanagari, Gaganbawda, Panhala is having high rainfall (6000 mm per year) and rest of having moderate rainfall (2000-3000 mm per year). On this basis liverworts and hornworts of Kolhapur district were grouped into three categories as follows:

a. High Rainfall Zone (more than 3000 mm per annum): It is one of the important climatic factors that restrict the distribution of liverworts and hornworts because liverworts and hornworts are water loving plants, grow well where the water content is high in the atmosphere and soil. Maximum numbers of liverworts and hornworts were collected from this region. They are as follows: *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cheilolejeunea intertexta*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Fossombronia himalayensis*, *F. indica*, *Folioceros dixitianus*, *Lejeunea discreta*, *L. flava*, *L. tuberculosa*, *Metzgeria himalayensis*, *Notothylas indica*, *N. levieri*, *Pallavicinia lyellii*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *R. santapau*, *R. cavernosa*, *R. crystallina*, *R. discolor*, *R. fluitans*, *R. frostii*, *R. glauca*, *R. melanospora*, *R.*

plana, *Pallavicinia lyellii*, *Solenostoma fossombronioides*, *S. tetragonum*, *Targionia hypophylla*, *T. hypophylla* var. *sinhgarhii* etc.

b. Moderate Rainfall Zone (above 1000 mm but below 3000 mm per annum): The liverworts and hornworts growing in this zone are as follows: *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Folioceros dixitianus*, *Lejeunea discreta*, *Notothylas indica*, *N. levieri*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *Riccia crystallina*, *R. discolor*, *R. fluitans*, *Solenostoma fossombronioides*, *Targionia hypophylla* etc.

c. Low Rainfall Zone (below 1000 mm per annum): Very few species were adapted to this region they are, *Anthoceros erectus*, *Asterella wallichiana*, *Cyathodium tuberosum*, *Notothylas indica*, *Plagiochasma appendiculatum*, *P. articulatum*, *P. pterospermum*, *Riccia crystallina*, *R. discolor*, *R. frostii*, *R. glauca*, *Solenostoma fossombronioides* and *Targionia hypophylla* etc.

DISTRIBUTION BASED ON TEMPERATURE:

It is one of the important climatic factors on which distribution of liverworts and hornworts depend. A very little change in temperature affects the diversity of liverworts and hornworts. During the present investigation liverworts and hornworts were grouped into three different categories based on the temperature as given below:

a. Low Temperature Zone: (below 20^o C): Species growing are: *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cheilolejeunea intertexta*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Fossombronia himalayensis*, *F. indica*, *Folioceros dixitianus*, *Lejeunea discreta*, *L. flava*, *L. tuberculosa*, *Metzgeria himalayensis*, *Notothylas indica*, *N. levieri*, *Pallavicinia lyellii*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *R. santapau*, *R. cavernosa*, *R. crystallina*, *R. discolor*, *R. fluitans*, *R. frostii*, *R. glauca*, *R. melanospora*, *R. plana*, *Pallavicinia lyellii*, *Solenostoma fossombronioides*, *S. tetragonum*, *Targionia hypophylla* and *T. hypophylla* var. *sinhgarhii* etc.

b. Moderate Temperature Zone (above 20^o C but below 28^o C): The liverworts and hornworts growing in this zone are as follows: *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Folioceros dixitianus*, *Lejeunea discreta*, *Notothylas indica*, *N. levieri*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *Riccia crystallina*, *R. discolor*, *R. fluitans*, *Solenostoma fossombronioides*, and *Targionia hypophylla* etc.

c. **High Temperature Zone (above 28° C):** Very few species were adapted to this region. They are *Anthoceros erectus*, *Asterella wallichiana*, *Cyathodium tuberosum*, *Notothylas indica*, *Plagiochasma appendiculatum*, *Riccia crystallina*, *R. discolor*, *Solenostoma fossombronioides* and *Targionia hypophylla* etc.

DISTRIBUTION BASED ON ATMOSPHERIC HUMIDITY:

Liverworts and hornworts are very sensitive to the change in atmospheric humidity. On this basis liverworts and hornworts are grouped into 3 perspective categories as follows

a. **High Humidity Zone (above 70%):** The liverworts and hornworts which grow in this zone are: *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cheilolejeunea intertexta*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Fossombronia himalayensis*, *F. indica*, *Folioceros dixitianus*, *Lejeunea discreta*, *L. flava*, *L. tuberculosa*, *Metzgeria himalayensis*, *Notothylas indica*, *N. levieri*, *Pallavicinia lyellii*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *R. santapau*, *R. cavernosa*, *R. crystallina*, *R. discolor*, *R. fluitans*, *R. frostii*, *R. glauca*, *R. melanospora*, *R. plana*, *Pallavicinia lyellii*, *Solenostoma fossombronioides*, *S. tetragonum*, *Targionia hypophylla* and *T. hypophylla* var. *sinhagrhi* etc.

b. **Moderate Humidity Zone:** The liverworts and hornworts grow in this zone are: *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Folioceros dixitianus*, *Lejeunea discreta*, *Notothylas indica*, *N. levieri*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *Riccia crystallina*, *R. discolor*, *R. fluitans*, *Solenostoma fossombronioides* and *Targionia hypophylla* etc.

c. **Low Humid Zone (below 25 %):** Very few species were adapted to this region. They are *Anthoceros erectus*, *Asterella wallichiana*, *Cyathodium tuberosum*, *Notothylas indica*, *Plagiochasma appendiculatum*, *Riccia crystallina*, *R. discolor*, *Solenostoma fossombronioides* and *Targionia hypophylla* etc.

DISTRIBUTION BASED ON FOREST TYPE:

The liverworts and hornworts grow in extensive range of forests. The following types are elaborated on the basis of forest type in Kolhapur district:

a. **Evergreen Forest:** It is a forest consisting entirely or mainly of evergreen trees that retain green foliage all year round. The liverworts and hornworts species found in this forest are as follows: *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Archilejeunea minutiloba*,

Asterella wallichiana, *Cheilolejeunea intertexta*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Fossombronia himalayensis*, *F. indica*, *Folioceros dixitianus*, *Lejeunea discreta*, *L. flava*, *L. tuberculosa*, *Metzgeria himalayensis*, *Notothylas indica*, *N. levieri*, *Pallavicinia lyellii*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *R. santapau*, *R. cavernosa*, *R. crystallina*, *R. discolor*, *R. fluitans*, *R. frostii*, *R. glauca*, *R. melanospora*, *R. plana*, *Pallavicinia lyellii*, *Solenostoma fossombronioides*, *S. tetragonum*, *Targionia hypophylla* and *T. hypophylla* var. *sinhagarhii* etc.

b. Semi Evergreen Forest: Semi-evergreen forests (west coast semi-evergreen forests) are generally considered as a transitional stage between evergreen and moist deciduous forests. The liverworts and hornworts species found in this forest are as follows: *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *Archilejeunea minutiloba*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *C. epiphytens*, *Folioceros dixitianus*, *Notothylas indica*, *N. levieri*, *Phaeoceros laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *Riccia crystallina*, *R. discolor*, *R. fluitans*, *Solenostoma fossombronioides* and *Targionia hypophylla* etc.

c. Dry Deciduous Forest: The canopy of the trees does not normally exceed 25 meters. The common trees are the Saal, a variety of *Acacia*, and Bamboo. The liverworts and hornworts species found in this forest are as follows: *Anthoceros erectus*, *Asterella wallichiana*, *Cyathodium tuberosum*, *Notothylas indica*, *Plagiochasma appendiculatum*, *Riccia crystallina*, *R. discolor* and *Targionia hypophylla* etc.

DISTRIBUTION BASED ON HABITAT:

The liverworts and hornworts grow in extensive range of habitats. The following types are elaborated on the basis of habitat given by [4], [3].

a. Open Plateau Region: The zone is fully covered by various types of grasses or herbaceous flora. Only few terrestrial species, viz. *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Cyathodium cavernarum*, *C. tuberosum*, *Notothylas indica*, *N. levieri*, *Riccia billardieri*, *R. cruciata*, *R. crystallina*, *R. discolor*, *R. fluitans*, *R. frostii*, *R. melanospora*, *R. plana* and *Targionia hypophylla* were found in this region.

b. Epiphytes: The liverworts and hornworts grow over tree trunks/branches. These are totally autotrophic and only for the sake of shelter they grow on tree trunks. The most common trees in Kolhapur district are *Mangifera indica*, *Ficus religiosa*, *Ficus benghalensis*, *Ficus racemosa*, *Terminalia* spp., *Syzygium* spp., *Cassia fistula*, *Bauhinia* spp., and *Dalbergia sissoo* serves as host for *Archilejeunea minutiloba*, *Cheilolejeunea intertexta*, *Cyathodium epiphytens*, *Lejeunea discreta*, *L. flava* and *L. tuberculosa*.

- c. Ravine liverworts and hornworts:** The liverworts and hornworts along the water channels, streams, rivers, and rivulets among rocks and boulders. The common ravine species are of *Aneura pinguis*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *Pallavicinia lyellii*, *Plagiochasma appendiculatum* and *Riccia fluitans*.
- d. Liverworts and hornworts near the domestic areas:** The liverworts and hornworts grow on houses or neighboring areas. These are *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *C. tuberosum*, *Notothylas indica*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *Riccia cruciata*, *R. crystallina*, *R. discolor*, *R. frostii* and *Targionia hypophylla* etc.
- e. Liverworts and hornworts along the bridal path, roadsides, border and cut-edges of the forests:** They are *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *Fossombronia himalayensis*, *Folioceros dixitianus*, *Notothylas indica*, *N. levieri*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccia billardieri*, *R. cruciata*, *R. crystallina*, *R. discolor*, *R. frostii*, *Solenostoma fossombronioides* and *Targionia hypophylla*.
- f. Aquatic liverworts and hornworts:** Very few species are adapted to aquatic ecosystem e.g. *Pallavicinia lyellii* and *Riccia fluitans*.

Habitat wise classification of the Liverworts and hornworts taxa given in the table 1.4 It seems to be general rule that liverworts and hornworts flourish well in the crevices where shade and moisture available more frequently.

Liverworts and hornworts from few forts of Kolhapur District can be divided in diverse habitats. The table 1.4 shows that 2 species are found in water (aquatic), 32 species are terrestrial out of which 23 species are found on rocks (Lithocolous), 26 on moist soil floors on clayey slopes on ditches (Terricolous), 13 on brick walls (Calcicolous) and 07 species are epiphytic growing on angiospermic plants (Phycocolous). Broadly speaking Thalloid liverworts shows their presence in lithocolous, terricolous and calcicolous habitats except leafy liverworts *Archilejeunea minutiloba*, *Cheilolejeunea intertexta*, *Lejeunea discreta*, *Lejeunea flava*, *Lejeunea tuberculosa*, *Cyathodium* sps. and *Riccia fluitans*. Hornworts mostly grow on moist shady places. The increasing urbanization, removal of shady habitats and niches, changed topography has all posed a threat to its survival.

Table 3: Distribution of the Liverworts and hornworts in different habitats in Kolhapur District

Name of the taxa	Habitat				
	Aq-uatic	Terrestrial			Epi-phytic (Physco-colous)
		Litho-colous	Terri-colous	Calci-colous	
<i>Solenostoma fossombronioides</i>	-	+	+	-	-
<i>Solenostoma tetragonum</i>	-	+	+	-	-
<i>Archilejeunea minutiloba</i>	-	-	-	-	+
<i>Cheilolejeunea intertexta</i>	-	-	-	-	+
<i>Lejeunea discrete</i>	-	-	-	-	+
<i>Lejeunea flava</i>	-	-	-	-	+
<i>Lejeunea tuberculosa</i>	-	-	-	-	+
<i>Aneura pinguis</i>	-	+	+	+	-
<i>Riccardia levieri</i>	-	+	+	+	-
<i>Riccardia santapau</i>	-	+	+	+	-
<i>Metzgeia himalayensis</i>	-	-	-	-	+
<i>Fossombronia himalayensis</i>	-	+	+	-	-
<i>Fossombronia indica</i>	-	+	+	-	-
<i>Pallavicinia lyellii</i>	+	+	+	-	-
<i>Asterella wallichiana</i>	-	+	+	+	-
<i>Plagichasma appendiculatum</i>	-	+	+	+	-
<i>Plagichasma intermedium</i>	-	-	-	+	-
<i>Plagichasma pterospermum</i>	-	+	-	+	-
<i>Cyathodium cavernarum</i>	-	+	+	-	-
<i>Cyathodium epiphytens</i>	-	-	-	-	+
<i>Cyathodium tuberosum</i>	-	+	+	+	-
<i>Targionia hypophylla</i>	-	+	+	+	-
<i>Targionia hypophylla</i> var. <i>sinhgarhii</i>	-	+	+	+	-
<i>Riccia cavernosa</i>	-	+	+		-
<i>Riccia crystalline</i>	-	+	-	+	-
<i>Riccia discolor</i>	-	+	+	-	-
<i>Riccia fluitans</i>	+	+	+	-	-

<i>Riccia frostii</i>	-	+	-		-
<i>Riccia glauca</i>	-	+	-	-	-
<i>Riccia melanospora</i>	-	+	+		-
<i>Anthoceros bharadwajii</i>	-	-	+	+	-
<i>Anthoceros crispulus</i>	-	+	-	-	-
<i>Anthoceros erectus</i>	-	-	+	+	-
<i>Anthoceros subtilis</i>	-	-	+	-	-
<i>Phaeoceros carolinianus</i>	-	-	+	-	-
<i>Phaeoceros himalayensis</i>	-	-	+	-	-
<i>Phaeoceros laevis</i> <i>subsp. laevis</i>	-	-	+	-	-
<i>Folioceros dixitianus</i>	-	-	+	-	-
<i>Notothylias indica</i>	-	-	+	-	-
<i>Notothylias levieri</i>	-	-	+	-	-
Total	02	23	26	13	07

ENDEMISM:

In Maharashtra 14 species of liverworts and hornworts are endemic out of which 6 endemic species viz., *Archilejeunea minutiloba*, *Riccardia santapau*, *Metzgeia himalayensis*, *Anthoceros bharadwajii*, *Folioceros dixitianus* are present on forts of Kolhapur district [1].

THREATS TO THE WEALTH OF LIVERWORTS AND HORNWORTS FROM FEW FORTS OF KOLHAPUR DISTRICT:

Anthropogenic pressure on the wealth of liverworts and hornworts may lead to decline in their diversity and species may become rare, endangered and threatened (RET).

Forest fragmentation:

Liverworts and hornworts are highly sensitive to the changes in microclimatic conditions caused by forest fragmentation and environmental pollution. Habitat fragmentation is anticipated as one of the main threats to bryodiversity. It is the process of breaking up large patches of forest into smaller pieces. This can be caused by many things, from clearing forest for roads or developmental activities viz., Construction of buildings, colleges, hotels and restaurants. Above activities were common at Panhala, Amba, Radhanagri, Ajara, Gagangad, and Chandgad. If this process continues, the ability of the remnant forests to maintain their original diversity of liverworts and hornworts and ecological processes will be significantly reduced.

Tourisms:

Similarly, large number of tourists visiting to Panhala, Vishalgad, Pargad, Shivgad, Paavangad, Kalanidhigad and Bhudargad every year. Hence there is tremendous anthropogenic pressure on liverworts and hornworts growing on roadside walls and plateaus.

Four species of liverworts *Riccardia levieri*, *Riccardia santapau*, *Riccia fluitans* and *Anthoceros subtilis* are rare in the study area as they were collected just once during the extensive survey in the Kolhapur District. In addition there are species like *Riccardia levieri*, *Riccia fluitans* and *Solenostoma fossombronioides* which are confined to just a single location viz., Panhala, Bhudargad and Gaganbavada respectively within the study area. *Riccia fluitans* was also collected from Panhala in 1998-99, but since 2004 it has been not seen from Panhala but collected from Bhudargad.

SUGGESTIONS FOR THE CONSERVATION OF LIVERWORTS AND HORNWORTS FROM FEW FORTS OF KOLHAPUR DISTRICT:

Many forts are showing some remarkable occurrence of liverworts and hornworts. But some unavoidable activities for the better management of these areas, such as construction of inspection paths, roads etc., may cause threat to the habitats where the species grow. To avoid these threats and to ensure more effective conservation of the liverworts and hornworts, the areas in and around the forts viz., Panhalgad, Gaganbavada, Pargad, Shivgad, Bhudargad, Vishalgad and their surrounding areas having luxurious growth may be declared and protected as, "Liverwort and Hornwort Sites", in different altitudinal zones. In Kolhapur District, such bryophyte luxuriant areas are Aamba Ghat, Amboli Ghat, Anuskura Ghat, Karul Ghat, Bhudargad, Gaganbavada, Panhalgad, Pargad, Patgaon, Pavangad, Radhanagari WLS, Vishalgad etc. which would also act as 'benchmark' sites for monitoring the health of species populations over a period of time. As the liverworts and hornworts plays an important tool for monitoring the health of forest ecosystem, periodical monitoring of the species populations in these areas would help to assess the impact of various management practices on the overall biodiversity of the Kolhapur District. Besides, these areas can be used for creating awareness among the people, academicians, researchers and the foresters about this interesting group of plants, their role in ecological balance and functions and the threats faced by them. Aamba Ghat, Amboli Ghat, Anuskura Ghat, Karul Ghat, Bhudargad, Gaganbavada, Panhalgad, Pargad, Patgaon, Pavangad, Vishalgad, Panhalgad are ideal habitats for the growth of liverworts and hornworts. Again Panhalgad would also be prudent to closely monitor the populations of the species which are represented by just a single collection or multiple collections from just a single location within the Kolhapur District.

The local inhabitants from the liverwort-hornwort luxuriant forts with interest in environment and conservation may be trained as parataxonomists to help in the effective monitoring of the species and their habitat on different forts in Kolhapur District. Besides, declaring the endemic species as “National Natural Heritage” for their environment in the conservation drive of such taxa of liverworts and hornworts will motivate people residing on the forts.

- i) There is an urgent need to carry out a systematic bryofloristic studies of liverworts and hornworts from all other forts of Maharashtra.
- ii) Identify areas from the forts of Maharashtra with luxuriant growth of liverworts and hornworts to understand their ecology and their role in the microenvironment.
- iii) It is necessary to ban new constructions of residential, commercial buildings and industries to minimize environmental pollution and interference in the microhabitats of the liverworts and hornworts on the forts by strictly enforcing the laws.
- iv) Panhalgad and Paavangad are the ideal habitats for the luxuriant growth of the liverworts and hornworts viz., *Aneura pinguis*, *Anthoceros bharadwajii*, *A. crispulus*, *A. erectus*, *A. subtilis*, *Asterella wallichiana*, *Cyathodium cavernarum*, *C. tuberosum*, *Folioceros dixitianus*, *Fossombronia himalayensis*, *F. indica*, *Lejeunea flava*, *L. discreta*, *Notothylas indica*, *N. levieri*, *Phaeoceros carolinianus*, *P. himalayensis*, *P. laevis*, *Plagiochasma appendiculatum*, *P. intermedium*, *P. pterospermum*, *Riccardia levieri*, *Riccia cavernosa*, *R. cruciata*, *R. crystallina*, *R. discolor*, *R. fluitans*, *R. frostii*, *R. melanospora*, *R. plana*, *Targionia hypophylla*, and *T. hypophylla* var. *sinhagarhii*. Thus these two forts are rich in bryodiversity. Hence it is necessary to declare these two forts as “National Natural Heritage”. There is an urgent need to ban new constructions of residential, commercial buildings and industries to minimize environmental pollution and interference in the microhabitats of the liverworts and hornworts on the Panhala and Paavangad by strictly enforcing the laws as early as possible.
- v) There is an urgent need to conserve the natural habitats of liverworts and hornworts on the forts by developing bryophyte gardens under the guidance of experts.

Finally it is necessary to take initiatives to conserve rare, endangered, threatened, endemic liverworts and hornworts through *ex-situ* and *in-situ* conservative methods.

CONCLUSION:

The fast increasing urbanization with its monasteries and recreation on the forts is putting extreme pressure on bryo-flora to the limits of their patience. Exploration, collection and conservation are one of the urgent needs of the day.

The extraordinary varied and rich bryo-flora of our vast country is not thoroughly explored. Besides Western Ghats, South-Western Maharashtra region abounding in moss or liverwort-covered valleys and hillsides, ridges and slopes still awaits exploration. A great deal of interesting information is shrouded in darkness. Moreover it has been an urgent call to bryologists and floristic researchers of these areas that un-explored regions deserve first priority for exploration. The need for more and more bryo-exploration in the still very inadequately known parts of the South-Western Maharashtra is absolutely essential otherwise many a species would perish and would disappear before being documented from these unexplored areas.

The present work could form a “starting point’ and foundation in our region on which more comprehensive qualitative and quantitative studies could rest in future with the response of liverworts and hornworts to mineral elements and their sources of supply and the factors influencing availability and uptake.

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ORIGINAL RESEARCH ARTICLE

DIVERSITY AND ETHNOMEDICINAL VALUE OF LIANAS IN EAST NIMAR OF
MADHYA PRADESH, INDIA

Shakun Mishra

Author affiliation:

Department of Botany, S.
N. Govt. P. G. College,
Khandwa, M. P., INDIA

E-mail:

dr.shakunmishra2012@gmail.com

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ABSTRACT:

Man has surveyed remote galaxies and has stood on the surface of moon but has not so far come anywhere near to completing taxonomic of the fewer than half a million species of higher plants that grow on our planet. According to present study 65 lianas are naturalized in all parts of East Nimar belonging to families 16 and 53 genera. A family - wise analysis of all the 65 lianas is carried out. Fabaceae emerges as the largest family that contributes (14 species), followed by Cucurbitaceae and Asclepiadaceae (10 species each), Convolvulaceae shares (8 species), Vitaceae and Dioscoriaceae (4 species each). The other families, such as Liliaceae shares (3 species), Aristolochiaceae (2 species), Psylloraceae, Polygonaceae, Basellaceae, Capparaceae, Sapindaceae, Celastraceae and Combretaceae (1 species each).

KEYWORDS: Diversity, Ethnomedicinal, Lianas, East Nimar

INTRODUCTION

From the advent of the human life on earth, human community has been depending on the natural resources especially the plants for their basic needs such as food, cloth, shelter and medicine. Plants and plant based medicines have been employed since dawn of civilization for prolonging life of man by combating various ailments. Ancient tribal societies around the world have learnt to utilize their neighborhood herbal wealth for curative as well as offensive purposes. Due to lack of literacy their knowledge of plants developed often at the cost of their dear life in their 'Human Laboratories' this centuries old experience could not be perfectly documented and it had rather descended from one generation to the next by oral communication. As the ethnic groups migrated from place to place in search of their livelihood, their folklore knowledge also became fragmented and traveled with them often with 'additions' and 'deletions'.

Out of 7500 ethnomedicinal plants used by Indian tribals, 65 lians species are collected from the study area. The common diseases of the tribals from this area are respiratory disorders, stomach and abdominal disorders, flatulence, diarrhoea and dysentery, malaria fever tuberculosis, skin diseases, venereal diseases, conjunctivitis. Besides, there are some diseases reported as specific to men, women or children in tribal communities. Men occasionally suffer from liver problems, possibly due to consumption of country liquor, typhoid, headache, eczema and venereal diseases. Constipation and appendicitis are not common among them because of consumption of large amount of leafy vegetable.

The common female diseases are intestinal worms, anaemia, leucorrhoea, hysteria, dysmenorrhoea (painful menstruation) etc. The abortion practice is not uncommon. The common diseases among children are blood dysentery, teething, intestinal worms, cough and cold, measles, dental caries, scabies, rickets, eye disease, amoebiasis etc. Malnutrition and diarrhoea is sometimes lethal in children of this region. Disease like conjunctivitis assumes epidemic proportion in children during the festivals associated with dancing and singing. Most of the diseases are treated by single plant species.

MATERIAL AND METHODS:

STUDY AREA:

East Nimar is situated in the South West corner of Madhya Pradesh. It lies between 21° 05' and 22° 25' N Latitude and between 75° 57' and 77° 13' E Longitude and 304 M above sea level. It is bounded by Betul, Hoshangabad and Amravati districts of Maharashtra on the East, Buldhana and Amravati district on the South West and Khargone and Dewas district on the West and North. The total geographical area is 10779 sq. Km. out of which forest occupies 8307 sq. Km. It lies between the valleys of Narmada and Tapti rivers and occupies a strip of mixed hill and plain Country.

THE PEOPLE:

The aboriginal and hill tribes met within this region are the Korkus, Gonds, Nihals, Bhils, Pradhans, Pardis, Bhujjiya, Orans and Bayare etc. The 1991 census records 5,08,532 Adiwasi (tribal) population. The number of Korkus is maximum (78.41%) in the district. The Gonds are second (16.01%) and Nihals are third in number (4.14%). The major tribes taken for study are Korkus, Gonds and Nihals.

Field observation on plants, the vernacular names and information, their uses were recorded in the field book. Voucher specimens were brought to laboratory and prepared according to the conventional herbarium technique [1]. All specimens were identified with the help of standard floras

[2, 3, 4]. The important plant parts like underground tubers, corms and fruits etc. were preserved in 4% formalin. The present work mainly covers the tribal villages situated at the foothills of Satpura, which inhabited by Korku, Gond and Nihal, tribes of East Nimar. The tribes are original inhabitants of this region. There are about six more tribes like Bharia, Bhil, Bhunjia, Oraen, Pradhan and Pardhi etc., who reside in this region.

Generally the medicines are prepared by crushing, boiling, shade drying. The preparation of tablets, syrups are made indigenously. Dry plant parts are usually made into powder. Local medicine men (padihar) prepare drug by decoction, infusion, mixture and paste. Tribals store either whole plant or a part of it after shade drying. Gond tribe stores plant parts making sort of garland after drying in shade.

CONCLUSION:

Korku, Gond and Nihal tribe of East Nimar use a good number of plant for material culture and economic lively hood. Present observation clearly includes that besides ethnomedicinal uses. Tribals are well aware of multifarious uses of plants in agriculture and fodder etc. The ethnomedicinal (human & veterinary) plants are used to treat wide range of discomfort of human beings and cattle. The tribals system of medicine is an elaborate and specialized one. It gives preferable to fresh drugs. Some of the drugs are exclusive treasures of Parihars, Bhopas and other medicine men, while other members of the tribes are also aware of the therapeutic properties of plants from their day to day experience. Nowadays, the useful plant resources are becoming scarce due to ruthless destruction of habitats, deforestation, climate change, global warming, industrialization, construction and pollution etc. It is necessary that the tribal knowledge and practice about plants are to be recorded before they are lost permanently.

Through native medicine still plays a significant role among the tribals, it is observed that the traditional knowledge of medicinal plants among the youths in tribal communities has been disappearing because of the ability to meet their own needs at present and for future. The pressure of ruthless exploitation without adequate regeneration measures is endangering many useful ethnomedicinal plants, plant species like *Abrus precatorius*, *Asparagus racemosus*, *Aristolochia bracteolata*., *Celastrus paniculatus*, *Ceropegia bulbosa*, *Cissus quadrangularis*, *Gloriosa superba* L., *Gymnema sylvestris*, *Hemidesmus indicus* (L.) R.Br. *Momordica dioica*, *Mucuna pruriens* and *Pueraria tuberosa* ect. among the tribals.

The plant species used exclusively by Korkus are 26 and Gond 4. Common species used by Korku, Gond and Nihal are 34 while Korku and Gond used 6 and Korku and Nihal use 6. The present study revealed that Korku is more knowledgeable about the plant wealth and their surroundings followed

by Gond and Nihal. The plants like *Ampelocissus latifolia* (Roxb.) Planch, *Aristolochia bracteolata* Lamk., *Celastrus paniculatus* Willd., *Cissus quadrangularis* L., are commonly used by all the tribal groups. This shows a cross cultural relationship between the tribal groups of this area. It can also be assumed that the indigenous knowledge about the plant wealth has come from a common origin but in course of time some new informations and practices has found in place into the day to day plant usage of the tribal groups.

SOME SUGGESTIONS:

- The tribe here developed the reuse of conservation but the exploitation of plant resources is inversely proportional to the conservation and regeneration efforts.
- The traditional knowledge and resource management practices of the indigenous people should be applied in modern development strategies. Traditional knowledge of indigenous people with modern tools of genetic engineering to get the desired results.
- Government should also provide indigenous people with suitable technology and infrastructure to increase the efficiency of their resource management.
- Exhaustive study may be conducted in future to explore, identify, record and indigenous knowledge which can serve as a data bank for strategies for health care system.
- Search for alternate substitute plants should also be given immediate attention.
- Medicinal garden and Nursery should be established to maintain constant supply of material to reduce pressure on wild populations.
- Some of the noble plant species should be scrutinized for their propagation through tissue culture techniques.
- Traditional customs and religious beliefs should also be utilized in technologies for conservation of vegetation
- The indigenous knowledge of the tribal people should be promoted for the development of their economy.
- Steps should be taken for in-situ / ex-situ conservation of rare and endangered plants.
- A detailed and systematic study may be conducted in future to explore record and preserve indigenous knowledge and information which can serve as data bank for strengthening and evolution of low cost, indigenous and sustainable plant based medicine for health care system.

Table 1. List of Lians species and used in ethno-medicine:

Scientific Name	Family	Vernacular Name	Category	Climbing Mode	Medicinal Uses
<i>Abrus precatorius</i> Linn.	Fabaceae	Ratti/Gunja/Gunchi (K and N); Jurum ti Velly (G)	WV	HC	Contraceptive, diabetes, cough, cold, colic pain, scorpion sting, sciatica and paralysis.
<i>Acacia sinuata</i> (Lour.) Merr.	Fabaceae	Kochi (K); Sitakali to Marra (G); Shikakali (N)	WV	HC	Dandruff and boils
<i>Ampelocissus latifolia</i> (Roxb.) Planch.	Vitaceae	Dokarbel/Kandvel/Nardel(K); Randa drakshi/Devdhar Marra(G); Popasvel(N)	WV	TC	Muscular pains, sores, bone fracture and pneumonial fever.
<i>Ampelocissus tomentosa</i> (Heyne ex Roth) Planch	Vitaceae	Dhotto(K)	WV	HC	----
<i>Antigonon leptopus</i> Hook. & Arnott	Polygonaceae	Madan-Mast ta Marra (G)	WV	TC	Aphrodisiac and in weakness.
<i>Argyreia nervosa</i> (Burm. f.) Boj.	Convolvulaceae	Vidharya Bela/Phanguda (K); Samundar ti Vely (G); Samundar Palak (N)	WV	ST	Tonic against anaemia, digestive and cardiac tonic.
<i>A. sericea</i> Dalz. & Gibson	Convolvulaceae	Kali Phang (K and N)	WV	ST	Conjunctivitis, swelling, bone fracture and irritation.
<i>A. strigosa</i> (Roth) Rober.	Convolvulaceae	Bhaisvel/Bhaislae/Meswal (K)	WV	ST	Tonic against anaemia.
<i>Aristolochia bracteolata</i> Lamk.	Aristolochiaceae	Kidamar/Gidhan/Chandbela (K, G and N)	HV	ST	Skin diseases and abortifacient.

<i>A. indica</i> L.	Aristolochiaceae	Sapsan/Kidamari/Gidhan/ Chandbela (K and N); Isharmuli ti Veli (G)	HV	ST	Antivenom and used in dyspepsia.
<i>Asparagus gracilis</i> Royle	Liliaceae	Saslyamusli (K)	WV	HC	To cure urinary problems, mental disorders and malaria.
<i>A. racemosus</i> Willd.	Liliaceae	Saslyamusli (K)	WV	HC	Sexual debility in men.
<i>Basella alba</i> L., Sp.	Basellaceae	Poi/Pasalei (K)	HV	HC	To cure general debility and anaemia.
<i>Butea superba</i> Roxb.	Fabaceae	Tunang/Raisitom (K); Palasvel (G); Belia palas (N)	WV	ST	To remove pimples and acne.
<i>Caesalpinia bonduc</i> (L.) Roxb.	Fabaceae	Sagargoti (K); Cutter ta Marra (G); Chirchirgoti (N)	WV	Str-A	To cure liver disorders.
<i>Cajanus scarabaeoides</i> (L.) du Petit.-Thouars	Fabaceae	Ban-tuar(K)	WV	ST	_____
<i>Canavalia gladiata</i> (Jacq.) DC.	Fabaceae	Ban-sem, Makhanssem(K)	WV	ST	_____
<i>Capparis zeylanica</i> L.	Capparaceae	Pachika (K); Jakhambela/Ardanda to Marra (G)	WV	Str-A	To cure rheumatic pain.
<i>Cardiospermum halicacabum</i> L.	Sapindaceae	Phatphatej/Ghanphod (K); Phutphutya/Wasanna Veli (G); Charmathari (N)	HV	HV	Hemicranias (adhasisi) and epilepsy.
<i>Cayratia trifolia</i> (L.) Domin	Vitaceae	Ambatvel (K)	WV	TC	Antidote for snakebite.
<i>Celastrus paniculatus</i> Willd.	Celastraceae	Pinguel (K); Malkangni ta Marra (G); Malkangni (N)	WV	Str-UA	To cure beri-beri in children (vit, B1 deficiency).

<i>Ceropegia bulbosa</i> Roxb.	Asclepiadaceae	Gakerkund/Gakaryakand/ Khatmarya (K)	ST	HV	General debility and bodyache.
<i>Cissampelos pareira</i> L.	Menispermaceae	Paharvel (K); Patha ti Veli (G); Patha/Venivel (N)	WV	Str-UA	To reduce high blood pressure.
<i>Cissus rependa</i> Vahl.	Vitaceae	Dekrabela(K),Pani-veli(G)	WV	RC	To cure sprain and bone fracture.
<i>Cissus quadrangularis</i> L.Mant.	Vitaceae	Hadjora (K, G and N)	WV	RC	To cure sprain and bone fracture.
<i>Citrullus colocynthis</i> L.	Cucurbitaceae	Ghorkakde (K); Tumba ti Veli (G)	HV	TC	Stomach pains and sciatica.
<i>Clitoria ternatea</i> L.	Papilionaceae	Gokarni ti Veli (G)	HV	TC	To hasten delivery during labour pains.
<i>Coccinia grandis</i> (L.) Voigt	Cucurbitaceae	Dhorkakri (K); Indravan ti Veli (G); Kundru (N)	WV	TC	To cure weakness and impotency in male
<i>Cocculus hirsutus</i> (L.) Diels	Menispermaceae	Aseen Zara/Bochan (K); Vasani ta Palla/Barmipalla/Patalgarudi/ Bosan (G); Wasanel/Pathari (N)	WV	ST	Brain tonic.
<i>Combretum albidum</i> G.	Combretaceae	Rhetbel/Retel (K)	WT	ST	To cure mental disorder, mania and insomnia.
<i>Corallocarpus epigaeus</i> (Rottl. & Willd.) Hook.	Cucurbitaceae	Mirichkand (K)	HV	TC	It is applied on swelling caused after snakebite.
<i>Cryptolepis buchmanii</i> Roem. & Schult.	Asclepiadaceae	Kaovel/Kawavel/Nagbel (K)	HV	ST	Useful in insect bites and scorpion sting.
<i>Cyphostema auriculatum</i> (Roxb.) P.Singh & Shetty	Vitaceae	Jongali-ongoor,Kajorny(K)	WV	TC	Used as a tonic.
<i>Desmodium triflorum</i> (L.) DC.	Fabaceae	Kudalya (K)	HV	ST	Applied on wounds twice a day for fast healing.

<i>Dioscorea bulbifera</i> L.	Dioscoriaceae	Kalyakand/Gathalu (K); Noska ti Velli (G); Gogdu/Bayal (N)	HV	ST	To cure abdominal pains (gripe).
<i>D. hispida</i> Dennst.	Dioscoriaceae	Kulu Kand (K); Baichandi ti Velli (G); Bhuikand(N)	HV	ST	Against bite of rabid dog.
<i>D. oppositifolia</i> L.	Dioscoriaceae	Dardee (K); Jangali Shakarkand (N)	HV	ST	To cure general debility.
<i>D. pentaphylla</i> L.	Dioscoriaceae	Babra/Suarkand/Suaralu (KandN); Kantaalu ti Velli (G)	HV	ST	To relieve rheumatoid arthritis.
<i>Diplocyclos palmatus</i> (L.) Jeffrey	Cucurbitaceae	Chatargoti/Chirchirgoti (K); Shivlingi ti Velli (G); Dangari (N)	HV	TC	To cure double pneumonia and convulsions in children.
<i>Gloriosa superba</i> L.	Liliaceae	Kallavi/Karihari/Singmudya/Karkari(K and N);Kadve ti Veli (G)	HV	TC	Joint pains and rheumatism.
<i>Gymnema sylvestris</i> (Retz.) R.Br.	Asclepiadaceae	Medsinghi/Gudmar (K and N)	WV	ST	To reduce glycosuria.
<i>Hemidesmus indicus</i> (L.) R.Br.	Asclepiadaceae	Anantvel (K); Anantmul ti Veli (G); Lahan (N)	HV	ST	Applied on eczema.
<i>Holostemma ada-kodien</i> Schulte	Asclepiadaceae.	Palkhevel (K and N); Morewan ti velli (G)	WV	ST	Spermatorrhoea.
<i>Ipomoea eriocarpa</i> R.Br.	Convolvulaceae	Ratlya (K)	HV	ST	Rheumatic pains.
<i>I. pes-tigridis</i> L.	Convolvulaceae	Panchpanya (K)	HV	ST	Sores, boils and pimples.
<i>I. obscura</i> (L.) Ker-Gawl.	Convolvulaceae	Pilaibonvari (K)	HV	ST	Cold, cough and coryza.
<i>Lagenaria siceraria</i> (Mol.) Standl.	Cucurbitaceae	Tumdi/Tumba (K)	WV	ST	For stomachache, kidney stones and appendix.

<i>Luffa acutangula</i> (L.) Roxb.	Cucurbitaceae	Jungali dodka/karu dodka (K); karu turai (N)	HV	TC	Applied in leprosy
<i>Marsdenia tenacissima</i> (Roxb.) Moon	Asclepiadaceae	Dudhia-bela (K); Sansbela (G)	WV	ST	To treat jaundice.
<i>Melothria maderaspatana</i> (L.) Cogn.	Cucurbitaceae	Kakadbhutta (K)	HV	TC	Toothache.
<i>Momordica dioica</i> Roxb. ex Willd.	Cucurbitaceae	Kartola/Karotla/Kankoda/Katlya (K)	HV	TC	To check bleeding from piles.
<i>Mucuna pruriens</i> (L.) DC.	Fabaceae	Kenwanch/Kanchkuri/Kaunch (K and G)	WV	ST	To expel intestinal worms (Dose depends upon age of patient).
<i>Oxystelma esculentum</i> (L.f.) Smith	Asclepiadaceae	Dodiyari/Dudhialata (K); Hirankhuri (G)	WV	ST	Used for gargle in mouth ulcers.
<i>Passiflora foetida</i> L.	Passifloraceae	Mukkha peera ti Veli (G)	HV	TC	Insomnia and hypertension.
<i>Pergularia daemia</i> (Forssk.) Chiov.	Asclepiadaceae	Dudhi/Dudhivel/Utaranvel/Ankod i (K and N)	HV	TC	To remove grittiness from eyes.
<i>Pueraria tuberosa</i> (Roxb. ex Willd.) DC.	Fabaceae	Ghorbel/Bharda/Paharbel (K)	WH	ST	Used in constipation, bodyache and as a tonic.
<i>Rhynchosia minima</i> (L.) DC.	Fabaceae	Jangli Urad (K)	HV	TC	Abortifacient.
<i>R. rothii</i> Benth	Fabaceae	Jangli Kulthi (K)	HV	TC	Scabies.
<i>Rivea hypocrateriformis</i> (Desr.) Choisy	Convolvulaceae	Phang/Phangi/Phanvel (K and N)	WV	ST	An antidote to snakebite.
<i>R. ornata</i> Choisy in Men.	Convolvulaceae	Phang (K)	WV	ST	Used to cure piles.

<i>Teramnus labialis</i> (L.f.) Spreng.	Fabaceae	Mashani (K)	WV	ST	Stomachache, rheumatic pains and bodyache.
<i>Tinospora cordifolia</i> (Willd.) Miers	Menispermaceae	Gulvel/Gudvel (K); Karial/Usnaide veli (G); Gahutakli (N)	WV	ST	Gonorrhoea, leucorrhoea, malaria and synochus.
<i>Trichosanthes anguina</i> L.	Cucurbitaceae	Karjari(K)	HV	TC	To treat jaundice.
<i>T. bracteata</i> (Lamk.) Voigt.	Cucurbitaceae	Gaulan/Kaundal (K); Gangagaulan (N)	HV	TC	Haemorrhoides and and gonorrhoea.
<i>Vinga trilobata</i> (L.) Verdc.	Fabaceae	Mungia(K)	HV	TC	Used as a diuretic.
<i>Wattakaka volubilis</i> (L.f.) Stapf	Asclepiadaceae	Nakchhikni/Ghaidudhivel/Dudhi (K and N); Bakar/Jamlasi ti Veli (G)	WV	ST	Urticaria, scabies, itching and psoriasis.

Abbreviations: ST: Stem twiner; WV: Woody vines; HV: Herbaceous vines; TC: Tendril climber; RC: Root climber; HC: Hook climber; Str-A: Stragglers-armed; Str- UA: Stragglers-unarmed and K-Korku, G-Gond and Nihal.

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