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RESEARCH ARTICLE

P_4-DECOMPOSITION OF LINE AND MIDDLE GRAPH OF SOME GRAPHS

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ABSTRACT

A decomposition of a graph G is a collection of edge-disjoint subgraphs G_1, G_2,... G_m of G such that every edge of G belongs to exactly one G_i, $1 \le i \le m$. $E(G) = E(G_1) \cup E(G_2) \cup \ldots \cup E(G_m)$. If every graph $G_i$is a path then the decomposition is called a path decomposition. In this paper, we have discussed the P_4-decomposition of line and middle graph of Wheel graph, Sunlet graph, Helm graph. The edge connected planar graph of cardinality divisible by 3 admits a P_4-decomposition.

Keywords: Decomposition, P_4-decomposition, Line graph, Middle graph.

Mathematics Subject Classification: 05C70

1. INTRODUCTION AND PRELIMINARIES

Let G = (V, E) be a simple graph without loops or multiple edges. A path is a walk where $v_i \neq v_j$, $\forall\ i \neq j$. In other words, a path is a walk that visits each vertex at most once. A decomposition of a graph G is a collection of edge-disjoint subgraphs G_1, G_2,... G_m of G such that every edge of G belongs to exactly one G_i, $1 \le i \le m$. $E(G) = E(G_1) \cup E(G_2) \cup \ldots \cup E(G_m)$. If every graph $G_i$is a path then the decomposition is called a path decomposition.

Heinrich, Liu and Yu (8) proved that a connected 4-regular graph admits a P_4decomosition if and only if $|E(G)| \equiv 0 \pmod 3$ by characterizing graphs of maximum degree 4 that admit a triangle-free Eulerian tour. Haggkvist and Johansson (5) proved that every maximal planar graph with atleast 4 vertices has a P_4-decomposition. C. Sunil Kumar (12) proved that a complete r-partite graph is P_4-decomposable if and only if its size is a multiple of 3. The name line graph comes from a paper by Harary & Norman (1960) although both Whitney (1932) and Krausz (1943) used the construction before this (9). The concept of middle graph was introduced by T. Hamada and I. Yoshimura (6) in 1974.

Definition 1.1. (10) A cycle graph is a graph that consists of a single cycle, or in other words, some number of vertices connected in a closed chain.

Definition 1.2. (10) A wheel graph is a graph formed by connecting a single vertex to all vertices of a cycle. A wheel graph with n vertices can also be defined as the 1-skeleton of an (n-1)-gonal pyramid.

Definition 1.3. (2) The -sunlet graph is the graph on vertices obtained by attaching pendant edges to a cycle graph.

Definition 1.4. (1) TheHelm graphis obtained from a wheel by attaching a pendant edge at each vertex of the -cycle.

Definition 1.5. (7) Let G be a graph, its Line graph L(G), is defined with the vertex set E(G), in which two vertices are adjacent if and only if the corresponding edges are adjacent in G.

Definition 1.6. (1) The Middle graph of G, denoted by M(G), is defined with the vertex set V(G) E(G), in which two elements are adjacent if and only if either both are adjacent edges in G or one of the elements is a vertex and the other one is an edge incident to the vertex in G.

Theorem 1.1. (12) $C_n$is P_4-decomposable if and only if $n \equiv 0 \pmod 3$.

Theorem 1.2. (12) K_n is P_4-decomposableif and only if $n \equiv 0 \pmod 3$ or $n \equiv 1 \pmod 3$.

P_4-DECOMPOSITION OF LINE GRAPHS

P_4-Decomposition of Line graph of Wheel graph

Let G be the wheel graph W_n. In $L(W_n)$, there are 2n number of vertices and $\frac{n(n+5)}{2}$ number of edges. Its maximum degree is n+1 and minimum degree is 4.

Theorem 2.1. The graph $L(W_n)$ is P_4 decomposable if and only if $n \equiv 0 \pmod 3$ or $n \equiv 1 \pmod 3$.

Proof: By definition of $L(W_n)$, let e_i, $1 \le i \le n$ands_i, $1 \le i \le n$be the vertices of W_n joining the vertices

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corresponding to the edges v_iv_{i+1}&v_nv_1 $(1 \le i \le n-1)$ and $vv_i(1 \le i \le n)$ respectively.

$E(L(W_n))$= $\{e_ie_{i+1} / 1 \le i \le n-1\} \cup \{e_ne_1\} \cup \{e_is_i / 1 \le i \le n\} \cup$

$\{e_is_{i+1} / 1 \le i \le n-1\} \cup \{e_ns_1\} \cup \{s_is_j / 1 \le i \le n-1 , 2 \le j \le n , i \ne j\}$

Case I : For $n \equiv 0(\text{mod } 3)$, $n > 3$

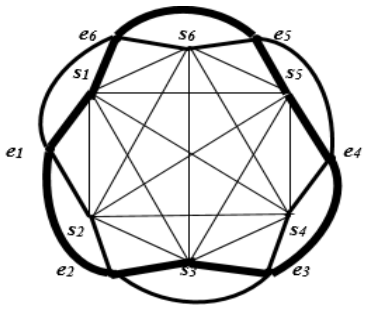

Fig.2.1. P_4-decomposition of $L(W_6)$.

$< s_i > \cong K_n$, $n \equiv 0(\text{mod } 3)$

$< s_ie_ie_{i+1}s_{i+2} > \cong (n-2)P_4$, $1 \le i \le n-2$

$< s_{n-1}e_{n-1}e_ns_1 > \cong P_4$

$< s_ne_ne_1s_2 > \cong P_4$

Hence $E(L(W_n))=E(K_n) \cup E((n-2)P_4) \cup E(P_4) \cup E(P_4)$.

Thus $L(W_n)$ is P_4-decomposable.

Case II: For $n \equiv 1(\text{mod } 3)$

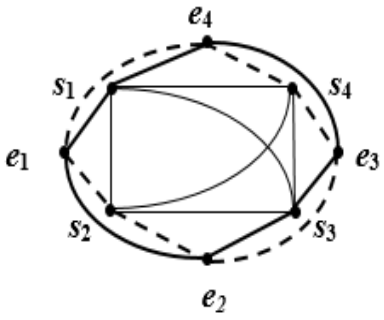

Fig.2.2. P_4-decomposition of $L(W_4)$.

$< s_i > \cong K_n$, $n \equiv 1(\text{mod } 3)$

$< s_ie_ie_{i+1}s_{i+2} > \cong (n-2)P_4$, $1 \le i \le n-2$

$< s_{n-1}e_{n-1}e_ns_1 > \cong P_4$

$< s_ne_ne_1s_2 > \cong P_4$

Hence $E(L(W_n))=E(K_n) \cup E((n-2)P_4) \cup E(P_4) \cup E(P_4)$.

Thus $L(W_n)$ is P_4-decomposable.

Conversely, suppose that $L(W_n)$ is P_4-decomposable.

Then $|E(L(W_n))| \equiv 0(\text{mod } 3)$ which implies that $\frac{n(n+5)}{2} \equiv 0(\text{mod } 3)$ and thus $n \equiv 0(\text{mod } 3)$ or $n \equiv 1(\text{mod } 3)$.

P_4-Decomposition of Line graph of Sunlet graph

Let G be the sunlet graph S_n. In $L(S_n)$, there are 2n number of vertices and 3n number of edges. Its maximum degree is 4 and minimum degree is 2.

Theorem 2.2. The graph $L(S_n)$ is P_4-decomposable for all values of n.

Proof: By definition of $L(S_n)$, let f_i , $1 \le i \le n$and e_i, $1 \le i \le n$ be the vertices of S_n joining the vertices corresponding to the edges v_iu_i $(1 \le i \le n)$ andv_iv_{i+1}&$v_nv_1(1 \le i \le n-1)$ respectively.

$E(L(S_n))$= $\{e_ie_{i+1} / 1 \le i \le n-1\} \cup \{e_ne_1\} \cup \{e_if_i / 1 \le i \le n\} \cup$

$\{e_if_{i+1} / 1 \le i \le n-1\} \cup \{e_nf_1\}$

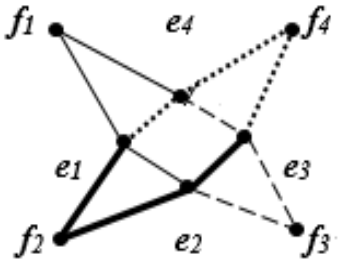

Fig.2.3. P_4-decomposition of $L(S_4)$.

$< e_if_{i+1}e_{i+1}e_{i+2} > \cong (n-2)P_4$, $1 \le i \le n-2$

$< e_{n-1}f_ne_ne_1 > \cong P_4$

$< e_nf_1e_1e_2 > \cong P_4$

Hence $E(L(S_n)) = E((n-2)P_4) \cup E(P_4) \cup E(P_4)$.

Thus $L(S_n)$ is P_4-decomposable.

P_4-Decomposition of Line graph of Helm graph

Let G be the helm graph H_n. In $L(H_n)$, there are 3n number of vertices and $\frac{n(n+11)}{2}$ number of edges. Its maximum degree is n+2 and minimum degree is 3.

Theorem 2.3. The graph $L(H_n)$ is P_4-decomposable if and only if $n \equiv 0(\text{mod } 3)$ or $n \equiv 1(\text{mod } 3)$.

Proof: By definition of $L(H_n)$, let f_i , $1 \le i \le n$; e_i,$1 \le i \le n$and s_i , $1 \le i \le n$ be the vertices of H_n joining the vertices corresponding to the edges v_iu_i $(1 \le i \le n)$;v_iv_{i+1}&$v_nv_1(1 \le i \le n-1)$ and$vv_i(1 \le i \le n)$ respectively.

$E(L(H_n))$= $\{f_is_i / 1 \le i \le n\} \cup \{f_ie_i / 1 \le i \le n\} \cup \{e_if_{i+1} / 1 \le i \le n-1\} \cup$

$\{e_nf_1\} \cup \{s_ie_i \ / \ 1 \le i \le n\} \cup \{e_is_{i+1} \ / \ 1 \le i \le n-1\} \cup \{e_ns_1\} \cup$

$\{e_ie_{i+1} \ / \ 1 \le i \le n-1\} \cup \{e_ne_1\} \cup \{s_is_j \ / \ 1 \le i \le n-1 \ , 2 \le j \le n \ , i \ne j\}$

Case I : For $n \equiv 1(\text{mod } 3)$

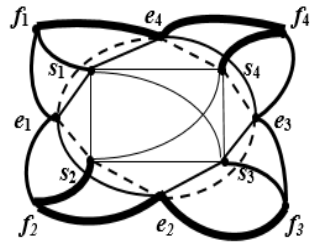

Fig.2.4. P_4-decomposition of $L(H_4)$.

$< s_i > \cong K_n, \ n \equiv 1(\text{mod } 3)$

$< s_if_ie_if_{i+1} > \cong (n-1)P_4, \ 1 \le i \le n-1$

$< s_nf_ne_nf_1 > \cong P_4$

$< s_ie_ie_{i+1}s_{i+2} > \cong (n-2)P_4 \ , \ 1 \le i \le n-2$

$< s_{n-1}e_{n-1}e_ns_1 > \cong P_4$

$< s_ne_ne_1s_2 > \cong P_4$

Hence $E(L(H_n)) = E(K_n) \cup E((n-1)P_4) \cup E(P_4) \cup E((n-2)P_4) \cup E(P_4) \cup E(P_4)$.

Thus $L(H_n)$ is P_4-decomposable.

Case II : For $n \equiv 0(\text{mod } 3)$, $n > 3$

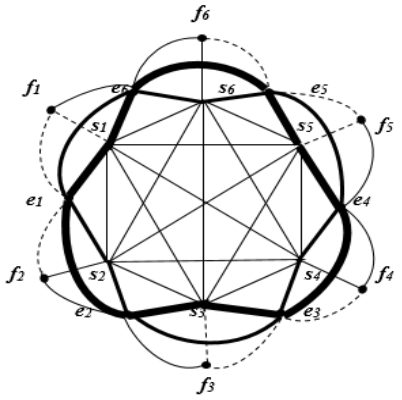

Fig.2.5. P_4-decomposition of $L(H_6)$.

$< s_i > \cong K_n, \ n \equiv 0(\text{mod } 3)$

$< s_if_ie_if_{i+1} > \cong (n-1)P_4 \ , \ 1 \le i \le n-1$

$< s_nf_ne_nf_1 > \cong P_4$

$< s_ie_ie_{i+1}s_{i+2} > \cong (n-2)P_4 \ , \ 1 \le i \le n-2$

$< s_{n-1}e_{n-1}e_ns_1 > \cong P_4$

$< s_ne_ne_1s_2 > \cong P_4$

Hence $E(L(H_n)) = E(K_n) \cup E((n-1)P_4) \cup E(P_4) \cup E((n-2)P_4) \cup E(P_4) \cup E(P_4)$.

Thus $L(H_n)$ is P_4-decomposable.

Conversely, suppose that $L(H_n)$ is P_4-decomposable.

Then $|E(L(H_n))| \equiv 0(\text{mod } 3)$ which implies that $\frac{n(n+11)}{2} \equiv 0(\text{mod } 3)$ and thus $n \equiv 0(\text{mod } 3)$ or $n \equiv 1(\text{mod } 3)$.

MIDDLE GRAPH OF CYCLE RELATED GRAPHS

P_4-Decomposition of Middle graph of Wheel graph

Let G be the wheel graph W_n. In $M(W_n)$, there are $3n+1$ number of vertices and $\frac{n(n+13)}{2}$ number of edges. Its maximum degree is $n+3$ and minimum degree is 3.

Theorem 3.1. The graph of$M(W_n)$ is P_4-decomposable if and only if $n \equiv 0(\text{mod } 3)$ or $n \equiv 2(\text{mod } 3)$.

Proof: Let $V(G) = \{v, v_1, v_2, \ldots, v_n\}$ be the vertices of W_n. By definition of $M(W_n)$,let $e_i, 1 \le i \le n$ and $s_i, 1 \le i \le n$ be the newly introduced vertices of W_n joining the vertices v_iv_{i+1}&$v_nv_1(1 \le i \le n-1)$and $vv_i \ (1 \le i \le n)$ respectively.

$E(M(W_n))$ $= \{v_ie_i \ / \ 1 \le i \le n\} \cup \{e_iv_{i+1} \ / \ 1 \le i \le n-1\} \cup \{e_nv_1\} \cup \{v_is_i \ / \ 1 \le i \le n\} \cup$

$\{e_ie_{i+1} \ / \ 1 \le i \le n\} \cup \{e_ne_1\} \cup \{vs_i \ / \ 1 \le i \le n\} \cup \{s_ie_i \ / \ 1 \le i \le n\} \cup$

$\{e_is_{i+1} \ / \ 1 \le i \le n-1\} \cup \{e_ns_1\} \cup \{s_is_j \ / \ 1 \le i \le n-1, 2 \le j \le n, i \ne j\}$

Case I : For $n \equiv 2(\text{mod } 3)$

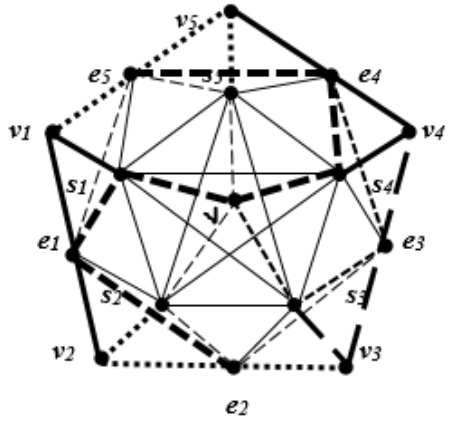

Fig.3.1. P_4-decomposition of $M(W_5)$.

$< s_iv_ie_iv_{i+1} > \cong (n-1) \ P_4, \ 1 \le i \le n-1$

$< s_nv_ne_nv_1 > \cong P_4$

$< vs_ie_ie_{i+1} > \cong (n-1) \ P_4 \ , \ 1 \le i \le n-1$

$< vs_ne_ne_1 > \cong P_4$

$< e_is_{i+1}s_is_{i+2} > \cong (n-2) \ P_4 \ , \ 1 \le i \le n-2$

$< e_{n-1}s_ns_{n-1}s_1 > \cong P_4$

$< e_ns_1s_ns_2 > \cong P_4$

Hence $E(M(W_n)) = E((n-1)P_4) \cup E(P_4) \cup E((n-1)P_4) \cup E(P_4) \cup$

$E((n-2)P_4) \cup E(P_4) \cup E(P_4)$.

Thus $M(W_n)$ is P_4-decomposable.

Case II : For $n \equiv 0 \pmod 3$

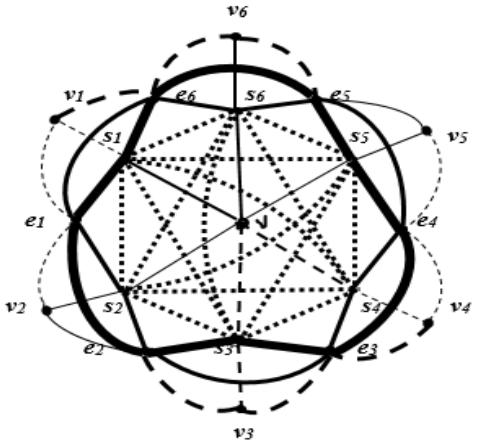

Fig.3.2. P_4-decomposition of $M(W_6)$.

$< s_i > \cong K_n$, $n \equiv 0 \pmod 3$

$< s_ie_ie_{i+1}s_{i+2} > \cong (n-2)P_4$, $1 \le i \le n-2$

$< s_{n-1}e_{n-1}e_ns_1 > \cong P_4$

$< s_ne_ne_1s_2 > \cong P_4$

$< s_iv_ie_iv_{i+1} > \cong P_4$, $1 \le i \le n-1$ & $i = i+3$

$< v_is_iv_is_{i+1} > \cong P_4$, $3 \le i \le n-3$ & $i = i+3$

$< v_ns_nv_s_1 > \cong P_4$

$< e_iv_is_iv > \cong P_4$, $2 \le i \le n-1$ & $i = i+3$

$< e_iv_{i+1}e_{i+1}v_{i+2} > \cong P_4$, $2 \le i \le n-2$ & $i = i+3$

$< e_{n-1}v_ne_nv_1 > \cong P_4$

Hence $E(M(W_n)) = E(K_n) \cup E((n-2)P_4) \cup E(P_4) \cup E(P_4) \cup E(P_4) \cup$

$E(P_4) \cup E(P_4) \cup E(P_4) \cup E(P_4) \cup E(P_4)$.

Thus $M(W_n)$ is P_4-decomposable.

Conversely, suppose that $M(W_n)$ is P_4-decomposable.

Then $\left|E(M(W_n))\right| \equiv 0 \pmod 3$ which implies that $\frac{n(n+13)}{2} \equiv 0 \pmod 3$ and thus $n \equiv 0 \pmod 3$ or $n \equiv 2 \pmod 3$.

P_4-Decomposition of Middle graph of Sunlet graph

Let G be the sunlet graph S_n. In $M(S_n)$, there are 4n number of vertices and 7n number of edges. Its maximum degree is 6 and minimum degree is 1.

Theorem 3.2. The graph $M(S_n)$ is P_4-decomposable if and only if $n \equiv 0 \pmod 3$.

Proof: Let $V(G) = \{v_1,v_2,...,v_n\}$ and $\{u_1,u_2,....,u_n\}$ be the vertices of S_n. By definition of $M(S_n)$, let f_i , $1 \le i \le n$ and e_i, $1 \le i \le n$ be the newly introduced vertices of S_n joining the vertices v_iu_i $(1 \le i \le n)$ and v_iv_{i+1} & v_nv_1 $(1 \le i \le n-1)$ respectively.

$E(M(S_n))$ $= \{v_ie_i / 1 \le i \le n\} \cup \{e_iv_{i+1} / 1 \le i \le n-1\} \cup \{e_nv_1\} \cup \{u_if_i / 1 \le i \le n\} \cup$

$\{f_iv_i / 1 \le i \le n\} \cup \{f_ie_i / 1 \le i \le n\} \cup \{e_if_{i+1} / 1 \le i \le n-1\} \cup$

$\{e_nf_1\} \cup \{e_ie_{i+1} / 1 \le i \le n-1\} \cup \{e_ne_1\}$

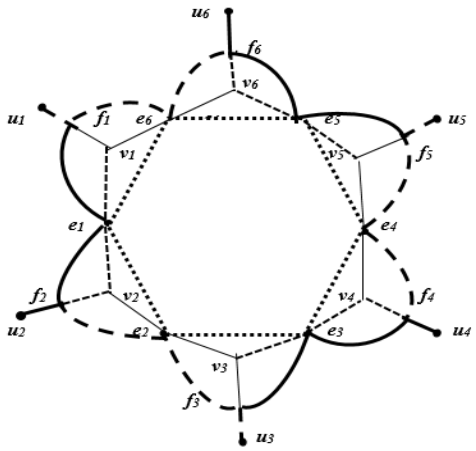

Fig.3.3. P_4-decomposition of $M(S_3)$.

$< u_if_ie_if_{i+1} > \cong (n-1)P_4$, $1 \le i \le n$

$< u_nf_ne_1f_1 > \cong P_4$

$< f_iv_ie_iv_{i+1} > \cong (n-1)P_4$, $1 \le i \le n$

$< f_nv_ne_nv_1 > \cong P_4$

$< e_i > \cong C_n$, $n \equiv 0 \pmod 3$

Hence $E(M(S_n)) = E((n-1)P_4) \cup E(P_4) \cup E((n-1)P_4) \cup E(P_4) \cup E(C_n)$.

Thus $M(S_n)$ is P_4-decomposable.

Conversely, suppose that $M(S_n)$ is P_4-decomposable.

Then $\left|E(M(S_n))\right| \equiv 0 \pmod 3$ which implies that $7n \equiv 0 \pmod 3$ and thus $n \equiv 0 \pmod 3$.

P_4-Decomposition of Middle graph of Helm graph

Let G be the helm graph H_n. In $M(H_n)$, there are 5n+1 number of vertices and $\frac{n(n+23)}{2}$ number of edges. Its maximum degree is n+4 and minimum degree is 1.

Theorem 3.3. The graph $M(H_n)$ is P_4-decomposable if and only if $n \equiv 0 \pmod 3$ or $n \equiv 1 \pmod 3$.

Proof: Let $V(G) = \{v, v_1, v_2, \ldots, v_n\}$ and $\{u_1, u_2, \ldots, u_n\}$ be the vertices of H_n.

By definition of $M(H_n)$, let f_i, $1 \le i \le n$; e_i, $1 \le i \le n$ and s_i, $1 \le i \le n$ be the newly introduced vertices of H_n joining the vertices v_iu_i $(1 \le i \le n)$; v_iv_{i+1} & v_nv_1 $(1 \le i \le n-1)$ and vv_i $(1 \le i \le n)$ respectively.

$E(M(H_n))$ $= \{v_ie_i / 1 \le i \le n\} \cup \{e_iv_{i+1} / 1 \le i \le n-1\} \cup \{e_nv_1\} \cup \{u_if_i / 1 \le i \le n\} \cup$

$\{f_iv_i / 1 \le i \le n\} \cup \{v_is_i / 1 \le i \le n\} \cup \{vs_i / 1 \le i \le n\} \cup \{f_is_i / 1 \le i \le n\} \cup$

$\{f_ie_i / 1 \le i \le n\} \cup \{e_if_{i+1} / 1 \le i \le n-1\} \cup \{e_nf_1\} \cup \{e_ie_{i+1} / 1 \le i \le n-1\} \cup$

$\{e_ne_1\} \cup \{s_ie_i / 1 \le i \le n\} \cup \{e_is_{i+1} / 1 \le i \le n-1\} \cup \{e_ns_1\} \cup$

$\{s_is_j / 1 \le i \le n-1, 2 \le j \le n, i \ne j\}$

Case I : For $n \equiv 0 \pmod 3$

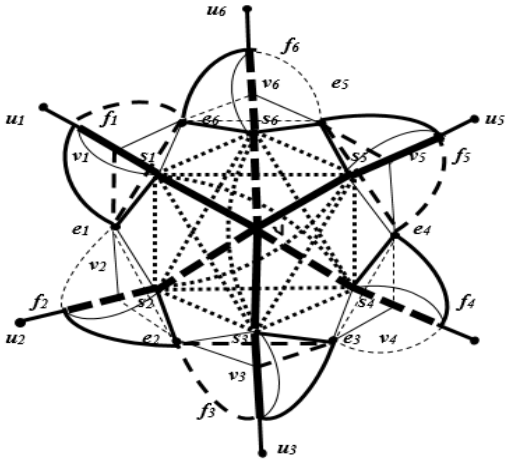

Fig.3.4. P_4-decomposition of $M(H_6)$.

$< s_i > \cong K_n$, $n \equiv 0 \pmod 3$

$< u_if_ie_is_i > \cong nP_4$, $1 \le i \le n$

$< vs_iv_if_i > \cong nP_4$, $1 \le i \le n$

$< f_1s_1e_nv_1 > \cong P_4$

$< f_is_ie_{i-1}v_i > \cong (n-1)P_4$, $2 \le i \le n$

$< v_1e_1e_nf_1 > \cong P_4$

$< v_ie_ie_{i-1}f_i > \cong (n-1)P_4$, $2 \le i \le n$

Hence $E(M(H_n)) = E(K_n) \cup E(nP_4) \cup E(nP_4) \cup E(P_4) \cup E((n-1)P_4) \cup$

$E(P_4) \cup E((n-1)P_4)$.

Thus $M(H_n)$ is P_4-decomposable.

Case II : For $n \equiv 1 \pmod 3$

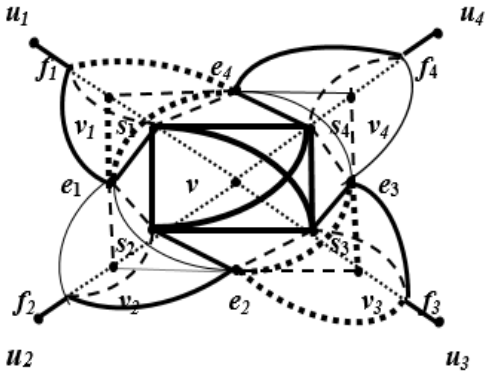

Fig.3.5. P_4-decomposition of $M(H_4)$.

$< s_i > \cong K_n$, $n \equiv 1 \pmod 3$

$< u_if_ie_is_i > \cong nP_4$, $1 \le i \le n$

$< vs_iv_if_i > \cong nP_4$, $1 \le i \le n$

$< f_1s_1e_nv_1 > \cong P_4$

$< f_is_ie_{i-1}v_i > \cong (n-1)P_4$, $2 \le i \le n$

$< v_1e_1e_nf_1 > \cong P_4$

$< v_ie_ie_{i-1}f_i > \cong (n-1)P_4$, $2 \le i \le n$

Hence $E(M(H_n)) = E(K_n) \cup E(nP_4) \cup E(nP_4) \cup E(P_4) \cup E((n-1)P_4) \cup$

$E(P_4) \cup E((n-1)P_4)$.

Thus $M(H_n)$ is P_4-decomposable.

Conversely, suppose that $M(H_n)$ is P_4-decomposable.

Then $|E(M(H_n))| \equiv 0 \pmod 3$ which implies that $\frac{n(n+23)}{2} \equiv 0 \pmod 3$ and thus $n \equiv 0 \pmod 3$ or $n \equiv 1 \pmod 3$.

4. CONCLUSION

In this paper, we have obtained the pattern for P_4-decomposition of line and middle graph of Wheel graph, Sunlet graph and Helm graph.

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RESEARCH ARTICLE

ON STAR COLOURING OF M($T_{M,N}$), M(T_N), M(L_N) AND M(S_N)

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ABSTRACT

A Star coloring of an undirected graph G is a proper vertex coloring of G in which every path on four vertices contains at least three distinct colors. The Star chromatic number of an undirected graph G, denoted by $\chi_s(G)$ is the smallest integer k for which G admits a star coloring with k colors. In this paper, we obtain the exact value of the Star chromatic number of Middle graph of Tadpole graph, Snake graph, Ladder graph and Sunlet graphs denoted by $M[T_{m,n}]$, $M[T_n]$, $M[L_n]$ and $M[S_n]$ respectively.

Keywords: Star coloring, Star chromatic number, Middle graph.

AMS Mathematical Subject classification: 05C15.

1. INTRODUCTION AND PRELIMINARIES

Throughout this paper we consider the graph G = (V,E) as a undirected, simple, finite and connected graph with no loops. A vertex coloring (4) of a graph is said to be proper coloring if no two adjacent vertices have the same color. In vertex coloring of G, the set of vertices with same color is known as color class. A proper vertex coloring of a graph is said to be star coloring if the induced subgraph of any two color classes is a collection of stars.

In 1973, Branko Grünbaum (5) introduced the concept of star coloring and also he introduce the notion of star chromatic number. In the beginning, he developed a new concept called acyclic coloring, where it is required that every cycle uses at least 3 colors, so the 2 color induced subgraphs are Forests. Later he established the star coloring concept as a special type of acyclic coloring. His works were developed further by Bondy and Hell (4). A star coloring of a graph is a vertex coloring such that the union of any two color classes does not contain a bicolored path of length 3 and the star chromatic number of a graph is a minimum number of colors which are necessary to star color the graph.

In 2004, Guillaume Fertin *et al.* (6) developed the exact value of the star chromatic number of different families of graphs such as cycles,trees, 2-dimensional grids, complete bipartite graphs, and outer planar graphs. Further, the authors studied and gave bounds for the star chromatic number of some graphs. Albertson *et al.* (4) proved that finding the star chromatic number is NPcomplete to find out whether $\chi_s(G) \leq 3$, even when G is a graph that is both planar and bipartite. They have also proved that, if G is a graph with minimum degreeΔ, the $\chi_s(G) \leq \Delta(\Delta - 1) + 2$.

In 1974, The concept of middle graph was introduced by Hamada and Yoshimura (4).

Let G be a graph with vertex set V(G) and edge set E(G). The Middle graph (3) of G,denoted by M(G), is defined as follow. The vertex set of M(G) is $V(G) \cup E(G)$ and any two vertices x,y in M(G) are adjacent in M(G), if one of the following cases holds: (i) x,y are in E(G) and x,y are adjacent in G.(ii) x is in V(G), y is in E(G) and x,y are adjacent in G.

The (m,n)-Tadpole graph(2) is a graph is obtained by joining a cycle graph C_m to a path graph P_n with a bridge. It is also known as dragon graph. It is denoted by $T_{m,n}$.

A Snake graph (3) is a Eulerian path in the hypercube that has no chords. In other words, any hypercube edge joining snake vertices is a snake edge. It is denoted by T_n.

The Ladder graph (7) is a planar undirected graph with 2n vertices and 3n-2 edges. It is denoted by L_n.

The n-Sunlet graph (1) is the graph on 2n vertices obtained by attaching n pendent edges to the cycle graph C_n. It is denoted by S_n.

2. STAR COLORING OF M ($T_{m.n}$)

Theorem 2.1. For the Tadpole graph $T_{m,n}$, where n>1 and m≥1, the Star chromatic number of Middle graph of Tadpole graph is 5.

(i.e).,$\chi_s[M(T_{m,n})] = 5$, n>1 and m≥1.

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Proof

Let $T_{m,n}$ be the Tadpole graph with joining the cycle C_m and path P_n , with m≥1 and n>1. Clearly, $V(T_{m,n}) = \{ v_i : 1 \le i \le n+m \}$ and $E(T_{m,n}) = \{ e_i : 1 \le i \le n+m \}$

By the definition of Middle graph, subdividing each edge of $T_{m,n}$ exactly once and joining all the new vertices of adjacent edges of $T_{m,n}$. The vertex set of Middle graph of $T_{m,n}$ is, $V[M(T_{m,n})] = \{ v_i : 1 \le i \le n+m \} \cup \{ u_i : 1 \le i \le n+m \}$

Let us consider the vertices $\{ v_i : 1 \le i \le m+n \}$ and $\{u_i : 1 \le i \le m+n \}$ in counter clockwise direction. It is clear that, the vertices $\{ v_1 \cup u_1 \cup u_m \cup u_{m+1} : m \ge 3 \}$ induce a clique of order 4. Therefore $\chi_s[M(T_{m,n})] \ge 5$.

Consider the color class C= $\{ c_i : 1 \le i \le 5 \}$. Assign a proper star coloring as follows

$C(v_i) = c_1$, for $1 \le i \le n$

$$C(u_i) = \begin{cases} c_2, & for\ i = 1 \\ c_3, & for\ i \equiv 0 (mod\ 2) \\ c_4, & for\ i \equiv 1 (mod\ 4) \\ c_5, & otherwise \end{cases}$$

From the above coloring procedure, it is clear that every path on 4 vertices contains at least 3 distinct colors which satisfies the definition of star coloring. Therefore $\chi_s[M(T_{m,n})] \le 5$. Hence, $\chi_s[M(T_{m,n})] = 5$.

2.1 Structural Properties of Middle Graph of Tadpole Graph

- Number of vertices in $M(T_{m,n}) = 2(n+m)$
- Number of edges in $M(T_{m,n}) = 3(n+m)+1$
- $\Delta[M(T_{m,n})] = 5$
- $\delta[M(T_{m,n})] = 1$

3. STAR COLORING OF M (T_n)

Theorem 3.1 For n≥2, the Star chromatic number of Middle graph of Snake graph is,

$\chi_s[M(T_n)] = 6$

Proof

By the definition of Triangular snake graph, it is a connected graph all of whose blocks are triangle. Clearly, $V(T_n) = \{ v_i \cup u_j : 1 \le i \le n+1, 1 \le j \le n \}$ and $E(T_n) = \{ e_i : 1 \le i \le 3n \}$

Consider $M(T_n)$, the vertex set of Middle graph of T_n is,

$V[M(T_n)] = \{ v_i \cup u_j \cup w_i \cup x_l : 1 \le i \le n+1 , 1 \le j \le n, 1 \le l \le 2n \}$

Clearly, the vertices $\{ v_i \cup w_j \cup w_{j+1} \cup x_{2k} \cup x_{2k+1} : 2 \le i \le n-1, 1 \le j \le n, 1 \le k \le 2n-1 \}$ induce a clique of order 5.Therefore $\chi_s[M(T_n)] \ge 6$.

Consider the color class C = $\{c_i : 1 \le i \le 6 \}$.

Now, assign a proper star coloring as follows

$C(v_i)$ and $C(u_j) = c_1$, for $1 \le i \le n+1, 1 \le j \le n$

$$C(w_j) = \begin{cases} c_3, & for\ j = 3\ and j \equiv 3 (mod\ 4) \\ c_4, & for\ j = 1\ and j \equiv 1 (mod\ 4) \\ c_5, & for\ j \equiv 0 (mod\ 4) \\ c_6, & for\ j = 2\ and j \equiv 2 (mod\ 4) \end{cases}$$

$$C(x_k) = \begin{cases} c_2, & for\ k \equiv 1 (mod\ 2) \\ c_3, & for\ k = 2\ and k \equiv 2 (mod\ 8) \\ c_4, & for\ k \equiv 2 (mod\ 4) \\ c_5, & otherwise \end{cases}$$

An easy check shows that, no path on 4 vertices is bicoloured which satisfies the definition of Star coloring, Therefore, $\chi_s[M(T_n)] \le 6$.

Hence, $\chi_s[M(T_n)] = 6$.

3.1 Structural Properties of Middle Graph of Snake Graph

- Number of vertices in $M(T_n) = 5n+1$
- Number of edges in $M(T_n) = 13n-4$
- $\Delta[M(T_n)] = 8$
- $\delta[M(T_n)] = 2$

4. STAR COLORING OF M (L_n)

Theorem 4.1 For n≥5, the Star chromatic number of Middle graph of Ladder graph is 6.

(i.e).,$\chi_s[M(L_n)] = 6$, n≥5.

Proof

Let L_n be the Ladder graph with 2n vertices and 3n-2 edges. Let $\{v_1,v_2,v_3,\ldots v_n\} \cup \{v_1',v_2',v_3',\ldots v_n'\}$ be the vertices of Ladder graph L_n. (i.e)., $V(L_n) = \{v_i \cup v_i' : 1 \le i \le n \}$ and $E(L_n) = \{e_j : 1 \le j \le 3n-2 \}$

Consider $M(L_n)$, the vertex set of Middle graph of L_n is,

$V[M(L_n)] = \{ v_i \cup v_i' \cup u_j \cup u_j' \cup w_i : 1 \le i \le n, 1 \le j \le n-1 \}$

Consider the color class C = $\{ci : 1 \le i \le 6 \}$.

Now, assign a proper star coloring as follows

$C(v_i)$ and $C(v_i^{'})$ = c1, for $1 \le i \le n$,

$$C(u_j) \text{ and } C(u_j^{'}) = \begin{cases} c_2, for\ j = 1\ and\ j \equiv 1(mod\ 2) \\ c_3, for\ j = 2\ and\ j \equiv 2(mod\ 4) \\ c_4, for\ j \equiv 0(mod\ 4) \end{cases}$$

$$C(w_i) = \begin{cases} c_5, for\ i = 1\ and\ i \equiv 1(mod\ 2) \\ c_6, for\ i \equiv 0(mod\ 2) \end{cases}$$

From the above coloring procedure, it is clear that no path on 4 vertices is bicolored.

Hence, $\chi_s[M(L_n)] = 6$.

4.1 Structural Properties of Middle Graph of Ladder Graph

- Number of vertices in $M(L_n) = 5n-2$
- Number of edges in $M(L_n) = 12(n-1)$
- $\Delta[M(L_n)] = 6$
- $\delta[M(L_n)] = 2$

5. STAR COLORING OF M (S_n)

Theorem 5.1 For n≥3 and n≠5, the Star chromatic number of Middle graph of Sunlet graph is 5.

(i.e).,$\chi_s[M(S_n)] = 5$, n≥3 and n≠5.

Proof

The Sunlet graph is the graph on 2n vertices obtained by attaching n pendant edges to a cycle C_n.Clearly, $V(S_n) = \{v_i \cup u_i : 1 \le i \le n\}$ and $E(S_n) = \{e_j : 1 \le j \le 2n\}$

By the definition of Middle graph, each edges of graph is subdivided exactly once by a new vertex and joining all the new vertices of adjacent edges of L_n. The vertex set of middle graph of S_n is, $V[M(S_n)] = \{ v_i \cup u_i \cup w_i \cup x_i : 1 \le i \le n \}$

Let us consider the vertices $\{v_i \cup u_i \cup w_i \cup x_i : 1 \le i \le n\}$ in the counter clockwise direction.

Consider the color class C = { ci : 1 ≤ i ≤ 5 } and assign a proper star coloring as follows

$C(v_i)$ and $C(u_j) = c_1$, for $1 \le i \le n$

$C(x_i) = c_2$, for $1 \le i \le n$

Case (i) : For $i \equiv 0(mod\ 4)$

To admit star coloring, for $1 \le i \le n$ assign the color sequences 3,4,3,5,3,4,3,5….3,4,3,5 to the successive vertices of w_i. An easy check shows that, it requires five minimum colors to color the vertices of $M(S_n)$ to satisfy the definition of star coloring.

Case (ii): For $i \equiv 3(mod\ 4)$

To admit star coloring , for $1 \le i \le n-3$ assign the color sequences 3,4,3,5,3,4,3,5,…3,4,3,5 to the successive vertices of w_i and for $n-2 \le i \le n$ assign the colors 3,4,5 to the respective vertices of w_i. It requires five minimum colors to color the vertices of $M(S_n)$ to satisfy the definition of star coloring.

Case (iii): For $i \equiv 5(mod\ 4)$

To admit star coloring, for i=5,6 assign the colors 4 and 5 to the vertices of w_i respectively, for $n-2 \le i \le n$ assign the colors 3,4,5 to the respective vertices of w_i and for $1 \le i \le n-3$ assign the color sequence 3,4,3,5,3,4,3,5,…3,4,3,5 to the successive vertices of w_i. An easy check shows that, it requires five minimum colors to color the vertices of $M(S_n)$ to satisfy the definition of star coloring

Case (iv): For $i \equiv 2(mod\ 4)$

To admit star coloring, for i=5,6 assign the colors 4 and 5 to the vertices of w_i respectively and for $1 \le i \le n$ assign the color sequences 3,4,3,5,3,4,3,5….3,4,3,5 to the successive vertices of wi. It requires five minimum colors to color the vertices of $M(S_n)$ to satisfy the definition of star coloring.

By the above cases, it is clear that, no path on 4 vertices is bicoloured.

Hence, $\chi_s[M(S_n)] = 5$.

5.1 Structural Properties of Middle Graph of Sunlet Graph

- Number of vertices in $M(S_n) = 4n$
- Number of edges in $M(S_n) = 7n$
- $\Delta[M(S_n)] = 6$
- $\delta[M(S_n)] = 1$

6. CONCLUSION

In this paper, we have found the Star chromatic number for Middle graph of Tadpole graph, Snake graph, Ladder graph and Sunlet graph. Further the results will be extended to obtain the bounds for various graphs.

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RESEARCH ARTICLE

ON DYNAMIC COLORING OF WEB GRAPH

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ABSTRACT

Dynamic coloring of a graph G is a proper coloring. The chromatic number of a graph G is the minimum k such that G has a dynamic coloring with k colors. In this paper we investigate the dynamic chromatic number for the Central graph, Middle graph, Total graph and Line graph of Web graph W_n denoted by $C(W_n)$, $M(W_n)$, $T(W_n)$ and $L(W_n)$ respectively.

Keywords: Dynamic coloring, Web graph, Middle graph, Total graph, Central graph and Line graph.

1. INTRODUCTION

Throughout this paper all graphs are finite and simple. The dynamic chromatic number was first introduced by Montgomery (13). A dynamic coloring is defined as a proper coloring in which any multiple degree vertex is adjacent to more than one color class. A dynamic coloring is thus a map c from V to the set of colors such that

- If $uv \in E(G)$, then $c(u) = c(v)$, and
- For each vertex $v \in V(G)$, $|c(N(v))| \geq \min\{2, d(v)\}$

The first condition characterizes proper colorings, the adjacency condition and second condition is double-adjacency condition. The dynamic chromatic number $\chi_d = \chi_d(G)$ is the minimum k for which G has a dynamic k-coloring. The dynamic chromatic number, $\chi_d(G)$, has been investigated in several papers, see, (1, 2, 3, 4, 5, 8, 13, 14). In 2001 Montgomery (13) conjectured that for a regular graph G, $\chi_d(G) - \chi(G) \leq 2$. Akbari *et al.* (2) proved this conjecture for bipartite regular graphs. Some upper bounds for the dynamic chromatic number of graphs have been studied in recent years. In (11, 12), Mohanapriya *et al*. studied δ-dynamic chromatic number of helm and fan graph families. There are many upper bounds and lower bounds for $\chi_d(G)$ in terms of graph parameters. For example, Theorem A [13]. Let G be a graph with maximum degree $\Delta(G)$. Then $\chi_d(G) \leq \Delta(G) + 3$. In this regard, for a graph G with $\Delta(G) \geq 3$, it was proved that $\chi_d(G) \leq \Delta(G) + 1$ [8]. Also, for a regular graph G, it was shown by Alishahi: Theorem (4). [rgb]1,0,0 If G is a r-regular graph, then $\chi_d(G) \leq \chi(G) + 14.06 \log r + 1$.

Another upper bound on $\chi_d(G)$ is $\chi_d(G) \leq 1 + l(G)$, where $l(G)$the length of a longest path in G (13) is. Theorem C (7). If G is a connected planar graph with $G \neq C5$, then $\chi_d(G) \leq 4$ Alishahi (4) proved that for every graph G with $\chi(G) \geq 4$, $\chi_d(G) \leq \chi(G) + \gamma(G)$, where $\gamma(G)$ is the domination number of a graph. Another upper bound for the dynamic chromatic number of a $d-$regular graph G in terms of $\chi(G)$ and the independence number of G, $\alpha(G)$, was introduced in (5). In fact, it was proved that $\chi_d(G) \leq \chi(G) + 2\log 2\,\alpha(G) + 3$. In (10), it has been proved that the computational complexity of $\chi_d(G)$ for a 3-regular graph is an NP-complete problem. Furthermore, in (9) it is shown that it is NP-complete to determine whether there exists a 3-dynamic coloring for a claw free graph with the maximum degree 3.

2. PRELIMINARIES

When it is required for an edge $uv = e \in E(G)$ to be represented by a vertex such vertex will be denoted by e'. The line graph (6) of a graph G, denoted by $L(G)$, is the graph in which, all edges $e_i \in E(G)$ are represented by $e_i' \in V(L(G))$ and an edge $e_i'e_j' \in E(L(G))$ if and only if the edges e_i, e_j share a vertex (are incident) in G.

The middle graph of G, denoted by $M(G)$ is defined as follows. The vertex set of $M(G)$ is $V(G) \cup E(G)$. Two vertices x, y in the vertex set of $M(G)$ are adjacent in $M(G)$ in case one of the following holds:

(i) x, y are in $E(G)$ and x, y are adjacent in G.

(ii) x is in $V(G)$, y is in $E(G)$, and x, y are incident in G.

The total graph (6) of G, denoted by has vertex set $V(G) \cup E(G)$, and edges joining all elements of this vertex set which are adjacent or incident in G.

The central graph (15) of a graph G denoted by $C(G)$ is formed by subdividing each

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edge of G by a vertex, and joining each pair of vertices of the original graph which were previously non-adjacent.

3. SOME PROPERTIES OF MIDDLE, TOTAL, CENTRAL AND LINE GRAPHS

MIDDLE GRAPH

- The number of vertices in $M(W_n) = 7n$
- The number of edges in $M(W_n) = 17n$.
- The maximum degree of $M(W_n) = \Delta(M(W_n)) = 8$.
- The minimum degree of $M(W_n), \delta(M(W_n)) = 1$.
- The number of vertices having maximum degree Δ in $M(W_n) = n$.
- The number of vertices having minimum degree δ in $M(W_n) = n$.

TOTAL GRAPH

- The number of vertices in $T(W_n) = 7n$.
- The number of edges in $T(W_n) = 21n$.
- The maximum degree of $T(W_n), \Delta(T(W_n)) = 8$.
- The minimum degree of $T(W_n), \delta(T(W_n)) = 2$.
- The number of vertices having maximum degree Δ in $T(W_n) = 2n$.
- The number of vertices having minimum degree δ in $T(W_n) = n$.

CENTRAL GRAPH

- The number of vertices in $C(W_n) = 7n$.
- The number of edges in $C(W_n) = \frac{3n(3n+1)}{2} + n$.
- The maximum degree of $C(W_n), \Delta(C(W_n)) = 3n - 1$.
- The minimum degree of $C(W_n), \delta(C(W_n)) = 2$.
- The number of vertices having maximum degree Δ in $C(W_n) = 3n$.
- The number of vertices having minimum degree δ in $C(W_n) = 4n$.

LINE GRAPH

- The number of vertices in $L(W_n) = 4n$.
- The number of edges in $L(W_n) = 9n$.
- The maximum degree of $L(W_n), \Delta(L(W_n)) = 6$.
- The minimum degree of $L(W_n), \delta(L(W_n)) = 3$.
- The number of vertices having maximum degree Δ in $L(W_n) = n$.
- The number of vertices having minimum degree δ in $L(W_n) = n$.

4. MAIN RESULTS

Theorem 4.1 **If** $n \geq 3$ the dynamic chromatic number of the middle graph of web graph $M(w_n)$, $\chi_d\ (M(w_n)\ ) = 5$.

Proof

Let $V(Wn) = \{ v_i, u_i, w_i \ for\ 1 \leq i \leq n \}$ and Let $(M(Wn)) = \{ v_i, u_i, w_i \ for\ 1 \leq i \leq n \}\ U\ \{ p_i, a_i, b_i, c_i \ for\ 1 \leq i \leq n \}$, where p_i, a_i, b_i, c_i are the vertices of $M(W_n)$ corresponding to the edge $v_i v_{i+1}$ of $W_n (1 \leq i \leq n-1), v_i u_i$ of $W_n (1 \leq i \leq n)$, $u_i u_{i+1}$ of $W_n\ (1 \leq i \leq n-1)$, $u_i w_i$ of $W_n (1 \leq i \leq n)$.

Note that any three consecutive vertices of the path must be colored differently in any dynamic coloring of $M(W_n)$, since the first and third vertices are the only neighbours of second vertex and must be colored differently (by double adjacency conditions) and also differently from the second vertex.

Therefore, $\chi_d (M(W_n)) \geq 5$.

Consider 5-coloring of $M(W_n)$ as dynamic.

Case 1 if n is even

- For $1 \leq i \leq n$, assign the color c_1 to the vertices v_i
- For $1 \leq i \leq n$, assign the color c_1 to the vertices u_i
- For $1 \leq i \leq n$, assign the color $c_4$to the vertices w_i
- For $1 \leq i \leq n$, ∀ n is odd, assign the color c_2 to vertices p_i
- For $1 \leq i \leq n$, ∀ n is even, assign the color c_3 to vertices p_i
- For $1 \leq i \leq n$, assign the color c_4 to the vertices a_i
- For $1 \leq i \leq n$, ∀ n is odd, assign the color c_2 to the vertices b_i
- For $1 \leq i \leq n$, ∀ n is even, assign the color c_3 to the vertices b_i
- For $1 \leq i \leq n$, assign the color c_5 to the vertices c_i

Case 2 if n is odd

- For $1 \leq i \leq n$, assign the color c_1 to the vertices v_i

• For $1 \leq i \leq n$, assign the color c_1 to the vertices u_i

• For $1 \leq i \leq n$, assign the color c_4 to the vertices w_i

• For $1 \leq i \leq n-1$, $\forall\, n$ is odd, assign the color c_2 to vertices p_i

• For $1 \leq i \leq n-1$, $\forall\, n$ is even, assign the color c_3 to vertices p_i and assign the color c_4 to vertex p_n

• For $2 \leq i \leq n-1$, assign the color c_4 to the vertices a_i and assign c_3 to a_1 and c_2 to vertex a_n

• For $1 \leq i \leq n-1$, $\forall\, n$ is odd, assign the color c_2 to the vertices b_i

• For $1 \leq i \leq n-1$, $\forall\, n$ is even, assign the color c_3 to the vertices b_i and assign c_4 to vertex b_n

• For $1 \leq i \leq n$, assign the color c_5 to the vertices c_i

From the cases above, it follows that $\chi_d(M(W_n)) \leq 5$.

Hence, $\chi_d(M(W_n)) = 5$, $\forall\ n \geq 3$. An easy check shows that this is minimum dynamic 5-coloring.

Theorem 4.2. If $n \geq 3$ the dynamic chromatic number of the total graph of web graph $T(Wn)$, $\chi_d(\mathrm{T}(\mathrm{W_n})) = \begin{cases} 7 \text{ if } n \text{ odd} \\ 6 \text{ if } n \text{ even} \end{cases}$.

Proof

Let $V(Wn) = \{v_i, u_i, w_i \text{ for } 1 \leq i \leq n\}$ and Let $((Wn)) = \{v_i, u_i, w_i \text{ for } 1 \leq i \leq n\} \cup \{p_i, a_i, b_i, c_i \text{ for } 1 \leq i \leq n\}$, where p_i, a_i, b_i, c_i are the vertices of $M(W_n)$ corresponding to the edge $v_i v_{i+1}$ of $W_n (1 \leq i \leq n-1), v_i u_i$ of $W_n (1 \leq i \leq n)$, $\mathrm{u_i} u_{i+1}$ of W_n $(1 \leq i \leq n-1)$, $u_i w_i$ of $W_n (1 \leq i \leq n)$.

Note that any three consecutive vertices of the path must be colored differently in any dynamic coloring of $M(W_n)$, since the first and third vertices are the only neighbors of second vertex and must be colored differently (by double adjacency conditions) and also differently from the second vertex.

Case 1 if n is odd

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_1 to vertices v_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color 2 to vertices v_i and assign the color $\mathrm{C_3}$ to vertex v_n

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_5 to vertices u_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_6 to vertices u_i and assign the color c_7 to vertex u_n

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_6 to vertices w_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_5 to vertices w_i

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_3 to vertices p_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_4 to vertices p_i and assign the color c_2 to vertex p_n

• Assign the color c_4 to vertex a_1 and c_1 to vertex a_n

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_1 to vertices a_i

• For $2 \leq i \leq n-1$, $\forall\, n$ is odd, assign the color c_2 to vertices a_i

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_3 to vertices b_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_4 to vertices b_i and assign the color c_2 to vertex b_n

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_1 to vertices c_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_2 to vertices c_i and assign the color c_3 to vertex c_n

Hence odd graph has 7 colors.

Case 2 if n is even

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_1 to vertices v_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_2 to vertices v_i

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_5 to vertices u_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color $c_6$to vertices u_i

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_6 to vertices w_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_5 to vertices w_i

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_3 to vertices p_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_4 to vertices p_i

• For $1 \leq i \leq n$, $\forall\, n$ is even, assign the color c_1 to vertices a_i

• For $1 \leq i \leq n$, $\forall\, n$ is odd, assign the color c_2 to vertices a_i

• For $1 \leq i \leq n$, $\forall n$ is odd, assign the color $c_3$to vertices b_i

• For $1 \leq i \leq n$, $\forall n$ is even, assign the color $c_4$to vertices b_i

• For $1 \leq i \leq n$, $\forall n$ is odd, assign the color c_1 to vertices c_i

• For $1 \leq i \leq n$, $\forall n$ is even, assign the color c_2 to vertices c_i

Hence even graph has 6-colors.

Hence, $\chi_d(T(Wn)) = \begin{cases} 7 \text{ if } n \text{ odd} \\ 6 \text{ if } n \text{ even} \end{cases}, \forall n \geq 3$. An easy check shows that this is minimum dynamic 5-coloring.

Theorem 4.3 If $n \geq 3$ the dynamic chromatic number of the central graph of web graph $C(W_n), \chi_d\ (C(W_n)) = 3n$.

Proof

Let v_i, u_i, w_i for $(1 \leq i \leq n)$ be the vertices of W_n. Let p_i, a_i, b_i, c_i be the subdivisions of the edges $v_i v_{i+1}$ of W_n $(1 \leq i \leq n-1)$, $v_i u_i$ of W_n $(1 \leq i \leq n)$, $u_i u_{i+1}$ of W_n $(1 \leq i \leq n-1)$, $u_i w_i$ of W_n $(1 \leq i \leq n)$.

Consider $3n$-coloring of $C(W_n)$ as dynamic.

• For $1 \leq i \leq n$, assign the color c_i to vertices v_i

• For $1 \leq i \leq n$, assign the color c_{n+i} to vertices u_i

• For $1 \leq i \leq n$, assign the color $c_{2n+i}$to vertices w_i

• For $1 \leq i \leq n-2$, assign the color c_{i+2} to vertices p_i, assign the color c_2 to vertex p_n and c_1 to vertices p_{n-1}.

• If a_i is even

For $1 \leq i \leq n, \forall n$ is odd, assign the color $c_2$to vertices a_i

For $1 \leq i \leq n, \forall n$ is even, assign the color c_3 to vertices a_i

• If a_i is odd

For $1 \leq i \leq n, \forall n$ is odd, assign the color c_2 to vertices a_i

For $1 \leq i \leq n, \forall n$ is even, assign the color c_3 to vertices a_i and assign the color c_4 to the vertex a_n

• For $1 \leq i \leq n$, assign the color c_1 to vertices b_i

• For $1 \leq i \leq n$, assign the color c_1 to vertices c_i

Thus we get, $\chi_d(C(W_n)) \leq 3n$.

Suppose $\chi_d(C(W_n)) = 3n-1$.

Here each p_i and p_{i+1}, a_i and a_{i+1}, b_i and b_{i+1}, c_i and c_{i+1} are non-adjacent vertices.

A $(3n-1)$ −coloring of $C(W_n)$ in which $p_i$and p_{i+1}, a_i and a_{i+1}, b_i and b_{i+1}, c_i and c_{i+1} receive the corresponding same colors and must satisfy both adjacency and double adjacency conditions unless the double adjacency condition is not satisfied for some vertex v, u, w adjacent to $p_i$and p_{i+1}, a_i and a_{i+1}, b_i and b_{i+1}, c_i and c_{i+1}. This is contradiction that the dynamic-coloring with $3n-1$ colors is not possible.

Therefore, $\chi_d(C(W_n)) \geq 3n$.

Hence, $\chi_d\left(C(W_n)\right) = 3n$, $\forall$ n ≥ 3.

Theorem 4.4 If $n \geq 3$ the dynamic chromatic number of the line graph of web graph $L(W_n)$, χ_d $(L(W_n)) = 4$.

Proof

By definition of line graph, each edge of W_n is taken to be as vertex is $L(W_n)$The vertices $p_i\ a_i b_i\ c_i$ for $(1 \leq i \leq n)$ induce a clique of order n in $L(W_n)$, That is $V(L(W_n)) = \{p_i : 1 \leq i \leq n\}\ U\ \{a_i : 1 \leq i \leq n\}\ U\ \{b_i : 1 \leq i \leq n\}\ U\ \{c_i : 1 \leq i \leq n\}$.

Thus we have, $\chi_d(L(W_n)) \geq 4$.

Now consider the vertex set $V(L(W_n))$ and color class $c = \{c_1, c_2, c_3, \ldots, c_n\}$. Assign the colors to $L(W_n)$ to obtain dynamic-coloring as follows:

Case 1 if n is even

• For $1 \leq i \leq n$, $\forall n$ is odd, assign the color c_1 to vertices p_i

• For $1 \leq i \leq n$, $\forall n$ is even, assign the color c_2 to vertices p_i

• For $1 \leq i \leq n$, assign the color c_3 to vertices a_i

• For $1 \leq i \leq n$, $\forall n$ is odd, assign the color c_1 to vertices b_i

• For $1 \leq i \leq n$, $\forall n$ is even, assign the color c_2 to vertices b_i

• For $1 \leq i \leq n$, assign the color c_4 to vertices c_i

Case 2 if n is odd

• For $1 \leq i \leq n$, $\forall n$ is odd, assign the color c_1 to vertices p_i

• For $1 \leq i \leq n$, $\forall n$ is even, assign the color c_2 to vertices p_i and assign the color c_3 to vertex p_n

• Assign the color c_2 to vertex a_1

• For $2 \leq i \leq n-1$, assign the color c_3 to vertices a_i and assign the color c_1 to vertex a_n

• For $1 \leq i \leq n$, $\forall n$ is odd, assign the color c_1 to vertices b_i

• For $1 \leq i \leq n$, $\forall n$ is even, assign the color c_2 to vertices b_i and assign the color c_3 to vertex b_n

• For $1 \leq i \leq n$, assign the color c_4 to vertices c_i

Thus, $\chi_d(L(Wn)) \leq 4$

Hence, $\chi_d(L(W_n)) = 4$, $\forall n \geq 3$. An easy check shows that this is minimum dynamic 4-coloring.

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RESEARCH ARTICLE

PREPARATION AND CHARACTERIZATION OF POLYVINYL ALCOHOL THIN FILMS FOR ORGANIC THIN FILM TRANSISTORS AND BIOMEDICAL APPLICATIONS

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ABSTRACT

Thin films of poly vinyl alcohol (PVA) were prepared on pre-cleaned glass substrates by Dip Coating Method. FTIR spectrum was used to identify the functional groups present in the prepared films. The vibrational peaks observed at 1260 cm^{-1} and 851 cm^{-1} are assigned to C–C stretching and CH rocking of PVA. The characteristic band appearing at 1432 cm^{-1} is assigned to C–H bend of CH_2 of PVA. The thickness of the prepared thin films were measured by using an electronic thickness measuring instrument (Tesatronic-TTD-20) and cross checked by gravimetric method. XRD spectra indicated the amorphous nature of the films. Surface morphology of the coated films was studied by scanning electron microscope (SEM). The surface revealed no pits and pin holes on the surface. The observed surface morphology indicated that these films could be used as dielectric layer in organic thin film transistors and as drug delivery system for wound healing.

Keywords: PVA, FTIR, XRD and SEM.

1. INTRODUCTION

In general, polymers are amorphous or polycrystalline substances, which have a great capacity of storing charges. Polyvinyl alcohol (PVA) is one of the promising representatives of polymeric materials and there are many proposals for its application in electronics, as well as packaging textile and food products due to its high clarity and excellent durability. In addition, PVA is used in the production of polarizing sheets (1,2). Due to the characteristics of easy preparation, excellent chemical resistance, good biodegradability and good mechanical properties, PVA has been used on many biomaterial applications (3). For example, PVA membranes have been used in the antioxidation, artificial pancreas, hemodialysis, and implantable biomaterials (4,5). The main purpose of this work is to study the morphological and structural properties of PVA films to identify the feasibility of using this PVA material for many other applications.

2. EXPERIMENTAL

The thin polymer film of polyvinyl alcohol (PVA) is deposited on pre-cleaned glass plate by Dip Coating method by isothermal immersion of a glass plate into the polymer solution of a suitable concentration held at a particular temperature for certain time. After bringing the solution to the required temperature the glass substrates, which has been cleaned well and held vertically above the solution inside the constant temperature bath by means of mechanical arrangement capable of slow and steady vertical moment are dipped inside the solution to deposit the films over the substrate. The substrates with deposited film were dried by keeping it inside the oven kept at 60^0C for 1 hr. The coated film thickness depends on i) nature of the substrate and solvent, ii) concentration and temperature of the solvent and iii) time for which the substrate is kept immersed in the solution. FTIR spectrums were used to identify the presence of the functional groups of the prepared films. The thickness of the coated films were measured by using an electronic thickness measuring instrument (Tesatronic-TTD-20) and cross checked by gravimetric method. The structural properties were investigated by using XRD and the morphology was studied by using Scanning Electron Micrographs (SEM). Pure PVA film of thickness 190 nm was used for FTIR, XRD and SEM analysis in the present investigation.

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3. RESULTS AND DISCUSSION

The infrared spectrum of PVA thin film is shown in the figures 1. The spectrum of PVA film is found to be consistent with the previous reports in literatures for PVA film (6, 7, 8).

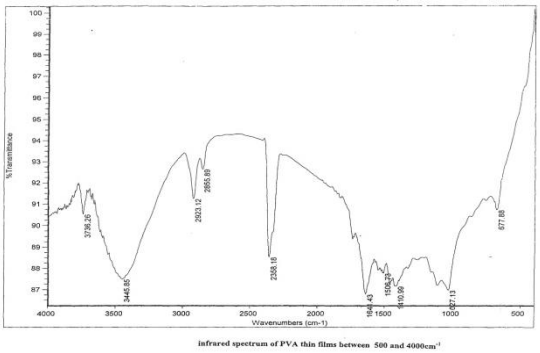

Fig. 1. FTIR spectrum of PVA film.

In general, the IR absorption bands of PVA are all quite broad and severally overlapped in 600-1500 cm^{-1} region. The O-H plane bending motion is coupled strongly with other molecular motions that involve frequencies in the range 600 - 1500 cm^{-1}. The bands at 677 cm^{-1} and 750cm^{-1} are assigned to out of plane O-H bending and γ(C-C) stretching vibration respectively. The band at about 1245 cm^{-1} results from wagging vibration of C-H. The band observed at around 1330 cm^{-1} result from wagging vibration of CH_2. The band at about 1410cm^{-1} is assigned to the symmetric bending mode $\gamma_\delta(CH_2)$. The bands at 1642 cm^{-1} and 1720 cm^{-1} of the carbonyl group are due to the absorption of the residual acetate groups due to the manufacture of PVA from hydrolysis of polyvinyl acetate. The absorption band obtained at about 2924 cm^{-1} result from stretching of CH_2 group. The relatively broad and intense absorption observed at around 3429 cm^{-1} indicates the presence of bonded O-H stretching vibration.

The bands at 660 cm^{-1} and 848 cm^{-1} are assigned to out of plane O-H bending and γ(C-C) stretching vibration and out of plane OH bending respectively. The band at about 1093 cm^{-1} is assigned to γ(C-O) stretching vibration of the ether groups**.** The band observed at 1332 cm^{-1} result from wagging vibration of CH_2. The band at about 1436 cm^{-1} is assigned to the symmetric bending mode $\gamma_\delta(CH_2)$. The bands at 1661 cm^{-1} and 1721 cm^{-1} of the carbonyl group are due to the absorption of the residual acetate groups due to the manufacture of PVA from hydrolysis of polyvinyl acetate (9). The relatively broad and intense absorption observed around 3380 cm^{-1} indicates the presence of bonded O-H stretching vibration (10).

Figures 2 shows the X-ray diffraction spectra of as grown PVA. The X-ray diffraction pattern indicates the large diffraction maxima that decrease at large diffraction angles.

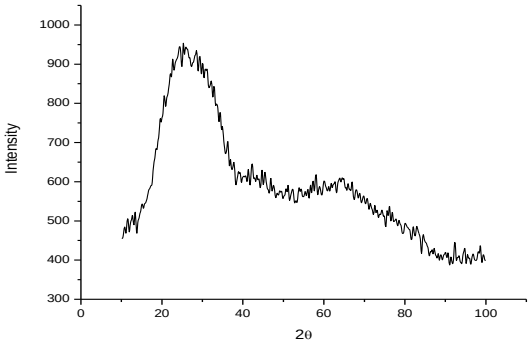

Fig.2. XRD spectrum of pure PVA film.

The first main maximum indicates the ordered packing of the polymer chains and the second maxima related to the effect of ordering inside the main chain. The diffraction of PVA film results from the strong intermolecular interaction between PVA chains through the intermolecular hydrogen bonding. The intensity of the diffraction peaks, the size of the diffraction peaks, and the size of the crystals are determined by the number of PVA chains packing together. The measurement revealed a broad pattern (characteristic of small particle size) for the as-prepared film. The absence of any intense peaks throughout the spectrum indicated the predominantly amorphous nature of the film.

The conclusive evidence of the occurrence of an amorphous state at the surface of the film is provided by SEM studies. The scanning electron micrographs of PVA film magnified to the order of 10000 is given in the Fig 3.

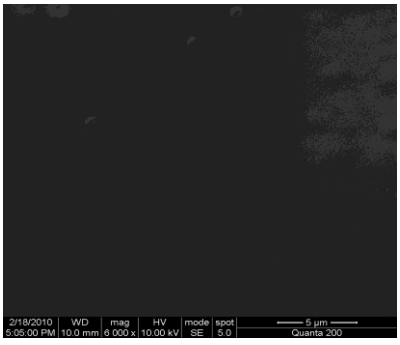

Fig. 3 SEM Micrographs of as grown PVA films.

The surface of the as grown PVA film appears to be very smooth and uniform. No pin holes and cracks are observed. The SEM figures

again revealed the amorphous nature of the film. This amorphous nature agrees with the assumption made in the model of film growth proposed by Chandar Shekar *et al* (11). That is on dissolution, the entangled PVA chains open up and assume various poly dispersed conformations. As the substrate is immersed, the PVA chain segments closest to the substrate surface adsorb on suitable sites on the substrate. The PVA film grows initially by adsorption of the chain, which is indicated by the strong dependence of the initial growth rate of the film on the nature of the substrate. After the initial adsorption of the chain segment, the films started growing at the ends of the first chain. This process of layer by layer growth by relay-adsorption results in overlapping of the chains. The extent of random overlapping increases with increase of the number of chain segments adsorbed. Consequently the mode of growth yields an amorphous layer of PVA chains at a certain distance from the substrate.

4. CONCLUSION

Smooth and uniform thin films were prepared by a simple and cost effective Dip Coating method. The X-ray diffraction analysis indicated the amorphous nature of the films prepared. The broad humps obtained in the spectrum indicated the presence of crystallites of very low dimensions. The scanning electron micrograph indicated the amorphous nature. The obtained pinhole free, smooth, amorphous phase and uniform film surface implies the feasibility of utilizing these films as gate dielectric layer in organic thin film transistors and as drug delivery system for wound healing.

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RESEARCH ARTICLE

SYNTHESIS, CHARACTERISATION, THERMAL ANALYSIS AND DNA CLEAVAGE ACTIVITY OF A NOVELZINC (II) COMPLEX OF PYRAZOLE SCHIFF BASES

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ABSTRACT

A hydrazone Schiff base Zn(II) metal complex is synthesised from the Shiff base ligand Thiophene-2-carboxylic acid hydrazide and 1, 3-diphenyl-1*H*-pyrazole-4-carboxaldehyde reacted together in 1:1 mole ratio to obtain Schiff base ligand (**HL**) which was subsequently, allowed to react with $Zn(CH_3COO)_2.2H_2O$. The Schiff base ligand and its Zn (II) complex prepared were characterized on the basis of elemental analysis, thermogravimetry, UV-Visible spectroscopy, FT-IR spectroscopy and NMR spectroscopy. IR spectrum of the zinc complex shows that the ligand (**HL)** is coordinated to the metal ion in monoanionicbidentate fashion with the 1:2 metal to ligand stoichiometry. The thermal behaviour of thecomplex shows a single step decomposition pattern leaving the respective ZnO residue. The DNA cleavage activity of the complex ismonitored using agarose gel electrophoresis method which indicates the potential of the complex to cleave supercoiled DNA.

Keywords: Characterisation, Thermal analysis, DNA Cleavage.

1. INTRODUCTION

Schiff base Hydrazone are of significant interest and attention because of their biological activity including anti-tumour, anti-bacterial, anti-fungal and anti-carcinogenic properties and catalytic activity (1). Schiff bases readily coordinate with metal ions with various modes of coordination under different reaction conditions and their metal complexes have potent chemical, physical, biological and catalytic properties (2,3,4).Schiff bases of pyrazoleheterocyles found their place in different fields of chemistry because of their wide biological activity like antimicrobial (5), anti-inflammatory (6), anti tubercular (7), anti tumor (8), anti angiogensis (9), anti parasitic (10), anti viral (11) and also possesses analgesic and anxiolytic activity (12). Many transition metal pyrazole Schiff base complexes are reported to have biological importance (13). Copper pyrazole complexes were found to be effective apoptosis inducers and inhibited angiogenesis on Matrigel and HUVEC migration *in* v*itro* (14). Some palladium pyrazole Schiff base complexes were synthesized and characterised for their cytotoxic effect against the fast growing head and neck squamous carcinoma cells SQ20B and SCC-25 and were found to have higher clonogenic cytotoxic effect than cisplatin when tested on SQ20B cell line (15). Among the transition metal complexes, zinc complex have a significant biological importance due to their presence in various enzymes and proteins (16). In this work, we synthesised zinc complex of pyrazole heterocyclic and characterised by elemental analysis, FT-IR, UV visible and NMR techniques. From the data obtained, a 1:2 metal to ligand tetrahedral coordination geometry was proposed for Zn complex.

2. MATERIALS AND METHODS

Reagent grade chemicals were procured commercially and used without subsequent purification. 1,3-diphenyl-1*H*-pyrazole-4-carboxaldehyde and thiophene carboxylic acid hydrazide were purchased from Sigma Aldrich. $[Zn(Ac)_2.2H_2O]$ were purchased from Lobachem and Rankem. The commercial solvents were used without further purification.

2.1. Physical measurements

Melting Points of the samples were determined using Raaga apparatus**.** FT-IR spectra of solid sample of ligands and complex were recorded using KBr pellets on a Nicolet Avatar instrument in the frequency range 400-4000 cm^{-1}. Microanalyses (C, H & N) were performed on a Vario EL III CHNS analyser. Electronic absorption spectra of the samples were recorded using a Jasco V-630 spectrophotometer.^{1}H NMR spectrum of the ligand was recorded on a Bruker Avance-3 spectrometer at 400 MHz.

2.2. Synthesis of schiff base

The Schiff base was prepared by reacting a mixture of thiophene carboxylic acid hydrazide (0.273 g, 1 mM) and 1,3-diphenyl-1*H*-pyrazole-4-carboxaldehyde (0.173g , 1mM) in 50 mL of aqueous methanol. A few drops of glacial acetic acid were added to the reaction mixture. The resulting

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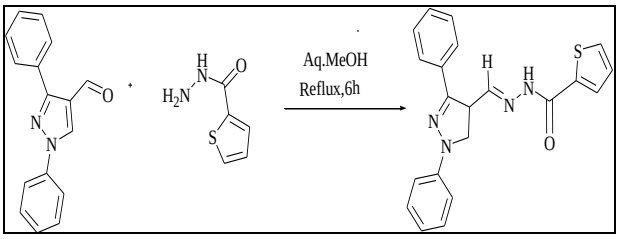
solution was refluxed for 6 h, cooled and the precipitate obtained was checked for purity. The analysis of the product by TLC revealed the formation of the ligand. Synthetic scheme for the preparation of the Schiff base is given in below.

Yield: 85%; Colour: Pale yellow; Melting Point:210°C.

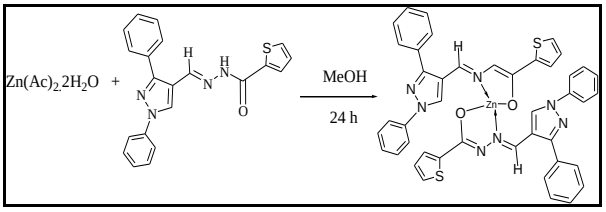


Scheme 1 Synthetic scheme for the preparation of Schiff base

2.3. Synthesis of complex

Methanolic solution of $[Zn(Ac)_2.2H_2O]$ (0.1455 g; 0.5 mM) was refluxed with equimolar quantity of the ligand, (0.217 g; 0.5 mM) in 20 mL of methanol for 24 h (scheme **2**).The solution was kept for evaporation to yield the yellowish white colour complex which was washed several times with petroleum ether and the purity of the complex was checked by TLC. The trials to crystallize the complex failed miserably.

Yield: 43 %; Colour: White; Melting point: 215 °C.



Scheme 2. Synthetic scheme of preparation of zinc complex

2.4. Determination of oxidative plasmid DNA strand breakage

Generally DNA damage is indicated by the conversion of supercoiled form of plasmid DNA to circular form. The potential of newly synthesized complex to cause oxidative plasmid DNA breakage was assessed by the plasmid DNA breakage assay (17).The 20, 30 and 40 µMconcentration of the test compounds were added to 500 ng of pBR322 supercoiled plasmid DNA along with the blank and incubated for 6h at ambient temperature under dark. Then, the samples were mixed with 6X orange loading dye (Fermentas, Mumbai) and loaded into 1% agarose gel containing Ethidium bromide. After 30 min of gel run, the extent of damage caused by the test compounds were visualized under UV light and documented using G-BOX (GE-health care, USA).

3. RESULTS AND DISCUSSION

The Schiff base ligand is synthesised by reacting equimolar quantities of thiophene carboxylic acid hydrazide and 1,3-diphenyl-1*H*-pyrazole-4-carboxaldehyde in methanol medium to yield pale yellow colour ligand thiophene 2-carboxylic acid (1,3 diphenyl 4,5- dihydro-1H-pyrazol-4-yl methylene)-hydrazide **(HL)**. The reactions of the ligand with $[Zn(Ac)_2.2H_2O]$ in methanol medium yielded complex of composition $[Zn(L)_2]$ (Scheme 2).Analytical data of the Schiff base ligand and its zinc complex are given in Table.1 and are in well agreement with the proposed molecular formulae. Zinc complex is white in colour, non-hygroscopic solidand stable in air. It is sparingly soluble in common organic solvents and completely soluble in DMF and DMSO.The ligand and the complex are characterized using IR, UV-visible and NMR spectroscopic techniques and elemental analysis method. Thermal analysis of the Zinccomplex was done to discover its formation as proposed.

3.1. Analytical data

Analytical data of the ligand (**HL**) and complexaregiven in table.**1** and they are in good agreement with the expected values.

Table.1. Analytical data of ligand and complex

Molecular formula	Mol. Wt	C %		H %		N %	
		Found	Calc.	Found	Calc.	Found	Calc.
$C_{21}H_{16}N_4OS$	372.44	67.43	67.72	4.21	4.33	14.95	15.04
$C_{42}H_{30}ZnN_8O_2S_2$	807.26	62.05	62.41	3.63	3.74	13.69	13.86

3.2. FT-IR spectral data of the ligand and complex

IR spectrum of the ligand showed a sharp band in the region 3232 cm^{-1} due to the presence of $\nu_{(N-H)}$ stretching vibrations. A very strong band found around 1647 and 1598 cm^{-1} was assigned as due to amide carbonyl symmetric and asymmetric stretching vibration. The other bands at 1547 and 1073 cm^{-1} were assigned to the $\nu_{(C=N)}$ and $\nu_{(N-N)}$ stretching frequencies of the ligand.

The bands due to $\nu_{(C=O)}$ and $\nu_{(N-H)}$ stretching vibrations of the hydrazones were absent in the IR spectra of these complex with the appearance of two new bands between 1547-1493 cm^{-1} due to the

$\nu_{(C=N-N=C)}$ function generated with the enolisation followed by deprotonation and attested the coordination of hydrazone ligand in the enol form. Furthermore, a decrease in the $\nu_{(C=N)}$ stretching frequency involving the azomethine nitrogen indicated its involvement in the coordination to the metal ion (18).

The analytical data and IR characteristics are in good agreement with the proposed structure of Zinccomplex. The important IR stretching frequencies of the ligand and complexare given in the Table 2.The IR spectrum of ligand and complex is shown in Figure 1 and 2.

Table.2. IR data of ligand and complex

Compound	ν (N-H)	ν (C=O)	ν (C=N)	ν (N-N)
HL	3282	1647	1598	1073
$[Zn(HL)_2]$	3169	-	1548	1069

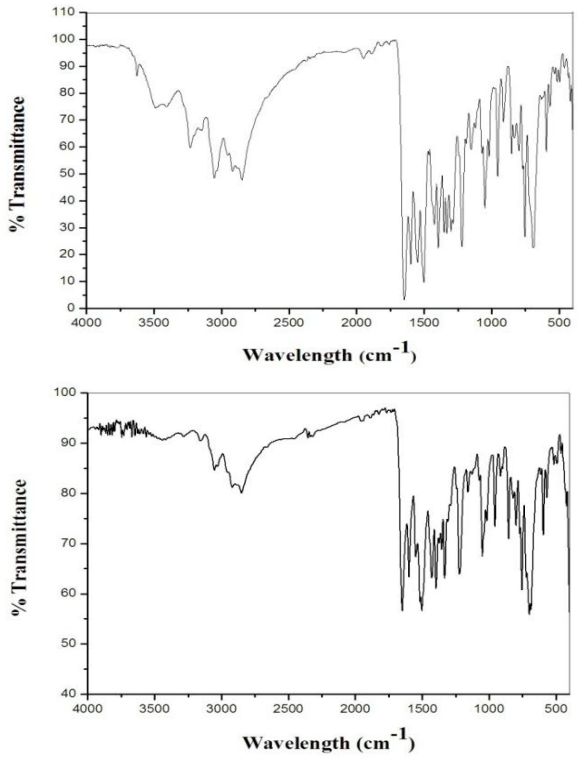


Fig.1. IR spectrum of ligand and zinc complex

3.3. ELECTRONIC SPECTRUM

The electronic spectra of the ligand and complex were recorded in DMSO solution. The ligand spectrum exhibited one broad band in the range 240-360 nm were assigned to the n→π* and π→π* intra ligand transitions which were of higher energy transitions. The spectrum of complex exhibited two bands in the range 240-380 nm region. The higher energy bands below 300 nm are attributable to n→π* and π→π* intra ligand transitions [16]. Other broad band that was observed in the 300-370 nm regions can be assigned to a ligand to metal charge transfer (LMCT) transitions of the imine group.

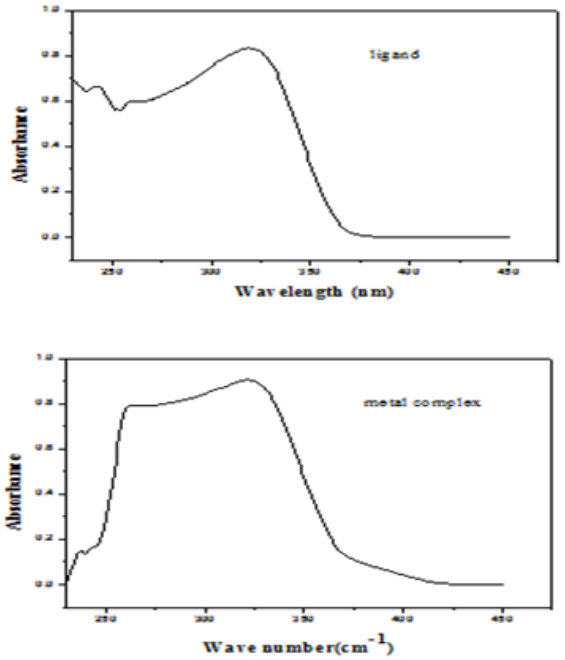
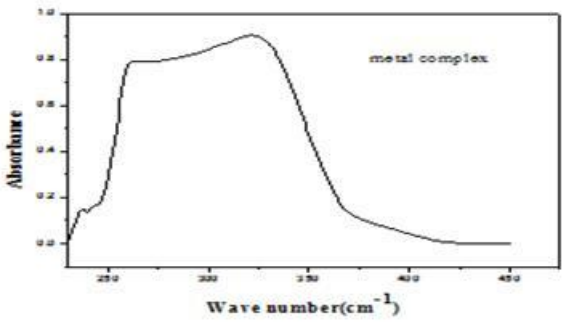


Fig.2. Electronic spectrum of ligand and Zinc complex

3.4. Proton NMR spectrum of the ligand

^{1}H-NMR spectrum of the free hydrazone ligand recorded using $CDCl_3$ as solvent was assigned on the basis of observed chemical shift. The spectrum displayed a singlet due to an NH proton in 9.0 ppm. The ligand showed a sharp singlet for azomethine (HC=N) at 8.87 ppm. Signals corresponding to the protons of benzene proton and thiophene proton of the ligand were observed as multiplets in the range of 7.22-8.58 ppm. NMR spectrum of the ligand ascertained its formation as expected.



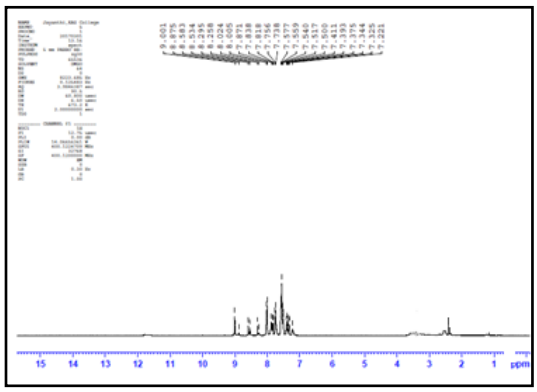


Fig. 3. ^{1}H NMR spectrum of the ligand

3.5. Thermal analysis of the complex

Thermo-gravimetric analysis of the zinc complex showed a single step decomposition pattern in the temperature range 180-356°C.The co-ordinated ligand present in the complex decomposed exothermically to yield ZnO residue.The percentage weight loss for the decomposition was found to be 89.97 % for the decomposition of the two ligands.The remaining 10.03% matches with the residue ZnO.Thus it confirmed the formation of the complex as proposed in the Scheme **2**.

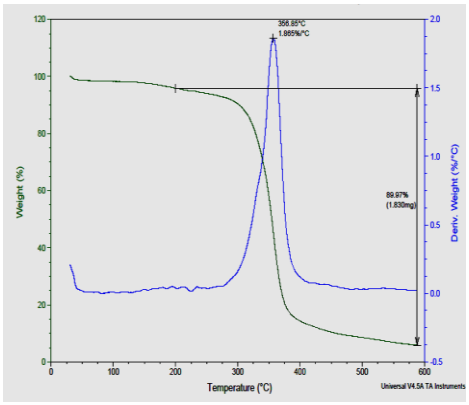


Fig. 8. TG-DTA curve of Zinc complex

Based on the above facts, a four coordinate tetrahedral geometry is proposed for the Zinc complex with 1:2 metal to ligand stoichiometry and the structure is given below.

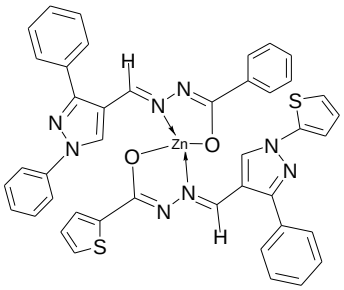


Fig.4. Proposed structure of zinc complex

3.6. DNA cleavage study

To check the role of synthesized complex on DNA breakage, plasmid DNA damage assay was performed using the pBR322 plasmid DNA and the efficiency of the cleavage was monitored by agarose gel electrophoresis.The DNA cleavage efficiency of the complex was due to the difference in the binding affinity of the complex to DNA. Results of the experiment revealed that complex significantly damaged the plasmid DNA upon treatment for 30 min (Fig.**5**). The efficiency of studied complex to cleave super-coiled DNA to linear form is the characteristic of anticancer drugs those could effectively bind to the nuclear DNA and impart damage to it and thus arrest the proliferation of cancerous cells.

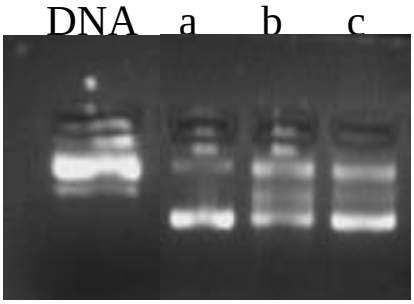


Fig. 5. pBR322 plasmid DNA cleavage by using different concentration of complex

4. CONCLUSION

Interesting coordination modes of hydrazone and their biological perspective provoked us to synthesize new zinc hydrazone complex by using the ligand prepared from 1,3 diphenyl pyrazole-1H 4carbaldehyde and thiophene carboxylic hydrazide (**HL**).The ligand was characterised by FT-IR,UV-visible and NMR spectral method showed its formation as expected. The elemental data of the ligand and the complex are in good agreement with the proposed molecular formulae of them. The IR spectral data of the zinc complex indicated the absence of N-H and carbonyl stretching vibrations and formation of new C=N vibrations. This shows the coordination of the ligand in monoanionicbidentate fashion in complex. UV spectral data of the complex showed four bands, two due to ligand centred transitions at 240-310 nm and another two metal centred transition in the range 320-450 nm. Based on the above spectral data tetrahedral geometry was proposed with 1:2 co-ordination of metal to ligand in which ligand formed NO chelate with the metal centre.The DNA cleavage studies showed that the complex have the potential to cleave DNA.

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RESEARCH ARTICLE

STUDIES ON FLORAL CHARACTERS AND SEX REVERSAL IN *CARICA PAPAYA*

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ABSTRACT

Fruits are the healthiest food with minerals, vitamins, antioxidants etc. Growing fruit trees in home gardens assure fresh and quality fruits. In the present work, cutting the male papaya plant at its base make them to sex reversal and thereby develop into hermaphrodite papaya plant. In the first time of flowering season it produces hermaphrodite flowers but does not produce fruits. All the flowers will drop down, but in second flowering season it develops fruit but they are not bulky, it is elongated. On microscopic studies it is observed that number of ovule development is more in hermaphrodite flowers than in female flower.

Keywords: *Carica papaya*, floral characters, sex reversal, hermaphrodite flower.

1. INTRODUCTION

Fruits are the source of health enhancers as it contains vitamins, anti oxidants, minerals etc. Fruits are one of the favourite diets from very old days to present. Its market value goes on increasing as it contains above said ingredients. Most of the countries have indigenous fruits and also introduced species. In India, Mango, Jack fruit etc are indigenous species. Pineapple, Papaya, Guava, Cherry, Plum, etc were introduced from various countries. Papaya is a tropical fruit which can thrive in many type of soil so an easiest fruit to cultivate. Among the states, Andhra Pradesh, Gujarat, Karnataka, Maharashtra are the leading producers of this fruit. The plant is with a single stem growing about 7- 10 m tall with leaves arranged spirally at the top of the trunk. The fruit which is berry are rich sources of antioxidant nutrients such as carotenes, vitamin C and flavonoids. The minerals such as potassium, copper, and magnesium are present. Papaya contains the digestive enzyme, papain. Papayas may be very helpful for the prevention of atherosclerosis and diabetic heart disease.

Three sexual morphism were noted in Papaya that is male, female, and hermaphrodite. The male produces only pollen and no fruit setting, the female will produce small, inedible fruits if not pollinated, while the hermaphrodite can self-pollinate and produce good fruits. For cultivation hermaphrodites are preferred than female papaya plant. Present study pointed how a male papaya plant in home gardens can be reversed to hermaphrodite plant for getting fruits.

2. MATERIALS AND METHODS

Three flower types were observed the staminate, pistillate and bisexual in different papaya plants. The male flowers are borne on inflorescence with long stock and each flower have have 10 anthers and rudimentary ovary. Female flowers are borne singly or as cymose inflorescence at each axil of newly formed leaves and may be white or yellow which bears bulged ovary but without any anthers. The hermaphrodite plant bears single flowers like female plants but with stamens and not as bulky as its flower.

In the present study, those plant from where male flowers are collected were cut using a sharp knife at its base above 50cm from the ground and observe the changes happening to the plant externally.

3. RESULTS AND DISCUSSION

Male flowers are usually borne as racemose inflorescence (Fig. 1). with about 10 epipetalous stamens arranged as two set with five each (Fig. 8, 9 and 10). Flowers from male plants have rudimentary ovaries and styles (Fig. 3 and 7 C). Female flowers are arranged as singly or cymose inflorescence (2A) without any pendulous axis as found in the male. Individual flowers are bulky with no stamen (Fig. 5). Ovary is large (Fig. 6 and 7 A) with a branched stigma at the tip of ovay. In hermaphroditic plants, flowers are borne at the apical region of the stem and branches in a cymose inflorescence fashion. Individual flowers are tubular (Fig. 2 B) with ten stamens arranged like those in the male flowers (Fig. 4). Staminate flowers from hermaphroditic plants have non-functional rudimentary ovaries and style while hermaphroditic flowers have functional ovaries, style and stigmatic surface. However, the ovaries are much smaller than those of typical females (Fig. 2B). In *Carica papaya*, female flowers are polypetalous while male and hermaphroditic

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flowers are gamopetalous (Fig. 2 ABC). All males and hermaphroditic flowers examined had rudimentary ovaries (Fig. 7 B and C) while the female flowers have bigger and functional ovaries (Fig. 7 A).

The plant grow with branches as we cut the trunk above 50cm from the ground. Only two branches are maintained for present study. In the present work, cutting the male papaya plant make them to sex reversal and there by develop into hermaphrodite papaya plant. In the first time of flowering season it produce hermaphrodite flowers but does not produce any fruits. But in second season it produce fruits. The number of ovule development is more in hermaphrodite (Fig. 11) than in female flower (Fig. 12).

Fig. 1

Fig. 2 A B C

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig.7 A B C

Fig. 8

Fig. 9

Fig. 10

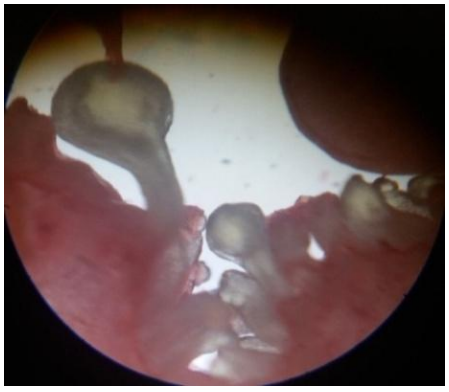

Fig. 11

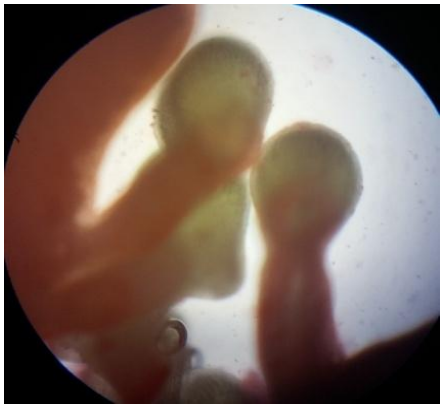

Fig. 12

In the present study cutting the male plant make the plant reversed to hermaphrodite and produce fruits. Environmental sex determination is well documented in the plant kingdom (1, 2). Such sexual transformation has been reported in *Carica*

papaya (3). The hermaphrodite plant is the preferred type of papaya plant for dependable fruit production, but under certain conditions its flower morphology is unstable and subject to "sex reversal." (4). The present study pointed the fruit formation in male plant when a stress is given externally to the plant.

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RESEARCH ARTICLE

STUDIES ON THE ARBUSCULAR MYCORRHIZAL FUNGAL BIODIVERSITY IN THE PLANT SPECIES OF YELLANAHALLI HILLS, VALLEY VIEW OF NILGIRIS, UDHAGAMANDALAM, TAMIL NADU, INDIA

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ABSTRACT

The present study to investigated that the arbuscular mycorrhizal fungal root colonization and spore population in some medicinal at Yellanahalli hills, valley view of Nilgiris, Udhagamandalam, Tamilnadu, India. Root and rhizosphere soil samples were collected during the month of August, 2017 - March, 2018 Soil pH was to be recorded. From the study results revealed that totally 25 plant species belonging to 13 families were recorded root colonization and rhizosphere spore population. A totally 12 Arbuscular mycorrhizal fungal species belonging to 7 genera and 2 different Orders were isolated and identified. The maximum spore population was found in the rhizosphere soil samples of *Justicia procumbens* (380 /100 g of soil) which belongs to the family Acanthaceae and the lowest spore population was observed in the *Crotalarieae juncea* (102 / 100 g of soil) belongs to Fabaceae. Among these plant species the highest 81% AM fungal infection was found in roots of *Solanum nigrum* belongs to the family Solanaceae While the lowest 23 % AM fungal association was found in the root of *Verbascum thapsus* belongs to Scrophulariaceae.

Keywords: AMF Spore population, medicinal plants, Yellanahalli hills.

1. INTRODUCTION

As the world population continues to increase, the demands placed on agriculture to supply future food and fiber needs will be one of the greatest challenges facing the agricultural community. In particularly soil is one of the most important along with various microorganisms colonizing the rhizosphere soil surface, mycorrhizae, the mutualistic symbiotic, play an important role in mobilizing phosphorus from the deeper layers of the soil and supplying it to the host plants. Among the mycorrhizae, Arbuscular mycorrhizae (AM) is the most prevalent type (1).

In recently, considerable importance is being given to AM fungi, because of awareness of environmental pollution and health hazards by the use of chemicals. The responsibility of AM fungi and PGPR's, in improving crop plants growth is well documented (2, 3). Arbuscular Mycorrhizal fungi are also known to several benefits of the hosts by improving the uptake of other nutrients such as nitrogen (4), copper (5), sulphur, potassium and calcium (6) and by limiting uptake of toxic heavy metals such as Zn and Cd from soil (5) and they also increase drought tolerance (7), disease resistance (8). Hence in this present research work, the arbuscular mycorrhizal fungal root colonization and spore population in the rhizosphere soil samples were invesigated in Yellanahalli hills, valley view of Nilgiris, Udhagamandalam, Tamilnadu.

2. MATERIALS AND METHODS

2.1. Study area

The present study area of Yellanahalli valley Coonoor (taluk) located in the Nilgiris District of Tamil Nadu State, India. The hill is located 11.404457°N 76. 712843°E (Fig. 1). The elevation of valley view ranges 2,400 msl (7,900ft). Near Yellanahalli are another two villages called Ketti and Aruvankadu. The Ketti is located to the south-west of Yellanahalli and is also sometimes referred to as the Switzerland of Southern India due to the year-round climatic conditions. The maximum annual rainfall 991mm and maximum temperature 24.3°C and minimum were 4.8°C.

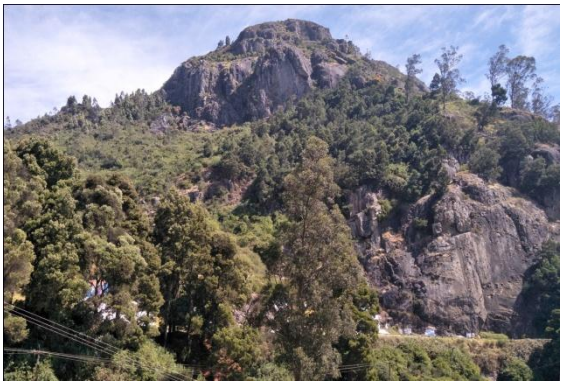

Fig. 1. View of the study area of Yellanahalli hills.

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2.2. Sample collection

The present study root and rhizosphere soils samples were collected from 25 plant species during the year August, 2017 to March, 2018. All the samples were placed in the polyethylene bags, labeled and then transported to the laboratory. The root samples were freshly processed, whereas rhizosphere soil samples were analyzed for mycorrhizal spore population and AM fungal root colonization.

2.3. Estimation of AM fungal root colonization

The fresh root samples were cleared and stained in tryphan blue following method of (9). Root samples of each plant species were washed gently under tap water and cleared in 2.5% KOH, acidified in 5 N HCL and stained in lacto glycerol with 0.05% Trypan blue. The stained roots were examined under a compound microscope (40x–100x). Hundred root segments for each sample were randomly selected for microscopic observation and the degree of colonization was estimated using the slide method (10).

The percentage of AM fungal infect ion was calculated using the formula:

$$\text{Percentage of colonization} = \frac{\text{No. of root segments colonized}}{\text{Total no of root segments of observed}} \times 100$$

2.4. AMF spore identification

AM fungal spores were extracted from 100 g rhizosphere soil by wet-sieving and decanting method (11) through a series of 710 to 37µm size sieve filter. For the identification and nomenclature of these AM fungal spore synoptic keys developed by (12, 13, 14) were used. The classification was based upon the color, shape, hyphae, structure, size, and cell wall thickness and spore diameter.

2.5. Soil pH

The pH of the rhizosphere soil samples was determined (soil-water suspensions 1:5) with the help of pH meter (Elico) and values were recorded.

3. RESULTS AND DISCUSSION

In the present research, revealed that AM fungal colonization and spore population totally 25 plant species belongs to 13 families and pH of rhizosphere soil samples ranges between 4.8 to 6.6 were recorded from the study region . The detailed information about the plant species and their family habit, parts used and medicinal uses presented in (Table-1, 2; Fig.2).

In this study, analysis of life forms indicates that 72% of them are herbs and 28% of them are shrubs (Fig. 3). As far as the plant part used is concerned, it was noted that the local people especially in Badagas employed almost all part of plant used as ethnomedicine. The leaf is most predominantly used 44 % followed by whole plant 32%, seed 8 %, flower 8%, fruit 4% and root 4% (Fig.4) respectively. Based on the present study, it has been found that the Badagas tribal community of Yellanahalli hills is rich in ethnobiological knowledge and this knowledge is being transmitted from one generation to another generation. These traditional medicines are the primary health care resources for the Badagas tribes to protect their health.

Our present study findings that AM fungal colonization, the highest percent root colonization 81% was observed in the root samples from the plant species *Solanum nigrum.* A least number of 23% AM fungal infection was observed in *Verbaseum thapsus.* The maximum spore population was noted in *Justicia procumbens* (380/100 g of soil) belongs to the family Acanthaceae and minimum spore population was recorded in *Crotalarieae juncea* (102/100 g of soil) belongs to Fabaceae (Fig. 5 and 6).

The Plant species like *Agapanthus africanus* 27% (Amaryllidaceae), *Helichrysum arenarium* 28% (Asteraceae), *Verbascum thapsus* 23% (Scrophulariaceae), *Rumexnepalensis* 29% (Polygonaceae), *Cestrum aurantiacum* 30% (Solanaceae), showed 20 and less than 30% of infection. The Plant species *Agertina adenophora* 33% (Asteraceae), *Dahlia imperialis* 35% (Asteraceae), *Plectranthus rugosus* 31% (Lamiaceae), showed 30 and less than 40% of AM fungal infection. The Plant species like *Anaphalis aristata* 45% (Asteraceae), *Crotalarieae juncea* 49% (Fabaceae), *Erigeron karvinkianus* 48% and *Helichrysum bracteatum* 45% both belongs to the family Asteraceae 48 %. *Euphorbia rothiana* 47% (Euphorbiaceae), *Leucas suffruticosa* 42% (Lamiaceae), *Phytolacca octandra* 44% (Phytolaccaceae), showed 40 and less than 50% of infection. The Asteraceae member *Parthinium hysterophorus* 55%, *Tricholepis amplexicaulis* 59% and Fabaceae member *Ulex europaeus* 60% showed 50 and less than 60% infection. The Plant species like *Diplazium esculentum* 61% (Athyriaceae), *Hypochaeris radicata* 66% (Asteraceae), *Ipomoea carnea* 69% (Convolvulaceae), showed 60 and less than 70% of infection. The Plant species like *Bidens trichosperma* 71% (Asteraceae), *Solanum nigrum* 81% (Solanaceae), *Vinca major* 77% (Apocynaceae) showed 70 and less than (90%) of infection.

Table 1. List plant species and their medicinal uses.

S. No	Plant Species	Family	Habit	Parts Used	Medicinal uses
1.	*Agapanthus africanus* (L.) Hoffmanns.	Amaryllidaceae	Herb	Whole plant	Allergy, fever, impotence, skin diseases
2.	*Ageratina adenophora* (Spreng.) King & H.Rob	Asteraceae	Shrub	Leaves	Itching, menus scanty,
3.	*Anaphalis aristata* (D C.)	Asteraceae	Herb	Whole Plant	Stomach Problems
4.	*Bidens trichosperma* (Michx.) Britton	Asteraceae	Herb	Flowers	Skin diseases and Itching
5.	*Cestrum aurantiacum* Lindl.	Solanaceae	Shrub	Leaves	Epilepsy
6.	*Crotalaria juncea* L.	Fabaceae	Herb	Whole plant	Swelling and Ulcers
7.	*Dahlia imperialis* Roezl ex Ortgies	Asteraceae	Herb	Flower	Skin treatments,
8.	*Diplazium esculentum* (Retz.)Sw.	Athyriaceae	Herb	Leaves	Fever cold, cough
9.	*Erigeron karvinskianus* D C.	Asteraceae	Herb	Leaves	Bee attractive Plant and Skin diseases
10.	*Euphorbia rothiana* Spreng.	Euphorbiaceae	Shrub	Leaves	cough, Abscesses, ulcer
11.	*Helichrysum aurantiacum* Boiss.& A.Huet	Asteraceae	Herb	Fruits	Gall bladder disorders,
12.	*Helichrysum bracteatum* (Vent).Haw	Asteraceae	Herb	Seeds	Chest complaints
13.	*Hypochaeris radicata* L.	Asteraceae	Herb	Whole plant	Cough and cold
14.	*Ipomoea carnea* Jace.	Convolvulaceae	Shrub	Leaves	Diabetic, Cancer,
15.	*Justicia procumbens* L.	Acanthaceae	Herb	Leaves	Diuretic, Asthma, Cough
16.	Leucas suffruticosa Benth.	Lamiaceae	Herb	Whole plant	Scorpion bites, Reduce fever
17.	*Parthenium hysterophorus* L.	Asteraceae	Herb	Roots	Rheumatic pain, Diarrhea
18.	*Phytolacca octandra* L.	Phytolaccaceae	Shrub	Whole plant	Impotency and also in down fever.
19.	*Plectranthus rugosus* Wall.ex Benth	Lamiaceae	Herb	Leaves	Cough and Cold,
20.	*Rumex nepalensis* Spreng.	Polygonaceae	Herb	Leaves	Skin sores
21.	*Solanum nigrum* L.	Solanaceae	Herb	Whole plant	Nonetheless and Locales
22.	*Tricholepis amplexicaulis* C.B. Clark	Asteraceae	Herb	Whole plant	Skin disease, Cough and Urinary troubles
23.	*Ulex europaeus* L.	Fabaceae	Shrub	Seeds	Blood problems
24.	*Verbascum thapsus* L.	Scrophulariaceae	Herb	Leaves	Respiratory, problems and ear pain, eczema
25.	*Vinca major* L.	Apocynaceae	Shrub	Leaves	Stomach problems, Cerebral stimulant

Table 2. AM fungal Colonization and spore Population of some Plant species in Yellanahalli, Valley view during, 2017-2018.

S. No	Plant Species	Family	pH	Types of infection			Spore Population (100g/soil)	(%) of root colonization
				Hyphal	Arbuscule	Vesicle		
1.	*Agapanthus africanus* (L.) Hoffmanns.	Amaryllidaceae	5.1	+	-	+	220	27
2.	*Ageratina adenophora* (Spreng.) King & H.Rob	Asteraceae	4.8	+	+		108	33
3.	*Anaphalis aristata* (D C.)	Asteraceae	6.1	+	-	+	110	45
4.	*Bidens trichosperma* (Michx.) Britton	Asteraceae	5.3	+	+	-	226	71
5.	*Cestrum aurantiacum* Lindl.	Solanaceae	6.4	+	-	+	177	30
6.	*Crotalaria juncea* L.	Fabaceae	5.5	+	+		102	49
7.	*Dahlia imperialis* Roezl ex Ortgies	Asteraceae	4.8	+	-	+	310	35
8.	*Diplazium esculentum* (Retz.)Sw.	Athyriaceae	5.2	+	+		265	61
9.	*Erigeron karvinskianus* D C.	Asteraceae	5.9	+	-	+	238	48
10.	*Euphorbia rothiana* Spreng.	Euphorbiaceae	6.0	+	+		224	47
11.	*Helichrysum aurantiacum* Boiss.& A.Huet	Asteraceae	5.3	+	-	+	188	28
12.	*Helichrysum bracteatum* (Vent).Haw	Asteraceae	5.6	+	+		134	45
13.	*Hypochaeris radicata* L.	Asteraceae	5.8	+	-	+	199	66
14.	*Ipomoea carnea* Jace.	Convolvulaceae	5.1	+	+		256	69
15.	*Justicia procumbens* L.	Acanthaceae	6.3	+	-	+	380	67
16.	Leucas suffruticosa Benth.	Lamiaceae	6.6	+	+		320	42
17.	*Parthenium hysterophorus* L.	Asteraceae	5.6	+	-	+	277	55
18.	*Phytolacca octandra* L.	Phytolaccaceae	5.8	+	+		219	44
19.	*Plectranthus rugosus* Wall.ex Benth	Lamiaceae	5.4	+	-	+	173	31
20.	*Rumex nepalensis* Spreng.	Polygonaceae	5.7	+	+	-	342	29
21.	*Solanum nigrum* L.	Solanaceae	5.9	+	-	+	287	81
22.	*Tricholepis amplexicaulis* C.B. Clark	Asteraceae	5.1	+	-	+	202	59
23.	*Ulex europaeus* L.	Fabaceae	5.0	+	-	+	258	60
24.	*Verbascum thapsus* L.	Scrophulariaceae	6.4	+	+	-	293	23
25.	*Vinca major* L.	Apocynaceae	6.2	+	-	+	328	77

Table 3. AM fungal genera and species were isolated from the rhizosphere soil samples in Yellanahalli hills Valley view of Nilgiri's.

S. No	AM fungal genera	Order	Family	Species
1	*Acaulospora*	Diversisporales	Acaulosporaceae	*levies* and *thomii*
2	*Claroideoglomus*	Glomerales	Claroideoglomeraceae	*etunicatum*
3	*Gigaspora*	Diversisporales	Gigasporaceae	*candida*
4	*Glomus*	Glomerales	Glomeraceae	*Glomus hoi, G. invermeyanum, G.macrocarpum, G. magnicaule, G.multicaulis,*
5	*Racocetra*	Diversisporales	Gigasporaceae	*verrucosa*
6	*Rhizophagus*	Glomerales	Glomeraceae	*fasciculatus*
7	*Sclerocystis*	Glomerales	Glomeraceae	*pachycaulis*

Fig. 2. Identification of collected plant species at Yellanahalli hills, Nilgiris.

a) *Agapanthus africanus* (L.) Hoffmanns. b) *Bidens trichosperma* (Michx.) Britton c) *Dahlia imperialis* Roezl ex Ortgies d) *Hypochaeris radicata* L.

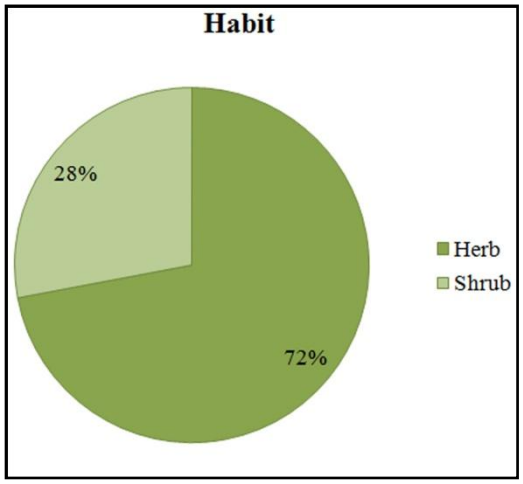

Fig. 3. Habit of plant species.

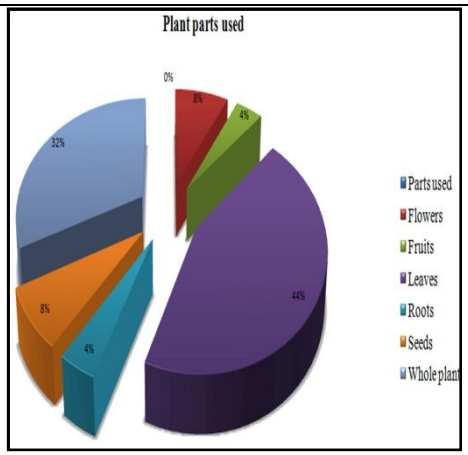

Fig. 4. Plant Parts Used.

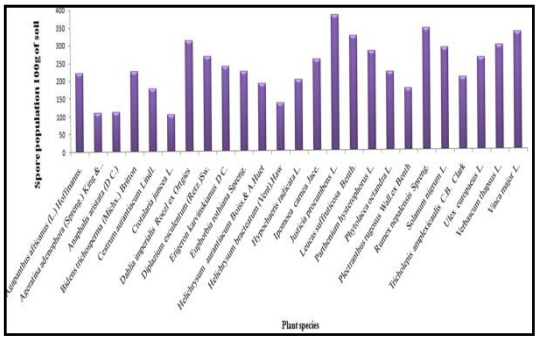

Fig. 5. AM fungal spore population in the plant species of Yellanahalli hills.

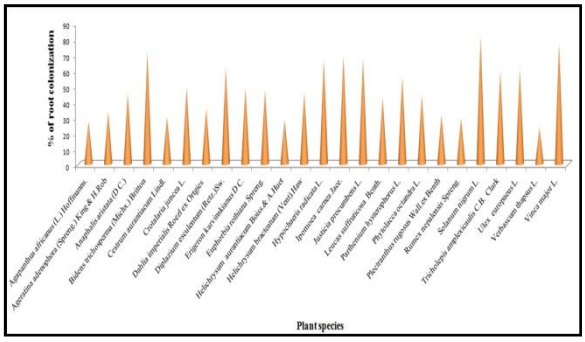

Fig. 6. Percentage of root colonization in the plant species of Collected plant families.

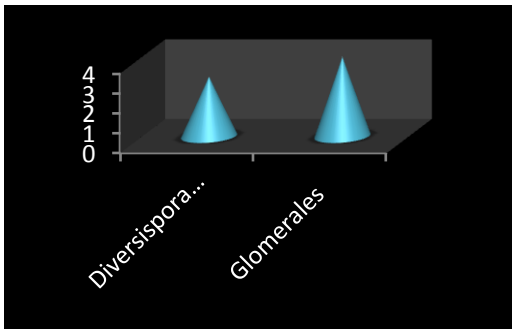

Fig. 7. Different oders of AM fungal species.

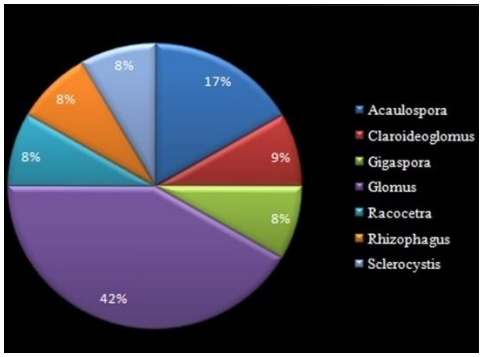

Fig. 8. Dominant species of the AM fungal genera.

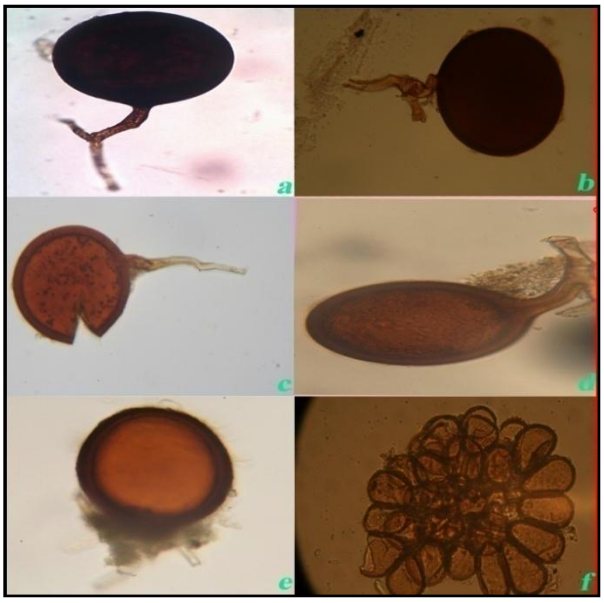

Fig. 9. Isolation and Identification of Arbuscular mycorrhizal fungal spores in Yellanahalli hills, Valley view, Nilgiris.

a) *Acaulospora levies* b) *Gigaspora candida* c) *Glomus invermayanum,* d) *Rhizophagus fasciculatus* e) *Glomus multicaulis* f) *Sclerocystis pachycaulis*

From rhizosphere soil samples of Yellanahalli hills, totally 12 AM fungal species belongs to 7 genera and 2 different Orders were isolated and identified (Fig. 7). Of these 2 species of *Acaulospora*, *Aca*. *levies*, *Aca. thomii*, 1 species of *Claroideoglomus*, *Cla*. *etunicatum,* 1 species of *Gigaspora*, *Gig. candida,* 5 species of *Glomus*, *Gl. hoi, Gl. invermayanum, Gl. macrocarpum, Gl. magnicaule, Gl. multicaulis,* 1 species of *Racocetra*, *Rac*. *verrucosa,* 1 species of *Rhizophagus*, *Rhiz. fasciculatus,* 1 species of *Sclerocystis*, *Scl. pachycaulis*. The genus *Glomus* was dominant and the name of the species were present in (Table. 3, Fig. 8, 9). Santhoshkumar and Nagarajan (15) reported that arbucular mycorrhizal fungal association in the rhizosphere soil and root colonization of some medicinal plant Species in Sirumalai Hills Eastern Ghats of Dindugul District, Tamilnadu and they were reported totally 39 AM fungal species belonging to six genera were isolated and identified. The genus *Glomus* were found dominate followed by *Acaulospora*, *Sclerocystis*, *Entrophospora* and *Gigaspora*. Priyadarshini *et al.* (16) also reported that occurrence of VAM fungi in Kalasalingam University campus. They were isolated totally 26 species of vesicular arbuscular mycorrhizal fungal spores from the rhizosphere soil samples of the plant species belonging to 14 families was reported.

4. CONCLUSION

Based on this result, concluded that arbuscular mycorrhizal fungal root colonization and spore population were observed in the plant species of Yellanahalli hills. The symbiotic association of these arbuscular mycorrhizal fungal species *Glomus* was more abundant in all rhizosphere soil of the plant species. Further studies need for the tissue culture technique using mycorrhizal inoculation for ensuring enhanced the plant growth especially in agricultural crops..

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RESEARCH ARTICLE

STUDIES ON THE ARBUSCULAR MYCORRHIZAL FUNGAL BIODIVERSITY IN THE PLANT SPECIES OF KONDRANGHI HILLS, DINDUGUL DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

The present study to investigated that the arbuscular mycorrhizal fungal root colonization and spore population in some medicinal at Kondrangi hills Eastern Ghats of Dindugul district, Tamilnadu, India. Root and rhizosphere soil samples were collected during the month of August, 2017-March, 2018 from the surface to 30 cm depth as well as pH were also recorded. Totally 32 plant species belonging to 21 families and 30 genera were identified. The present result showed arbuscular mycorrhizal spore population in the rhizosphere soil and root colonization of all the plant species. A total of 20 AM fungal species belonging to 7 genera and 2 different orders were recorded from the rhizosphere soil samples of this study region. The *Glomus* was dominant had seen in rhizosphere soil samples in all the medicinal plant species. The maximum spore population was found in the rhizosphere soil samples of *Phyllanthus amarus* (440 /100 g soil) which belongs to the family Euphorbiaceae and the lowest spore population was observed in the *Tephrosia purpurea* (110 /100g soil) belongs to Fabaceae. family. The highest 87% AM fungal infection was found in roots of *Plumbago zeylanica* belongs to the family Plumbaginaceae. While the lowest 24% AM fungal association was found in the root of *Striga angustifolia* belongs to the family Scrophulariaceae.

Keywords: Arbuscular mycorrhizal fungi**,** Medicinal plants, Kondrangi hills.

1. INTRODUCTION

Fungi constitute a megadiverse kingdom. There are at least 1.5 million, but probably as many as 3–5 million species, of which only about 100,000 have been described formally. Fungi play an important role in the rhizosphere; one among them Arbuscular Mycorrhizal symbiotic association with plant and enhances the absorption of water and nutrients, especially in phosphorous. It also increases the tolerance of plants to biotic and abiotic stresses, as pathogens, drought and high salinity (1). Besides that, the Arbuscular Mycorrhizal plays a critical role in the functional and successional processes of plant communities as soil formation, management and nutrient cycling (2, 3).

In the present study area of kondrangi hills located at eastern region of Dindugul district, a rich diversity of medicinal plants scattered over the hills and hillocks. Publish information on the AM fungal association in the medicinal plants at kondrangi hills is not available till date. Hence, the present research to investigate the diversity of arbuscular mycorrhizal fungi in the rhizosphere soil samples and root colonization of medicinal plants species were collected from the kondrangi hills, Eastern Ghats of Dindugul district, Tamil Nadu India.

2. MATERIALS AND METHODS

2.1. Study area

The present research area of Kondarangi hills Keeranur is situated at Eastern Ghats of Ottanchattram (Taulk), Dindugul district, Tamilnadu, India. The altitude ranges between 10.627988°N 77.730901°E. The hill elevation 1165.86 meters (3825 Feet) m. s. l. (Fig. 1). The maximum temperature was recorded in the month of May 33^{0}C. The maximum annual rainfall ranges 800 mm. The main activity of the local people is agriculture. They depend upon wells for irrigating the lands.

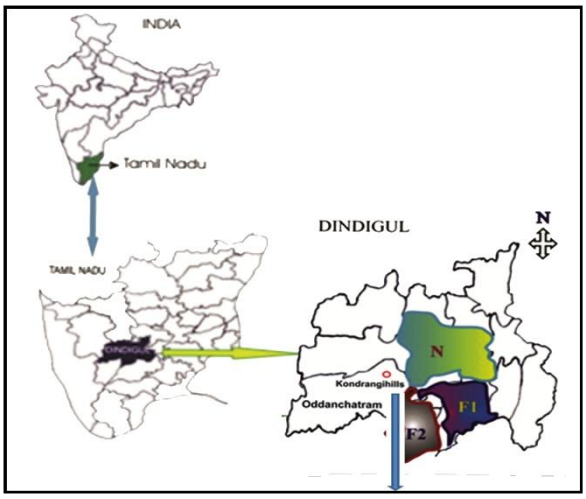

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Fig.1. View of the study area of Kondrangi hills, Dindugul district.

2.2. Sample collection

In this present study, root and rhizosphere soil samples of 32 plant species were collected for the duration of August, 2017- March, 2018. The collected soil and root samples were placed in the polyethylene bags, labeled and then transported to the laboratory. The root samples were freshly processed, whereas rhizosphere soil samples were analyzed for mycorrhizal spore population and AM fungal root colonization in study species.

2.3. Estimation of AM fungal root colonization

The root samples were cleared and stained in tryphan blue with a modified version of following method by Philips and Hayman's (4). The collected roots samples were cut into 1-2 cm pieces, heated at 90ºC in 10% KOH for about 1 hour. For thicker and older roots, the duration was increased. The root segments were rinsed in water and acidified with dilute HCl. The root pieces were stained with 0.05% tryphan blue in lacto phenol for 5 minutes and the excess stain was removed with clear lacto phenol.

The percentage of AM fungal infection was calculated using the formula:

$$\text{Percentage of colonization} = \frac{\text{No. of root segments colonized}}{\text{Total no of root segments of observed}} \times 100$$

2.4. Identification of AM fungi

The present study isolation and identification of AM fungal spores based upon their morphological characters such as spore size, color, hyphal attachement, cell wall layer characters, were identified in addition with nomenclature, keys of the following manual authors were used: Raman and Mohankumar (5); Schenk and Perez (6) and Schubler and Walker (7). The Photomicrographs were taken with the help of a Magnus Olympus Microscope.

2.5. Soil pH

The pH of the soil samples was determined (soil-water suspensions 1:5) with the help of pH meter (Elico) and values were recorded.

3. RESULTS AND DISCUSSION

In the present result reveals that totally 32 medicinal plant species belongs to 21 families were examined AM fungal colonization and spore population at kondrangi hills, Dindugul district, Tamilnadu (Fig. 2,3). The collected and identification of the plant species for their respective family, habit, plant parts used and therapeutic uses are presented (Table.1, 2; Fig. 4,5). The present findings that the rhizosphere soil samples of kondrangi hills, the maximum spore population was observed in the plant species of *Phyllanthus amarus* (440/100g of soil) belongs to Euphorbiaceae and minimum was observed in *Tephrosia purpurea* (110/100g of soil) belongs to Fabaceae. In the present investigation the highest AM fungal infection was recorded in *Plumbago zeylanica* 87%belongs to Plumbaginaceae and minimum was noticed in *Striga angustifolia* 24% belongs to Scrophulariaceae. The plant species like *Portulaca oleracea* 36% (Portulacaceae) *Heliotropium scarbrum* 35% (Boranginaceae), *Meremiea tridenta* 40% (Convolvulaceae), *Evolvulus alsinoides* 33% and *Ipomea pesti-gridis* 28% belongs to (Convolvulaceae), *Justicia tranubariensis* 32% (Acanthaceae), *Plectranthus barbatus* 40% (Lamiaceae), *Striga angustifolia* 24% (scrophularaceae) and the two members of Euphorbiaceae *Euphorbia hirta* 28%, *Phyllanthus amarus* 39% showed 20 to 40 % of infection. Logaprabha and Tamilselvi (2015) observed that some of the plants which were previously reported to be-non-mycorrhizal, were found to possess the mycorrhizal association. The level of AM infection markedly differed with various plants. The plant species *Cynodon dactylon* belongs to Poaceae member showed AM fungal colonization Sampath kumar *et al*. (2007). The similar findings were noticed in the present study of other species *Cymbopogan citratus* belongs to Poaceae member. The results was observed in the present research clearly indicated that the plants species belonging to the family Poaceae showed Arbuscular mycorrhizal fungal colonization. In this, study revealed that the rhizosphere soil samples of all the plant species the genus *Glomus* was predominant than other and *Gigaspora* occupied the second position. The present study also concluded that there is a high incidence of AM fungi in the study area. All the plant species studied were colonized by AM fungi.

Table 1. Identification of Plant species and their medicinal uses of Kondrangi hills, Dindugul district, Tamilnadu.

S.No.	PLANT SPECIES	FAMILY	PART USED	MEDICINAL USES
1	*Cleome monophylla* L.	Capparidaceae	Whole plant	Ulcer, Swelling
2	*Portulaca oleracea* L.	portulacaceae	Whole plant	Heart attack, digestive problem
3	*Corchorus aestuans* L.	Tiliaceae	Whole plant	Headache,flavouring
4	*Cissus quadrangularis* L.	Vitceae	Stem	Diabetes,allergies,asthma
5	*Indigofera villosa* L.	Fabaceae	Leaf	Snakebites,swelling,ulcer
6	*Tephrosia purpurea* sensu Baker	Fabaceae	Whole plant	Ulcer,asthma,tumors
7	*Mollugo pentaphylla* L.	Aizoaceae	Leaf	Stomach pain, anticancer
8	*Borreria ocymoides* (Burm.f.) DC.	Rubiaceae	Whole plant	Headache, wounds, eczema
9	*Oldenlandia aspera* L.	Rubiaceae	Leaf and root	Tuberculosis,asthma,snake bites
10	*Oldenlandia umbellata* Steud.	Rubiaceae	Whole plant	Asthma, snake bites
11	*Plumbago zeylanica* L.	Plumbaginaceae	Whole plant	Dysentery, leucoderma,piles
12	*Pergularia daemia* (Forssk.)chiov.	Asclepiadaceae	Whole plant	Leprosy, haemorrhoids, ulcer
13	*Heliotropium scabrum* Retz.	Boranginaceae	Whole plant	Blood loss, yaws, skin ulcer
14	*Merremiea tridenta*(L.)Hallier f.	Convolvulaceae	Whole plant	Dysentery, snake bites
15	*Evolvulus alsinoides* (Linn.) Linn.	Convolvulaceae	Whole plant	Syphilis, scrofula, snake bites
16	*Ipomoea pesti-gridis* L.	Convolvulaceae	Leaf	Pimples,tumours, headache
17	*Didymocarpus tomentosa* Wight	Gesneriaceae	Leaf	Fever, skin allergy, kidney stone
18	*Sesamum orientale* L.	Pedileaceae	Whole plant	Diarrhoea, dysentery
19	*Barleria prionitis* L.	Acanthaceae	Whole plant	Fever, rheumatism, jaundice
20	*Andrographis echionides* (L.)	Acanthaceae	Whole plant	Fever, stomach-ache, dysentery
21	*Justicia trangubariensis* L.f.	Acanthaceae	Whole plant	Fever, stomach pain
22	*Plentranthes barbatus* Andrews	Lamiaceae	Leaf, root	Blood pressure, digestion
23	*Leucas aspera*(Willd.)Link	Laminaceae	Leaf	Fever, skin diseases
24	*Striga angustifolia* (D. Don)C J.Saldanha	Scrophulariaceae	Leaf and stem	Healing process, dye skins blue-black
25	*Allmania nodiflora* (L)R.Br.ex Wight	Amaranthaceae	Whole plant	Fever, cold, snake bites
26	*Aerva javanica* (Burm.f.)juss.ex Schult.	Amaranthaceae	Whole plant	Headache, toothache
27	*Euphorbia hirta* L.	Euphorbiaceae	Whole plant	Asthma, Fever, cold
28	*Phyllanthus amarus* Schumach & Thonn.	Euphorbiaceae	Whole plant	Jaundice, stomach pain
29	*Phyllanthus maderaspatenesis* L.	Euphorbiaceae	Whole plant	Skin, rheumatism, jaundice
30	*Gloriosa superba* L.	Liliaceae	Whole plant	Cancer, ulcer, piles
31	*Typhonium trilobatum*. schott.	Araceae	Tuber	Piles, stomach pain, ulcer
32	*Cymbopogan citrates*(DC.)stapf,	Poaceae	Leaf and root	Achy joints, fever, cold

Table. 2. AM fungal root colonization and spore population in the plant species of Kondrangi hills, Ottanchantram, Dindugul district, during August, 2017-March, 2018.

S. No	Plant Species	pH	Types of infection			Spore Population (100g/soil)	(%) of root colonization
			Hyphae	Arbuscule	Vesicle		
1.	*Cleome monophylla* L.	5.1	+	-	+	375	45
2.	*Portulaca oleracea* L.	4.8	+	+	--	260	36
3.	*Corchorus aestuans* L.	6.8	+	-	+	403	60
4.	*Cissus quadrangularis* L.	5.3	+	+	-	180	55
5.	*Indigofera villosa* L.	6.4	+	-	+	340	53
6.	*Tephrosia purpurea* Sensu Baker	5.5	+	+	-	110	70
7.	*Mollugo pentaphylla* L.	4.8	+	-	+	303	66
8.	*Borreria ocymoides* (Burm.f.) DC.	5.2	+	+	-	245	46
9.	*Oldenlandia aspera* L.	5.9	+	-	+	210	54
10.	*Oldenlandia umbellata* Steud.	6.0	+	+	-	359	77
11.	*Plumbago zeylanica* L.	5.3	+	-	+	390	87
12.	*Pergularia daemia* (Forssk.) Chiov.	5.6	+	+	-	412	68
13.	*Heliotropium scabrum* Retz.	5.8	+	-	+	231	35
14.	*Meremiea tridenta* (L.) Hallier f.	5.1	+	+	-	195	40
15.	*Evolvulus alsinoides* (Linn.) Linn.	6.3	+	-	+	204	33
16.	*Ipomoea pestigridis* L.	6.6	+	+	-	365	28
17.	*Didymocarpus tomentosa* Wight	4.5	+	-	+	301	50
18.	*Sesamum orientale* L.	5.8	+	+	-	297	48
19.	*Barleria prionitis* L.	5.4	+	-	+	247	63
20.	*Andrographis echionides* (L.) Nees.	5.7	+	+	-	380	59
21.	*Justicia trangubariensis* L. f.	5.9	+	-	+	430	32
22.	*Plentranthes barbatus* Andrews	5.1	+	-	+	399	40
23.	*Leucas aspera*(Willd.) Link	5.0	+	-	+	341	69
24.	*Striga angustifolia* (D. Don) C J.Saldanha	6.4	+	+	-	258	24
25.	*Allmania nodiflora* (L)R.Br.ex Wight	6.2	+	-	+	382	57
26	*Aerva javanica* (Burm.f.) juss. ex Schult.	5.8	+	+	-	304	44
27	*Euphorbia hirta* L.	5.3	+	+	-	312	28
28	*Phyllanthus amarus* Schumach & Thonn.	5.5	+	-	+	440	39
29	*Phyllanthus maderaspatenesis* L.	6.2	+	-	+	228	71
30	*Gloriosa superba* L.	6.5	+	+	-	174	42
31	*Typhonium trilobatum*.schott.	5.8	+	+	-	280	58
32	*Cymbopogan citrates* (DC.) Stapf	5.6	+	+	-	360	61

Table. 3. AM fungal genera and species were isolated from the rhizosphere soil samples of Kondrangi hills.

S. No	AM fungal genera	Order	Family	Species
1	*Acaulospora*	Diversisporales	Acaulosporaceae	*levies*
2	*Claroideoglomus*	Glomerales	Claroideoglomeraceae	*etunicatum*
3	*Gigaspora*	Diversisporales	Gigasporaceae	*candida* and *decipiens*
4	*Glomus*	Glomerales	Glomeraceae	*Gl.hoi, Gl.albidum*, *Gl. arborences*, *Gl. austral*, *Gl. citricola*, *Gl. delhience*, *Gl. dimorphicum*, *Gl. favisporum*, *Gl. microcarpum*, *Gl. glomerulatum*, *Gl. heterosporum*, *Gl. macrocarpum*, *Gl. multisubstensum*,
5	*Rhizophagus*	Glomerales	Glomeraceae	*fasciculatus*
6	*Sclerocystis*	Glomerales	Glomeraceae	*pachycaulis*
7	*Redeckera*	Diversisporales	Gigasporaceae	*fulvum*

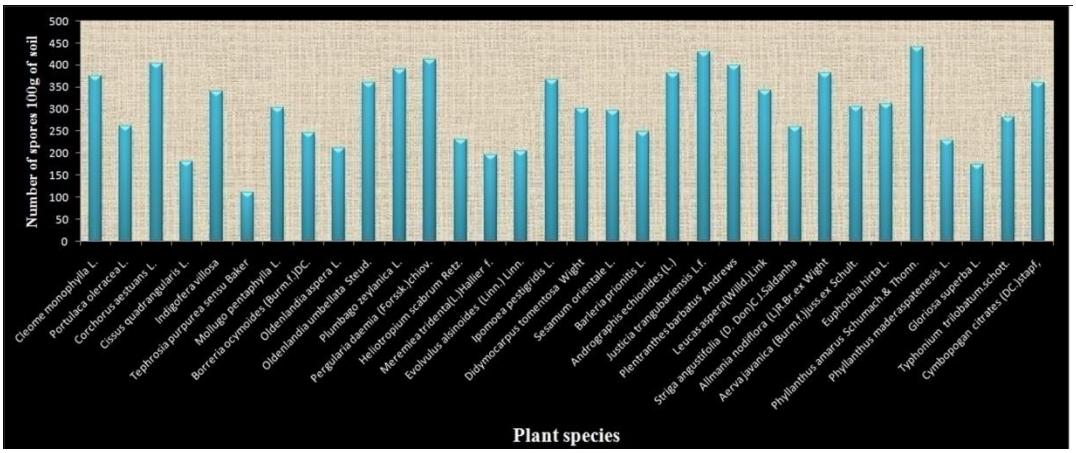

Fig. 2. Isolation of AM fungal spores in the rhizosphere soil samples of different plant species collected from the Kondrangi hills.

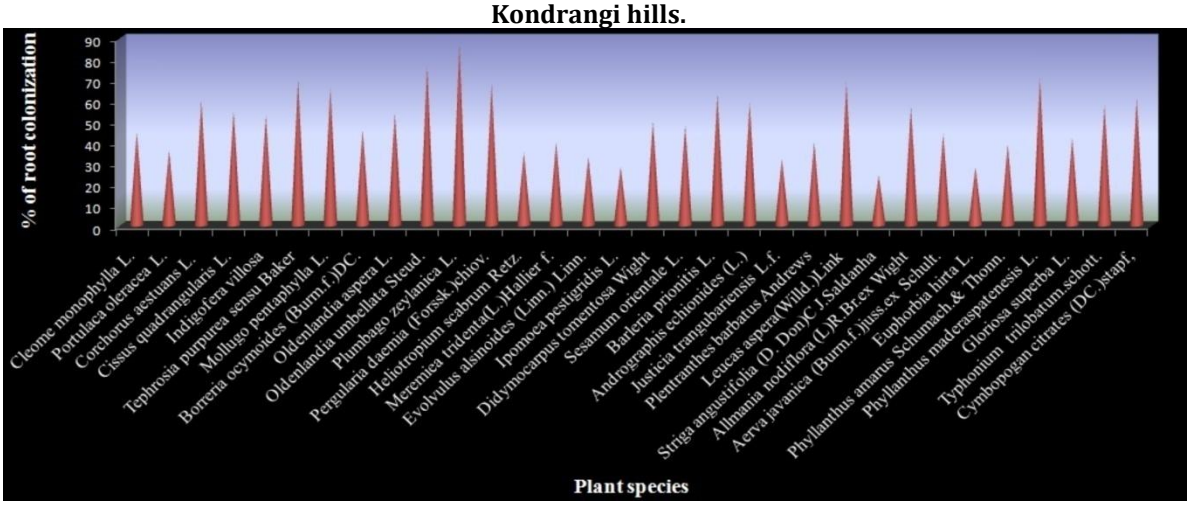

Fig. 3. AM fungal colonization in the root samples of from the plant species in Kondrangi hills.

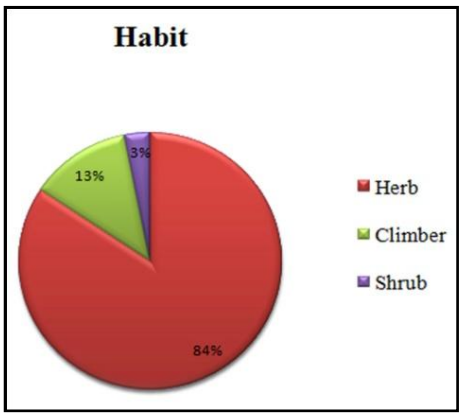

Fig. 4. Habit of the plant species

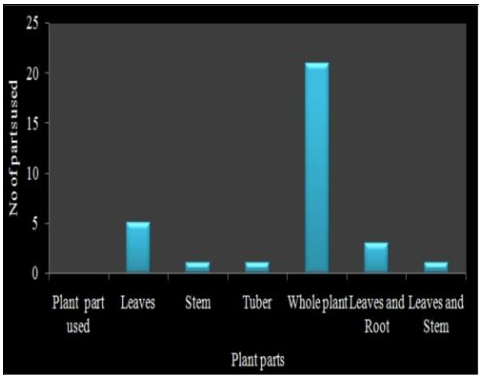

Fig. 5. Plant part used in collected plant species

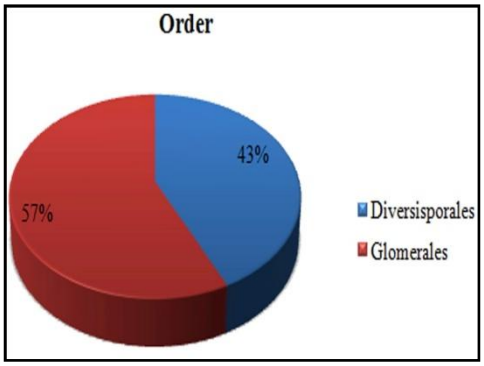

Fig. 6. Order wise distribution AM fungal species

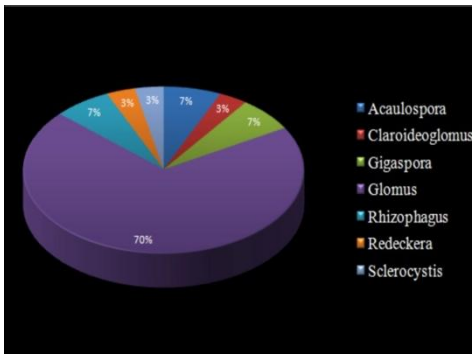

Fig.7. Dominant AM fungal species in rhizosphere soil samples

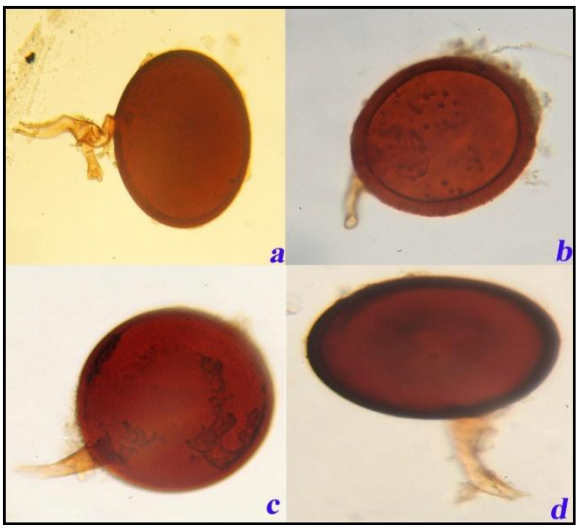

Fig. 8. Isolation and identification AM fungal species from the rhizosphere soil samples in collected plant species

The present study reveals that *Glomus* is the dominant AM fungal genus which seems to be dominant in the root regions of the plant species. Similar findings are in conformity that the genus *Glomus* was predominance in arid and semi arid areas (10-13). Natalia *et al*. (14) reported that mycorrhizae are key components of natural ecosystems because of their essential role in sustain vegetation cover. The present study revealed that the *Allmania nodiflora* belongs to Amaranthaceae member showed 57% of arbuscular mycorrhizal colonization was observed. The present studies believed to be non mycorrhizal plants were found to be associated with AM fungi.

As far as the rhizosphere soil samples of Kondrangi hills, totally 20 AM fungal species belong to 7 genera and 2 different order (Fig. 6,7) were isolated and identified. Of these 1 species of *Acaulospora*, *Aca*. *levies*, 1 species of *Claroideoglomus etunicatum,* 2 *species of Gigaspora, Gig. candida* and *Gig. decipiens*, 13 species of *Glomus, Gl.hoi, Gl.albidum*, *Gl. arborences*, *Gl. austral*, *Gl. citricola, Gl*. *delhience*, *Gl*. *dimorphicum*, *Gl. favisporum*, *Gl. microcarpum*, *Gl. glomerulatum*, *Gl. heterosporum*, *Gl. macrocarpum*, *Gl. multisubstensum*, 1 Species of *Sclerocystis, Scl. pachycaulis*, 1 Species of *Redekera fulvum*, 1 Species of *Rhizophagus fasciculatus* were observed (Table. 3; Fig. 8). Santhoshkumar and Nagarajan (15) reported that AM fungal association in the Rhizosphere soil of some Pteridophytic plant species in Valparai Hills, Western Ghats of Tamilnadu. Totally 34 AM fungal spore species was identified six genera from 12 plant species belongs to 7 families, Of these AM fungal spores of the genus *Glomus* was recorded as the most population,

followed by *Aculospora*, *Gigaspora*, *Scutellispora*, *Sclerocystis* and *Entrophospora* respectively.

4. CONCLUSION

The AM colonization and spore population in 32 medicinal plants species were investigated in kondrangi hills, Dindugul district, Tamilnadu. From the present findings of the research work, conclude that root colonization and spore population was abundant in all the plant species, however the genus *Glomus* was the dominant seen in all the rhizosphere soil. In this mutualistic association significance on medicinal plants, improving plant growth and also increasing secondary metabolite production, especially in agricultural crops.

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RESEARCH ARTICLE

DIVERSITY AND CONSERVATION STATUS OF RED-LISTED MEDICIANL PLANTS IN TAMIL NADU

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ABSTRACT

Tamil Nadu has rich repository of medicinal plant wealth and equally threatened with several number of factors. There has been enumerated a total of 119 species Red Listed medicinal plants, from which 27 species have assessed global RL status. Fourteen species have been assigned Critically Endangered (CR) status, 27 species are Endangered (EN), 31 species are Vulnerable (VU) and 10 species are Near Threatened (NT). 18 of these Red Listed medicinal plant species have been recorded in high volume trade in the national level trade study. The present paper analysed the diversity status of endemic medicinal plant diversity, assessment methods, policy terms related to medicinal plant conservation and conservational areas in Tamil Nadu.

Keywords: Endemic medicinal plants, Red Listed, threatened, endangered and conservation.

1. INTRODUCTION

The entire plant kingdom consisting of more than 3.5 lakhs species originated in 35 mega biodiversity centers around the world. Western Ghats falls within the Indian subcontinent, which covers an area of 20000 sq. km. It is notable for its rich bio-diversity and endemism. About 1500 species of medicinal herbs are found here and are used in indigenous systems of medicine such as Siddha and Ayurveda. Plants like lemon grass, patchouli and vettiver species have originated in this area. Tamil Nadu had ranked first position among all the states in the Country with 5,740 species of higher plants out of 18,672 species in India. This includes 533 endemic species, 230 red-listed species, 1559 species of medicinal plants and 260 species of wild relatives of cultivated plant (1).

Over the centuries, people in India have had a fascination and respect for the natural heritage, traditional plant ethics and tried to conserve it in varied ways possible. The Biodiversity Conservation Act 1999 emphasizes the conservation of biodiversity rich areas and their sustainable use especially, in the developing countries. And for a country like India which is diverse with all variety of flora and fauna. Conservation of natural wealth becomes a priority in the urban sprawl. The International Convention on Biological Diversity 1992 obliges all parties, including India to prepare an inventory and monitoring biodiversity and make all attempts to conserve these natural resources. This enormous task is not possible only by ground survey and research. The global Biodiversity Assessment recommends that such assessment requires a detailed knowledge of species distribution in particular landscape. India's biodiversity Act 2002 aims to promote conservation, sustainable use and equitable sharing of benefits of India's biodiversity resources. The medicinal plant diversity of all the states of India is very rich and traditional wisdom. The value of which is more or less to a large extent restricted to experts in the field and to the traditional folks (2).

In the case of medicinal plants, it is known that populations of a particular species from certain localities have been traditionally preferred. There are no systematic studies on medicinal plants with reference to gene based differences in the production of therapeutically active chemical constituents, but there are several indications. For example, a therapeutically useful lectin (a specific class of protein) from the seed of Jack fruit (*Artocarpus heterophyllus*) showed 2,500 times more activity in a sample from Bangalore, than in a sample from Chennai (3). This is one aspect of chemical diversity, a component of genetic diversity. Studies on chemical diversity, both quantitative and qualitative, on medicinal plants are largely absent and very much needed.

2. STATUS AND THREATS

Somewhat surprisingly given their commercial importance and concerns regarding population declines, information on the status of the species throughout their range was generally limited. Information on declines and rarity appeared to be based largely on expert opinion, sometimes developed through Conservation Assessment and Management Plan (CAMP)

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workshops organized by members of the IUCN/SSC Medicinal Plant Specialist Group. Population surveys appeared to be limited to a small number of sites, with little evidence of more widespread surveys to determine the status of the species at either the country or the global level. This situation can be explained in part by the vast size and remoteness of the species' habitats. For example, the appropriately named *Cistanche deserticola* is found in arid areas in China and Mongolia, while *Nardostachys grandiflora, Picrorhiza kurrooa* and *Neopicrorhiza scrophulariiflora* occur across large areas of the alpine Himalaya. Based on the information that is available, it appears that all seven species have declined in the wild owing to over-collection to supply domestic and foreign medicinal markets. As a result, all are also considered to be threatened with extinction in at least parts of their range, although only one, the tree species *Pterocarpus santalinus,* has thus far been reviewed and classified as globally threatened (Endangered) in the IUCN Red List. In some cases, *P. santalinus* being one example, the threat of harvest for medicinal use appears to be secondary to that of harvest for other uses, e.g. timber and dyes. In other case, that of *Rauvolfia serpentina,* an Indian snake root, was collection from the wild considered the primary threat; here, the main threat was habitat destruction. The principles and criteria for working on medicinal and aromatic plants have been drafted by the IUCN/MPSG (5) (Table 1).

The total of 119 species have enumerated as RL status in Tamil Nadu, 27 have a global RL status as these are endemic (or nearly so) the state/region. Fourteen species have been assigned Critically Endangered (CR) status, 27 species are Endangered (EN), 31 species are Vulnerable (VU) and 10 species are Near Threatened (NT). 18 of these Red Listed medicinal plant species have been recorded in high volume trade in the national level trade study (Table 2). Plate 1 showed the photographs of some importance red-listed medicinal plants in Tamil Nadu.

Table 1. ISSC-MAP Principles and Criteria (Working Draft, June 2006)

SECTION 1: WILD COLLECTION AND CONSERVATION REQUIREMENTS

Principle 1. Maintaining Wild MAP Resources

Wild collection of MAP resources shall be conducted at a scale and rate and in a manner that maintains populations and species over the long term.

1.1 Conservation status of target MAP species

The conservation status of target MAP species and populations is assessed and regularly reviewed.

1.2 Knowledge-based collection practices

MAP collection and management practices are based on adequate identification, inventory, assessment, and monitoring of the target species and collection impacts.

1.3 Collection intensity and species regeneration

The rate (intensity and frequency) of MAP collection does not exceed the target species' ability to regenerate over the long term.

Principle 2. Preventing Negative Environmental Impacts

Negative impacts caused by MAP collection activities on other wild species, the collection area, and neighbouring areas shall be prevented.

2.1 Sensitive taxa and habitats

Rare, threatened, and endangered species and habitats that are likely to be affected by MAP collection and management are identified and protected.

2.2 Habitat (landscape level) management

Management activities supporting wild MAP collection do not adversely affect ecosystem diversity, processes, and functions.

SECTION II: LEGAL AND ETHICAL REQUIREMENTS

Principle 3. Complying with Laws, Regulations, and Agreements

MAP collection and management activities shall be carried out under legitimate tenure arrangements, and comply with relevant laws, regulations, and agreements.

3.1 Tenure, management authority, and use rights

Collectors and managers have a clear and recognized right and authority to use and manage the target MAP resources.

3.2 Laws, regulations, and administrative requirements

Collection and management of MAP resources complies with all international agreements and with national, and local laws, regulations, and administrative requirements,

including those related to protected species and areas.

Principle 4. Respecting Customary Rights

Local communities' and indigenous peoples' customary rights to use and manage collection areas and wild collected MAP resources shall be recognized and respected.

4.1 Traditional use, access rights, and cultural heritage

Local communities and indigenous people with legal or customary tenure or use rights maintain control, to the extent necessary to protect their rights or resources, over MAP collection operations.

4.2 Benefit sharing

Agreements with local communities and indigenous people are based on appropriate and adequate knowledge of MAP resource tenure, management requirements, and resource value.

3. IMPORTANCE OF MEDICINAL PLANTS

The curative properties of drugs are due to the presence of complex chemical substances of varied composition (present as secondary plant metabolites) in one or more parts of these plants. These plant metabolites in one, according to their composition, are grouped as alkaloids, glycosides, corticosteroids, essential oils, etc. The alkaloids form the largest group, which includes morphine and codein (poppy), strychnine and brucine (nux-vomica), quinine (*Cinchona*), ergotamine (ergot), hypocyamine (beeladona), scolapomine (datura), emetine (ipecac) cocaine (coco), ephedrine (*Ephedra*), reserpine (*Rauvolfia*), caffeine (tea dust), aconitine (aconite), vaccine (vasaca), santonin (*Artemisia*), lobelin (*Lobelia*) and a large number of others. Glycosides form another important group represented by digoxin (foxglove), stropanthin (strophanthus), glycyrrhizin (liquorice), barbolin (aloe), sennocides (senna), etc. Corticosteroids have come into prominence recently and diosgenin (Dioscorea), solasodin (*Solanum* sp.), etc. now command a large world demand. Some essential oils such as those of valeriana and peppermint also possess medicating properties and are used in pharmaceutical industry.

During the last two decades, the pharmaceutical industry has made massive investments on pharmacological, clinical and chemical researches all over the world in an effort to discover and still more potent plant drugs ; in fact, a few new drug plant have suceessfully passed the tests of commercial screening. However, benefits of this labour would reach the masses when the corresponding support for agricultural studies for commercial cultivation is provided. Infact, agricultural studies on medicinal plants, by its very nature, demand an equally large investment and higher priority. India, in particular, has a big scope for the development of the phytopharmaceutical and phytochemical industry.

4. RED LIST ASSESSMENT AND MANAGEMENT PLANNING FOR MEDICINAL PLANTS

Members of the MPSG South Asia regional sub-group continue to make this region an active centre of medicinal plant conservation status assessment, applying the IUCN Red List criteria and methods for conservation management planning (the CAMP process) developed by the SSC Conservation Breeding Specialist Group (CBSG). The formal terms of reference for Red List Authorities may require some flexibility in their application to medicinal plants, given the diversity of taxa included in this group, and the overlapping taxonomic and regional Red List authority of other Specialist Groups. At present, it need to focus efforts on collaborating with Red List authorities for taxonomic groups that include threatened or potentially threatened species of medicinal plants, ensuring that any activities involving Red List assessments of medicinal plants (such as Conservation Assessment and Management Planning – CAMP workshops) are applying the current IUCN Red List Categories appropriately (version 3.1, 2001, http://www.iucn.org/themes /ssc/redlists/RLcats2001booklet.html), reporting the assessment results adequately to the SSC Red List Programme, and creating training opportunities to increase Red List capacity for researchers working on medicinal plants.

5. TERMS OF REFERENCE FOR RED LIST AUTHORITIES

The Red List Authority takes responsibility for ensuring that taxa specified in the appointment contract are evaluated against the IUCN Red List Categories. The Red List Authority (RLA) will ensure that each taxon within its mandate that has already been evaluated against the Categories is re-evaluated at least every 10 years, and if possible every 5 years. The Red List Authority will also seek to expand the number of taxa evaluated against the Categories in particular in response to the priorities identified in collaboration with the SSC Red List Programme. Each Red List Authority will appoint a Red List focal point person for the Authority to liaise with the Red List Programme Officer. A Red List Authority can comprise as many people as required (but a minimum of two is necessary). How

each RLA is constructed and how it operates is entirely at the discretion of each group but the terms of reference outlined above need to be borne in mind.

Each RLA focal point person will be responsible for verifying Red List assessments through:

1. ensuring that at least two named evaluators agree the status of each taxon assessed;

2. ensuring that the evaluators are competent in the relevant fields;

3. ensuring that the evaluators are familiar with and up-to date with the Red List Categories and Criteria, and their application;

4. requiring evaluators to take full account of present and past literature (published and grey) and other reliable sources of information, relating to the taxon;

5. assisting evaluators to seek and locate the best available background data relating to the threats likely to affect the taxon;

6. requiring the evaluators to consult internally within the Red List Authority, and externally with appropriate specialists and other interest groups;

7. ensuring that for each evaluation, the evaluators provide supporting information in line with the documentation requirements, as set out in the Annex 2 to these terms of reference;

8. ensuring that for each evaluation, the evaluators adhere to the taxonomic standards, as set out in Annex 3 to these terms of reference;

9. in the case of a petition against the listing of any taxon for which the Authority is responsible, following the process for handling petitions as set out in Annex 4 to these terms of reference, and abide by any decisions of the arbitrating Red List Standards Working Group; and

10. submitting the results of new assessments including changes in categorisation to the IUCN Red List Officer in the format required and within schedules set for annual and occasional updates of the IUCN Red List of Threatened Species.

6. BIOLOGICAL DIVERSITY ACT, 2002

The Government has enacted the Biological Diversity Act in 2002 and notified the Biological Diversity Rules in 2004, with the aim of conserving and sustainably using biological diversity, and regulating the biological resources (including the medicinal plants) and associated traditional knowledge of country with the purpose of securing equitable sharing of benefits arising out of these resources and associated knowledge. About 29 species of medicinal plants have so far been identified and notified by Director General of Foreign Trade, Ministry of Commerce, New Delhi. Export of these 29 plants, plant portions and their derivatives and extracts as such obtained from the wild except the formulations made there from is prohibited as these species required protection against over-exploitation.

7. BIODIVERSITY ASSESSMENT URGENT FOR MEDICINAL PLANTS

The number of medicinal plants in India, both indigenous and introduced has been estimated between 3,000 to 3,500 species of higher plants. The Glossary of Indian Medicinal Plants has listed around 3,000 plants (5). About 8,500 plants have been reported to be used in ethnomedicine and folk medicine (6). The number of plants listed in Ayurvedic Materia Medica is 560. The Unani system of medicine describes 440 plants out of which 360 are common to other systems of medicine practiced in the country. The number of plants having confirmed therapeutic properties or yielding a clinically useful chemical compound thus, lies 700 species (7).

Tamil Nadu is a hub of the wild-collected medicinal industries in India, but key species have declined due to over-collection to supply domestic and export trade. Researchers from TRAFFIC and IUCN, the International Union for Conservation of Nature, examined the trade in seven medicinal plants species with very different life histories, uses and trade patterns, to give a broad overview of Asia's medicinal plant trade. India emerged as a major destination for trade in all but three of the seven species studied in Tamil Nadu such as *Dioscorea deltoidea, Pterocarpus santalinus* and *Rauvolfia serpentina* (Plate 1.j).

But all seven species are declining through over-harvesting, although not necessarily of the plants themselves. All the species are protected under national legislation and international trade controls—the latter through listing in CITES, which requires international trade to be maintained within sustainable levels, but despite these measures, wild populations continue to decline. Medicinal Plant Specialist Group (MPSG) is a global network of specialists contributing within our own institutions and in our own regions, as well as world-wide, to the conservation and sustainable use of medicinal plants. The MPSG was founded in 1994 to increase global awareness of conservation threats to medicinal plants, and to promote sustainable use and conservation action.

8. PROTECTED AREAS FOR CONSERVATION

The protected areas of Tamil Nadu extend to 3305 km^2 constituting 2.54% of the geographic area and 15% of the recorded forest area. Tamil Nadu ranks 14th among all the States and Union Territories of India in terms of protected area. There are 8 wildlife sanctuaries over 2, 82,685.57 ha and 12 bird sanctuaries over 17,074.59 ha, 5 National Parks over 30784.23 ha, 3 Tiger Reserves, 4 Elephant Reserves and 3 Biosphere Reserves for in situ conservation of wild fauna and flora. There is one Conservation Reserve in Tamil Nadu.

MPCAs are reserve forest sites of high bio diversity value and known for their medicinal plant diversity. In these areas, presence of endangered species are identified and conserved. MPCAs are "no harvest area" mainly intended to be "*in situ*" gene bank. They serve as research sites and source of planting materials. There are eleven MPCAs in Tamil Nadu such as Alagarkoil (Dindigul division), Kodaikanal (Kodaikanal division), Kolli hills (Namakkal division), Kodikarai (Nagapattinam division), Kurumbaram (Villupuram), Courtallum (Tirunelveli), Mundanthurai (Ambasamuthiram), Pechiparai (Kanyakumari), Thaniparai (SriVilliputhur), Thenmalai (Tirpathur) and Topslip (Pollachi) (8).

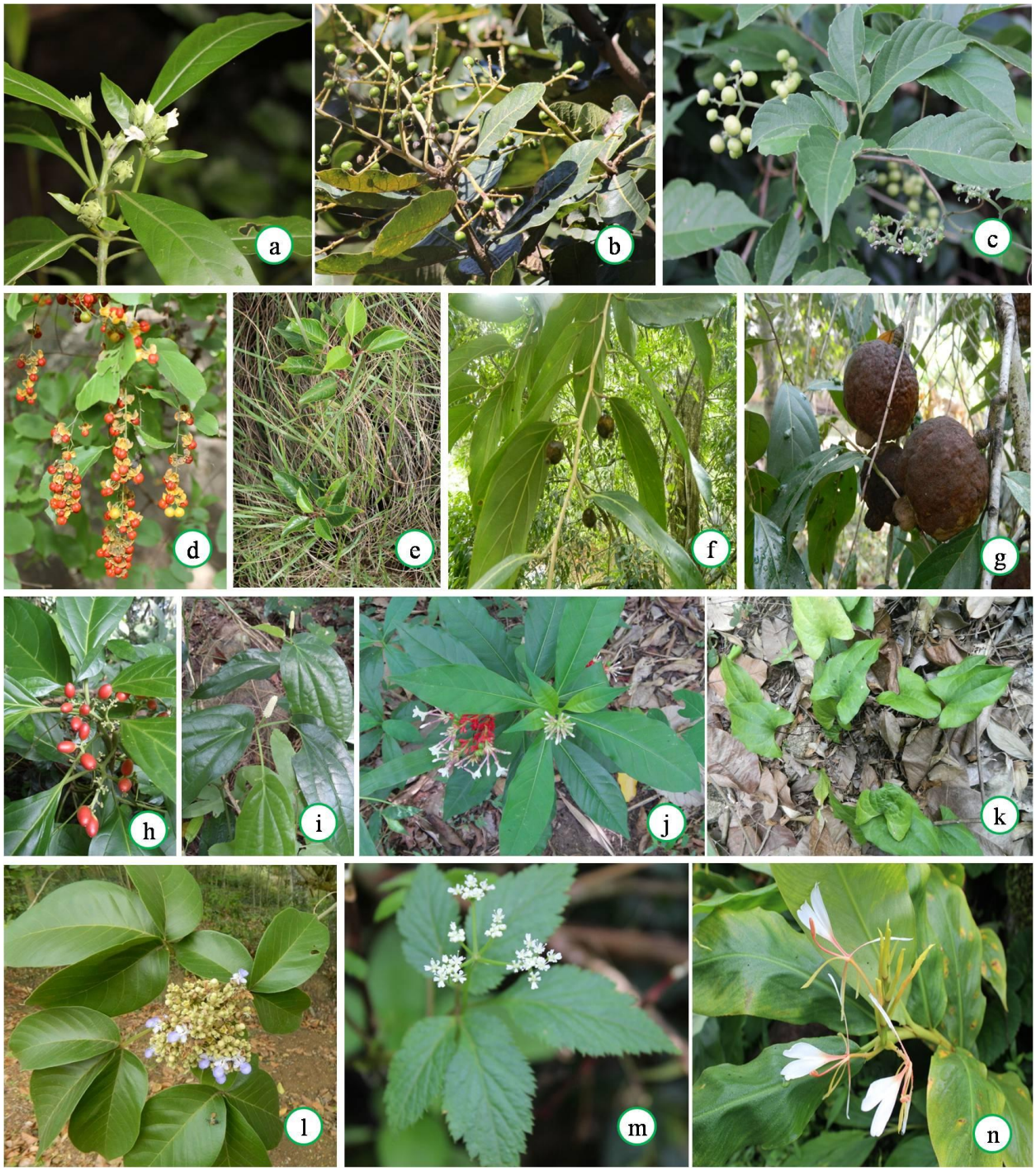
Table 2. Red-listed medicinal plants of Tamil Nadu and its diversity status.

S. No.	Name of the medicinal plant species	Family	IUCN category	Distribution
1.	*Acorus calamus* L.	Araceae	VU	Western Ghats
2.	*Justicia beddomei* C.B.Clarke	Acanthaceae	CE	Western Ghats
3.	*Aegle marmelos* (L.) Corr.	Rutaceae	VU	All over Tamil Nadu
4.	*Aerva wightii* Hook.f.	Amaranthaceae	EX	Tirunelveli district
5.	*Alpinia galanga* L.	Zingiberaceae	DD	Western Ghats
6.	*Ampelocissus araneosa* (Dalz. & Craib.) Planch.	Vitaceae	VU	Western Ghats
7.	*Ampelocissus arnottiana* Planch.	Vitaceae	EN	Western Ghats
8.	*Andrographis paniculata* Wall ex Nees	Acanthaceae	LC	All over Tamil Nadu
9.	*Aphanamixis polystachya* (Wall.) Parker	Meliaceae	VU	Western Ghats
10.	*Aristolochia tagala* Cham.	Aristolochiaceae	VU	Western and Eastern Ghats
11.	*Artocarpus hirsutus* Lam.	Moraceae	VU	Western and Eastern Ghats
12.	*Asparagus rottleri* Barker	Asparagaceae	EX	Western Ghats
13.	*Balanites aegyptiaca* (L.) Delile	Balanitaceae	LC	All over Tamil Nadu
14.	*Baliospermum montanum* (Willd.) Muell.-Arg.	Euphorbiaceae	VU	Western Ghats
15.	*Buchanania lanzan* Spr.	Anacardiaceae	LC	Western and Eastern Ghats
16.	*Caralluma truncato-coronata* Sedgewick	Apocynaceae	EN	Nilgiri hills
17.	*Calophyllum apetalum* Willd.	Calophyllaceae	VU	Western Ghats
18.	*Canarium strictum* Roxb.	Burseraceae	VU	Western Ghats
19.	*Cayratia pedata* (Lam.) Juss.	Vitaceae	CE	Western Ghats
20.	*Celastrus paniculatus* Willd.	Celastraceae	VU	Western and Eastern Ghats
21.	*Chonemorpha fragrans* (Moon) Alston	Apocynaceae	EN	Western and Eastern Ghats
22.	*Cinnamomum macrocarpum* Hook.	Lauraceae	VU	Western Ghats
23.	*Cinnamomum sulphuratum* Nees	Lauraceae	VU	Western Ghats
24.	*Cinnamomum wightii* C.F.W. Meissn.	Lauraceae	VU	Western Ghats
25.	*Cinnamomum zeylanicum* Bl.	Lauraceae	NE	Western Ghats
26.	*Cleome burmanni* Wight & Arn.	Cleomaceae	DD	Western and Eastern Ghats
27.	*Coscinium fenustratum* (Gaertn.) Coleb.	Menispemaceae	CE	Western Ghats
28.	*Curcuma pseudomontana* Graham	Zingiberaceae	VU	Western Ghats
29.	*Cycas circinalis* L.	Cycadaceae	CE	All over Tamil Nadu

30.	*Cyclea fissicalyx* Dunn	Menispermaceae	EN	Western Ghats
31.	*Dalbergia horrida* (Dennst.) Mabb.	Fabaceae	DD	Western Ghats
32.	*Decalepis hamiltonii* Wight & Arn.	Apocynaceae	EN	All over Tamil Nadu
33.	*Dioscorea deltoidea* Wall. ex Kunth.	Dioscoreaceae	CE	Western Ghats
34.	*Diospyros candolleana* Wight	Ebenaceae	VU	Western Ghats
35.	*Diospyros paniculata* Dalz.	Ebenaceae	VU	Western Ghats
36.	*Dipterocarpus indicus* Bedd.	Dipterocarpaceae	EN	Western Ghats
37.	*Drosera indica* L.	Droseraceae	VU	All over Tamil Nadu
38.	*Drosera peltata* Willd.	Droseraceae	VU	Western Ghats
39.	*Dysoxylum malabaricum* Bedd.	Meliaceae	EN	Western Ghats
40.	*Elaeocarpus serratus* L.	Elaeocarpaceae	LC	Western Ghats
41.	*Embelia ribes Burm*.f.	Myrsiniaceae	LC	Western Ghats
42.	*Embelia tsjeriam-cottam* DC.	Myrsiniaceae	VU	All over Tamil Nadu
43.	*Eulophia cullenii* (Wight) Bl.	Orchidaceae	CE	Western Ghats
44.	*Garcinia indica* (Dup.) Choisy.		VU	Western Ghats
45.	*Garcinia travancorica* Bedd.		CE	Western Ghats
46.	*Gardenia gummifera* L.f.	Rubiaceae	LC	All over Tamil Nadu
47.	*Gloriosa superba* L.	Liliaceae	LC	All over Tamil Nadu
48.	*Glycosmis macrocarpa* Wight	Rutaceae	LC	Western Ghats
49.	*Gnetum ula* Brong.	Gnetaceae	VU	Western and Eastern Ghats
50.	*Gymnema montanum* (Roxb.) Hook.	Apocynaceae	EN	Western Ghats
51.	*Hedychium coronarium* Koenig.	Zingiberaceae	LC	Western Ghats
52.	*Hedychium spicatum* Buch.-Ham.	Zigiberaceae	VU	Western Ghats
53.	*Helminthostachys zeylanicus* (L.) Hook.	Pteridaceae	EN	Western Ghats
54.	*Heracleum candolleanum* (Wight & Arn.) Gamble	Apiaceae	VU	Western Ghats
55.	*Heracleum rigens* Wall.	Apiaceae	DD	Western and Eastern Ghats
56.	*Holostemma ada-kodien* Schult.	Apocynaceae	VU	Western Ghats
57.	*Humboldtia vahliana* Wight	Caesalpiniaceae	EN	Western Ghats
58.	*Hydnocarpus alpina* Wight	Achariaceae	EN	Western Ghats
59.	*Hydnocarpus kurzii* (King) Warb.	Achariaceae	EN	Western Ghats
60.	*Hydnocarpus macrocarpa* (Bedd.) Warb.	Achariaceae	VU	Western Ghats
61.	*Iphigenia indica*	Liliaceae	VU	Western and Eastern Ghats
62.	*Ipomoea turpethum* (L.) R.Br.	Convolvulaceae	VU	All over Tamil Nadu
63.	*Decalepis arayalpathra* (J.Joseph & V.Chandras.) Venter	Apocynaceae	CE	Western Ghats
64.	*Kaempferia galanga* L.	Zingiberaceae	CE	Western Ghats
65.	*Kingiodendron pinnatum* (Roxb. Ex DC.) Harms.	Mimosaceae	EN	Western Ghats
66.	*Knema attenuata* (Wall.) Warb.	Myristicaceae	LC	Western Ghats
67.	*Luffa tuberosa* (Klein) Roem.	Cucurbitaceae	DD	Ramanathapuram and Madurai districts
68.	*Madhuca longifolia* (Koen.) Macler.	Sapotaceae	EN	Western Ghats
69.	*Nothapodytes nimmoniana* (J.Graham) Mabb.	Myrsiniaceae	VU	Western Ghats
70.	*Michelia champaca* L.	Magnoliaceae	VU	Western Ghats
71.	*Michelia nilagirica* Zenk.	Magnoliaceae	VU	Western Ghats
72.	*Moringa concanensis* Nimmo ex Dalz. & Gibson	Moringaceae	VU	Western Ghats
73.	*Myristica dactyloides* Gaertn.	Myristicaceae	VU	Western Ghats
74.	*Myristica malabarica* Lam.	Myristicaceae	VU	Western Ghats
75.	*Nervilia aragoana* Gaud.	Orchidaceae	EN	Western Ghats

76.	*Nilgirianthus ciliatus* (Nees) Bremek.	Acanthaceae	EN	Western Ghats
77.	*Ochreinauclea missionis* (Wall. ex D.Don) Ridsdale	Rubiaceae	VU	Western Ghats
78.	*Oroxylum indicum* (L.) Vent.	Bignoniaceae	VU	Western Ghats
79.	*Persea macrantha* (Nees) Kost.	Lauraceae	EN	Western and Eastern Ghats
80.	*Piper barberi* Gamble	Piperaceae	CE	Western Ghats
81.	*Piper longum* L.	Piperaceae	LC	Western and Eastern Ghats
82.	*Piper mullesua* D.Don	Piperaceae	VU	Western Ghats
83.	*Piper nigrum* L.	Piperaceae	VU	Western and Eastern Ghats
84.	*Plectranthus nilgherricus* Benth.	Lamiaceae	VU	Western Ghats
85.	*Pseudarthria viscida* Wight & Arn.	Fabaceae	LC	Western and Eastern Ghats
86.	*Pterocarpus santalinus* L.f.	Fabaceae	EN	Eastern Ghats
87.	*Pterospermum xylocarpum* (Gaertn.) Sant. & Wagh.	Tiliaceae	LC	Western Ghats
88.	*Pueraria tuberosa* (Roxb. Ex Willd.) DC.	Fabaceae	LC	Western and Eastern Ghats
89.	*Rauvolfia serpentina* (L.) Benth.	Apocynaceae	EN	Western Ghats
90.	*Rhaphidophora pertusa* Schott.	Araceae	EN	Western and Eastern Ghats
91.	*Santalum album* L.	Santalaceae	EN	Western and Eastern Ghats
92.	*Sapindus emarginatus* Vahl.	Sapindaceae	LC	All over Tamil Nadu
93.	*Saraca asoca* (Roxb.) Wild.	Caesalpiniaceae	EN	Western Ghats
94.	*Schrebera swietenioides* Roxb.	Meliaceae	VU	Western Ghats
95.	*Semecarpus travancorica* Bedd.	Anacardiaceae	EN	Western Ghats
96.	*Smilax wightii* L.	Smilaxaceae	DD	Western Ghats
97.	*Smilax zeylanica* L.	Smilaxaceae	VU	Western Ghats
98.	*Strychnos minor* Dennst.	Loganiaceae	DD	Western Ghats
99.	*Strychnos nux-vomica*	Loganiaceae	LC	All over Tamil Nadu
100.	*Strychnos potatorum*	Loganiaceae	LC	All over Tamil Nadu
101.	*Swertia angustifolia* Ham.	Gentianaceae	EN	Western and Eastern Ghats
102.	*Swertia corymbosa* (Griseb.) Wight ex Clarke	Gentianaceae	VU	Western Ghats
103.	*Swertia lawii* Burkill	Gentianaceae	EN	Western Ghats
104.	*Symplocos cochinchinensis* S.Moore	Symplocaceae	LC	Western Ghats
105.	*Symplocos racemosa* Roxb.	Symplocaceae	VU	Western Ghats
106.	*Syzygium travancoricum* Gamble	Myrtaceae	CE	Western Ghats
107.	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae	LC	All over Tamil Nadu
108.	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	VU	Western and Eastern Ghats
109.	*Tragia bicolor* Miq.	Euphorbiaceae	VU	Western Ghats
110	*Trichopus zeylanicus*	Dioscoreaceae	EN	Western Gahts
111.	*Trichosanthes anamalayensis* Bedd.	Cucurbitaceae	CE	Western Ghats
112.	*Trichosanthes cucumerina* L.	Cucurbitaceae	DD	Western Ghats
113.	*Urginea indica* (Roxb.) Kunth.	Liliaceae	VU	All over Tamil Nadu
114.	*Utleria salicifolia* Bedd.	Apocynaceae	CE	Western Ghats
115	*Vanasushava pedata* Mukh. & Const.	Apiaceae	EN	Western Ghats
115.	*Vateria indica* L.		LC	Western Ghats
116.	*Vateria macrocarpa* B.L. Gupta		CE	Western Ghats
117.	*Vernonia anthelmintica* (L.) Willd.	Asteraceae	LC	All over Tamil Nadu
118.	*Vitex trifolia* L.f.	Verbenaceae	LC	All over Tamil Nadu
119.	*Woodfordia fruticosa* (L.) Kurz.	Lythraceae	LC	Western Ghats

Plate 1. Red-listed medicinal plants of Tamil Nadu



a. Adhatoda beddomei; b. *Buchanania lanzan*; c. *Cayratia pedata*; d. *Celastrus paniculatus*; e. *Decalepis arayalpathra*; f. *Hydnocarpus alpina*; g. *Hydnocarpus macrocarpus*; h. *Nothapodytes nimmoniana*; i. *Piper longum*; j. *Rauvolfia serpentina*; k. *Trichopus zeylanicus*; l. *Vitex trifolia*; m. *Vanasushava pedata*; n. *Hedychium spicatum*

9. CONCLUSION

Conservation is the planned management of natural resources, to retain the natural balance, diversity and evolutionary change in the environment. It is a protective measure taken to prevent the loss of genetic diversity of a species, to save a species from becoming extinct, and to protect an ecosystem from damage so as to promote its sustained utilisation.

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RESEARCH ARTICLE

PRELIMINARY PHYTOCHEMICAL STUDIES OF SELECTED MEDICINAL PLANT *PACHYGONE OVATA* (POER.) HOOK.F. & THOMS FROM MENISPERMACEAE FAMILY FOR BIOACTIVE CONSTITUENTS

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ABSTRACT

The present study deals with the phytochemical examination of *Pachygone ovata* (Poer.) Hook.f.& Thoms., an important medicinal plant from menispermaceae family. Leaf and Stem extracts were prepared by using different solvents systems and phytochemical screening was performed using the standard methods given by Harborne. Leaf and stem extracts were prepared from aqueous and organic solvents like petroleum ether, acetone, ethyl acetate and ethanol. Qualitative phytochemical analysis of the petroleum ether, acetone,ethyl acetate, ethanol and aqueous extracts prepared from *P. ovata* leaf and stem part. Leaf part revealed the presence of alkaloids, flavonoids, glycosides, cardiac glycosides, phenols and tannins. Stem part revealed the presence of alkaloids, flavonoids, glycosides, Resin, Steroids, phenols and tannins. The ethanolic extract showed higher amount of secondary metabolites than the other solvent extracts. This observation becomes important in the context of the therapeutically and drug applications of *P. ovata*.

Keywords: *Pachygone ovata* (Poer.) Hook.F. & Thoms, Endemic, Western ghats and preliminary phytochemical screening.

1. INTRODUCTION

Plants were main sources of new pharmacological active compounds, many important drugs being derived from plant meterials. (1, 4). In Indian folk medicine, members of the Menispermaceae family have been used against many diseases like diabetes, oedema, pain, rheumatoid arthritis, bone fracture, nephritis, pyrexia and hypertension (3, 8, 9, 10). In Menispermaceae family have been indicate to be rich in secondary metabolites; mainly alkaloides. In the present study, the medicinal potential activities of the plant *Pachygone ovata* (Poir.) Miers ex Hook. f. et. Thoms was investigated to learn more about their healthful effects on humans.

2. MATERIALS AND METHODS

2.1. Collections of plant material

Leaf and stem parts of *Pachygone* ovata were collected from Western ghats region of Coimbatore district, Tamilnadu, India. The voucher specimen has been deposited in Kongunadu Arts and Science College, Coimbatore.

2.2. Description of the selected plants

Pachygone ovata (Poir.) Miers ex Hook. f. & Thoms., Fl. Ind. 203. 1855 & in Hook. f., Fl. Brit. India 1: 105. 1872; Gamble, Fl. Pres. Madras 31 (22). 1915; Gangop. in B. D. Sharma et al., Fl. India 1:329.1993; Sasidh., Fl. Chinnar WLS 15. 1999. *Cissampelos ovata* Poir. in Lam., Encycl. 5:10. 1804. *Cocculus plukenetii* DC., Syst. Nat. 1: 520. 1817.

Family: Menispermaceae

Common Name(s): Katukodyvally

Habit: Climber

Flowering & Fruiting: January-September

Distribution*:* Indo-Malesia to Australia

2.3. Preparation of plant extract

The Leaf and stem parts of *Pachygone* ovata were washed with tap water and shade dried for a week and powdered coarsely. Then they were powdered mechanically by using Pulverizer and passed through 40 mesh sieve and stored in airtight containers. About 30g of powdered leaf and stem parts were extracted by using shaker apparatus with petroleum ether, ethyl acetate, acetone and ethanol. The extract was dried under reduced pressure at low temperature (40-50°C). The last traces of the solvent were removed under vacuum drier and the solid mass obtained was stored at 4°C until further use.

2.4. Phytochemical study

The stored filtrate was used for the various phytochemical and biological studies. A preliminary phytochemical analysis to screen the samples for the presence of phytochemical components such as alkaloids, glycosides, tanins, phenol, saponin and

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tannins was performed according to the method described (7).

2.4.1 Qualitative Analysis

The qualitative analysis were completed to get the presence of the active phytochemicals in the various solvent extracts (2, 5, 6).

Alkaloids (Mayer's test)

To the extract added 1% HCl and 6 drops of Mayer's reagent were added. An organic yellow precipitate indicated the presence of alkaloids in the sample.

Flavonoids (Lead acetate test)

The aqueous extract was treated with few drops of 10% lead acetate solution. The formation of yellow precipitate confirmed the presence of flavonoids.

Terpenoids (Salkowski test)

10mg of the extract was dissolved in 1ml of chloroform, 1ml of acetic anhydride was added following the addition of 2ml of conc. H_2SO_4. Formation of reddish violet colour indicates the presence of triterpenoides.

Cardiac glycosides (Keller-Killiani test)

0.5g of extract diluted to 5ml of water then added 2ml of glacial acetic acid containing one drop of ferric chloride solution. In this test was underlayed with 1ml of concentrated sulphuric acid. A brown ring at the border indicates the presence of a deoxysugar characteristic of cardenolides. A violet ring may show below the brown ring, while in the acetic acid layer a greenish ring may appearance just above the brown ring and slowly spread throughout this layer.

Phenols (Ferric chloride test)

Various solvent extracts were treated with 2-4 drops of ferric chloride solution. Development of bluish black colour indicates the presence of phenols.

Sterols (Liberman-Burchard's test)

Various solvent extracts were treated with chloroform and filtered. The filtrates were treated with few drops of acetic anhydride, boiled and cooled. Conc. Sulphuric acid was added. Development of brown ring at the junction indicates the presence of phytosterols.

Saponins (Froth Test)

Extracts were diluted with distilled water to 20ml and this was shaken in a graduated cylinder for 15 minutes. Development of 1cm layer of foam indicates the presence of saponins.

Tannins (Lead acetate test)

In a test tube containing about 5ml of an aqueous extract a few drops of % solution of lead acetate was added. A yellow or red precipitate was formed indicating the presence of tannin.

Resins

To 2ml of chloroform extract 5-10ml of acetic anhydride was added, dissolved by gently heating coding and then 0.5ml of sulphuric acid was added. Bright purple colour was produced. It indicates the presence of resins.

Glycosides

A small amount of alcohol extract samples was dissolved in 1ml water and then aqueous sodium hydroxide solution was added. Formation of a yellow colour indicators the presence of glycosides.

Triterpenoids

10mg of the extract was dissolved in 1ml of chloroform, 1ml of acetic anhydride was added following the addition of 2ml of conc. H_2SO_4. Formation of reddish violet color indicates the presence of triterpenoid.

Reducing sugar

The crude extract of each plant was shaken with 5ml of distilled water and filtered. The filtrate was boiled with drops Fehling's solution A & B for 2 minutes. An orange red precipitate indicates the presence of reducing sugar.

3. RESULTS AND DISCUSSION

Phytochemical are organic chemicals that are produced by plants. They may be nutritive or non-nutritive in nature. These can be regarded as naturally occurring non-nutritive chemicals of plant origin. In the present study the phytochemical compounds present in *P. ovate* leaf and stem illustrated in (Table 1). This plant is highly medicinal and endemic to Western Ghats region, which belong to the family Menispermaceae. The various solvent systems like petroleum ether, Acetone, ethyl acetate, ethanol and aqueous were employed to extract the various phytochemical constituents in shade dried plant parts. The qualitative test of extracts confirmed in the presence of alkaloid, flavonoid, phenol, tannin, steroids and cardiac glycosides in leaf and stem extracts. Stem extract showed the better result when compared to stem and root extracts. The presence of these secondary metabolites may vary with solvents. This might be due to various degrees of solubility of different solvents for different

phytoconstituents and the phytochemical constituent alkaloid is indicated in high degree in all extracts like leaf and stem extract. Therefore the plant *P. ovata* highly medicinal and needed wide research.

Table 1: Preliminary phytochemical analysis of different solvent extracts of whole plant of *P. ovata.*

Secondary Metabolites	Petroleum ether		Acetone		Ethyl acetate		Ethanol		Aqueous	
	Leaves	Stem	Leaves	Stem	Leaves	Stem	Leaves	Stem	Leaves	Stem
Alkaloid	+	+	+	+	+	+	+	+	+	-
Flavonoid	-	-	+	+	-	-	+	-	-	-
Phenol	+	+	+	+	+	+	+	+	+	+
Tannin	-	-	+	+	-	+	-	-	-	-
Glycoside	+	+	+	+	+	+	-	-	-	-
Saponin	-	-	-	-	-	-	-	-	-	-
Resin	-	+	-	+	-	+		-	-	-
Steroids	-	-	-	+	-	+	-	-	-	-
Terpanoids	-	-	-	-	-	-	-	-	-	-
Cardiac glycosides	+	-	+	-	+	-	-	-	-	-

6. CONCLUSION

The present investigation proved that the presence of alkaloid, flavonoid, phenol, tannin, steroids and cardiac glycosides in leaf and stem extracts. The phytochemical constituent alkaloid glycoside is indicated in high content in all extracts like leaf and stem extract. The results are proved that plant *P. ovata* is highly medicinal and effective for the treatment of various ailments. A more comprehensive research is needed to isolate the essential compounds in this medicinal plant. More over this study also highlights the importance of conservation and sustainable utilization of such potential medicinal herbs to future generation.

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RESEARCH ARTICLE

IN VITRO ANTIOXIDANT ACTIVITY OF AQUEOUS AND ETHANOL LEAF EXTRACTS OF *RHINACANTHUS NASUTUS* (LINN.) KURZ. (ACANTHACEAE)

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ABSTRACT

In the present research work was to examine the possible antioxidant activities of the aqueous and ethanol leaf extract of *Rhinacanthus nasutus* (Linn.) Kurz. DPPH, Hydroxyl radical scavenging and reducing power assays were employed. The results showed that the DPPH activity of aqueous and ethanol leaf extract at the dose of 50µg/ml has exhibited in 63.81±0.013 and 79.36±0.028 inhibition with an IC_{50} value of 21.39 and 29.41µg/ml. The highest Hydroxyl radical scavenging activity showed aqueous and ethanol leaf extract at the dose of 50µg/ml has exhibited in 96.18±0.029 and 121.23±0.081 inhibition with an IC_{50} values of 30.19and 41.39µg/ml, the reducing power assay aqueous and ethanol leaf extract showed the 0.59 and 0.71 absorption at 700 nm extract at the dose of 50µg/ml suggested that promising antioxidant activity of crude aqueous and ethanol extract could be used as a source of natural antioxidants of *R. nasutus* and needs further studies to bring new natural products into pharmaceutical industries.

Keywords: *Rhinacanthus nasutus,* antioxidant activities, DPPH, Hydroxyl radical scavenging activity, reducing power assay.

1. INTRODUCTION

The large number of medicinal, aromatic, modern medicines, spice and other plants contain the phytochemical constituents exhibiting antioxidant activities. In oxidative process is one of the most important ways for producing free radicals in drugs, foods and even in alive systems (1). Mostly effective path to abolish and diminish the action of free radicals which can be cause the oxidative stress is antioxidative defense mechanisms. In antioxidants substance can be possessing free radical chain reaction breaking the properties. Recently there has been increases of importance in the therapeutic prospective medicinal plants have antioxidants to re-antioxidants in reducing oxidative stress induced tissue injury (2). Several plant species are naturally occurring to the antioxidants; phenol, ascorbic acid, carotenoids and phytochemical compounds in effective (3).

Rhinacanthus nasutus (Linn.) Kurz belong to the family Acanthaceae it is an important medicinal plant, widely distributed in several part of sub-continent of India, China, Thailand and East-Asia (4). Plant also commonly known as snake jasmine, it is called as Nagamalli in Tamil. The Naga means snake in Sanskrit and this plants treating with snake bite. The freshly root and leaves, injured and mixed with lime juice are used remedy for skin affections and ringworm. The seeds are more than effective in ringworm, bark and root is a very good remedy for dhobie's itch. Some people are said to possess extraordinary aphrodisiacal powers of roots boiled in a milk presence much active by Hindu practitioners. Roots, believed in some parts of India to be an antidote in the bites of poisonous snakes.

2. MATERIALS AND METHODS

2.1. Collection of plant material

The plant *R. nasutus* collected from the wild areas of Western Ghats, Valparai. Then the plant identified and authenticated by referring herbarium. The collected plants were washed in tap aqueous to remove the impurities, separate the leaves and dried in a room temperature. The dried leaf materials pulverized and stored in an air tight container for further usage.

2.2. Preparation of extracts

50g leaves extract with 250 ml of ethanol using for the soxhlet extractor in 9-12 hours. And another set of leaves powder extracted to be aqueous placed in an aqueous bath at 100 ^{0}C for 2 hurs. The extract was filtered through what man No.1 filter with paper to remove all undisclosed substance, including to the cellular materials and other phytochemical constituents that are insoluble in the extraction solvents. Final extract were used in antioxidant activities.

2.3. DPPH radical scavenging activity

The scavenging effect of extracts on DPPH radials activity was determined according to the

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method of Shimada *et al.* (5). The various concentrations of plant extract (4 ml) were mixed with 1ml of aqueous and ethanol solution containing DPPH radicals, resulted in the final concentration of DPPH being 0.2mM. Then mixture were well shaken well and left to stand in 30min and absorbance was measured at 517nm. The percentage of inhibition was calculated according to the formula by: (A0-A1)/A0] × 100, where A0 was the absorbance of the control and A1 was the absorbance of the sample.

2.4. Hydroxyl radical scavenging assay

Hydroxyl radical scavenging activity of plant extracts were assay by the method of (6). The reaction mixture 3.0 ml contained 1.0 ml of 1.5 mM FeSO4, 0.7ml of 6mM hydrogen peroxide, 0.3 ml of 20 mM sodium salicylate and various concentrations of the extract. After incubation period of 1 hour at 37°C, the absorbance of the hydroxylated salicylate complex was measured at 562nm. % inhibition = $[(A0-A_1)/A_0]\times100$,where A_0 is absorbance of the control (without extract) and A_1 is the absorbance in the presence of the extract, A_2 is the absorbance without sodium salicylate.

2.5. Reducing power

The reducing power performed according to the method of Oyaizu (7). Different concentrations of aqueous and ethanol extracts (10, 20, 30, 40 and 50µg/ml) of the study sample was mixed with 1ml of 200 mM sodium phosphate buffer (pH 6.6) and 1ml of 1% potassium ferriccyanide followed by incubation at 500 C for 20 minutes. After that 1ml of 10% trichloroacetic acid, was added and centrifuged at 3000 rpm for 10 minutes. Then, the supernatant was mixed with 2 ml of distilled water and 0.5 ml of 1% ferric chloride. After incubation of 10 minutes, the absorbance was measured at 700 nm.

3. RESULTS AND DISCUSSION

The effects of aqueous and ethanol leaf extracts of *R. nasutus* was investigated for its antioxidant activity on various *in vitro* models like DPPH, Hydroxyl radical scavenging and reducing power assays different levels. In the present study some free radical scavenging activities of aqueous and ethanol leaf extracts of *R. nasutus* was investigated by DPPH scavenging assay. Aqueous and ethanol leaf extract of *R. nasutus* have got profound antioxidant activity. DPPH antioxidant assay was based on the ability of the DPPH, a free radical are stable, which can be gets decolorized in the presence of antioxidants (8,9). The ability to scavenge the stable free radical DPPH was measured by decrease in the absorbance at 517 nm. The aqueous and ethanol leaf extracts of *R. nasutus* exhibited a significant at a dose dependent inhibition of DPPH activity. A concentration dependent assay was carried out with these extracts and the results are presented in table 1. The IC_{50} value of this plant both extract found to be 21.39 and 29.41µg/ml respectively. Generally the presence of phenolic compounds in *R. nasutus* extracts were responsible for the antioxidant activity and it could be due to the presence of hydroxyl group in the compounds which showed antioxidant activity.

Table 1.DPPH radical scavenging activity of aqueous and ethanolic leaf extracts of *R. Nasutus.*

S. No	Aqueous extract			Ethanolic extract		
	Concentration (µg/mL)	% of inhibition		Concentration (µg/mL)	% of inhibition	
1	10	14.36±0.024	IC_{50} 21.39	10	18.34±0.018	IC_{50} 29.41
2	20	19.41±0.019		20	26.93±0.019	
3	30	28.18±0.053		30	42.18±0.025	
4	40	48.56±0.036		40	65.13±0.048	
5	50	63.81±0.013		50	79.36±0.028	

Table 2. Hydroxyl radical-scavenging activity at various concentrations of aqueous and ethanolic leaf extracts of *R. nasutus.*

S. No	Aqueous extract			Ethanol extract		
	Concentration (µg/mL)	% of inhibition		Concentration (µg/mL)	% of inhibition	
1	10	21.67±0.037	IC_{50} 30.19	10	31.46±0.031	IC_{50} 41.39
2	20	35.81±0.022		20	39.08±0.067	
3	30	46.31±0.048		30	71.19±0.027	
4	40	67.23±0.019		40	95.46±0.041	
5	50	96.18±0.029		50	121.23±0.081	

Table 3. Reducing power at various concentrations of aqueous and ethanolic leaf extracts of *R. nasutus.*

S. No	Aqueous extract		Ethanol extract	
	Concentration (µg/mL)	% of inhibition	Concentration (µg/mL)	% of inhibition
1	10	0.29	10	0.39
2	20	0.34	20	0.41
3	30	0.39	30	0.59
4	40	0.42	40	0.63
5	50	0.59	50	0.71

It is capable of neutralizing the deleterious effect of free radicals and their redox properties. Fruits and vegetables are natural sources of antioxidants and they provide protection against harmful free radicals (10,11). The highly hydoxyl radical scavenging effect at 50µg /ml concentration. The aqueous and ethanol leaves extracts of *R. nasutus* showed higher scavenging activity showed in (Table 2). The IC_{50} value of this plant extracts found to be 30.19and 41.39µg/ml respectively. This ability of the both plant extracts shows in the quenching ability of hydroxyl radicals, which seems to be a very good scavenger, of active oxygen plant species thus reducing the rate of chain reaction. The reducing power assay leaves of both extract showed the 0.59 and 0.71 absorption at 700 nm extract at the dose of 50µg/ml in (Table 3). The reducing power activity is often used to be an study ability of natural occurring antioxidant to donate electron (12,13).

4. CONCLUSION

Finally, concluded that present research work plant extracts possessed variable but interesting antioxidant properties. These properties were significantly correlated to their total phenolics content and they could be used as a source of natural antioxidants in food, cosmetic and pharmaceutical industries. It can be also necessary that complete structural identification of the active phytochemical components of antioxidant of plants is, therefore, required and their biological properties could be investigated.

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RESEARCH ARTICLE

HABITAT AND PHYTOSOCIOLOGICAL CHARACTERS OF THE ENDANGERED PLANT SPECIES, *EXACUM BICOLOR* ROXB.

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ABSTRACT

Study on the phytosociological characters like distribution, abundance, density etc of a species in its established habitats is a tool to determine the effect of environmental conditions on variations in population characteristics. Based on this concept, four leaf shape variants (ovate, linear- lanceolate, oblanceolate and ovate – elliptic) of the plant species, *Exacum bicolor* distributed in four different grasslands habitats *viz.,* Payyanur, Taliparamba, Paithal mala and Thirunelli at Kannur and Wayand districts of Kerala were selected in the present study. The populations of the study species showed distinct expression of ecological attributes across the four leaf shape variants in four habitats studied. The distribution level determined through the annual mean frequency percentage was higher (89.29 %) in the populations of ovate leaf shape variant in Taliparamba, where as it was lower (5.71 %) in the populations of linear – lanceolate leaf shape variant in Payyanur. Similarly, the annual abundance of the population was higher (5.08/ m^2) for ovate – elliptic leaf shape variant (Taliparmba) and lower (1.43/ m^2) for linear – lanceolate leaf shape variant (Thirunelli). The annual density obtained by the population was also higher for ovate leaf shape variant present in Taliparmba (4.10/ m^2) and lower for the population of linear – lanceolate leaf shape variant present in Thirunelli, (0.09/ m^2). From these ecological studies, it is understood that among the four leaf shape variants, generally ovate leaf shape variant has established well. In addition, the grassland community at Taliparamba is determined to have most suitable microclimate also for this variant than the other habitats studied.

Keywords: Exacum bicolor, phytosociological characters.

1. INTRODUCTION

Exacum bicolor (Family: Gentianaceae) is an endangered medicinal herb distributed in hillocks of northern Kerala between the altitude 50-200 m above MSL. Unique feature of this plant is limited dispersion with very few individuals in large stretch of grasslands. (10,11). In addition, in the districts of northern Kerala like Kannur, Wayanad, Calicut, Palakkad etc this species is represented by four ecological variants on basis of leaf shape such as ovate leaved, linear-lanceolate leaved, oblanceolate leaved and ovate-elliptic leaved.

E. bicolor have high ornamental value and in Kerala, it is in use of different ailments since many centuries. Whole part of the plant is used as a tonic, febrifuge and stomachic and antifungal agent (7, 13, 5, 2, 9). The plant also yields dye also (12). Being bitter in taste, local people take it as herbal remedy for diabetes, and skin disorders (8). In Kerala, the traditional practitioners prescribe decoction of the whole plant for the treatment of fever, eye and skin diseases and urinary disorders. Traditional healers of Pundra and Bilaspur regions of Chhattisgarh use this plant as blood purifier and for the treatment of malaria. Flowers of this plant were given great religious importance in old Valluvanadan region of Kerala. It is one of the choicest flowers to adorn Trikkakkarayappan, the earthern diety worshiped during Onam an important regional festival. Except few works on distribution status, no ecological studies have been carried out for this species. Hence, to know the status of the degree of distribution, density and abundance the present works has been done in all the four leaf variants.

2. MATERIALS AND METHODS

Phytosociological studies for the four leaf shape variants of the species, *Exacum bicolor* were carried out for a period of seven months from May, 2009 to November, 2009 at monthly intervals in all the four studied grasslands of Kerala *viz.,* Taliparamba (55m above MSL), Payyanur (15m above MSL), Paithal mala (1350m above MSL) of Kannur district and Thirunelli (900m above MSL) of Wayanad district. The minimum quadrat size of 1 x 1m was fixed by the species-area curve method, and each time, 20 quadrats were laid by randomized method. The minimum number of quadrats (i.e. 20) was determined as described by Greig - Smith (1). For this, the mean number of individuals of the first five, ten, fifteen, twenty, etc.,

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quadrats were calculated and plotted against the number of observations. It will be seen that the mean at first fluctuates, steadying as the required number of quadrats was reached.

The number of individuals of all the four leaf shape variants of *E. bicolor* in each quadrat was recorded. From the observations, the quantitative characters such as frequency, density and abundance were calculated using the following formulae:

$$\text{Frequency} = \frac{\text{Number of quadrats in which the species present}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of the species in all quadrats}}{\text{Total number of quadrats studied}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of the species in all quadrats}}{\text{Number of quadrats of occurrence of the species}}$$

3. RESULTS AND DISCUSSION

The study on local distribution revealed that the four ecological variants of the study species, *Exacum bicolor* are site specific (Tables 1). The ovate, oblanceolate and ovate-elliptic leaf shape variants of *E. bicolor* are noted to be present in Payyanur and Taliparamba grasslands and linear-lanceolate leaf shape variant has distributed in Paithal mala and Thirunelli grasslands. In early study, (11) also reported the site specific distribution of variants of this species in northern Kerala. This may be explained due to the microclimatic preferences of the variants at soil level (10).

The ovate leaf variant registered its highest number of individuals, 115/20m^2 in Taliparamba during the month of August, 2009 . The lowest number (34/20m^2) for the same variant was found to be observed in Payyanur grassland during the month, May, 2009. The range of variation in the number of individuals over the period of study across the grasslands for the linear-lanceolate leaf variant was lying between 1 (in Thirunelli during May, June, October and November, 2009) and 95/20m^2 (in Paithal mala grassland during August, 2009). The oblanceolate leaf variant showed its higher number of individuals (119/20m^2) in Taliparamba grassland during August, 2009 and its lower number (36/20m^2) was present in Payyanur grassland during the month, May, 2009. The ovate-elliptic leaf shape variant showed its higher appearance (128 / 20m^2) in Taliparamba grassland during August, 2009 and lower appearance (49/20m^2) in Payyanur grassland during May, 2009 (Table 1).

The monthly variation in frequency percentage for ovate leaf shape variant was ranging between 55 (Payyanur grassland during May, 2009) and 100% (Payyanur grassland during August, 2009 and Taliparamba grassland during July, August, September and October, 2009). The linear-lanceolate leaf shape variant recorded higher frequency of occurrence (100%) in Paithal mala grassland during August, 2009 and the lower frequency (5%) of that variant was noted during the months, May, June, July, September, October and November, 2009 in Thirunelli. The range of frequency percentage for oblanceolate leaf shape variant was lying between 45 (Payyanur during the month of May, 2009) and 100 (Taliparamba and Payyanur during the month, August, 2009). The ovate-elliptic leaf shape variant showed its highest frequency as 100% in Payyanur grassland during August, 2009 and in Taliparamba during August and September, 2009. Its lower frequency percentage was noted as 55 during May, 2009 in Payyanur grassland and in Taliparamba grassland during November, 2009. The overall distribution of the four leaf shape variants on basis of annual mean value was varied according to grassland. The Taliparamba grassland was observed to have the ovate leaf variant with higher areas of distribution (89.29 %) (Table 2). On the other hand, the Paithal mala and Taliparamba grasslands hold respectively the linear – lanceolate leaf variant and oblanceolate leaf variant with more area of distribution. The Taliparamba grassland also encompassed the ovate- elliptic leaf variant with higher area of distribution. Odum (4) pointed out that the differences in macroclimatic conditions and certain microclimatic factors like the availability of soil moisture due to the angle of slope etc may influence the distribution of any species within the biome. Further, it is known from the present study that the ovate leaf variant of the study species recorded higher area of distribution than the other leaf variants studied. It may be explained due to the fitness of this variant in the natural herbaceous communities of northern Kerala in terms of germination and adaptability.

The abundance for ovate leaf shape variant was existing between 2.92 (Taliparamba during May, 2009) and 5.75 individuals/m^2 (Taliparamba during August, 2009). In the similar fashion, the abundance value for the linear-lanceolate leaf shape variant was also considerably varied between the months in each grassland. For the oblanceolate, the lowest abundance value was determined as 3.64 individuals/m^2 in Payyanur grassland during November, 2009 and the highest abundance value, 5.95 individuals/m^2 was determined in Taliparamba grassland during August, 2009. The minimum and maximum

abundance for ovate-elliptic leaf shape variant were 3.60 individuals/m^2 (Payyanur during October, 2009) and 6.40 individuals/m^2 (Taliparamba during August, 2009). The annual abundance of the population was higher (5.08/ m^2) for ovate – elliptic leaf shape variant (Taliparmba) and lower (1.43/ m^2) for linear – lanceolate leaf shape variant (Thirunelli) (Table 3). Among the four variants analyzed, the ovate-elliptic leaf variant was found to be greater in abundance. This may be accounted that generally the limited distribution with more number of individuals of this variant in the study areas.

Table 1. Number of individuals of four leaf shape variants of *Exacum bicolor* in the studied grasslands.

Variants and grasslands	Months						
	May	Jun	Jul	Agu	Sep	Oct	Nov
Ovate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	34 (11)	65 (16)	91 (19)	106 (20)	89 (19)	79 (19)	72 (13)
Taliparamba	38 (13)	71 (17)	96 (20)	115 (20)	93 (20)	84 (20)	77 (15)
Thirunelli	-	-	-	-	-	-	-
Linear- lanceolate leaved	30(12)	33(12)	48(15)	95 (20)	61 (13)	50 (10)	36 (9)
Paithal mala	-	-	-	-	-	-	-
Payyanur	-	-	-	-	-	-	-
Taliparamba	1(1)	1(1)	2(1)	4 (2)	2 (1)	1 (1)	1 (1)
Thirunelli							
Oblanceolate leaved	-	-	-	-	-	-	-
Paithal mala	36 (9)	56 (12)	72 (15)	103 (20)	76 (16)	65 (13)	40 (11)
Payyanur	42 (10)	66 (13)	83 (15)	119 (20)	85 (18)	79 (14)	48 (13)
Taliparamba	-	-	-	-	-	-	-
Thirunelli							
Ovate-elliptic leaved	-	-	-	-	-	-	-
Paithal mala	49(11)	63 (14)	85 (16)	115 (20)	90 (18)	54 (15)	50 (12)
Payyanur	53 (13)	68 (15)	96 (17)	128 (20)	105 (20)	65 (14)	55 (11)
Taliparamba	-	-	-	-		-	-
Thirunelli							

'-' mark in the columns indicates the absence of the ovate leaf shape variant.
Figures in parentheses are the number of quadrats in which the variant present, out of 20 quadrats (1 m^2 each) sampled.

Table 2. The frequency percentage of the four leaf shape variants of *Exacum bicolor* in the studied grasslands.

Variants and grasslands	Months						
	May	Jun	Jul	Agu	Sep	Oct	Nov
Ovate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	55	80	95	100	95	95	65
Taliparamba	65	85	100	100	100	100	75
Thirunelli	-	-	-	-	-	-	-
Linear- lanceolate leaved	60	60	75	100	65	50	65
Paithal mala	-	-	-	-	-	-	-
Payyanur	-	-	-	-	-	-	-
Taliparamba	5	5	5	10	5	5	5
Thirunelli							
Oblanceolate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	45	60	75	100	80	65	65
Taliparamba	50	65	75	100	90	70	65
Thirunelli	-	-	-	-	-	-	-
Ovate-elliptic leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	55	70	80	100	90	75	60
Taliparamba	65	75	85	100	100	70	55
Thirunelli	-	-	-	-		-	-

Annual mean frequency (%)	Ovate leaved Paithal mala (-), Payyanur (83.57), Taliparamba (89.29), Thirunelli (-) Linear- lanceolate leaved Paithal mala (65), Payyanur (-), Taliparamba (-), Thirunelli (5.71) Oblanceolate leaved Paithal mala (-), Payyanur (68.57), Taliparamba (73.57), Thirunelli (-) Ovate-elliptic leaved Paithal mala (-), Payyanur (75.71), Taliparamba (78.57), Thirunelli (-)

Table 3. Abundance of the four leaf shape variants of *Exacum bicolor* in the studied grasslands.

Variants and grasslands	Months						
	May	Jun	Jul	Agu	Sep	Oct	Nov
Ovate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	3.09	4.06	4.79	5.30	4.68	4.16	5.54
Taliparamba	2.92	4.18	4.80	5.75	4.65	4.20	5.13
Thirunelli	-	-	-	-	-	-	-
Linear- lanceolate leaved							
Paithal mala	2.50	2.75	3.20	4.75	4.69	5.00	4.00
Payyanur	-	-	-	-	-	-	-
Taliparamba	-	-	-	-	-	-	-
Thirunelli	1	1	2	2	2	1	1
Oblanceolate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	4.00	4.67	4.80	5.15	4.75	5.00	3.64
Taliparamba	4.20	5.08	5.53	5.95	4.72	5.64	3.69
Thirunelli	-	-	-	-	-	-	-
Ovate-elliptic leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	4.45	4.50	5.31	5.75	5.00	3.60	4.17
Taliparamba	4.08	4.53	5.65	6.40	5.25	4.64	5.00
Thirunelli	-	-	-	-		-	-
Annual mean abundance (%)	Ovate leaved Paithal mala (-), Payyanur (4.52), Taliparamba (4.52), Thirunelli (-) Linear- lanceolate leaved Paithal mala (3.84), Payyanur (-), Taliparamba (-), Thirunelli (1.43) Oblanceolate leaved Paithal mala (-), Payyanur (4.57), Taliparamba (4.97), Thirunelli (-) Ovate-elliptic leaved Paithal mala (-), Payyanur (4.68), Taliparamba (5.08), Thirunelli (-)						

Table 4. Density of the four leaf shape variants of *Exacum bicolor* in the studied grasslands.

Variants and grasslands	Months						
	May	Jun	Jul	Agu	Sep	Oct	Nov
Ovate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	1.70	3.25	4.55	5.30	4.45	3.95	3.60
Taliparamba	1.90	3.55	4.80	5.75	4.65	4.20	3.85
Thirunelli	-	-	-	-	-	-	-
Linear- lanceolate leaved							
Paithal mala	1.50	1.65	2.40	4.75	3.05	2.05	1.80
Payyanur	-	-	-	-	-	-	-
Taliparamba	-	-	-	-	-	-	-
Thirunelli	0.05	0.05	0.10	0.20	0.10	0.05	0.05
Oblanceolate leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	1.80	2.80	3.60	5.15	3.80	3.25	2.00
Taliparamba	2.10	3.30	4.15	5.95	4.25	3.95	2.40

Thirunelli	-	-	-	-	-	-	-
Ovate-elliptic leaved							
Paithal mala	-	-	-	-	-	-	-
Payyanur	2.45	3.15	4.25	5.75	4.50	2.70	2.50
Taliparamba	2.65	3.40	4.80	6.40	5.25	3.25	2.75
Thirunelli	-	-	-	-		-	-

Annual mean density (%)

Ovate leaved
Paithal mala (-), Payyanur (3.84), Taliparamba (4.10), Thirunelli (-)
Linear- lanceolate leaved
Paithal mala (2.52), Payyanur (-), Taliparamba (-), Thirunelli (0.09)
Oblanceolate leaved
Paithal mala (-), Payyanur (3.20), Taliparamba (3.73), Thirunelli (-)
Ovate-elliptic leaved
Paithal mala (-), Payyanur (3.61), Taliparamba (4.07), Thirunelli (-)

For ovate leaf shape variant, the minimum and maximum densities were 1.70 individuals/m^2 (Payyanur during the month of May, 2009) and 5.75 individuals/m^2 (Taliparamba during August, 2009). The highest annual mean density for linear-lancceolate leaf shape variant (2.52 individuals/m^2) was determined in Paithal mala grassland. For oblanceolate leaf shape variant, the lowest density of 1.80 individuals/m^2 was determined in Payyanur grassland during May, 2009 and the highest density, 5.95 individuals/m^2 was determined in Taliparamba during August, 2009 for this variant. For ovate-elliptic leaf shape variant, the range of density was existing between 2.45 individuals/m^2 (Payyanur during May, 2009) and 6.40 individuals/m^2 (Taliparamba during August, 2009). The density is the most important quantitative character of any species in a community to know its structural and functional contribution to the ecosystem. In addition, the determination of density for a species or variant is more useful to know its microclimatic preferences in a common macroclimatic condition. In homogenous community, the density character is used to find out the dominant species also. The annual density obtained by the population was also higher for ovate leaf shape variant present in Taliparmba (4.10/ m^2) and lower for the population of linear – lanceolate leaf shape variant present in Thirunelli (0.09/ m^2) (Table 4).

In the present study, the density of all the four leaf variants of the study species, *E. bicolor* was increasing during rainy season. It is of common fact that in tropical and subtropical regions, the limiting factor, soil wetness increases the seed germination and stock sprouting rates and hence the density during rainy season for almost all species in a community (3). The enhancement of density for the studied four leaf shape variants was site specific *i.e* .ovate, oblanceolate and ovate-elliptic leaf variants attained higher densities in Taliparamba grassland. The linear- lanceolate leaf shape variant showed its higher density in the grassland of Paithal mala. It indicates the specific fitness of these variants to the above mentioned grasslands in respect of density. The pH, angle of slope in the respective grassland, content of micronutrients in soil and intensity of light available in the grasslands may be the possible factors for this fact (6). Vijayakumar (14) also reported the site specific preference of leaf variants of the medicinal plant, *Gaultheria fragrantissima* in the shola grasslands of Nilgiris. On basis of density, it is known that the Taliparamba grassland was found to have more favourable factors and condusive environment for the growth, reproduction and perpetuation of the study species *E. bicolor* particularly for the ovate leaf shape variant.

4. CONCLUSION

Based on the ecological attributes like frequency, abundance and density studied, it is understood that among the four variants, generally the ovate leaf shape variant of the species, *E. bicolor* has established well. In addition, the grassland community at Taliparamba is determined to have most suitable microclimate also for this variant than the other areas studied. Therefore, if any cultivation attempts will be made in future on demand, the Taliparamba habitat and other habitats similar to Taliparamba may be preferred partially for ovate leaf shape variant.

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RESEARCH ARTICLE

RECOLLECTION OF STROBILANTHES PAPILLOSUS T. ANDERSON (ACANTHACEAE) FROM TYPE LOCALITY

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ABSTRACT

Strobilanthe spapillosus T. Anderson (Acanthaceae) is, an endemic and highly threatened species, recollected from the type locality after a lapse of 83 years. A short description with an illustration, relevant note is provided here for further collection and identity in field.

Keywords: *Strobilanthe spapillosus,* Endemic.

1. INTRODUCTION

Strobilanthes Blume (Acanthaceae) with *ca* 300 species is restricted to hills of tropical Asia. Among these, *ca* 150 species are found in Indian subcontinent. While study the flora of Nilgiri Biosphere Reserve, we came across an interesting species of *Strobilanthes* Blume (Acanthaceae). On the critical studies and perusal of literature, we identified and confirmed as *Strobilanthes papillosus* T. Anderson. It is an endemic (1) and a highly threatened taxon (7). For the easy identification and further exploration, a short description along with an illustration, flowering and fruiting period, specimens examined, etc is provided here.

2. ANCIENT COLLECTIONS

Based on the collection of Hohenacker no.: 1431 from the Nilgiri Hills, Tamil Nadu and Law from the Bababuddan Hills, Karnataka, T. Anderson (2) described as *Strobilanthes papillosus* T. Anderson. Later, it was recollected by R.H. Beddome in 1867 & 1869; J.S. Gamble in 1883; P.F. Fyson in 1919 from Nilgiri Hills, Tamil Nadu. Kumari (5) treated it under *Nilgirianthus papillosus* (T. Anderson) Bremek. in the Flora of Tamil Nadu. While revising the genus *Strobilanthes* in Peninsular India, Venu (7) merged the following genera *Didyplosandra* Wight ex Bremek., *Goldfussia* Nees, *Leptacanthus* Nees, *Nilgirianthus* Bremek., *Phlebophyllum* Nees and *Xenacanthus* Bremek. Under *Strobilanthes* Blume based on the priority. Hence, the present collection is a noteworthy after a lapse of 83 years from the type locality *viz:* the Nilgiri Hills, Tamil Nadu.

Strobilanthes papillosus T. Anderson in J. Linn. Soc.(Bot.) 9: 468. 1867; Bedd., Icon. Pl.Ind.Orient.: 47, t. 207. 1868-1874; C.B. Clarke in Hook.f., Fl. Brit. India 4: 445. (3); Gamble, Fl. Pres. Madras 2: 1039. 1924; Venu, *Strobilanthus* Penin.India: 159, t. 39. 2006. *Nilgirianthus papillosus* (T. Anderson) Bremek. in Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect. 41: 173. 1944; B.D. Sharma *et. al*., in Biol. Mem.2: 108. (6); Kumari in A.N. Henry & al., Fl. Tamil Nadu 2: 155. 1987.

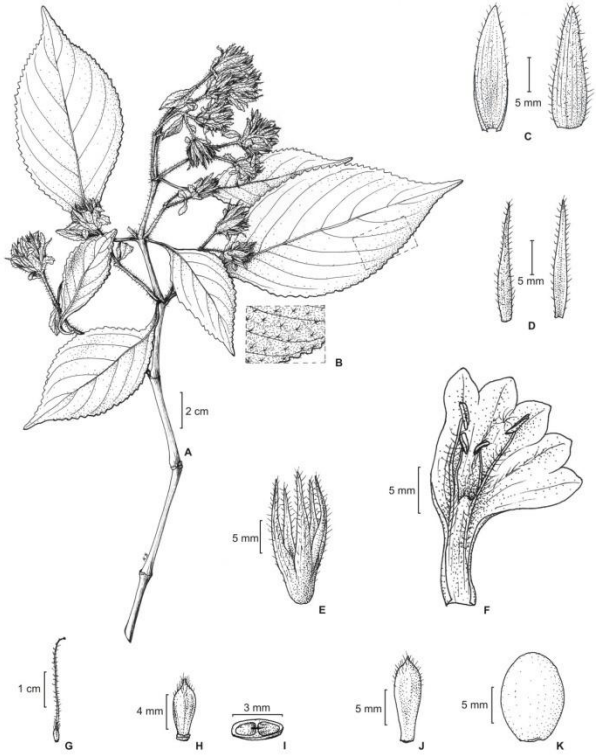

Fig. 1. (A - K). Strobilanthes papillosus T. Anderson
A. Twig; **B.** Leaf-portion enlarged; **C.** Bract (adaxial & abaxial); **D.** Bracteoles (abaxial & adaxial); **E.** Calyx; **F.** Corolla - split open; **G.** Pistil; **H- I.** Ovary - entire & C.S.; **J.** Capsule; **K.** Seed.

Large shrub, to 3 m high; branches tuberculate, glabrate; branchlets pubescent. Leaves ovate, cuneate at base, callous-serrate at margins, acute or abruptly acuminate at apex, 6 - 22 x 2.5 - 9.5 cm, coriaceous, rugose, sparsely bulbous based hairy above, pubescent below; nerves *ca* 8 pairs, prominent below. Inflorescence terminal or subterminal corymb, to 20 cm long, glandular pubescent. Flowers *ca* 1 cm across, violet-purple, *ca* 6, in head; bracts: outer 2 pairs, foliaceous,

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overlapping, papillose, reflexed, to 5 cm long; inner lanceolate very rigid, scabrous, papillose, to 1.8 cm long bracteoles 2, as long as calyx lobes. Calyx lobes 5, linear - lanceolate, 1.5 - 1.7 cm long, subequal. Corolla ventricose, violet; lower tube narrow, *ca* 1.5 - 1.7 cm long; upper tube broad, 1.5 - 2 cm long; lobes 5, ovate, *ca* 6 mm diameter, obtuse with apiculed at apex. Stamens 4, didynamous; filaments monadelphous, unequal, hairy on larger one; glabrous on shorter one; anthers 2-celled, oblong, latrose. Ovary globose, 2 - 3 mm long, pubescent, 2-celled; ovule 2 in each; style filiform, *ca* 2.2 - 2.5 cm long, pubescent; stigma simple. Capsule obovate, *ca* 1 cm long; fertile seeds 2, orbicular, *ca* 5 x 4 mm, glabrous, without areoles; abortive 2, minute (Fig.1).

Fl. & Fr.: March.

Distribution: Endemic to Nilgiri Hills (Burliyar, Dodabetta & Sispara) - Tamil Nadu and Bababuddan Hills- Karnataka, India.

Note: Only few collections from the Nilgiri Hills, Tamil Nadu but there was no any further collection and report from Bababuddan Hills, Karnataka at MH.

Specimens examined: India, Tamil Nadu, Nilgiri District, Nilgiris,? Month, 1867, *R.H. Beddomes.n.* (M.H. *Acc. No.* 37948) & ?Month 1869, *R.H. Beddomes.n.* (M.H. *Acc. No.*37950); Dodabetta, 8000 ft, Oct. 1883, *J.S. Gamble* 12995 (MH *Acc. No*. 37768), Sispara, Nov. 1883, *J.S. Gamble s.n.* (MH *Acc. No.* 37767); Burliyar, 18 Mar. 2006, *ca* 700 m, *C. Murugan* 119171(MH).

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RESEARCH ARTICLE

A STUDY ON BUSINESS SCHOOL BRANDING

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ABSTRACT

The study stemmed from the idea of "Action belief gap" in the sense that often institutions talk of ideals and when comes to action, it ends up in indifference to it. Vision statement one such thing, often it remains as a mere rhetoric in many companies. While Customer Based Brand Equity (CBBE) is an external litmus test of brand power, this research is an internal driver of brand and Brand Vision, Brand Objectives, Brand Essence, Brand Culture and Brand Resource and Implementation as variables studied. The study was a pan India one with Business Schools across the nation with the use of questionnaire to find efforts under way to build the brand around the institution. The study being a first of its kind globally, now the questionnaire serves as template for an institution to introspect on their work on branding.

Keywords: Brand Vision, Objectives, Essence, Culture, Resource, Implementation.

1. BRAND VISION

Brand vision is about considering how a brand could benefit its stake holders over a long-time horizon. Externally the stake holders are customers, nation and internally the employees, suppliers etc., The inductively generated themes uncover internalizing issue of reference to owners and managers relatively to: vision and alignment; creative growth; creative evaluation and rewards (1). From the vision springs an aligning of the entire employee in the organizational towards the company's goal. The concept of using leadership to develop organizational messaging draws on research of human memory capabilities to identify structures for messaging that are both meaningful and memorable (2). Unless there is as strong 'indoctrination' of the vision, employees spontaneous use of it in work, fails. . It is a mental model for the organizational to work for. Having likeminded people together reinforces the common mental model amongst a management team and makes it difficult for a new model to be accepted (3) while vision comes from the man at helm, the people down the line are the ones who make it happen. Just to give a perspective, it is worth mentioning MRF tyre advertisement. The advertisement says,"the Tyres we race are the tyres you buy" and the brand is truly associated with race for many decades.

2. BRAND CULTURE

Organization's culture is relatively more important than market orientation in affecting organizational performance (4). After all organization are social systems runs with certain norms and values evolved over a period. The culture in a society or a community also evolves based on certain belief systems. But in an organization, the founders' vision influences it. When the promoters think "growth as a way of life" as vision it only implies that grow inorganically. Such firm's growth is always more than the industry average growth and it means holding lion's share in which ever market they are in, strong brand image and goodwill. Customers the key stake holder of a brand in the market spontaneously and explicitly judge service encounters based on service employee's effort and abilities, perceived through certain behavioural cues (5). A well settled culture even in a society assumes – consistency. Firms are not exception to it. If there is a strong brand culture, consistency is sustainable. When there is no in consistency it is natural trust emerges deeply too. The culmination is esteemed brand performance. Schein (6). A typical brand-orientedculture inevitably would put customer solutions, relations, emotional bonding, it is only illustrative and not exhaustive.

3. BRAND OBJECTIVES

There is a saying that what cannot be measured, cannot be evaluated. Business planning is undertaken to assist companies grow, while management development concerns planning an individual's growth in a company. Obviously these two kinds of growth are interdependent. As management development becomes more scientific, it must do more than keep up with change; it must lead change. Company organization directly influences a company's environment for management development (7). Companies

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undergoing reengineering found that defining the driving objectives—such as reducing costs, elapsed time, or work hours, or improving quality—mapped the path for successful teamwork. it is objective that influences the organization structure too. Pharmatuicals are driven by Research and Development (R&D) and so here R&D overwhelms in all actions. Research reveals that both stakeholder influence and environmental sector volatility are important in determining organizational objectives (8).

4. BRAND ESSENCE

What is the brand essence of USA? Economic super power. What is the brand power of Saudi Arabia? World's richest oil nation. What is it for Harvard Business School? Benchmarked in every sense of a B school functioning. When consumers think when the company and the competitors selling a parity product, then the company reputation can be a valuable asset (9). In case of products like Toyota, it is quality, for Volvo it is road safety, for South West., pioneer of low cost carrier.

5. BRAND RESOURCES AND IMPLEMENTATION

But for resources brand suffer in the market . brand needs communication, image and all call for committed resources. The results shows that controlled communication and brand have a significant effect on customer satisfaction, brand attitude and reuse intension (10). . When one think of making corporate choices and allocating resources ,the process calls to mind a vision of a CEO who has been provided with a broad menu of business opportunities from which he can simply choose the most month- watering and supply the money and people required to pursue than (11). As people do not buy products and only buy brand, some spends million on brand first recall, some on brand positioning, some on brand visibility and so on.

6. RESEARCH OBJECTIVES

1. To find the overall performance of MBA institutions on internal brand elements.
2. To find the zonal level differences within the country (India) on internal brand elements.
3. To find the performance level difference on internal brand elements between stand alone MBA institutions and the integrated institutions
4. To find the performance level difference on internal brand elements between management institutions based on the quantum of students intake.
5. The find the performance level difference on internal brand elements between early and late entrants to management education.
6. To find the performance level difference on internal brand elements between business schools in state capitals and other towns.
7. To find out the performance level difference on internal brand elements based on business school ranking.
8. To identify clusters in Business schools based on brand elements.
9. To examine brand elements that can discriminate the groups of business schools.

7. THE RESEARCH HYPOTHESES

1. There is no significant difference between the business schools in metros and in other center in the branding process.
2. There is no significant difference between the business schools in State capital and in other towns in the branding process.
3. There is no significant difference between the business schools in established prior to 1997 and the business schools established after 1997 in the branding process as the year 1997 and later a huge surge in Business schools population surged
4. There is no significant difference between the business schools with lower intake and higher intake of students in the branding process
5. There is no significant difference between the stand alone business schools and the integrated business schools in the branding process
6. There is no significant difference between the business schools in northern, southern, eastern and western regions of India in the branding process
7. There is no significant difference between the business schools that are in the ranking list and the business schools that are not in the ranking list , in the branding process

8. DEPENDANT AND INDEPENDENT VARIABLES

The independent variables are as follows:

1. Brand vision

1. Brand culture

2. Brand objectives
3. Brand essence
4. Brand resource & Implementation

The dependent variables are:

1. The place of existence- Metro

This variable is chosen because in a metro, the faculty resources can be better managed and visiting faculty out sourcing is also easy. Outside the metro, it is expensive and difficult to manage. Generally quality students would like to migrate to metro institutions for the benefit of better quality faculties and company inter face..

2. The year of establishment- prior to 1997 and after 1997

The time line for the institution matters in branding. All educational institutions since not- for – profit organization, they seldom do the way for profit organizations do. Year after year, the concern for brand image raises and so for the branding concern.

3. The intake of students – 60 or above 60

Here the assumption is customer stake in the institution.. When the intake goes up, there is brand power at work and it is vice versa too. All leading MBA institutions globally send more than 300 students to job market in a year..

4. The ranking-

The business school ranking is done as a means to select the best institutions. This is often done by business magazines like Business India (BI), Business today and Business world. Amongst them, BI is the pioneer in India and in their 21.10.2007 edition, the eighth year survey report was published. There are 1200 institutions took part and dimensions for ranking are academic programs, faculty details, students profile, infrastructure, curriculum & pedagogy, placements, intellectual interface, management development programs with a cumulative score of 1000 and 164 institutions got the rating from A++, A +, A,B++,B+,B,C++.

5. The institution status- Stand alone or integrated one

The AICTE gives approval for MBA as a standalone institution as well as, as additional course to an engineering college. Stand alone college teaches only MBA subjects.

6. The State Capital

The business schools located in the state capitals have similar edge the metro institutions have. Thus there is a difference between the institutions that are located in the state capital and the rest outside of it.

The use of statics tools :

For testing hypotheses techniques like *t*-test, ANOVA and cluster analysis have been used. ANOVA has been used to find if any differences exist in each of the internal brand components (brand vision, brand culture, brand objectives, brand essence and brand resourcing and implementation) among the four regions (north, south, east and west).

T- test has been used to find if any differences exist in each of the internal brand components between ranked and unranked institutions, B-Schools established prior to 1997 and after 1997, B-Schools in Metros and Non-Metros, B-Schools in State Capitals and those in non State Capitals, B-Schools with 60 students or less and more than 60 students, stand alone B-Schools and integrated B-Schools. Cluster analysis has been used to find out if homogenous groups of respondents existed in the data set. Attempt has also been made to device a mathematical equation that best describes the two groups on using engagement of corporate branding using discriminant analysis.

The key findings of the study:

On brand vision variable, the component of "employee commitment", has a good score followed by the component "Leadership support". On brand culture variable, one third of the institutions do not have brand driven culture. On the brand objectives variables, three fourth of the institutions do not have a catalectic mechanism to realize the brand vision. On brand essence, 52% do not have quality as part of brand element. No brand with out quality can do well in the market. The last variable of resource provision for brand health, the score is low on all counts.

An attempt has been made to find whether there exist regional differences in the five dimensions, viz, Vision, Culture, Objective, Essence, and Resourcing, of the current study. It is observed that no regional differences are found in all the parameters except the parameter, A-3 where the northern zone has significantly higher score than the other three regions.

The B schools ranked by Business India, performance when compared to the rest, there are

no significant difference except on the item "The management providing strong leadership for the brand sustenance". In the area of Brand culture, again ranked ones have edge over items like "Organizational culture supporting the brand vision and brand vision strongly entrenched in overall corporate vision. Over the variable brand objectives, again ranked ones holds sway on the item of brand objective finding a place in the annual plan. Only on brand resourcing and implementation, there are so significant differences between the two.

There is no difference significantly except on leadership support for the sustenance of the brand vision and it goes in favor of above 60 students in take institutions. Higher students intake institutions' culture supports the brand vision, there is a cogent sub culture and it is brand oriented. Short term documented plan is a sign of organized approach to branding process, higher strength institutions stand at 4.033. Here the difference is significant and in favor of higher in take institutions. Barring customer value chain capturing mechanism where the higher strength institutions holds a sway, rest there are no significant differences.

There is a significant difference on items "Employee awareness of brand vision and commitment" and it goes to B schools outside the state capital. Again similar position for the item "brand vision being apart of overall corporate vision" with in brand culture. As regards the other variables, brand objective, essence and resourcing & implementation there is no significant difference between the two.

There is a significant difference in favor of stand alone for attributes like leadership support for brand vision, ability to inspire employees and making employees being aware of brand vision. Stand alone stand out on attributes like culture supporting brand vision, supportive sub culture in all function and strongly entrenched in overall corporate goals. There is a significant difference on items such as "brand has clear short-term objectives and brand long-term goals are more qualitative in nature and stand alone B schools overall score also at .023. Stand alone B schools brand functional capability and brand image when compared with the integrated ones , difference is significant and overall score is also significant. The brand value chain delivery system as a score goes in favor of stand alone with significant difference and for other items, there is no significant difference between the two groups.

An attempt has been made to find whether there exist regional differences in the five dimensions, viz, Vision, Culture, Objective, Essence, and Resourcing, of the current study. The hypothesis that the mean values are the same in all the four regions for each one of the items listed under each dimension. It is observed that no regional differences are found in all the parameters except the parameter; brand vision awareness by employees where the northern zone has significantly higher score than the other three regions

Scores obtained by the B-school in all the 26 parameters of the five dimensions, viz., Brand Vision, Culture, Objectives, Essence, and Resources and Implementation are used to find out the groups of respondents existed in the data set. It is found that there are two groups of opinions by the B-Schools covered in the present study. The first cluster consisted of 114 B-schools, and the second cluster consisted of 44 B-schools. The first cluster of B-schools has significantly higher scores in all the five aspects compared to that of the second cluster. This has been established using Cluster Analysis.

To devise a mathematical equation that best describes the two groups discriminant function has been used using the five dimensions.

The discriminant function is given by:

Z = - 5.536 + 1.907 x Vision + 0.572 x Brand Culture - 0.374 x Brand Objective - 0.340 x Brand Essence - 0.306 x Brand Resource and Implementation

It is found that the correct classification using this function is nearly 70%. If one wishes to find out whether a new B-school is having the perceptions closer to Metro Schools or Non metro schools, the scores on the five aspects are to be obtained. These scores should be substituted in the equation given above. If the Z value obtained for the new B- school is less than or equal to - 0.1355, then it should be assigned to Metro group of B-schools; and if the Z value of this school is greater than - 0.1355, then it should be assigned to Non-metro group.

9. CONCLUSION

It is observed that no regional differences in all the parameters except the parameter, "The employees awareness of brand vision" where the northern zone has significantly higher score than the other three regions. There is clear evidence that among the four geographical zones in India , east performance is good followed by south, north and

east in the end. But the future research can be undertaken with response from the students as they are the important stake holders for educational institutions. A study can be done on the basis of customer based brand equity for B schools as a brand.

It is believed that metro B schools level of commitment as brand custodian is more intense than the rest but the reverse is true in this study. Similar result is obtained for state capital institutions and the rest. Together we can conclude tier one cities fare poorly, and the centersout side of it show relatively good scores. As AICTE provides a clear frame work for running B schools approved by it to ensure quality, the resource gap can be a research in itself and can be undertaken to find the level of dilution by B schools. Stand alone B schools fare well than the MBA run in engineering colleges and others implying the better focus by the former than the later. A further research on customer satisfaction (students) can be undertaken as a comparative study between the stand alone and the integrated ones.

The instrument (questionnaire) since stood well with the confirmatory factor analysis test very well, a study relating to internal brand building task for any organization can be used. This is considered to be a big contribution in the area of brand research as there is no similar research is done till date.

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SCIENTOMETRIC ANALYSIS OF ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE PUBLICATIONS

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ABSTRACT

This paper discusses about the Asian countries Library and Information Science publications during the period of 1996-2016 and its citation available in the Scimago Journal and Country Rank data base by the authors from top 15 countries (based on publications). The relevant data are collected from Scimago Journal and Country Rank data base and it was analyzed. It shows among the Asian countries Library and Information Science publications totally 21233 articles were published which are indexed in Scimago database. Among the publications, maximum of 8506(40.06%) articles published by China and followed by Taiwan with 2764(13.02%) publications and India is in 3rd place with 2626(12.37%) publications during the study period.

Keywords: Asian Countries, Library and Information Science, Scimago Journal and Country Rank, Citations, Self Citations, Citable Documents, H- Index.

1. INTRODUCTION

The true measurement of assessing the quality and quantity of a journal is the Citation Index. While discussing citation, one needs to know the citation. Simply, when another refers other works in his/her article, we describe the article referred is cited. In other words the citation is called as the earlier work which is referred in the present work. The quality of a given work can precisely be deemed through the number of citations that it gets. Therefore, a firm piece of article or research paper is carrying more number of citations get more impact than the work carrying less citation. Therefore, we always refer to some indexing and abstracting databases like Web of Science, Scopus, or even Google Scholars to know the impact of a particular journal, a article or a particular author. Scimago Journal and Country Rank database developed by Scimago Lab and powered by Scopus

2. REVIEW OF LITERATURE

Senthilkumar.R. *et al.* (1) this study analyzes the Astrophysics research output in India from 1989 to 2014. The study revealed that the highest number of publications is in the year 2013 with 913 records having a GCS of 4342 and LCS of 324. The major source of publication in Astrophysics research comes in the form of articles**.** Rajneesh *et al.* (2) have analyzed research output of Computer Science Literature, articles published in the "Journal of the ACM", for ten years in from 1999 to 2008. The study envisages that a total number of 336 papers comprise of 10799 citations. The highest average citations per article were 37.25 the overall average of the citations per article is 32.14. Journals and conference proceedings and both of them together have shared 77% of the total citations. 3926 (36.88%) citations authored by a single author, whereas 6719 citations (63.12%) were multiple authors. It is evident that Computer science is one of the emerging disciplines. Krishnan *et al.* (3) have the Current science Publications research output, for the period of 2000 to 2013. Among 2357 records, the most productive author was Aswal V. K with 108 papers and the highest number of records 334 published in 2011 and 322 records in the year 2010. Total 73.8% of the literature was published records were articles. India was the top produced country with 1363 publications (57.8%) followed by USA with 293 publications (12.4%). Most productive Institution was Bhabha Atomic Research Center (BARC), which topped with 143 publications. Seeman *et al.* (4) have analyzed the growth rate of environmental science literature output in nineteen Universities of South India the period of 2000 – 2012 were retrieved from Web of Science database Among total 6784 journal articles, the highest output was in the year 2012 that accounts for 13.97% and the 7694 journal articles occupy predominant position sharing 88.17% of total research output. A core set of 38 journals has covered about one third of the total publications made by the environmental science researchers in selected universities from South

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India. Khatun *et al.* (5) have examined the periodical articles on diarrheal disease research in Bangladesh. The articles were derived from PubMed, Web of Science and Scopus databases from the period of 1971 to 2009 (38 Years). The total number of retrieved records was 1.521 (PubMed 488; WoS 419; and Scopus 614). The unique 711 records were retained for analysis. The literature growth increased with an average 18.23 articles published per year. The majority of journals 99 (65.55%) were published in the USA and UK.

3. METHODOLOGY

This study aims to discuss about the Asian countries Library and Information Science publications and its citation available in the Scimago Journal and Country Rank data base (6) by the top 15 countries (based on publications). The relevant data are collected from Scimago Journal and Country Rank database. Based on the available sources, the following discussions are made.

4. ANALYSIS AND INTERPRETATION:

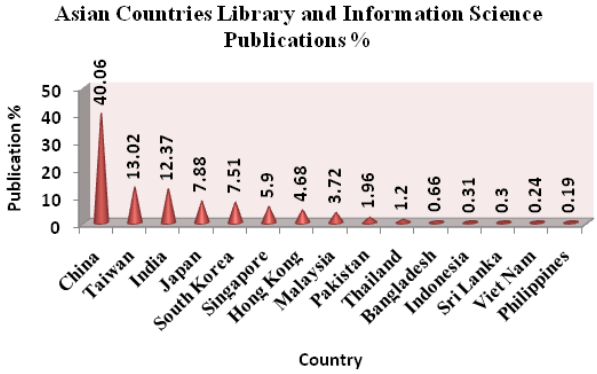
The distributions of the Asian countries Library and Information Science publications by the top 15 countries that is available in Scimago Journal and Country Rank data base which were analyzed in the table 1.

ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE PUBLICATIONS (TOP 15 COUNTRIES)

Table 1. Asian Countries Library and Information Science Publications (Top 15 Countries)

S.NO	Country	Library & Information Science Publication	%
1	China	8506	40.06
2	Taiwan	2764	13.02
3	India	2626	12.37
4	Japan	1674	7.88
5	South Korea	1594	7.51
6	Singapore	1253	5.90
7	Hong Kong	994	4.68
8	Malaysia	790	3.72
9	Pakistan	416	1.96
10	Thailand	255	1.20
11	Bangladesh	141	0.66
12	Indonesia	66	0.31
13	Sri Lanka	64	0.30
14	Viet Nam	51	0.24
15	Philippines	39	0.19
	Total	21233	100

The above Table shows that the country-wise distribution of Asian Countries Library and Information Science Publications From 1996 to 2016, totally 21233 articles were published which are indexed in Scimago database. Among the publications, maximum of 8506(40.06%) articles published by China and followed by Taiwan with 2764 (13.02%) publications and India is in 3rd place with 2626(12.37%) publications.



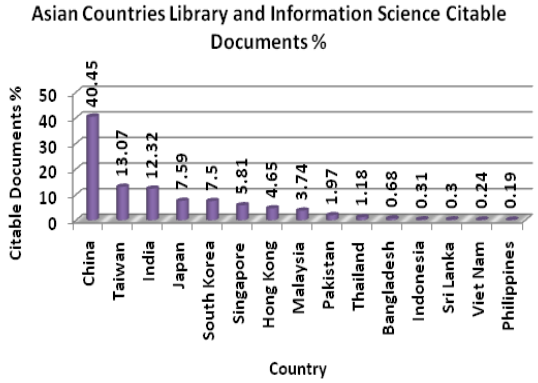
ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE CITABLE DOCUMENTS

Table 2. Asian Countries Library and Information Science Citable Documents

S.NO	Country	Library& Information Science Citable Documents	%
1	China	8422	40.45
2	Taiwan	2722	13.07
3	India	2566	12.32
4	Japan	1581	7.59
5	South Korea	1562	7.50
6	Singapore	1209	5.81
7	Hong Kong	969	4.65
8	Malaysia	778	3.74
9	Pakistan	409	1.97
10	Thailand	245	1.18
11	Bangladesh	141	0.68
12	Indonesia	65	0.31
13	Sri Lanka	63	0.30
14	Viet Nam	50	0.24
15	Philippines	39	0.19
	Total	20821	100

The above Table presents the country-wise distribution of Asian Countries Library and Information Science citable documents (includes

articles, reviews and conferences papers), from top 15 countries from 1996 to 2016, 20821 citable documents were available which are indexed in Scimago database. Among the citable documents maximum of 8422(40.45%) by China followed by Taiwan with 2722(13.07%) and India contributed 2566(12.32%) citable documents.

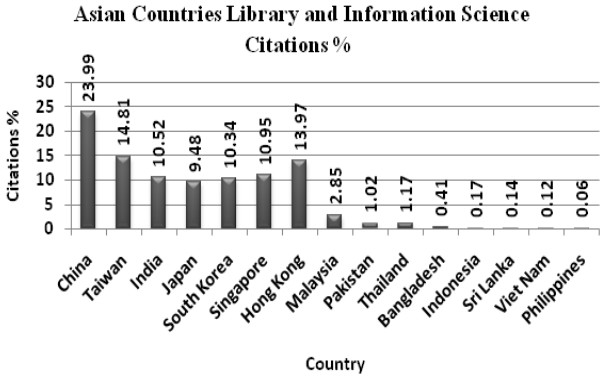


ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE CITATIONS:

Table 3: Asian Countries Library and Information Science Citations

S.No	Country	Library & Information Science Citations	%
1	China	38816	23.99
2	Taiwan	23967	14.81
3	India	17028	10.52
4	Japan	15346	9.48
5	South Korea	16733	10.34
6	Singapore	17726	10.95
7	Hong Kong	22597	13.97
8	Malaysia	4607	2.85
9	Pakistan	1643	1.02
10	Thailand	1884	1.17
11	Bangladesh	656	0.41
12	Indonesia	273	0.17
13	Sri Lanka	221	0.14
14	Viet Nam	187	0.12
15	Philippines	102	0.06
	Total	161786	100

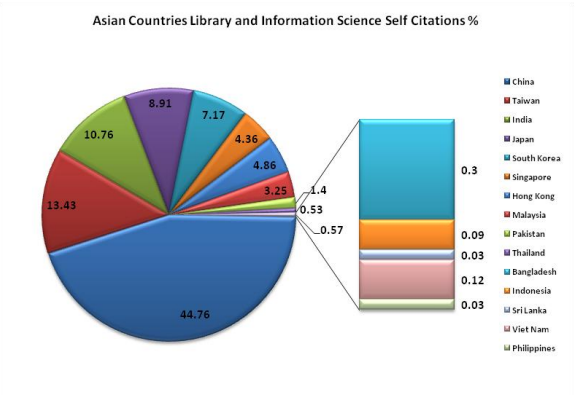
The above Table shows the distribution of Asian Countries Library and Information Science citations, from top 15 countries from 1996 to 2016. Among the citations maximum of 38816(23.99%) by China followed by Taiwan with 23967(14.81%) and India contributed 17028(10.52%) Citations.



ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE SELF CITATIONS:

Table 4: Asian Countries Library and Information Science Self Citations

S.No.	Country	Library& Information Science Self Citations	%
1	China	18336	44.76
2	Taiwan	5504	13.43
3	India	4408	10.76
4	Japan	3649	8.91
5	South Korea	2937	7.17
6	Singapore	1785	4.36
7	Hong Kong	1992	4.86
8	Malaysia	1332	3.25
9	Pakistan	573	1.40
10	Thailand	217	0.53
11	Bangladesh	124	0.30
12	Indonesia	38	0.09
13	Sri Lanka	13	0.03
14	Viet Nam	50	0.12
15	Philippines	10	0.03
	Total	40968	100



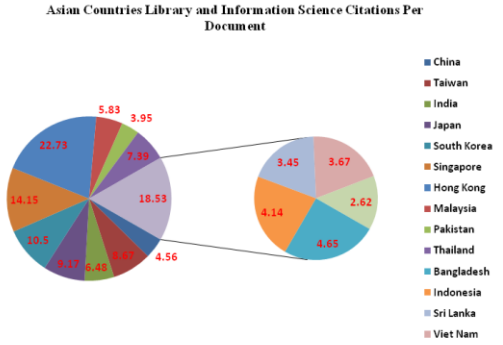
The above Table reveals the distribution of Asian Countries Library and Information Science self citations, from top 15 countries from 1996 to 2016. Among the Asian Countries Library and Information Science self citations maximum of 18336(44.76%) by China followed by Taiwan with 5504(13.43%) and India's self citation is 4408(10.76%).

RANKING OF ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE CITATIONS PER DOCUMENT:

Table 5: Ranking of Asian Countries Library and Information Science Citations Per Document

S.NO	Country	Citations Per Document	Ranking
1	China	4.56	X
2	Taiwan	8.67	V
3	India	6.48	VII
4	Japan	9.17	IV
5	South Korea	10.5	III
6	Singapore	14.15	II
7	Hong Kong	22.73	I
8	Malaysia	5.83	VIII
9	Pakistan	3.95	XII
10	Thailand	7.39	VI
11	Bangladesh	4.65	IX
12	Indonesia	4.14	XI
13	Sri Lanka	3.45	XIV
14	Viet Nam	3.67	XIII
15	Philippines	2.62	XV

The above Table depicts that the ranking of Asian Countries Library and Information Science Citations per Document (Average citations to documents published during 1996-2016), from top 15 countries. Among the Ranking of citations per document study Hong Kong is in first rank with 22.73 followed by Singapore with 14.15 in second rank and South Korea is in third rank with 10.50 citations per document used.

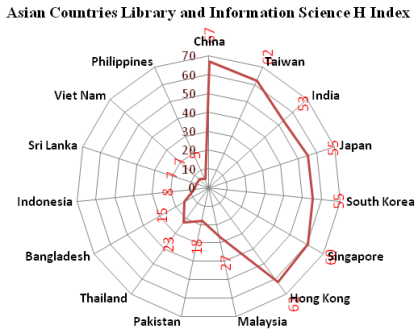


RANKING OF ASIAN COUNTRIES LIBRARY AND INFORMATION SCIENCE H INDEX:

Table 6: Ranking of Asian Countries Library and Information Science H Index

S.NO	Country	H Index	Ranking
1	China	67	I
2	Taiwan	62	II
3	India	53	V
4	Japan	55	IV
5	South Korea	55	IV
6	Singapore	60	III
7	Hong Kong	62	II
8	Malaysia	27	VI
9	Pakistan	18	VIII
10	Thailand	23	VII
11	Bangladesh	15	IX
12	Indonesia	8	X
13	Sri Lanka	7	XI
14	Viet Nam	7	XI
15	Philippines	5	XII

The data presented in the above table shows that the ranking of Asian Countries Library and Information Science distribution of H Index (country's number of articles (h) that have received at least h citations) the China is in the first rank with 67 H indexes followed by Taiwan and Hong Kong with 62 H indexes respectively and Singapore is in third rank with 60 H indexes. Also India is in fifth rank with 53 H Indexes.



5. CONCLUSION

The superiority and magnitude of research are made obtainable through indexing journals with citations of various articles. There is wanting, for providing citations to other articles which authors cite. For reviewing the prior articles which are very much important for behind your article value added point for publishing. It is a good practice to give self citation for their previous works and it follows up of the previous one and improved one. During the study period from 1996 to 2016, among the

publications, maximum of 8506 (40.06%) articles published by China and follow ed by Taiwan with 2764 (13.02%) publications and India is in 3rd place with 2626 (12.37%) publications. The present study proves that the maximum number of citable documents 8422 (40.45%) by China followed by Taiwan with 2722 (13.07%) and India contributed 2566(12.32%) citable documents. The above study shows that the maximum number of citations 38816 (23.99%) by China followed by Taiwan with 23967 (14.81%) and India contributed 17028 (10.52%) Citations. The above study reveals that maximum number of self citations 18336 (44.76%) by China followed by Taiwan with 5504 (13.43%) and India's self citation is 4408 (10.76%).Among the citations per document study, Hong Kong is in first rank with 22.73 followed by Singapore with 14.15 in second rank and South Korea is in third rank with 10.50 citations per document used. The H Index study shows that China is in the first rank with 67 H indexes followed by Taiwan and Hong Kong each with 62 H indexes and Singapore is in third rank with 60 H indexes. Also India is in fifth rank with 53 H Indexes**.** It is concluded that the maximum number of Asian Countries Library and Information Science publications, Citable documents, citations, self citations are in the rank of China, Taiwan and India respectively.

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