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Effects Of Combination Of Different Levels Of Auxin (Naa) And Cytokinin (Bap) On *In Vitro* Propagation Of *Dioscorea Rotundata L* . (White Yam)

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Abstract: Studies were carried out with the aim of evaluating *in vitro* the effects of growth regulators - auxin (NAA) and cytokinin (BAP) combined at different levels on *Dioscorea rotundata* regeneration potentials, on modified Murashige and Skoog media. Concentrations OF 0, 0.25, 0.5, 0.75, 1.00 mg/l and 0, 0.1, 0.2, 0.3 and 0.4 mg/l of NAA and BAP respectively were used to subculture healthy white yam plantlets. The plant height, number of leaves, nodes, vines, roots and fresh weights were evaluated. Results obtained when analyzed at 5% level of significance showed that the concentration of both hormones (auxin and cytokinin) had significant effects on plant regeneration. BAP (0.2mg/l) in combination with NAA (0.5mg/l) showed more increase in almost all the parameters measured when compared to other concentrations combined. It was however noted that the control NAA (0 mg/l) + BAP (0mg /l) produced taller plantlets than other levels. Also the heights in other media series produced plantlets with reduced heights and short internodes when the BAP level was increased. The MS media containing 0.5mg/L NAA + 0mg/L BAP was optimal for production of higher fresh weight compared to other combinations. [New York Science Journal. 2009;2(5):1-8]. (ISSN: 1554-0200).

Keywords: Effects, Different combinations, Auxin and Cytokinin, *in vitro*, propagation, *Dioscorea rotundata*.

Introduction

The white guinea yam, *Dioscorea rotundata* is a monocotyledon, native of the rainforest zones of West Africa (Onwueme, 1998) and belongs to the edible species of Dioscoreaceae. Among the species making up the yams, the white guinea yam is the most widely cultivated. The yield is low, probably because not much reaearch efforts have been dedicated to the genetic improvement of this specie (Onwueme, 1994). Yams are however difficult to breed by hybridization because of their polyploidy and high heterozygosity. So far, the quickest means of crop plant multiplication has been through *in vitro* micro propagation. According to Otto *et. Al.* (2005), the minisett technique has gone a long way towards solving the problem in the yam belt of West Africa.

Plant tissue culture carried out under aseptic conditions has important applications in plant biotechnology. The potential impact of emerging technologies such as micropropagation techniques via *in vitro* propagation may be assessed by their potential efficiency to overcome the limitations posed by basic breeding operations (Thottapily *et al*. 1992, in Kyesmu and Mantell, 2000).

The method of using tissue culture in the propagation of white yam is effective in maintaining disease-free plants and avoiding genetic instability (Long 1989). Cortes-Monller and Liu (1993) achieved four fold multiplication in *D. rotundata* within 2 to 3 months using a nodal segment of 0.5cm to 1cm grown on Murashige and Skoog medium with 2 mg/l IAA and 2 mg/l kinetin followed by transferring the shoot to MS medium with 1 mg/l Naphthalene

Acetic Acid (NAA) to obtain roots and found that the age of the nodal segment influenced the growth. Node cuttings of *D. rotundata* and *D. alata* were also regenerated to plantlets on MS medium supplemented with 2% sucrose, 0.5 mg/l kinetin, 20 mg/l cytokinin and 0.6% agar (Ng, 1994 and 1996c).

Though the technique of tissue culture has been used for the propagation of white yam, yet much has not been done on the effects of various concentrations of BAP and NAA on the *in vitro* regeneration of complete plants of white yam, hence this work is aimed at helping to ascertain the best level of combination of the two phytohormone and also help to create a new yam cropping technique.

Materials and Methods

This research was conducted at the tissue culture laboratory of National Root Crop Research Institute, Umudike, Umuahia, Abia State, Nigeria in September, 2008. The yam plantlets used were obtained from the culture room of the Institute. The nutrient media contained minerals and elements according to Murashige and Skoog (1962).

The NAA stock solution was prepared by dissolving 10mg of NAA in few drops of 0.5N NaOH. Distilled water was added to make up the solution up to 100ml. The BAP stock solution was prepared by dissolving 10 mg of BAP in 95% ethanol and made up to 100ml using distilled water.

The media used contained macro and micro salts according to Murashige and Skoog (1962), iron salts, vitamins, myo-inositol, sucrose and phytagel or gelrite. In addition, NAA and BAP were added to the MS medium in different concentrations and combinations (Table 1). The pH of the medium was adjusted to 5.8 with drop wise of 0.5N NaOH. It was then dispensed into culture vessels and autoclaved at 121^0C at 1.5 $Kgcm^{-1}$ (15 psi) pressure for 15 minutes.

Healthy explants were isolated from initiated mother plants in the culture room. Explants were washed in running water to reduce microbial load. They were later transferred into a beaker containing Tween 20 placed in the laminar air flow hood already sterilized with 70% ethanol. They were washed several times with DDH_2O till all traces of foams were off. They were transferred into a beaker containing 70% ethanol and stirred for one minute. The alcohol was washed off and they were transferred into another beaker containing 0.5% NaOCl solution and stirred for 20 minutes. Finally they were transferred into DDH_2O and washed severally (at least 3 changes) till all traces of the sterillants were off. Each explant was cut into two nodal parts and inoculated into the freshly prepared culture media. It was then sealed and labeled appropriately and kept inside the culture room maintained at 29^0C ± 2^0C and 16/8 duration photoperiod. These were observed daily for growths. Readings were taken after 8, 10 and 12 weeks after subculture.

Results

Hormonal application of BAP and NAA stimulated the production of vine in *D. rotundata*. BAP (0.2) + NAA (0.5) mg/l recorded the highest mean in this regard which differed significantly ($P< 0.05$) from other combinations of NAA and BAP (Table 1). The same trend was also observed in number of leaves and nodes produced (Tables 2 and 3, Plate 1).

As regards to plant height, the control BAP (0) + NAA (0) produced taller plantlets with longer internodes than other levels. The heights of plantlets in the other media series were shorter and with reduced internodes especially when there was an increased BAP concentration in the medium. This differed significantly at ($P<0.05$) (Table 4, plate 2).

From table 5, BAP (0.2) + NAA (0.5) mg/l gave the highest mean value when the number of roots produced were analysed. It was noted that media series with 1.0 mg/l NAA concentration irrespective of the BAP concentrations moved toward callus formation of the plantlets. (Table 5 Plate 3)

The trend in the response of *D. rotundata* in terms of fresh weight was not consistent with either the increase or decrease in BAP and NAA combinations. (Table 6). It was found that BAP (0) + NAA (0.5) mg/l recorded the highest mean value for fresh weight (Table 6). This however was not of any significance ($P>0.05$) when compared to BAP (0.2) + NAA (0.5) mg/l but differed from other levels of BAP and NAA combination.

Table 1: Effects of combination of different levels of Auxin (NAA) and Cytokinin (BAP) on the number of vines of *in vitro* propagation of *Dioscorea rotundata*.

Treatments	**Weeks After Subculture**		
(Mg/L)	**8**	**10**	**12**
BAP (0) + NAA (0)	2.20 def	2.80 ef	3.40 bc
BAP (0) + NAA (0.25)	2.20 def	3.00 ef	3.60 bc
BAP (0) + NAA (0.5)	2.40 def	3.20 def	3.20 bc
BAP (0) + NAA (0.75)	2.60 def	2.80 ef	3.20 bc
BAP (0) + NAA (1.0)	3.20 cdef	3.40 cdef	3.60 bc
BAP (0.1) + NAA (0)	2.20 def	3.00 ef	3.60 bc

BAP (0.1) + NAA (0.25)	2.20 def	3.00 ef	3.80 bc
BAP (0.1) + NAA (0.5)	2.0 def	3.0 ef	3.80 bc
BAP (0.1) + NAA (0.75)	4.40 bcde	4.50 bcdef	4.00 bc
BAP (0.1) + NAA (1.0)	1.20 f	2.00 f	2.20 c
BAP (0.2) + NAA (0)	4.20 bcde	4.60 bcdef	4.80 bc
BAP (0.2) + NAA (0.25)	5.00 bc	5.60 bcde	6.20 b
BAP (0.2) + NAA (0.5)	9.20 a	9.40 a	9.60 a
BAP (0.2) + NAA (0.75)	5.80 bc	6.00 bcde	6.20 b
BAP (0.2) + NAA (1.0)	6.20 b	6.50 b	6.30 b
BAP (0.3) + NAA (0)	6.00 b	6.40 bc 6.30 b	
BAP (0.3) + NAA (0.25)	6.00 b	6.20 bcd	6.20 b
BAP (0.3) + NAA (0.5)	5.80 bc	6.00 bcde	6.10 b
BAP (0.3) + NAA (0.75)	6.20 b	6.50 b	6.30 b
BAP (0.3) + NAA (1.0)	6.20 b	6.40 bc 6.30 b	
BAP (0.4) + NAA (0)	4.80 bcd	5.20 bcde	6.10 b
BAP (0.4) + NAA (0.25)	4.60 bcde	5.80 bcde	6.00 b
BAP (0.4) + NAA (0.5)	6.20 b	6.50 b	6.30 b
BAP (0.4) + NAA (0.75)	4.90 bcd	5.20 bcde	5.40 bc
BAP (0.4) + NAA (1.0)	5.60 bc	6.00 bcde	6.10 b
LSD (0.05)	**2.70**	**3.08**	**3.21**

Means with the same letter(s) down the column are not significantly different

Table 2: Effects of combination of different levels of Auxin (NAA) and Cytokinin (BAP) on the number of leaves of *in vitro* **propagation of** *Dioscorea rotundata*.

Treatments		**Weeks After Subculture**	
(Mg/L)	**8**	**10**	**12**
BAP (0) + NAA (0)	1.20 f	1.40 h	1.40 d
BAP (0) + NAA (0.25)	1.40 f	2.20 gh	2.40 cd
BAP (0) + NAA (0.5)	1.60 f	2.20 gh	3.00 bcd
BAP (0) + NAA (0.75)	1.60 f	2.20 gh	3.20 bcd
BAP (0) + NAA (1.0)	1.60 f	2.60 fh	3.2 bcd
BAP (0.1) + NAA (0)	1.80 ef	2.80 efgh	3.20 bcd
BAP (0.1) + NAA (0.25)	1.80 ef	3.20 defgh	3.80 bcd
BAP (0.1) + NAA (0.5)	2.00 ef	3.20 defgh	3.80 bcd
BAP (0.1) + NAA (0.75)	2.20 def	3.20 defgh	4.00 bcd
BAP (0.1) + NAA (1.0)	2.80cdef	3.40 cdefgh	4.00 bcd
BAP (0.2) + NAA (0)	3.60 cde	3.80 bcdefg	3.50 bcd
BAP (0.2) + NAA (0.25)	3.60 cde	3.80 bcdefg	4.80 bc
BAP (0.2) + NAA (0.5)	6.80 a	7.80 a	8.40 a
BAP (0.2) + NAA (0.75)	4.80 b	5.60 b	5.40 b
BAP (0.2) + NAA (1.0)	4.60 b	5.50 bc	5.40 b
BAP (0.3) + NAA (0)	4.00 bcd	5.20 bcd	4.80 bc
BAP (0.3) + NAA (0.25)	4.00 bcd	4.80 bcde	4.40 bc
BAP (0.3) + NAA (0.5)	4.00 bcd	4.80 bcde	4.40 bc
BAP (0.3) + NAA (0.75)	4.00 bcd	4.40 bcdef	4.20 bcd
BAP (0.3) + NAA (1.0)	4.20 bc	4.20 bcdefg	4.20 bcd
BAP (0.4) + NAA (0)	4.50 bc	4.70 bcdefg	4.00 bcd
BAP (0.4) + NAA (0.25)	4.00 bcd	4.20 bcdefg	4.00 bcd
BAP (0.4) + NAA (0.5)	4.80 b	4.90 bcde	4.80 bc
BAP (0.4) + NAA (0.75)	4.00 bcd	5.00 bcd	5.20 bc
BAP (0.4) + NAA (1.0)	4.20 bc	4.40 bcdef	4.80 bc
LSD (0.05)	**1.80**	**2.14**	**2.85**

Means with the same letter(s) down the column are not significantly different

Table 3: Effects of combination of different levels of Auxin (NAA) and Cytokinin (BAP) on the number of nodes of *in vitro* propagation of *Dioscorea rotundata*.

Treatments (Mg/L)	Weeks After Subculture 8	10	12
BAP (0) + NAA (0)	1.00 g	2.00 gh 1.40 f	
BAP (0) + NAA (0.25)	1.00 g	2.00 gh 1.40 f	
BAP (0) + NAA (0.5)	1.20 fg	2.40 fgh	1.60 ef
BAP (0) + NAA (0.75)	1.00 g	2.60 efgh	1.60 ef
BAP (0) + NAA (1.0)	1.40 efg	2.66 efgh	1.60 ef
BAP (0.1) + NAA (0)	1.40 efg	2.60 efgh	1.60 ef
BAP (0.1) + NAA (0.25)	1.40 efg	2.78 efgh	1.80 def
BAP (0.1) + NAA (0.5)	1.40 efg	2.80 efgh	2.00 cdef
BAP (0.1) + NAA (0.75)	1.80 defg	2.80 efgh	2.00 cdef
BAP (0.1) + NAA (1.0)	1.80 defg	2.92 efgh	2.20 bcdef
BAP (0.2) + NAA (0)	1.60 efg	1.80 h	2.20 bcdef
BAP (0.2) + NAA (0.25)	1.60 efg	3.00 efgh	2.40 bcdef
BAP (0.2) + NAA (0.5)	4.90 a	6.58 a	4.80 a
BAP (0.2) + NAA (0.75)	3.00 bc	4.80 bc	3.40 b
BAP (0.2) + NAA (1.0)	3.60 b	5.00 b	3.40 b
BAP (0.3) + NAA (0)	3.60 b	3.18 defgh	3.20 bc
BAP (0.3) + NAA (0.25)	2.80 bcd	3.40 cdefg	3.00 bcd
BAP (0.3) + NAA (0.5)	2.20 cdef	3.90 bcdef	3.00 bcd
BAP (0.3) + NAA (0.75)	2.40 cde	3.60 bcdef	3.20 bc
BAP (0.3) + NAA (1.0)	2.20 cdef	3.80 bcdef	3.20 bc
BAP (0.4) + NAA (0)	2.00 cdefg	4.00 bcdef	3.00 bcd
BAP (0.4) + NAA (0.25)	2.20 cdef	4.06 bcde	2.90 bcde
BAP (0.4) + NAA (0.5)	2.80 bcd	4.66 bcd	3.00 bcd
BAP (0.4) + NAA (0.75)	2.40 cde	4.72 bcd	3.40 b
BAP (0.4) + NAA (1.0)	2.40 cde	4.08 bcde	3.20 bc
LSD (0.05)	**1.04**	**1.56**	**1.38**

Means with the same letter(s) down the column are not significantly different

Table 4: Effects of combination of different levels of Auxin (NAA) and Cytokinin (BAP) on Plant height of *in vitro* propagation of *Dioscorea rotundata*.

Treatments (Mg/L)	Weeks After Subculture 8	10	12
BAP (0) + NAA (0)	11.92 a	11.95 a 12.00 a	
BAP (0) + NAA (0.25)	7.00 b	7.02 b	7.50 b
BAP (0) + NAA (0.5)	5.40 b	5.48 b	6.50 b
BAP (0) + NAA (0.75)	4.70 b	4.80 b	6.08 b
BAP (0) + NAA (1.0)	4.68 b	4.72 b	5.60 b
BAP (0.1) + NAA (0)	4.60 b	4.66 b	4.98 b
BAP (0.1) + NAA (0.25)	4.56 b	4.50 b	4.98 b
BAP (0.1) + NAA (0.5)	4.28 b	4.46 b	4.78 b
BAP (0.1) + NAA (0.75)	4.28 b	4.42 b	4.74 b
BAP (0.1) + NAA (1.0)	4.12 b	4.38 b	4.62 b
BAP (0.2) + NAA (0)	4.00 b	4.36 b	4.58 b
BAP (0.2) + NAA (0.25)	3.64 b	4.36 b	4.52 b
BAP (0.2) + NAA (0.5)	3.64 b	4.06 b	4.50 b
BAP (0.2) + NAA (0.75)	3.52 b	3.94 b	4.46 b

BAP (0.2) + NAA (1.0)	3.40 b	3.82 b	4.22 b
BAP (0.3) + NAA (0)	3.32 b	3.80 b	3.82 b
BAP (0.3) + NAA (0.25)	3.30 b	3.38 b	3.80 b
BAP (0.3) + NAA (0.5)	3.20 b	3.20 b	3.38 b
BAP (0.3) + NAA (0.75)	3.14 b	3.18 b	3.32 b
BAP (0.3) + NAA (1.0)	3.06 b	3.14 b	3.22 b
BAP (0.4) + NAA (0)	3.02 b	3.04 b	3.20 b
BAP (0.4) + NAA (0.25)	3.02 b	2.92 b	3.20 b
BAP (0.4) + NAA (0.5)	3.00 b	2.78 b	3.14 b
BAP (0.4) + NAA (0.75)	2.52 b	2.66 b	3.10 b
BAP (0.4) + NAA (1.0)	2.50 b	2.40 b	2.50 b
LSD (0.05)	**4.84**	**4.42**	**4.41**

Means with the same letter(s) down the column are not significantly different

Table 5: Effects of combination of different levels of Auxin (NAA) and Cytokinin (BAP) on the number of roots of *in vitro* **propagation of** *Dioscorea rotundata*.

Treatments	**Weeks After Subculture**		
(Mg/L)	**8**	**10**	**12**
BAP (0) + NAA (0)	2.40 defghi	3.00 defg	4.20defgh
BAP (0) + NAA (0.25)	4.60 cde	5.20 cde	6.20 cdef
BAP (0) + NAA (0.5)	9.20 b	11.00 b	12.00 b
BAP (0) + NAA (0.75)	0.4 ghi	1.00 g	1.20 i
BAP (0) + NAA (1.0)	0.00 I	1.00 g	1.20i
BAP (0.1) + NAA (0)	2.60 defghi	4.40cdefg	4.40 cdefghi
BAP (0.1) + NAA (0.25)	5.20 cd	6.40 cd	7.80 c
BAP (0.1) + NAA (0.5)	5.60 c	6.80 c	7.40 cd
BAP (0.1) + NAA (0.75)	2.80 cdefghi	2.80 defg	3.00 fghi
BAP (0.1) + NAA (1.0)	1.20 ghi	1.40 fg	1.42 hi
BAP (0.2) + NAA (0)	0.00i	1.00 g	1.40 i
BAP (0.2) + NAA (0.25)	4.20 cdef	5.40 cde	6.60cde
BAP (0.2) + NAA (0.5)	12.30 a	15.20 a	15.60 a
BAP (0.2) + NAA (0.75)	4.20 cdef	6.20 cd	7.40 cd
BAP (0.2) + NAA (1.0)	1.40 fghi	1.50 fg	2.80 fghi
BAP (0.3) + NAA (0)	0.40 ghi	1.00 g	2.80 fghi
BAP (0.3) + NAA (0.25)	3.20 cdefg	.4.80 cdef	6.60 cde
BAP (0.3) + NAA (0.5)	3.00 cdefgh	4.60 cdefg	6.20 cdef
BAP (0.3) + NAA (0.75)	2.60 defghi	4.40 cdefg	5.20 cdefg
BAP (0.3) + NAA (1.0)	0.20 hi	1.80 efg	2.00 ghi
BAP (0.4) + NAA (0)	2.60 defghi	4.40cdefg	4.20defghi
BAP (0.4) + NAA (0.25)	2.80 cdefghi	4.20 cdefg	5.00 cdefgh
BAP (0.4) + NAA (0.5)	2.60 defghi	4.00 cdefg	5.00 cdefgh
BAP (0.4) + NAA (0.75)	2.20 efghi	3.00defg	4.60cdefghi
BAP (0.4) + NAA (1.0)	2.00 efghi	3.00 defg	3.80efghi
LSD (0.05)	**2.92**	**3.67**	**3.57**

Means with the same letter(s) down the column are not significantly different

Table 6: Effects of combination of different levels of Auxin (NAA) and Cytokinin (BAP) on fresh weight of *in vitro* propagation of *Dioscorea rotundata*.

Treatments (Mg/L)	Weeks After Subculture 12
BAP (0) + NAA (0)	0.12 fg
BAP (0) + NAA (0.25)	0.33 bcd
BAP (0) + NAA (0.5)	0.55 a
BAP (0) + NAA (0.75)	0.35 bc
BAP (0) + NAA (1.0)	0.32 bcde
BAP (0.1) + NAA (0)	0.28 cdef
BAP (0.1) + NAA (0.25)	0.26cdefg
BAP (0.1) + NAA (0.5)	0.18 cdefg
BAP (0.1) + NAA (0.75)	0.24 cdefg
BAP (0.1) + NAA (1.0)	0.35 bc
BAP (0.2) + NAA (0)	0.33 bcd
BAP (0.2) + NAA (0.25)	0.27 cdef
BAP (0.2) + NAA (0.5)	0.50 ab
BAP (0.2) + NAA (0.75)	0.15 defg
BAP (0.2) + NAA (1.0)	0.32 bcde
BAP (0.3) + NAA (0)	0.20 cdefg
BAP (0.3) + NAA (0.25)	0.27 cdef
BAP (0.3) + NAA (0.5)	0.26 cdef
BAP (0.3) + NAA (0.75)	0.23 cdef
BAP (0.3) + NAA (1.0)	0.14 efg
BAP (0.4) + NAA (0)	0.17 cdefg
BAP (0.4) + NAA (0.25)	0.11 fg
BAP (0.4) + NAA (0.5)	0.26 cdefg
BAP (0.4) + NAA (0.75)	0.19 cdefg
BAP (0.4) + NAA (1.0)	0.08 g
LSD (0.05)	**0.19**

Means with the same letter(s) down the column are not significantly different

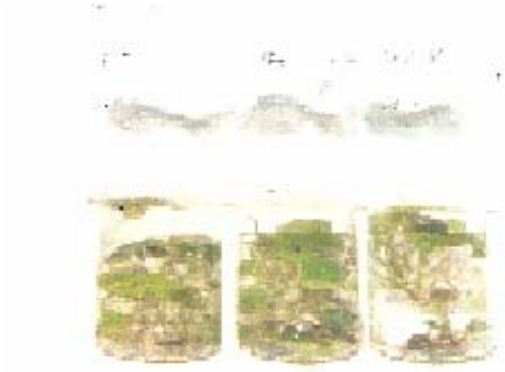

Plate 1: Best growth at concentration BAP (0.2) + NAA (0.5) mg/l

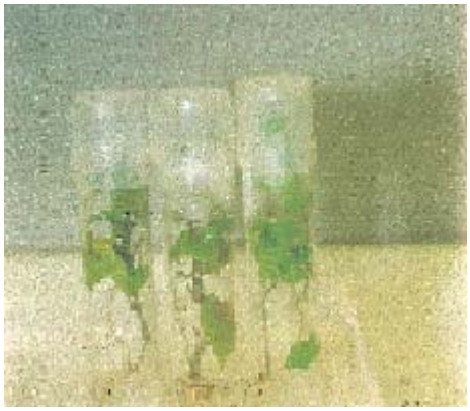

Plate 2: Tall plantlets obtained at BAP (0) + NAA (0) mg/l

Plate 3: Callused tissues obtained at concentration of BAP (0) + NAA(1.0) mg/l

Discussion

Both phytohormones Auxin and Cytokinin are important in *in vitro* propagation, since combination of both favours the *in vitro* performance of *D. rotundata* to give an optimum result. Also the performance of all the parameters in BAP (0.2) + NAA (0.5) showed that the endogenous content of these two phytohormones are low in *D. rotundata*, hence their combination complement each other.

Ammirato (2004) reported that in *D. bulbifera* and *D. alata*, cytokinin at moderate concentrations enhanced shoot development. Chaturvedi (1977) obtained from cultures of *D. floribunda*, an average of 5-6 shoot in 20 days by culturing single node cuttings on a medium containing 8.8µm BAP which is in agreement with this work. The control, BAP (0) + NAA (0) mg/l gave the tallest height which is also in agreement with Lakshmi *et al* (2006) when they observed that the growth and morphogenetic responses of *in vitro* cultures depend among other factors, on the correct constituents and balances of growth regulators.

Synergy between BAP and NAA exhibited positive effect in the induction of roots. The phenomena of *in vitro* micro tuberization were observed in MS medium with 0.25 mg/l BAP and 0.5 mg/l NAA. This phenomenon was also observed by Mantell (2002) when he cultured *D. rotundata* with media containing 5 mg/l IAA and in the presence of 0.5 mg/l kinetin. The *in vitro* recalcitrance observed in the MS medium with 1.0 mg/l NAA irrespective of BAP levels is in agreement with the findings of Belarmino and Rosario (1991), who cultured axillary buds of yam, observed that above 1.0 mg/l of NAA, roots move towards callusing. Also Aslam *et al* (2006) showed that a callogenic response varies from hormonal concentration whether applied singly or in combination.

The classic experiments of Skoog and Miller (1957) showed that at higher concentrations of phytohormones, a hard undifferentiated callus was obtained consisting of small thick walled cells. The outcome of this research therefore recommend the use of different levels of combinations of phytohormones for *in vitro* propagation of *D. rotundata* for the genetic improvement of this specie.

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Improving The Teaching And Learning Of Mathematics In Second Circle Institutions In Ghana: Paper II

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ABSTRACT: Mathematics subject had seriously become problematic and is posing limitations to our children/wards in seeking admission into the tertiary institution of learning. The paper II is a follow up to paper I and continues the ways of improving the teaching and learning of mathematics in second circle institutions in Ghana. [New York Science Journal. 2009;2(5):9-11]. (ISSN: 1554-0200).

Keywords: Mathematics, Second Cycle Institutions, SSCE, Teaching and Learning, Mathematics Association of Ghana (MAG), Ghana Mathematical Society (GMS), National Mathematics Institute (NMI).

INTRODUCTION

"The old slogan of fail in Mathematics, fail in all other subjects" is back on the stage because no applicant can gain admission to higher/tertiary institutions without a credit pass in mathematics. It has now been the awareness that "mathematics" is the key to all subjects be it the Sciences, Technology Accounting and Social Sciences or even law. Not only these, the overall national development of any nation and building of a healthy happy and prosperous society or nation can not be successfully achieved without mathematics. The pursuit of mathematics is therefore, vital and imperative for any society, or community or nation in order to maintain its independence and ensure increased prosperity and keep its place amongst the civilize nations (society) of the world is this era of technology. The rich and more advanced country of the world have attained their affluence through advanced which they made in mathematics which links sciences and technology. This implies that mathematics education is a very important input in the scientific and technological development of any society. It is now obvious that mathematics subject is a tool for science and technology.

Mathematics has now entered into the field of studies which were thought to be non-mathematics in the past. Mathematics is now been seen as the pivot on which all other subjects revolve. As a result, the poor performance of students in the subject cannot be allowed to go unattended to. Right from childhood, in nursery classes, mathematics is one of the basic skills impressed. This shows how mathematics forms the foundation of any solid education. In the paper I, we looked into the probable causes of student's poor performance in the subject with recipes to the problems, the paper II, is an extension of paper I.

There is awareness of Our students' poor performance in Mathematics as evidenced by the results of trends in International Mathematics and Science Study (TIMSS), which was conducted in 2003,when the results were ranked from the highest to the lowest in performance, Ghana occupied the 44^{th} position out of the 45 participating Countries. The results are very painful to those of us who brag about the Ghanaian's academic prowess. Brooding over the results is of no use though; rather concrete steps must be taken to stop the down ward trend of performance in Mathematics, stabilize the situation and then gradually move the whole Nation towards understanding and appreciating the beauty and utility of Mathematics in today's World (1 and 3)

METHODS OF IMPROVING THE TEACHING AND LEARNING OF MATHEMATICS

It is worthy to mention that government of Ghana alone count shoulder the enormous responsibility to better and improve the quality as well as standard of education at all levels. It is therefore imperative that other agencies, organization of private individual, NGOs etc. should assist in improving the standard of education in the country; this can be done by organizing workshop so as to positively support the efforts of government.

Train-the-trainers workshop: this is another method of improving the teaching and learning of mathematics. By train-the trainers we means, a situation where by we have two teachers, i.e. one from junior and another from senior schools need to be selected to train each others. They will be expected to impact knowledge to each other and to other teachers on their return to schools after the workshop when a teacher has adequate knowledge of what is expected of him/her, imparting the knowledge in such field will not be a problem and our students will not end by being drop outs after failing their terminal examination.

- Our Association (MAG) Mathematical Association Ghana, Ghana Mathematical Society (GMS) and National Mathematics Institute (NMI) should be powering mathematics workshop to every schools within some jurisdictions, this may led to improvement in the teaching and learning of mathematics
- Provision of mathematical laboratory to the second circle institutions. If our second circle students can see some of what they are being taught in laboratory, that means we move from abstract to reality, this can bring out improvement in the teaching and learning of mathematics.
- Provision of mathematics models, film strips will also help in improving the teaching and learning of mathematics in our second circle institutions.
- The Mathematical Association of Ghana (MAG), Ghana Mathematical Society (GMS) and National Mathematics Institute (NMI) should be organizing mathematics competition between/among the second circle institution with in a jurisdiction and any school came first should be rewarded specifically. If this is done, there will be improvement in the teaching and learning of mathematics.
- The member of the Mathematical Association of Ghana should be going round the second circle institution in Ghana, to give Maths funfair, lectures or symposia etc. this will also aid in the teaching and learning of Mathematics.
- Mathematics Teachers' through Mathematical Association of Ghana (MAG) need to be supported to attend International Conferences this will bring in exposure to what Mathematics is everyday. MAG, GMS, NMI needs to be organizing International Conferences for its members by inviting other international mathematics association.
- MAG should expand its membership to include those who are not classroom teachers of mathematics. MAG members can gain valuable knowledge by interacting with such people and this can bring about improvement in the teaching and learning of mathematics.
- MAG and GMS leadership need to open up to new ideas that will make MAG and GMS a truly professional body that will spearhead mathematics education in Ghana and it could bring about improvement in teaching and learning of mathematics.
- Mathematics teachers' should encourage their students and however change the wrong notion developed by our Society over many years which some of the teachers have transferred to Children and Pupils that Mathematics is difficult.
- Mathematics teachers should try to do their best to create a friendly classroom atmosphere where teaching is easier and learning is easy and even enjoyable; not a place of war where criticism is rampant and teaching and learning is difficult. So teachers should use to praise instead of threats to get students to learn.
- Teacher should plan carefully their work and spend part of their holidays for planning on how to cover their syllabus before the school reopens. The problem of teaching and learning mathematics is as a result of the fact that some of the basic topics/foundation topics were untaught and that has created "holes" in the minds of our students or pupils. Teacher should remedy it and not add to the problem by skipping some topics.

- Teachers of Mathematics subjects should always use concrete objects to teach children because children learn from concrete to abstract.
- Teachers of Mathematics subjects should be endeavour to the use of continuous assessment to assess the work and progress of their pupil, this could bring improvement to the teaching and leaning of Mathematics.
- Teachers of Mathematics should stop attempting to "pour" knowledge into the "empty" heads of students rather than providing them the opportunity to study and understand Mathematics.

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Analysis of the phytochemical and *invivo* antimalaria properties of P*hyllanthus fraternus* webster extract

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Abstract
The Phytochemical screening and *in vivo* antimalaria and acute toxicity properties of the crude (water) plant extract of *Phyllanthus fraternus* Webster was investigated. The phytochemical screening of the plant extract revealed the presence of alkaloids, flavonoids, tannins, glycosides, saponin, carbohydrates, resins and phenols. Acute toxicity (LD_{50}) test of the crude extract on malaria parasites *P. berghei* gave a value of 692.8mg/kg ±2.8. The *in vivo* antimalaria activity of the extract against *Plasmodium berghei berghei* was assessed within 4 days of suppressive test. *P. fraternus* extract showed antimalaria property for both suppressive and curative tests. Chemo suppression of 77.23%, 85.15% and 86.39% was recorded on mice at 50mg/kg, 100mg/kg and 200mg/kg body weight dosages respectively as compared to 97.03% curative rate obtained from chloroquine (reference drug). The finding highlights the importance of plant products for the treatment of diseases such as malaria and other major tropical disease in Africa. [New York Science Journal. 2009;2(5):12-19]. (ISSN: 1554-0200).

Key words: *phytochemical*, *invivo*, *antimalaria properties*, P*hyllanthus fraternus*, *extract*

Introduction

Ethno-medicinal study is today recognized as the most viable method of identifying new medicinal plants or refocusing on those earlier reported for bioactive constituents (Adjanahoun *et al*., 1991; Farnsworth, 1966).

Medicinal plant, according to Sofowora (1982), is one which (one or more of) its organs contain substances that can be used for therapeutic purposes. It may be in form of vegetable drug, which may either be organized (material which possess a cellular structure e.g. leaf, bark, petal, root etc) or unorganized (non cellular structural medicinal agents such as gum, latex etc). It may be a decoction, which may be in cold water or prepared by bringing it to boil and allowing it to cool, or tisane, which is tea made by either decoction, or infusion (Peters, 1965). Today, traditional medicine has brought to focus a wider coverage of primary healthcare delivery, not only in the African region but also, to various countries of the world. It is the first choice of healthcare treatment for at least 80% of Africans suffering from high fever and other common ailments (Elujoba *et al.*, 2005).

Traditional medicine, a major African socio-cultural heritage, obviously in existence for several decades, was once believed to be primitive and wrongly challenged with animosity by foreign religions and conventional or orthodox medical practitioners (Elujoba *et al*., 2005). In recent years, natural products are of interest because drug resistance by diseases is on the increase (White and Nosten, 1993) and herbal remedies are being sought by a cross section of scientist for various ailments (Odetola and Bassir, 1980). The use of herbs for disease management in Africa and Nigeria in particular could be traced to early man who probably acquired the skill of healing through deliberate or accidental selection of plants and their parts (Sofowora, 1982).

The plant *Phyllanthus fraternus* Webster (**Family:** *Euphorbiaceae)* commonly called; gulf leaf-flower, Chanca piedra, quebra pedra, stone braker, arranca-pedras, carry-me-seed, hurricane weed, para-parai mi, quinine weed Mache da goyo (Hausa), Gbogbon owun lese (Yoruba) is a small, erect, annual herb

(Dicotyledonous) that grows 30–40 cm in height (Wunderlin and Hansen, 2002). It is indigenous to the rainforests of the Amazon and other tropical areas throughout the world, including the Bahamas, southern India, and China. *P. fraternus* is quite prevalent in the Amazon and other wet rainforests, growing and spreading freely (much like a weed). Closely related species are *P. amarus, P. sellowianus* and *P. niruri.* The *Phyllanthus* genus contains over 600 species of shrubs, trees, and annual or biennial herbs distributed throughout the tropical and subtropical regions of both hemispheres (Leslie, 2003).

The plant is employed for numerous uses by the indigenous peoples. These include treatment of blennorrhagia, colic, diabetes, dysentery, fever, flu, tumors, jaundice, vaginitis, and dyspepsia. Based on its long documented history of use in the region, the plant is considered analgesic and as an aperitif, carminative, digestive, laxative, stomachic, tonic, and vermifuge (Leslie, 2003).

The wide usage of this plant in the treatment of disease suggest it trial test against the causative agent of malaria (*P. berghei).*

MATERIALS AND METHODS

Study area

This research was carried out at the National Institute for Pharmaceutical Research and Development (NIPRD), Idu – Abuja, Nigeria. The plant *Phyllanthus fraternus* Webster was collected from Minna in Niger State and identified at the herbarium of NIPRD, Idu – Abuja.

Drying / micronization of plant parts

The plant material (leaves and stems), was spread thinly on a flat, clean tray (to prevent spoilage by moisture condensation) and allowed to dry at room temperature for seven days (Sofowora, 1982). The dried plant material was pounded using a clean mortar and pestle and then blended into fine powder with electric blender (Binatone model BLG – 400). Mercerization was done to enhance the penetration of the extracting solvent (water) into the cells, thus facilitating the release of active ingredients (Sofowora, 1982).

Extraction

Sixty two grams (62g) of the powdered plant was macerated in 200ml of water for 48hours. It was filtered and evaporated with a rotary evaporator to concentrate the filtrate. The semi-solid extract was transferred into a sterile container and stored in the refrigerator.

Column Chromatographic analysis of extract

2.20g of water extract of *Phyllanthus fraternus* Webster was dissolved in a mixed solvent of hexane, ethyl acetate and methanol (table 1). 30g of silica gel was used as stationary phase.

Hexane:	Ethyl Acetate:	Methanol:	Volume (ml)
100	0	0	100
70	30	0	100
50	50	0	100
0	100	0	100
0	70	30	100
0	50	50	100
0	30	70	100
0	0	100	100

Eight fractions eluted from the column and thin layer chromatography (TLC) of the fractions was carried out using the solvent system hexane: ethyl acetate: methanol in the ratio 3:2:1. The retention factor (Rf) was calculated thus:

Rf = Distance moved by solute/Distance moved by solvent

Phytochemical screening of extract

The phytochemical screening of *Phyllanthus fraternus* extract was carried out to determine the following compounds; alkaloid, flavonoids, tannins, anthraquinones, saponins, glycosides, resins, terpenes and phenols (Sofowora 1993).

In-Vivo antimalaria test
Swiss albino mice (18-25g) obtained from the National Veterinary Research Institute, Vom, Nigeria were acclimatized for a period of 10 days at National Institute for Pharmaceutical Research Development, Idu, Abuja. The mice were infected with 0.2ml of infected blood containing about 1 x 107 dose of *P. berghei berghei* (about 64.0%) from a donor mouse (obtained from IPRD Idu) using a hemocytometer. Each mouse was inoculated on day one, intraperitoneally (Odetola & Bassir, 1980).

Drug administration: The drug (chloroquine) was positive control, distilled water (placebo) was negative control and the extracts of *P. fraternus* used in the study was administered intraperitoneally (treatment drug).

Acute toxicity (LD_{50}) test: Lorke's (1983) method of determining LD_{50} was used to determine the toxicity level of the extracts in mice. Three groups (A,B,C) containing four mice each were subjected to treatment intraperitoneally with the extract at 500mg/kg, 1000mg/kg and 1500mg/kg body weight respectively for phase I test. They were kept in check for ten days and mortality recorded from each group.
In view of the result obtained from phase I treatment, phase II treatment was carried out using a dosage of 600mg/kg, 800mg/kg and 1000mg/kg on another three groups of four mice respectively. Route of administration was also intraperitoneal and mortality was recorded.
Toxicity was calculated using the formula:
LD_{50} = √maximum dose for all survival x minimum dose for all death

SUPPRESSIVE TEST (Evaluation of schizontocidal activity on early infection**):** Peters' 4 –day suppressive test against *Plasmodium berghei berghei* infection in mice was employed (Peters, 1970).
The mice were divided into five groups of five mice each. The first three groups were administered 50,100 and 200 mg/kg/day doses of the extract for four consecutive days, while the fourth group was administered chloroquine 5mg/kg/day and the fifth group was administered an equivalent volume (5ml) of normal saline (control group) for four consecutive days (D_1-D_4).
On the fifth day (D_5), thin blood films were prepared from blood collected from the tail. The films were air-dried, fixed in methanol for 30seconds, and stained with 10% giemsa for 20minutes. The slide was rinsed carefully and thoroughly under running tap water and left to stand in an upright position to dry (Inger *et al*., 2004).
Prepared slides were viewed under the X100 objective (oil immersion) light microscope with special ocular and the condenser sufficiently close to give a good contrast. Parasites were search in -an area of a giemsa-stained thin blood film and without moving the slide; the numbers of infected erythrocytes in the whole area (i.e. the big and small squares) were counted. The slide was moved to randomly adjacent fields and counting continued as above. More fields were counted until the sum of 100 erythrocytes in the small fields was reached. The average percentage suppression of parasitaemia was calculated in comparison to controls as shown below:
Average % suppression = average % Parasitaemia in control groups – average % parasitaemia in treated groups X 100/Average % parasitaemia in control group

That is: $\frac{\text{Control mean - Dose mean}}{\text{Control mean}} \times \frac{100}{1}$
The means were calculated as Mean ± Standard Error of Mean (SEM) where
SEM = $\frac{\text{Standard deviation}}{\sqrt{n}}$

CURATIVE TEST: Peter's (1970) method was used.
25 mice infected with 0.2ml of the standard inoculum were weighed, labeled and grouped into five. Doses of 50, 100 and 200mg/kg body weight/day of the plant extract and 5mg/kg/body weight per day of chloroquine (standard group) and 5ml/kg/body weight per day normal saline (control group) were administered for five days (D_1-D_5). At D_6 thin blood films collected from the tail region were prepared for parasitaemia. The blood films were examined using a light microscope and the parasitized erythrocytes on each slide counted.

Results

Of the 62 g weight of powdered *Phyllanthus fraternus* 9 g (14.52%) was extracted and used for treatment test. Phytochemical screening of the extract showed that alkaloids, flavonoids, tannins, saponin, glycosides, phenols and resins were present in the extract while anthraquinones and terpenes were absent. Based on the lethal concentration, dose treatments of up to 200 mg/kg were prepared for the suppressive test and the result are as presented in table 2 and 3 below;

Table 1: Result of Acute Toxicity (LD_{50}) Test in Mice.

CODE	WEIGHT (g)	DOSE	SURVIVAL
RA	16.5		
LL	20.2	500mg/kg	All survived beyond 24 hours
BKTL	20.0		
RLRS	23.4		
RLLA	18.6		
RLRA	15.3	600mg/kg	All survived beyond 24 hours
RALL	20.6		
HDBKTL	23.5		
TLRS	20.7		
HDLS	21.4	800mg/kg	All died within 24 hours
LARA	23.5		
RLLS	24.2		
RL	16.9		
HDRL	21.4	1000mg/kg	All died within 24 hours
RS	19.5		
HDLL	20.4		
LS	17.4		
HDTL	22.3	1500mg/kg	All died within 24 hours
LA	18.2		
HDRA	24.0		

KEY:

TL = Tail, HD = Head, BK = Back, RL = Right Leg, R = Right, LL = Left Leg, L = Left or Leg, A = Arm and S = Side. For example RA= right arm, HDLS= head left side and HDBKTL= head back tail. These are the parts of the animal that were marked with ink for identification.

The LD_{50} was calculated using Lorke's method (1983) as:

LD_{50} = √maximum dose for all survival X minimum dose for all death

LD_{50} = √600 x 800 = √480000

LD_{50} = ± 692.8mg/kg.

Table 2: Antimalaria Properties of Water Extract of *Phyllanthus fraternus* (Suppressive Test on *Plasmodium berghei*)

Code	**Wt (g)**	**Vol. of Treatment**	**Dose**	**No. of Parasites**	**Mean Parasitaemia**
RS	24	0.12		20	
RL	21.4	0.15	5mg/kg/day	26	
BKRL	24.3	0.12	Normal Saline	18	20.2±1.69
HD	20.2	0.1	(control)	16	
LS	27	0.13		21	
TLRA	21.2	0.1		10	
TLLS	24	0.12	50mg/kg/day	6	4.6 ± 1.54
BK	25.4	0.12	Extract	2	
TLLA	27	0.13		3	
LL	29.1	0.14		2	
NM	22	0.22		2	
RLLA	24	0.24	100mg/kg/day	4	3 ± 0.63
RALS	25	0.25	Extract	5	
HDBK	27	0.27		2	
LARA	29	0.29		2	
BKLL	23	0.46		2	
TLRS	23	0.46	200mg/kg/day	4	2.75 ± 0.42
HDRL	26	0.52	Extract	0	
RA	26	0.52		3	
LLRL	31	0.62		2	
BKTL	17.3	0.08		0	
HDTL	24.1	0.12	5mg/kg/day	0	0.6 ± 0.40
TL	25.2	0.12	Chloroquine	2	
LA	27	0.13	(Standard)	1	
LSRS	27.4	0.14		0	

Standard Error of Mean (SEM) = $\frac{\text{Standard Deviation}}{\sqrt{n}}$

Table 3: Summary of Suppressive Test with Water extract

TREATMENT	DOSE	MEAN PARASITAEMIA COUNTS	% INHIBITION
NORMAL SALINE (CONTROL)	5ml/kg	20.2 ± 1.69	0.00
EXTRACT	50mg/kg	4.6 ± 1.54	77.23
EXTRACT	100mg/kg	3.0 ± 0.63	85.15
EXTRACT	200mg/kg	2.75 ± 0.42	86.39
CHLOROQUINE (STANDARD)	5mg/kg	0.6 ± 0.40	97.03

Table 3: Antimalaria Properties of Water Extract of *Phyllanthus fraternus* (Curative Test on *Plasmodium berghei*)

Code	**Wt (g)**	**Vol. of Treatment**	**Dose**	**No. of Parasites D4**	**D7**
NM	19	0.08		21	30
HDRL	19	0.08	5ml/kg/day	24	35
BKLS	22	0.11	Normal Saline	28	40
RS	22	0.11	(Control)	16	38
RA	33	0.16		22	28
RL	20	0.1		20	7
LL	22	0.11	50mg/kg/day	19	4
BK	24	0.12	(Extract)	17	10
HD	27	0.14		24	10
HDBK	29	0.15		15	2
HDLL	21	0.21		35	8
TLRS	22	0.22	100mg/kg/day	20	5
BKRA	25	0.25	(Extract)	26	2
BKLA	27	0.27		18	1
LS	29	0.29		22	7
TLRA	21	0.42		27	8
LSRS	22	0.44	200mg/kg/day	30	2
LLRL	25	0.50	(Extract)	28	2
RLLS	26	0.52		18	5
TLLS	30	0.60		34	0
BKTL	27.8	0.14	5mg/kg	30	1
TL	22	0.11	Chloroquine	22	0
HDTL	24	0.12	(Standard)	18	2
LA	27	0.13		21	2
TLLA	28	0.14		19	0

Table 4: Summary of Curative Test for Water Extract.

TREATMENT	DOSE	PRETREATMENT	POSTTREATMENT
NORMAL SALINE (CONTROL)	5ml/kg/day	22.2 ± 1.96	34.2 ± 2.29
EXTRACT	50mg/kg/day	19 ± 1.52	6.6 ± 1.60
EXTRACT	100mg/kg/day	24.2 ± 3.01	4.6 ± 1.36
EXTRACT	200mg/kg/day	27.4 ± 2.64	3.4 ± 1.40
CHLOROQUINE (STANDARD)	5mg/kg/day	2 ± 2.12	1 ± 0.45

Table 5: Mean survival time of mice receiving various doses of water extract of *P. fraternus* during an established *P. berghei berghei* infection in mice.

Drug/Extract	**Dose (mg/kg/day)**	**Mean Survival Time (Day)**
P. fraternus Extract	50	11.5±3.51
	100	20.5 ±0.63
	200	25.5± 0.54
Chloroquine (Standard)	5ml	27.5± 0.73
Normal saline (Control)	5ml	7.5 ±0.76
One-way ANOVA	F	3.176
	P	<0.05

Discussion

Phytochemical screening of the *Phyllanthus fraternus* plant extract revealed the presence of alkaloids, tannins, saponin, flavonoids, glycosides, resins, phenols and carbohydrates. This is similar to research findings on *Phyllanthus amarus* plant by Olonisakin et al (2004) and Okokon et al (2005). Of all of these metabolites, carbohydrate was the most frequent followed by alkaloids, flavonoids, saponin and glycosides. Resins and phenols were the least frequent.

The suppressive activity of the extract is shown on table 2(a) with the summary on table 3(b). The extract at 50mg/kg, 100mg/kg and 200mg/kg weight of mice yielded 77.23%, 85.15% and 86.39% inhibition respectively as against 97.03% for chloroquine. Results after 4 days treatment showed mean Parasitaemia of 4.6±1.54, 3.00±0.63, 2.75±0.42, 0.6±0.40 and 20.2±1.69 for 50mg/kg, 100mg/kg, and 200mg/kg of extract, chloroquine and normal saline respectively. Percentage chemo suppression was also observed to increase as extract concentration increased. The curative activity showed decrease in Parasitaemia with increase in dose similar to but lower than the chloroquine standard group as shown on table 3(b).

The plant Phyllanthus fraternus was observed to show some intrinsic antimalaria activity by its percentage chemo suppression and even curative ability compared to that of chloroquine which is the standard drug. The activity might be attributed to the presence of alkaloids or flavonoids which has been identified present in this work; or even a combined action of more than one metabolite. However, the active compound(s) known to give this observed activity need to be identified.

This study has however, established the rationale for traditional use of this plant in Nigeria as remedy for malaria infection.

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Investigations Of Heavy Metals In Commercial Spices Brands

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Abstract:
In present study concentrations of some heavy metals such as iron(Fe), copper(Cu), chromium(Cr), lead (Pb), cadmium(Cd) and cobalt (Co) present in common spices of two brands widely used in Pakistan coded as A & B were determined using atomic absorption spectroscopy. The studies showed differences in metal concentrations in different spices samples. The concentration of Fe ranged from 144.5 to 1260 $mgkg^{-1}$ on dry weight basis, where as that of Cu was ranged from 9 to 44 $mgkg^{-1}$ to 3.05 mg kg^{-1}. The concentration level of Cr was from 115 to368 mg kg^{-1}. Concentration of Co and Cd varied little and ranged from 11.5 to 15 $mgkg^{-1}$ and 0.5 to $mgkg^{-1}$ respectively. While variable levels of Pb were detected from 54 to 70 mg kg-1. Daily intake limit was calculated and compared with MRL (minimum risk level) values given by ATSDR (2001). Results showed that concentrations of Cr and Pb of all spices samples under study were much lager than those of MRL values. Thus intake of these spices can cause accumulation of these hazardous metals in body. Metal to metal correlation study showed strong correlation between. Pb, Cu and Co. [New York Science Journal. 2009;2(5):20-26]. (ISSN: 1554-0200).

Keywords: Heavy metals, spices, atomic absorption spectroscopy.

Introduction:

Trace metals composition of foods is of interest because of their essential or toxic nature [(1)]. The accumulation of heavy metals can have middle-term and long term health risks, and strict periodic surveillance of these contaminants is therefore advisable [(2)]. Micronutrients constitute a small fraction of the entire diet but play important roles in different metabolic processes [(3)]

Food composition data is important in nutritional planning and provides data for epidemiological studies [(4)]. Environmental pollution is the main cause of heavy metal contamination in food chain. The trace metal contents of individual foods varies and is dependent upon the trace metals introduced in the growing, transport, processing and fortification of food [(5)]. The other technological processes used to bring the food to the consumer can significantly increase the total trace metal contents of the food [(6,7)]

Spices are dried parts of plants, which have been used as diet components often to improve color, aroma, palatability and acceptability of food. Most of these are fragrant, aromatic and pungent. Natural food spices such as pepper and mustard have been reported to contain significant quantities of some trace metals [(8)]. These trace metals in spices and medicinal plants play vital role as structural and functional components of metalloprotiens and enzymes in living cells [(9)]. The addition of spices –that may be contaminated with trace and heavy metals- to food as a habit may result in accumulation of these metals in human organs. Subjecting to trace and heavy metals above the permissible affect the human health and may result in illness to human fetus, abortion and preterm labor, and mental retardation to children. Adults also may experience high blood pressure, fatigue and kidney and brain troubles.

Pakistan has a high diversity of plants used as spices, herbs, and traditional medicines. Several herbs and spices are either produced on small farmlands or naturally grow in different regions. There is little information available about the safety of those plants and their products in respect to heavy metal contamination. In Pakistan majority of population use more spices than any other beverages. Due to the use of enormous amount of spices daily, it is important to know the toxic metal contents in these The objective of this work is to estimate the levels of some heavy metals i.e. lead, cadmium, cobalt, iron, copper, and chromium that may be present in two major spices brand available in local markets in Pakistan. Also, the levels of investigated metals were recommended by the International Organizations.

Materials and methods:

Sample collection and processing:

Various food taste enhancers (seasoning and culinary condiments) and spices including chili powder, Black pepper powder, tumeric powder, and different mix spices e.g. garam masala powder, Chat masala mix, quorma masala mix and biryani masala mix of brand A & brand B were purchased from liberty market Lahore. These food condiments represent the most widely used taste enhancers in Pakistan. Spices from open market were also purchased coded as C. A total of fifty one samples were collected (three of each type) and analyzed.

Analysis:

The samples were carefully opened and dried to constant weight.1g sample was digested with 20mL of 2:1 HNO_3 /$HClO_4$ (Anal grade), and heated until evolution of white fumes. Where necessary more acid mixture was added and the sample digested until evolution of white fumes marking the end of the digestion process. The digests were filtered into standard 50mL volumetric flask and made up to mark with distilled water. This was subsequently analyzed for Pb, Cd, Cu, Cr, Co and Fe by air-acetylene flame atomic absorption spectrometry (Hitachi Z – 5000) by the standard calibration technique. Calibration standards were prepared by dilution of the high purity commercial metal standards (Applichem) for atomic absorption analysis. Adequate quality assurance measures were carried out to ensure reliability of results. Glassware was properly cleaned and reagents (HNO_3, $HClO_4$ and distilled water) were of analytical grade. Spikes and blanks were also introduced. Results reported are average of duplicates.

The daily intake ($mgkg^{-1}day^{-1}$) was calculated based on these suppose

1) The human weight is 50 kg and

2) The human intake from spices per day is 20 g.

The daily intake ($mgkg^{-1}day^{-1}$) = metal concentration in spice × 20/1000 /50 (Eq.1)

Results and Discussion:

Fifty one samples of spices available in markets of Pakistan were analyzed for iron, copper, chromium, cobalt, cadmium and lead. Of the total samples analyzed all the six metal were detected in each sample. Iron was present in highest amount followed by Cr and Pb. Metal to metal correlation showed that only three elements Pb, Cu and Co were strongly correlated in spices samples. Significant correlation was found ($r>0.5$) between Pb & Cu and Pb and Cu.

Iron:

As revealed by analytical results (see Table 2) iron content of spices samples ranged between 144.5 to 1260$mgkg^{-1}$. The highest mean level of Fe was found in sample C-1 chili powder from open market. On the other hand, lowest mean value was found in sample B-1. The samples of B-4 and B-2 and C-3 were relatively richer in Fe concentration.

Although there was a high content of Fe in all the samples, but daily intake was less then MRL (minimal risk level) value (see Fig: 1). So Fe intake from spices has no effect on health.

Fe is an essential element .It is a constituent of active site of various reproductive hydrogenases, most frequently associated with sulfur containing ligands. Fe together with heamoglobin and ferrodoxin plays a central role of metabolism. Fe facilitates the oxidation of carbohydrates, proteins and fat to control body weight which is an important factor in some diseases (diabetes).

Copper:

As revealed by analytical results (see Table 2) copper content of spices samples ranged between 9 to 44$mgkg^{-1}$ The highest mean level of copper was found in sample A-1 and lowest mean value was found in sample A-3. In all other samples the concentration was close to 15 to 25$mgkg^{-1}$. Daily intake was much less then MRL (minimal risk level) value in all samples (see Fig 2). Copper intake from spices has no effect on health.

Although copper is an essential element in trace amount but can be toxic at excess level. Copper build can result in a tendency for hyperactivity in autistic children. An excess of copper can cause oily skin loss of skin tone (due to ability to block vitamin C) and cause a dark pigmentation of skin specially, around face. It can attribute to hair loss specially, in women.

Chromium:

In case of chromium highest mean concentration was found in sample B-4 and lowest mean concentration in B-7. Chromium particularly Cr (III) plays an important role in the body function in trace amount but it is toxic in excess amount. Cr (VI) is toxic and have no role in body. Daily intake values were less than MRL values for Cr (III) in all samples while higher than those for Cr (VI) (see Fig 3). MRL values are not a bright line for health risk but as the distance of experimental daily intake increases from MRL increase risk level also increases. So all the spices samples under study are source of Cr accumulation in body and are thus health hazards.

Cobalt:

In case of cobalt there was a small variation in concentration for all samples ranging from 11.5 to 15mgkg^{-1}. Daily intake values were found to be much lower than MRL values (see Fig 4). So there is no effect on health due to intake of cobalt from spices. Although cobalt is toxic at elevated levels, however the body needs in small amount. Co in the form of vitamin B_{12} is in active physiological form.

Cadmium:

There was a little variation in case of cadmium. The concentration ranged between 0.5 to 2 mgkg^{-1} while permissible limit of Cd is 6 mgkg^{-1} for all foods in Pakistan. (10). Daily intake values were much lower than MRL values (see Fig 5). So there was no harm by intake of cadmium from spices under study.

Lead:

As revealed by the analytical data high concentration of Pb was found in A-1 (70mgkg^{-1}). In other samples concentration of Pb ranged between 54 to57.5 mgkg^{-1} i.e. greater than permissible standard limit of Pb (0.3mgkg^{-1}) for herbs. Daily intake was much higher than MRL values (see Fig 6). It means intake of spices under this study can cause Pb accomulation in body. It has been reported to competitively inhibit Pb uptake in cells [(11)]. Pb is a heavy metal poison which forms complexes with oxo-groups in enzymes to affect virtually all steps in the processes of heamoglobin synthesis and porphyrin metabolism [(12)]. Toxic levels of Pb in man have been associated with encephalopathy seizures and mental retardation [(13).]

Conclusion:

On the basis of results it can be concluded that the spices of two widely used brands in Pakistan and spices from open markets of Pakistan are not only source of trace metals but also source of contamination of toxic heavy metals especially Pb(II) & Cr(III). Thus excess use of these spices in foods is health hezard.

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Table 1: Instrumental parameters used by FAAS (Hitachi Z - 5000).

Metal	Wavelength (nm)	Slit width (nm)	Air:acetylene ($Lmin^{-1}$)	Upper measureable limit (mgL^{-1})
Fe	248.3	0.2	2.0	20
Cu	324.8	1.3	2.2	30
Cr	359.3	1.3	2.8	100
Co	240.7	0.2	2.2	10
Cd	228.8	1.3	2.0	6
Pb	283.3	1.3	2.2	200

Table 2: Levels of lead, cadmium, cobalt, iron, copper, and chromium present inspicessamples of two brands available in local markets in Pakistan.

Spices Sample	**Fe ($mgkg^{-1}$)**	**Cu ($mgkg^{-1}$)**	**Cr ($mgkg^{-1}$)**	**Co ($mgkg^{-1}$)**	**Cd ($mgkg^{-1}$)**	**Pb ($mgkg^{-1}$)**
A1	716±3.1	44±0.8	207.5±2.2	15.5±0.5	2±0.08	70.5±0.8
A2	536.5±2.1	20±1.7	134±1.3	12±0.45	1±0.1	57.5±5.2
A3	416±0.7	9±1.1	175±0.8	11.5±0.3	1±0.1	55.5±0.8
A4	183±4.1	21.5±0.5	162.5±0.7	11.5±0.5	0.5±0.05	56.5±3.4
A5	577±2.3	15±0.8	205±1.2	11.5±0.02	1±0.02	55.5±0.9
A6	372±4.5	18±0.09	204.5±1.5	11.5±0.1	1±0.1	56.5±1.7
A7	835±2.2	16±0.6	192.5±0.9	13±0.09	0.5±0.4	57.5±1.3
B1	144.5±4.3	26.5±1.3	152±1.5	11.5±0.05	1±0.2	57.5±1.5
B2	523.5±2.2	26.5±1.1	183.5±2.2	11.5±0.1	1±0.1	57.5±2.5
B3	405±0.7	13.5±1.1	175.5±0.6	11.5±0.8	1±0.05	57.5±1.2
B4	1181.5±5.2	24±1.8	368.5±1.8	14±0.2	1±0.08	57.5±1.1
B5	619±0.7	16±0.6	192.5±1.7	13±0.2	0.5±0.1	57.5±0.5
B6	352±3.2	19.5±1.8	226±2.5	12±0.7	1±0.05	55.5±1.8
B7	699.5±1.3	15.5±1.8	115±2.2	11.5±0.5	1±0.05	57.5±2.4
C1	1260±4.9	21.5±1.2	123±2.5	12±0.3	1±0.0.3	56.5±1.3
C2	1024±2.4	26.5±1.9	165±3.1	11.5±0.8	1±0.05	54.5±1.5
C3	1171±1.2	20.5±1.3	150±1.7	12±0.6	0.8±0.011	54±1.4

Table 4: Multiple Metal Correlation Coefficient Matrixes for Various Metals in Spices Samples

	Fe	Cu	Cr	Co	Cd	Pb
Fe	1.0	0.0328	0.0605	0.1239	0.0394	0.0313
Cu		1.0	0.0673	0.4585	0.3466	0.5686
Cr			1.0	0.2475	0.0029	0.0364
Co				1.0	0.3232	0.561
Cd					1.0	0.363
Pb						1.0

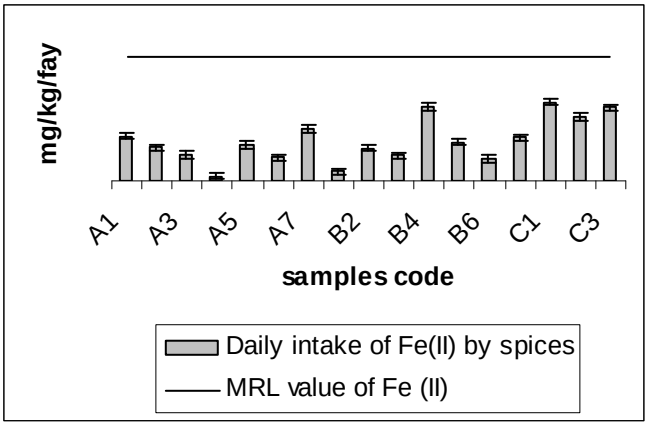

Fig 1: Comparison of MRL values with daily intake to assess health effect of Fe(II) assuming daily intake of spicesbeing studied is 20g & wt. of human body is 50kg.

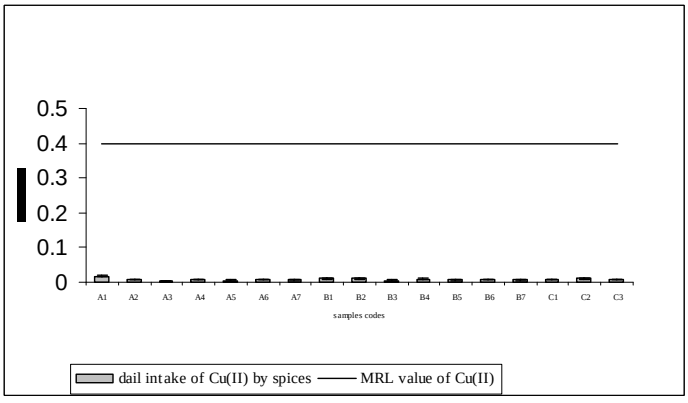

Fig 2: Comparison of MRL values with daily intake to assess health effect of Cu(II) assuming daily intake of spicesbeing studied is 20g & wt. of human body is 50kg.

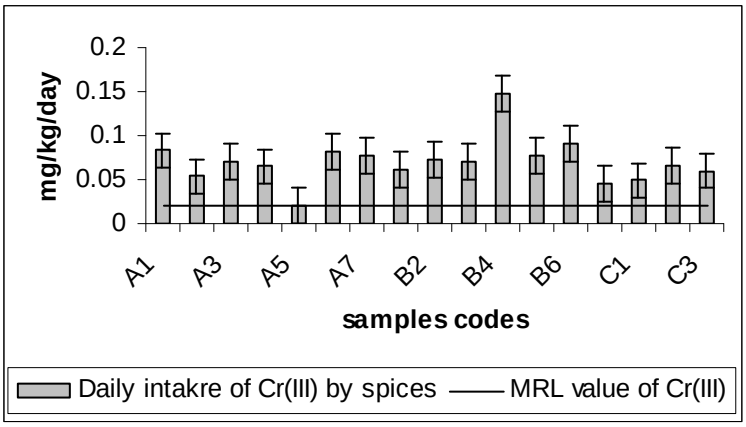

Fig 3: Comparison of MRL values with daily intake to assess health effect of Cr(III) assuming daily intake of spicesbeing studied is 20g & wt. of human body is 50kg.

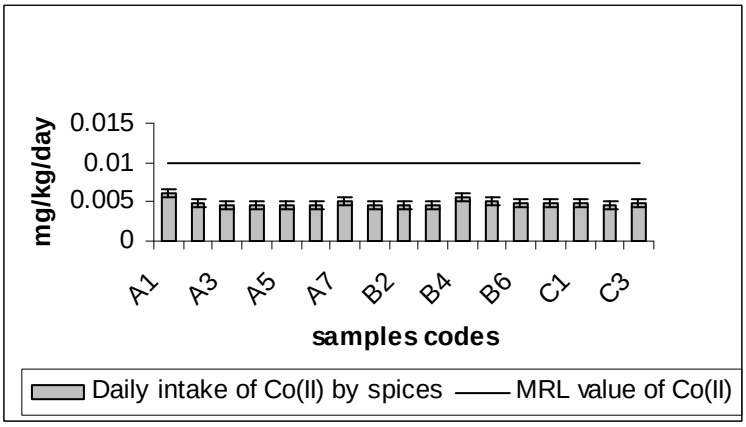

Fig 4: Comparison of MRL values with daily intake to assess health effect of Co(II) assuming daily intake of spicesbeing studied is 20g & wt. of human body is 50kg.

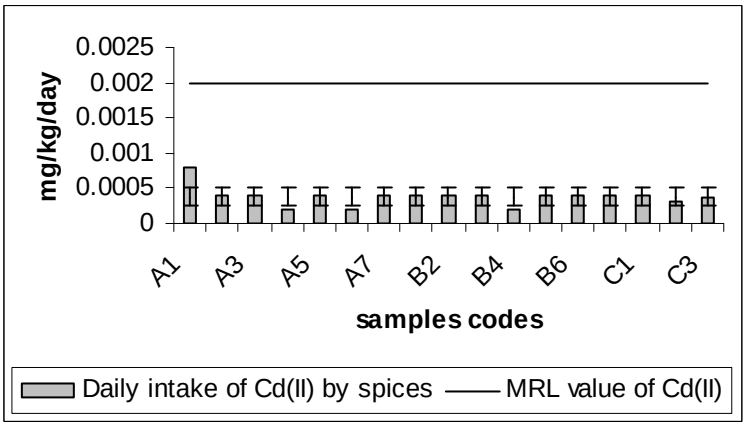

Fig 5: Comparison of MRL values with daily intake to assess health effect of Cd(II) assuming daily intake of spicesbeing studied is 20g & wt. of human body is 50kg.

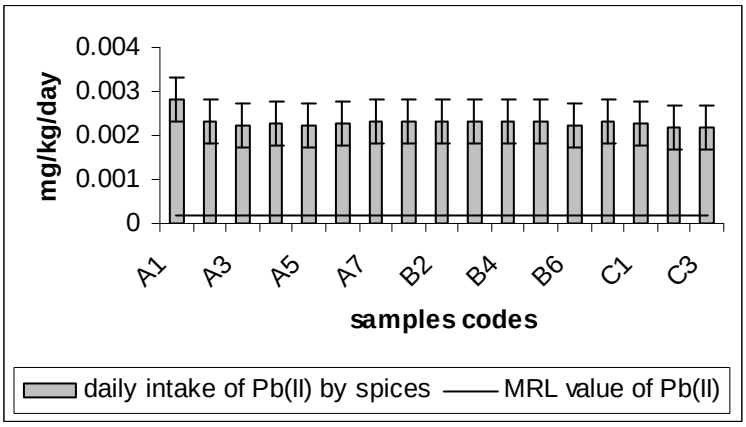

Fig 6: Comparison of MRL values with daily intake to assess health effect of Pb(II) assuming daily intake of spicesbeing studied is 20g & wt. of human body is 50kg.

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Analysis of flavonols in the peels of vegetables by High Performane Liquid Chromatography.

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Abstract: Flavonoids are compounds found in fruits, vegetables, and certain beverages that have diverse beneficial biochemical and antioxidant effects. Quercetin, myricetin and kaempferol were used as standards. Eight vegetables were selected for the study. These vegetables were purchased from the local market in JAN 2009. Flavonols were analyzed using HPLC. Acidified 50% acetonitrile was used as mobile phase. %ages of flavonols were compared in different vegetables. Three different extraction solvents were used to extract flavonols. The purpose of this study was to analyze the better extraction condition for the utilization of vegetable peels as the source of flavonols. Then overall comparison between three type of extracted samples showed that MEOH: H_2O (80; 20) was best solvent for the extraction of flvonols from the peels of vegetables under study. [New York Science Journal. 2009;2(5):27-31]. (ISSN: 1554-0200).

Key Words: Flavonols, Vegetable peels, HPLC

INTRODUCTION:

Among dietry sources, fruits rich in flavonoids include apples (*Pyrus malus*), red fruits, and citrus fruits [1, 2]. In general the more colorful components of the food, like the skins of fruits contain the highest concentration of flavonoids. An exception to this rule, however, is the white pulpy inside of oranges [3]. Pome trees, apple, pear, and quince, are classified into the subfamily Pomoideae, belonging to the Rosaceae family. Quince (*Cydonia oblongo* Miller), followed by 'Red Delicious', peel extracts shows the highest phenolic content (160.33 and 110.90 mg/100 g of fresh weight). Red skin apple and quince peels are of great interest as important antioxidant and antimicrobial polyphenol sources [4]. Total amount of glycosilated flavonols was higher in the whole berries of red grapes where the most abundant phenolic compound was quercetin 3-O -glucoside [5]. Tomato plants can be engineered to produce isoflavones without comprising the levels of endogenous flavonols, which are also health-beneficial, but it may be necessary to enhance the expression levels of chalcone isomerase simultaneously to achieve significant yields in edible tissues such as fruit peels [6]. Flavonol O- and xanthone C-glycosides are extracted from mango (*Mangifera indica L.*) peels. Seven quercetin O-glycosides, one kaempferol O-glycoside, and four xanthone C-glycosides are found in mango. On the basis of their fragmentation pattern, the latter were identified as mangiferin and isomangiferin and their respective galloyl derivatives. A flavonol hexoside was identified as a rhamnetin glycoside.The results obtained in study confirm that peels originating from mango fruit processing are a promising source of phenolic compounds that might be recovered and used as natural antioxidants or functional food ingredients [7]. In the present study peels of eight commonly used vegetables were selected for their flavonol contents.

MATERIALS AND METHODS Chemicals

All reagents were of analytical grade and were used as received. Quercetin (3,3,4,5,7-tetrahydroxyflavonol), myricetin (3,3,45,5,7-hexahydroxyflavone), kaempferol were purchased from sigma Aldrich. Acetonitrile was from Merck.

Instrumentation

The HPLC system (Waters) consisted of a pump (1500 series), a UV detector (2487) was used in the study. Column was a C18, 250 x 4.6 mm, 5 mm particle sizes. Water was HPLC grade and acidified with 1 % acetic acid. Qualitative analysis was made with samples, in isocratic mode, with acetonotrile/water 1:1 at a flow- rate of 1 mL min-1. The injection volume was 10 *uL* and the elute was monitored at 254 nm. The filtered samples of vegetables were injected under these conditions, as well as a mixture of authentic standards of myricetin, quercetin and kaemferol was also injected.

Sample preparation

All vegetables were purchased from a local market. The vegetable and fruits were dried at room temperature and for analysis the weighed portions of the dried sample were homogenized into powder. Ultrasonic extraction was performed using a mixture of methanol and water. For the extraction 15 g of the ground vegetable was weighed and 30 mL of the extraction mixture was added. The sample was left at room temperature for 60 min and in an ultrasonic bath at room temperature for 20 min. The extract was filtered through a 0.45 µm filter and stored at + 4 °C in dark.

RESULTS:

Table: 1 Details of vegetables under study

Sr no	Name	Scientific name	Colour	Date of collection	Date of analysis
1	Ginger	*Zingiber offocinarum*	Yellow	8.1.09	9.1.09
2	Carrot	*Daucus carota*	Red	8.1.09	9.1.09
3	Garlic	*Allium sativum*	Whitish-yellow	5.1.09	6.1.09
4	Onion	*Allium cepa*	White/Pink	8.1.09	9.1.09
5	Pumpkin	*Cucurbita pepo*	Light green	5.1.09	6.1.09
6	Turnip	*Brassica napus*	White/Purple	5.1.09	6.1.09
7	Potato	*Solanum tuberosum*	Brown	2.1.09	3.109
8	Tomato	*Lycopersicum esculentum*	Red	2.1.09	3.109

Table 2: Detail of the codes of fruits and vegetables

Sr no	Name of vegetable/fruit	Codes50%	80%	90%
1	Ginger Peel	G.P.01	G.P.02	G.P.O3
2	Carrot Peel	C.P.01	C.P.02	C.P.03
3	Garlic Peel	Ga.P.01	Ga.P.02	Ga.P.03
4	Onion Peel	O.P.01	O.P.02	O.P.03
5	Pumpkin Peel	Pu.P.01	Pu.P.02	Pu.P.03
6	Turnip Peel	T.P.01	T.P.02	T.P.03
7	Potato Peel	Po.P.01	Po.P.02	Po.P.03
8	Tomato Peel	To.P.01	To.P.02	To.P.03

Extraction solvent: MEOH**: H_2O 50:50**

Table: 3 Qualitative and quantitative analysis of flavonols in peels of vegetables

Sr.no	Vegetable	Flavonol aglycons Mg/kg			*Total mg/kg
		Quercetin	Myricetin	Kaemfherol	
1	G.P.01	0.97±0.3	2.04±0.3	0.35±0.3	3.36±0.3
2	C.P.01	0.31±0.3	3.02±0.2	0.13±0.3	3.46±0.2
3	Ga.P.01	1.16±0.4	8.4±0.3	1.11±0.2	10.67±0.3
4	O.P.01	0.53±0.2	7.24±0.4	0.075±0.4	7.845±0.2
5	Pu.P.01	2.22±0.2	3.55±0.3	0.311±0.4	6.081±0.4
6	T.P.01	0.97±0.4	0.88±0.2	0.311±0.2	2.161±0.4
7	Po.P.01	0.04±.03	1.95±0.2	0.088±0.3	2.078±0.4
8	To.P.01	0.14±.02	0.53±0.3	0.88±0.3	1.55±0.3

 Each reading is the mean of three HPLC readings. *****
Sum of three flavonols.

Extraction Solvent: MEOH: H_2O 90:10

Table:4 Qualitative and quantitative analysis of flavonols in peels of vegetables

Sr.no	Vegetable	Flavonol aglycons mg/kg			*Total mg/kg
		Quercetin	Myricetin	Kempherol	
1	G.P.O3	1.53±0.2	3.46±0.2	0.75±0.3	5.74±0.3
2	C.P.03	1.13±0.3	7.33±0.3	0.66±0.2	9.12±0.2
3	Ga.P.03	1.68±0.3	3.95±0.3	1.733±0.3	7.363±0.2
4	O.P.03	14.2±0.2	41.3±0.4	1.86±0.4	57.36±0.3
5	Pu.P.03	2.25±0.4	38.2±0.4	0.44±0.4	40.89±0.4
6	T.P.03	0.66±0.3	21.89±0.3	0.17±0.3	22.72±0.4
7	Po.P.03	0.39±0.3	0.66±0.3	0.04±0.2	1.09±0.2
8	To.P.03	0.84±0.4	0.84±0.2	0.62±0.2	2.3±0.3

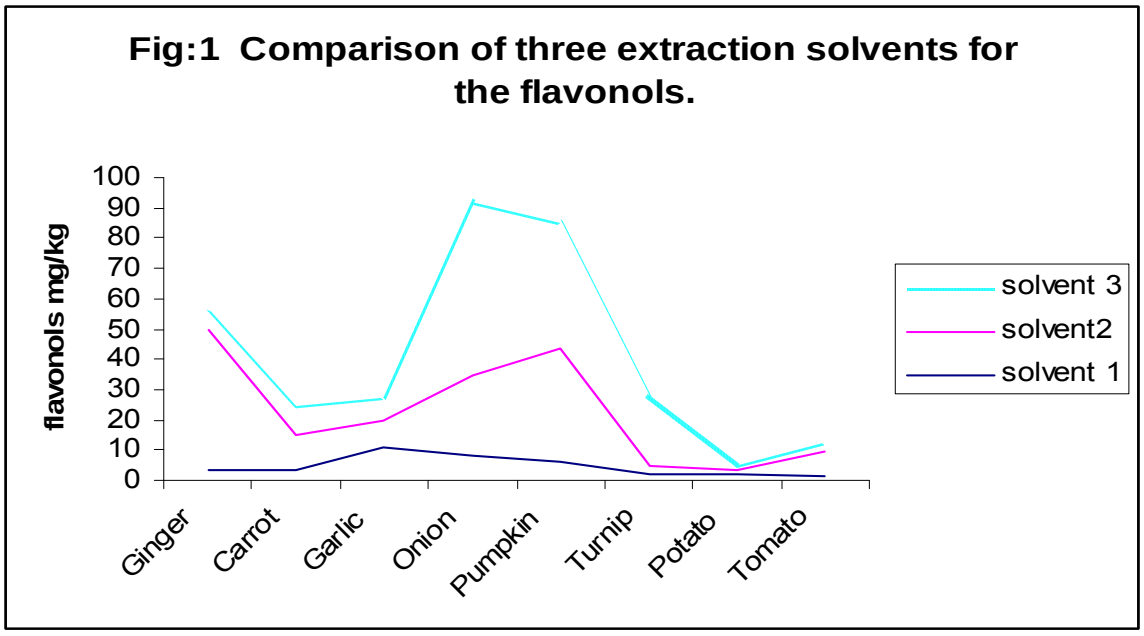
- Each reading is the mean of three HPLC readings.
  * Sum of three flavonols.

Extraction Solvent: MEOH: H_2O 80:20

Table: 5 Qualitative and quantitative analysis of flavonols in peels of vegetables

Sr.no	Vegetable	Flavonol aglycons mg/k			*Total mg/kg
		Quercetin	Myricetin	Kempherol	
1	G.P.02	1.9±0.3	42.6±0.3	1.68±0.3	46.18±0.2
2	C.P.02	1.13±0.4	9.55±0.2	1.06±0.2	11.74±0.3
3	Ga.P.02	3.9±0.3	4.75±0.3	0.62±0.4	9.27±0.2
4	O.P.02	3.63±0.4	22.2±0.4	0.97±.03	26.8±0.3
5	Pu.P.02	3.99±0.2	33.77±0.4	37.76±0.4	75.52± 0.2
6	T.P.02	1.95±0.2	0.88±0.2	0.11±0.3	2.94±0.3
7	Po.P.02	0.17±0.2	1.28±0.3	0.088±0.2	1.538±0.2
8	To.P.02	3.11±0.3	1.955±0.3	3.11±0.3	8.175±0.3

 Each reading is the mean of three HPLC readings. *
Sum of three flavonols.



Discussion:

In the present study three extraction solvents were used to study the extraction and analysis of flavonols in the vegetable peels. Eight vegetables were used for analysis. Their details are given. **[Table: 1]**. Analysis of flavonols in solvent system 1(50:50 MEOH: H_2O) in peels of vegetables showed that garlic peels were richest in flavonols and contained flavonols (10.67 mg/kg) greater than any other vegetable peels. Minimum amount was present in tomato peels (1.32 mg/kg). Onion and pumpkin peels also contained reasonable amounts of flavonols (7.845 mg/kg and 6.081 mg/kg respectively). **[Table: 3]**

Analysis of flavonols in vegetable peels in this extraction system 2(90:10 MEOH: H_2O) showed that ginger peels were richest in flavonols and contained flavonols (46.18 mg/kg) greater than any other vegetable peels. Pumpkin and onion peels also contained a reasonable amount of flavonols (37.76 mg/kg and 26.8 mg/kg respectively). The lowest amount of flavonols was present in potato peels (1.538 mg/kg) **[Table: 4]**. Analysis of flavonols in vegetable peels, during this method of extraction (80:20 MEOH: H_2O),

showed that onion peels were richer in flavonols (57.36 mg/kg) than any other vegetable peels. Minimum amount was present in potato peels (1.09 mg/kg). Pumpkin also contained great amount of flavonols (40.89 mg/kg) **[Table: 5].** It was observed that solvent system 3(80:20 MEOH: H_2O) was best for the extraction of flavonols from the most vegetables because these give high amount of flavonols in this system **[FIG: 1]**

CONCLUSION:

It is concluded from the study that a good amount of flavonols was present in peels of vegetables, so they could be used as a source of flavonols.

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Reverse Phase High Performance Liquid Chromatographic analysis of flavonoids in two *Ficus* species.

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Abstract: HPLC is gaining increasing importance for the analysis of plant extracts. The flavonoids are also thought to have antioxidant, anti-allergenic, and anti-inflammatory effects, thus contributing to human health. Reversed-phase HPLC has been used in a number of occasions for the analysis of flavonoids in plants. In present study two *Ficus* species were analyzed for their flavonoid contents. Kaempferol,rhamnetin, myricetin, isorhamnetin and quercetin were used as standards. Results showed that quercetin was most abundant flavonol present and it was extracted in diethyl ether layer after fractionation. How ever myricetin was also present in good amounts. It was observed that *Ficus bhengalensis* contained a very high amount of flavonoids as compared to *Ficus religiosa.* [New York Science Journal. 2009;2(5):32-35]. (ISSN: 1554-0200).

Key words: HPLC, Qualitative and quantitative HPLC, Flavonoids, Quercetin

INTRODUCTION

Plants have the ability to produce a large variety of secondary metabolites, such as terpenoids, phenylpropanoids, flavonoids, and alkaloids, which together account for over 200,000 compounds [Dixon, RA, .et al. 2003]. The National Cancer Institute has identified a host of compounds found in foods and plants that possess cancer preventing properties. Among these are antioxidants, phytosterols, carotenoids, triterpenes, saponins, tannins, and flavonoids. These phytochemicals may augment immune function, inhibit the formation of cancer-causing nitrosamines, hinder hormonal activity, as well as induce phase I or phase 2 detoxification enzymes, thus protecting the body against chronic diseases, such as cancer. Even so, a substantial amount of additional research is needed in order to obtain a better understanding of the role these agents play in cancer chemoprevention. Flavonoids, including the anthocyanins, flavonols and flavones, are among the most intensely studied secondary products with over 6,000 known compounds [Harborne, 2000]. Many of them play important roles as flower and fruit pigments, UV protectants, signaling molecules between plants and microbes, and regulators of auxin transport [Dooner, 1991][Dixon, 1991]. The flavonoids are also thought to have antioxidant, anti-allergenic, and anti-inflammatory effects, thus contributing to human health [Scalbert, 2005][Ross, 2002].

The qualitative analysis by HPLC which produces a “fingerprint” chromatogram obtained under standard conditions can be very useful for quality control of phytochemicals. Although TLC is a powerful and simple technique used for this purpose, there are situations in which it can produce doubtful results. HPLC can also be a useful tool in chemosystematics helping, for example, to characterize species on the basis of their secondary metabolite contents.

Reversed-phase HPLC has been used in a number of occasions for the analysis of flavonoids in plants. In one study it was used to distinguish species based on the quantitative variation of flavonoids among them.

Experimental

Chemicals

All reagents were of analytical grade and were used as received. Quercetin (3,3,4,5,7-tetrahydroxyflavonol), myricetin (3,3,45,5,7-hexahydroxyflavone), kaempferol, rhamnetin, and isorhamnetin were purchased from sigma Aldrich.

Acid Hydrolysis:

Controlled acid hydrolysis was carried out with 10% acetic acid under reflux for 3.5 hours. These fractionated samples were then analyzed by HPLC without any further separation [Filippo Imperato]

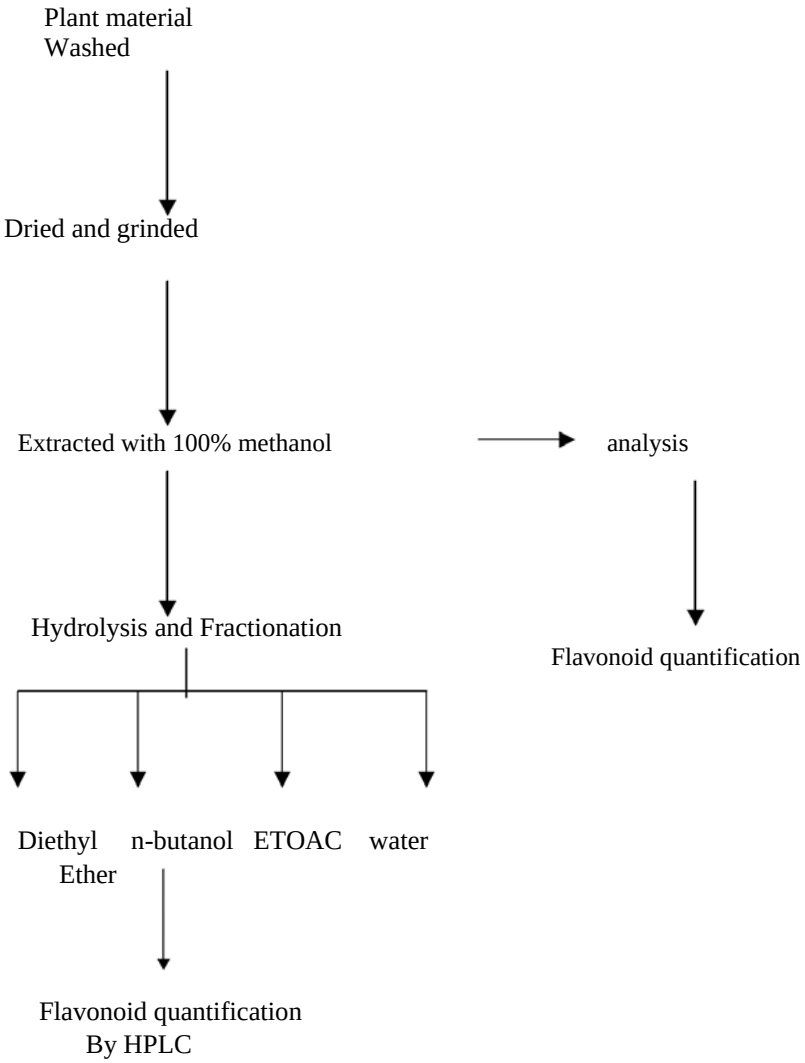
HPLC conditions

The HPLC system (Waters) consisted of a pump (1500 series), a UV detector (2487) was used in the study. Column was a C18, 250 x 4.6 mm, 5 mm particle sizes. Acetonitrile was from Merck. Water was HPLC grade. Qualitative analysis was made with samples, in isocratic mode, with acetonotrile/water 1:1 at a flow- rate of 1 mL min-1. The injection volume was 10 *uL* and the elute was monitored at 254 nm. The filtered samples were injected under these conditions, as well as a mixture of authentic standards of leuteolin, myrcetin, quercetin, Kampherol,rhamnetin and isorhamnetin was also injected.

Sample preparation

Plants were collected from the university campus a voucher specimen were deposited at LCWU Herbarium. These were then dried at room temperature and for analysis the weighed portions of the dried sample were homogenized into powder. Ultrasonic extraction was performed using 100 % methanol. For the extraction 0.5 g of the ground plant was weighed and 5 mL of the extraction solvent was added. The sample was left at room temperature for 60 min and in an ultrasonic bath at room temperature for 20 min. The extract was filtered through a 0.45 µm filter and stored at + 4 °C in dark. The methanol extracts were then fractionated using diethyl ether, n-butanol, ethyl acetate and water to evaluate the most suitable solvent for separation.

Scheme for sample preparation:



Qualitative analysis

The method developed for HPLC fingerprinting provided a quick analysis of the methanolic extract and fractions obtained after fractionation. The conditions used led to a good separation of the peaks which could be identified by comparing the chromatogram with the chromatogram of the reference compounds obtained under the same conditions.

Quantitatification of flavonols:

Quantitative studies of flavonols were made by comparing with standard solutions of known concentration.

RESULTS AND DISCUSSION

Table-1: Percentage of methanol extracts of experimental plants

Names of Plants	**Code**	**Wt. of Fresh plant**	**%age Concentration of MEOH extract**
Ficus bhenghalensis	FB	1 Kg	7.056%
Ficus religiosa	FR	1Kg	6.966%

Table-2: Percentage of Flavanoids in different extracts of needles of *Ficus benghalensis* and *Ficus religiosa.*

Fraction	Myricetin	Kampherol	Rhamnetin	Isorhamnetin	Quercetin
FB Methanol	**2.857±0.1mg/kg**	0	0	0	**21.426±0.2 mg/kg**
FB- Diethyl ether	**2.07±0.3 mg/kg**	0	0	0	**5.712±0.1 mg/kg**
FB –n-butanol	0	0	0	0	**15.714 ±0.3 mg/kg**
FB -ethyl acetate	0	0	0	0	0
FB -Water	0	0	0	0	0
FR- Methanol	**1.0±0.5 mg/kg**	0	0	0	**4.29 ± 0.4 mg/kg**
FR -Diethyl ether	**0.08±0.3 mg/kg**	0	0	0	**2.857±0.1 mg/kg**
FR - n-butanol	0	0	0	0	**1.428± 0.5 mg/kg**
FR - Ethylacetate	0	0	0	0	0
FR -Water	0	0	0	0	0

Both plants were extracted with methanol and their methanolic extract weights were noted [table: 1]. These methanolic extracts were then hydrolyzed to convert glycosides into aglycones. Then fractionated with diethyl ether, n-butanol and ethyl acetate. These fractions were again subjected to HPLC analysis. It

was observed that most aglycone were present in diethyl ether layer after hydrolysis. Also it was clear from the study that quercetin was the most abundant flavonol in both species of *Ficus*[Table:2].

CONCLUSION

Ficus religiosa and *Ficus bhengalensis* are rich in flavonoids. The most important one Quercetin has been reported to have interesting biological activities including the inhibition of the cancer, heat shock protein-9 (Hsp90) [Nagai et al. 1995][Hansen et al. 1997][Kudo et al. 1999][Wu & Yu 2000].

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Corrosion In Petroleum Pipelines

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ABSTRACT: The corrosion in petroleum pipelines has been investigated by the study of the corrosion of mild steel in crude oil and refined petroleum products which include premium motor spirit (PMS), dual purpose kero (DPK), automotive gas oil (AGO), and engine oil. Weight loss technique was used in which test coupons, with a known weight, were immersed in the test media for a total exposure time of 60 days, the weight loss was measured at an interval of 10 days, and the corrosion rate was determined. The results show zero weight loss and zero corrosion rate for engine oil while both quantities are highest for PMS followed by DPK, AGO and crude oil, in that decreasing order. The observed pattern in the corrosion behavior is consistent with the density and weight percent of hydrogen in the hydrocarbon products. The weight loss and corrosion rate increase with decreasing density and increasing weight percent of hydrogen. [New York Science Journal. 2009;2(5):36-40]. (ISSN: 1554-0200).

Keywords: Mild steel, corrosion rate, weight loss, crude oil, petroleum products, hydrocarbon

INTRODUCTION

Transmission pipelines have a good safety record due to a combination of good design, materials and operating practices. However, like any engineering structure, the best-designed and maintained pipeline will become defective as it progresses through its design life. One of the major causes of pipeline defects around the world is corrosion (Callister, 1997). The selection of pipe for a particular situation is dependent on what is going through the pipe, the pressure and temperature of the contents. Pipes are fabricated from different material types to suit stringent needs and services desired. The most commonly used material for petroleum pipelines is mild steel because of its strength, ductility, weldability and it is amenable to heat treatment for varying mechanical properties (Smith and Hashemi, 2006; AbdulHameed, 2005**;** Bolton, 1994; Davies and Oelmann, 1983). However, mild steel corrodes easily because all common structural metals form surface oxide films when exposed to pure air but the oxide formed on mild steel is readily broken down, and in the presence of moisture it is not repaired (Badmos and Ajimotokan, 2009). Therefore, a reaction between steel (Fe), moisture (H_2O), and oxygen (O_2), takes place to form rust. This reaction is complex but it can be represented by a chemical equation of the following type:

$$4Fe + 2H_2O + 3O_2 = 2Fe_2O_3.H_2O \quad (1)$$

$Fe_2O_3.H_2O$ is the rust, and as it is not usually protective, therefore, the corrosion process is not impeded (British Steel Corporation Corrosion (BISRA), 1965).

This work examines the corrosion of mild steel in crude oil and its various refined products which include premium motor spirit (PMS), dual purpose kero (DPK), automotive gas oil (AGO), and engine oil. The aim of this study is to assess the corrosiveness of the various hydrocarbons to enhance material selection and effective surface treatments of pipelines for apt quality of passivity layers to prevent corrosion.

MATERIALS AND METHODS

The crude oil was obtained from the oil field while the refined products, Premium Motor Spirit (PMS), Dual purpose kero (DPK), Automotive gas oil (AGO), and Engine oil were procured from the Filling Station and the pH of each medium was measured. Sheets of mild steel metal of 0.15 cm thickness was mechanically cut into coupons, 6x3.5cm, centrally perforated with hole of 0.7cm diameter and were surface-prepared using emery cloth, ethanol and water. Previously weighed coupons were exposed to the various test media in beakers; and the beakers were kept stationary to avoid displacement effect. Each test coupon was exposed for a total period of 60 days with six weight measurements taken at an interval of 10 days. The average corrosion rates of the coupons, measured in millimeter per year, (*mpy*), were determined using the following established relation (Lawal, 2005; Osarolube et al., 2004; Avwiri, 2004; Gregory, 2004; Ovri and Ofeke, 1998; Fontana, 1987):

$$Corrosion\ Rate = 534\ W/\rho AT \qquad (2)$$

where W is the weight loss in mg, ρ is the metal density in mg/m^3, A is the exposed area of the test coupon in m^2 , T is the exposure time in hours. The exposed area of the test coupon is determined as, A = total surface area of coupon-area of the drilled hole.

RESULTS AND DISCUSSION

The chemical composition, density and pH values of the various media are shown in Table 1. Generally, the density appears to increase with decreasing weight percent of hydrogen content of the media. The densities of PMS and AGO are respectively 763.2 and 835.4 kg/m^3 while their weight percent hydrogen contents are 14.4 and 12.8 respectively.

Uniform corrosion was observed in all the test coupons immersed in the media and the results of the weight loss and corrosion rate measurements are as shown in Tables 2 and 3, respectively. The corresponding plots of weight loss and corrosion rate as a function of exposure time are shown in Figures 1 and 2. Weight loss and corrosion rates are shown to be highest in PMS and negligible in engine oil. The values of the weight loss and corrosion rates for the other media are in the following decreasing order, DPK, AGO and Crude oil.

Table 1: Elemental compositions, densities and pH values of Test Media

Elemental Composition	PMS *(wt.%)*	DPK *(wt.%)*	AGO *(wt.%)*	Engine oil *(wt.%)*
Carbon c	85.5	86.3	86.3	86.1
Hydrogen H	14.4	13.6	12.8	11.8
Sulfur S	0.1	0.1	0.9	2.1
Density (kg/m^3)	763.2	794.0	835.4	823.0
pH value	6.6	7.0	6.2	7.0

Sources: Adebayo, 2004; Beckwith et al., 1987

Table 2: Weight Loss by Mild Steel in the Test Media

Exposure Period (Days)	PMS *(gm)*	DPK *(gm)*	AGO *(gm)*	CRUDE OIL *(gm)*	ENGINE OIL *(gm)*
10	0.004	0.002	-	-	-
20	0.007	0.004	0.002	0.002	-
30	0.011	0.006	0.004	0.004	-
40	0.015	0.009	0.006	0.004	-
50	0.019	0.011	0.008	0.006	-
60	0.023	0.014	0.010	0.006	-

Table 3: Corrosion Rate of Mild Steel in the Test Media

Exposure Time *(Days)*	PMS *(mpy)x10^{-05}*	DPK *(mpy)x10^{-05}*	AGO *(mpy)x10^{-05}*	Crude oil *(mpy)x10^{-05}*	Engine oil (mpy) *x10^{-05}*
10	2.54	1.27	-	-	-
20	2.23	1.27	0.637	0.637	-
30	2.33	1.27	0.849	0.849	-
40	2.39	1.43	0.955	0.637	-
50	2.41	1.40	1.01	0.784	-
60	2.44	1.49	1.06	0.637	-

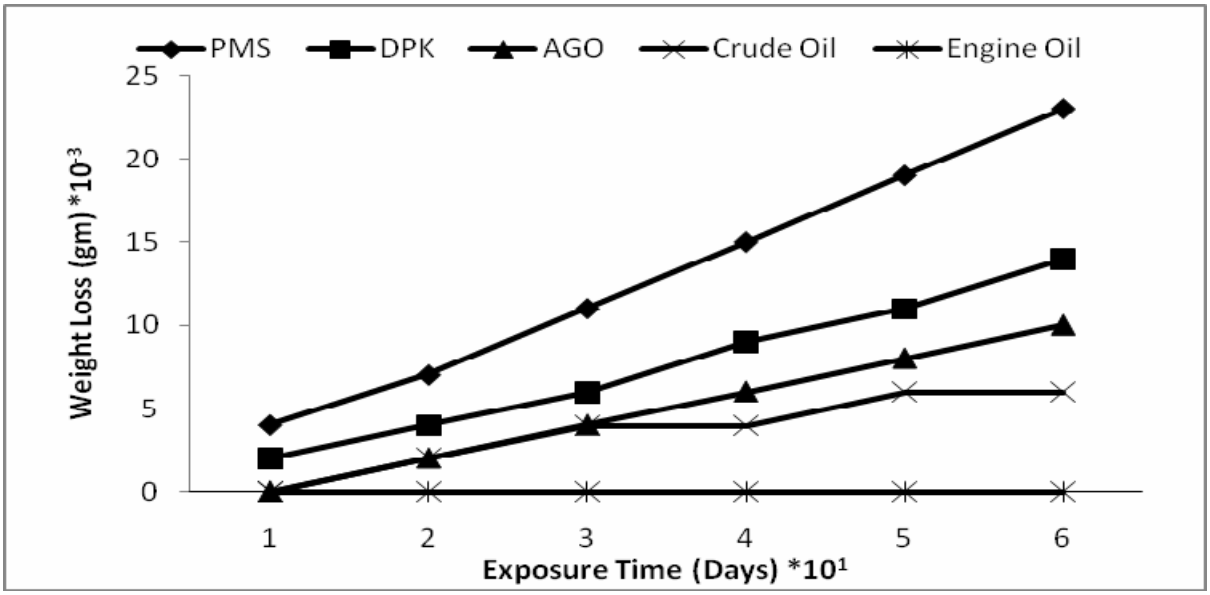

Figure 1: Variation of Weight Loss Vs Exposure Time for all Media

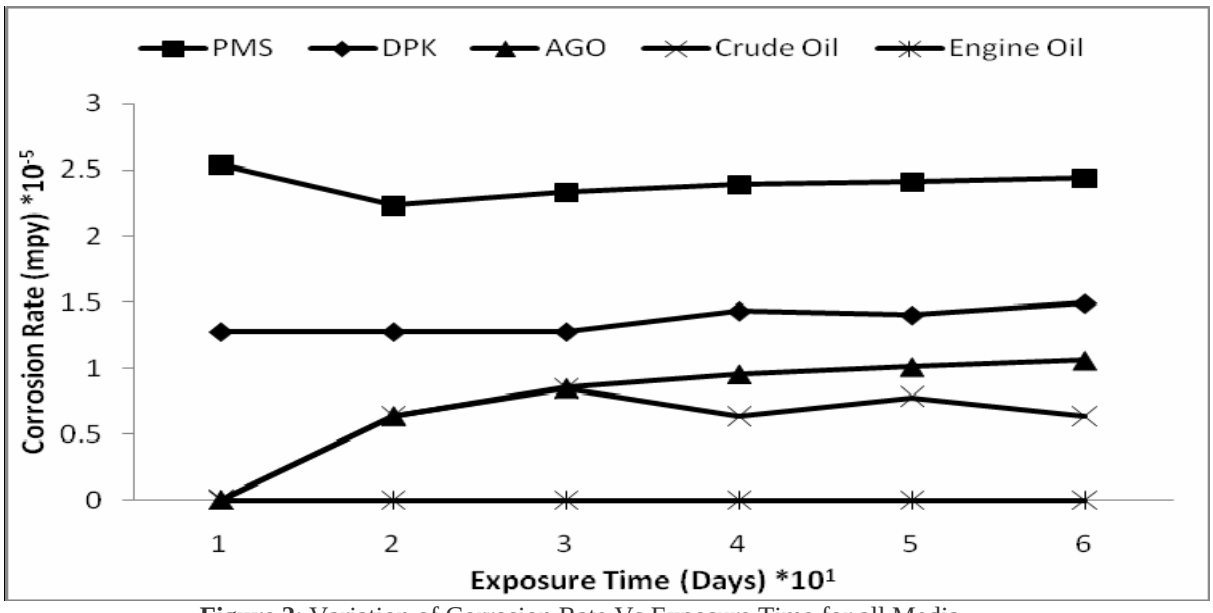

Figure 2: Variation of Corrosion Rate Vs Exposure Time for all Media

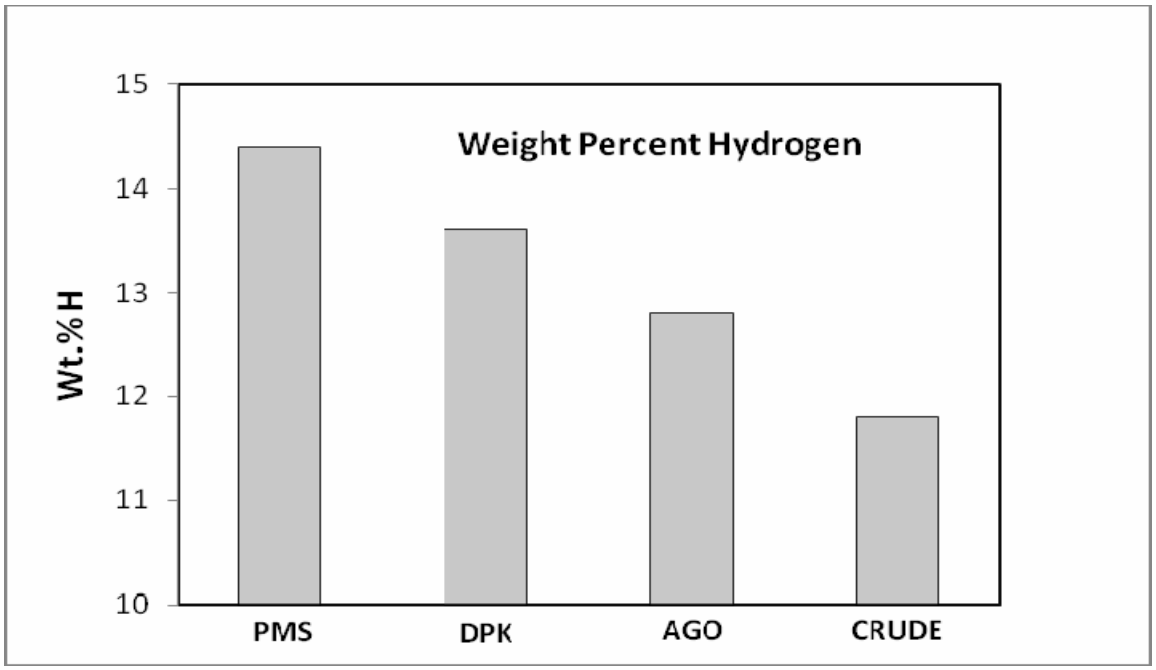

Figure 3: Weight Percent of Hydrogen in the Hydrocarbon Media

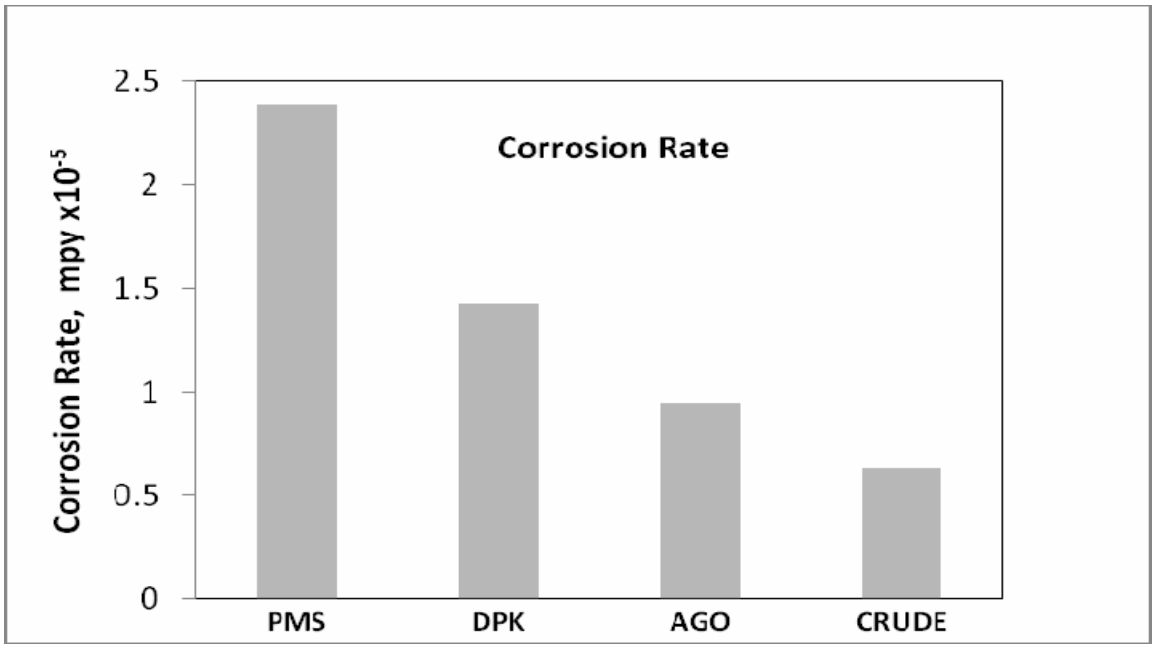

Figure 4: Average Corrosion Rates of the Hydrocarbon Media

CONCLUSIONS

Corrosion in petroleum pipelines have been investigated by the study of the corrosion of mild steel in crude oil and its products which include the premium motor spirit, PMS, dual purpose kero, DPK, automotive gas oil, AGO, and engine oil. The following observations were made.

1. Generally, density appears to increase with decreasing weight percent of hydrogen in the hydrocarbon media.
2. Corrosion rate is highest in PMS, negligible in engine oil, and in the following decreasing order for the other media, DPK, PMS, and Crude oil.
3. Corrosion rate is observed to decrease with decreasing weight percent of hydrogen content in the hydrocarbon media.

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Medicinal Strength of Some Alpine and Sub-Alpine Zones of Western Himalaya, India

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Abstract: The Uttarakhand region is the easternmost part of the Western Himalaya. The vegetational wealth of Western Himalaya is well known since ancient time. The varying topographic conditions of this region thrive on different types of vegetation. It has a rich medicinal plant flora of over 1000 documented species having medicinal value. Out of these, more than 700 species are much in use in the country, mostly by local people living in the villages as a household remedy in several diseases. With the increasing biotic pressure, the forests and alpines are getting degraded and in the process ground flora and shrubs which happen to provide bulk of the medicinal plants are also under strain. In the present study a field survey made from August to December 2008 in four alpine and sub-alpine zone viz. Tungnath of district Rudraprayg and Rudranath, Mandal and Valley of Flower of district Chamoli in order to refine the medicinal strength of above places. The altitudinal range, local name, part used, use/cure and status of some important medicinal plants are compiled based on the earlier publications as well as personal communication with local persons, rural folks and vaidyas. [New York Science Journal. 2009;2(5):41-46]. (ISSN: 1554-0200).

Introduction:

The Himalaya has been a perennial source of attraction, curiosity and challenge to human intellect throughout the ages. Amongst several assets, the vegetation provides an everlasting field of investigation. The diversity, copiousness as well as uniqueness of the plant components in various habitats retained sound and aesthetic environment of the Himalaya. However, in the recent past couple of years excessive exploitation of vegetation, unplanned land use, natural disasters and several developmental processes, accelerated deterioration of biodiversity and harmonious ecosystem of the Himalaya (Gaur, 1999). The state of Uttarakhand is bestowed with a divers array of natural vegetation ranging from the sal forests to Terai-Bhabar to treeless herbaceous meadows in the high alpine region. The alpine meadows, locally called *Bugyals* in Uttarakhand, are said to be nature's own garden where a multitude of colorful herbs, a variety of medicinal plants and nutritious grass grow in great profusion. Besides forming the crucial headwaters of the Hiamalayan Rivers and habitat for high altitude fauna, *Bugyals* are closely linked with the local livelihoods and religious sentiments (Rawat, 2005).

The alpine zone represents one of the most fascinating biomes in the Himalaya. It forms nearly 33% of the geographical area in the region, of which about 25.88% area is vegetated and remaining 7.12% are falls under perpetual snow (Anonymous, 1989). In the state of Uttarakhand the alpine zone forms about 24.11% of the geographical area. Limited by a distinct tree-line towards lower elevation which ranges between 3300-3600 m above sea level in the western and 3700-4000 m above sea level in the eastern Himalaya, the alpine vegetation comprises closely matted dwarf shrubs, herbaceous meadows, bogs, and snow-swept grounds characterized by cushion shaped plants. In greater Himalaya, alpine region is generally separated by a distinct tree-line where forests of birch-rhododendron (*Betula utilis-Rhododendron campanulatum*), high altitude fir (*Abies spectabilis*) and brown oak (*Quercus semecarpifolia*) terminte. The broad physiognomic units of alpine vegetation in the Western Himalaya include the stunted forests or *Krummholz*, alpine scrub, alpine meadows, and pioneer communities on scree slopes and moraines (Rawat and Rodgers, 1988).

Material and Methods:

Present study is based on the field survey made from August to December 2008 in four alpine and sub-alpine zone viz. Tungnath of district Rudraprayg and Rudranath, Mandal and Valley of Flower of district Chamoli (Fig.1) in order to refine the medicinal strength of above places. The notable contribution to medicinal strength of above places have also been reported by several workers (Gaur, 1999; Rawat,

1989; Rawat, 2005; Kala et al., 1998; Nautiyal et al., 2000; Rau, 1975; Rawat and Pangtey, 1987; Rawat et al., 2001; Samant et al., 1998).

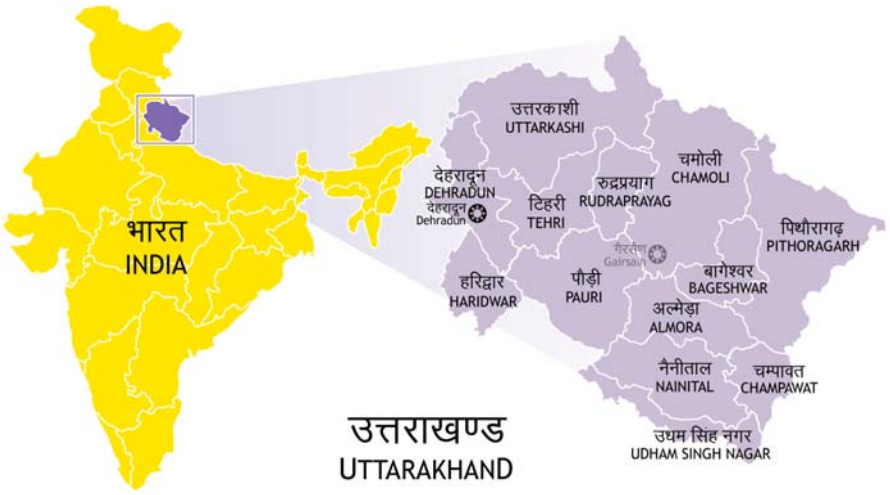

Fig.1 Map of Uttarakhand Districts, India

Result and Discussion:

It is generally known that the distribution of alpine vegetation is governed by adverse edaphic and climatic factors. Scanty rainfall, high wind velocity, low temperature, high ultraviolet (UV) radiation, snow-storms, and blizzards are common at high altitudes. Vegetation in the alpine zone exhibits a characteristic adaptation to the environment. The plants are generally dwarfed, stunted, wooly or spiny, and develop a mosaic patch of different plant forms. They possess an early growth initiation with a short vegetative span ranging from several days to a few months (Nautiyal et al., 2001).

A large number of medicinal plants of great commercial value grow spontaneously in the alpine and sub-alpine zone of Rudraprayag and Chamoli district. Some of these grown in the valleys, some in sub-mountain tracts while some other in high altitudes. In the present study altitudinal range, local name, part used, use/cure (Table-1) and status (Table-2; Plate-1-a-j) of some important medicinal plants are compiled based on the earlier publications as well as personal communication with local persons, rural folks and vaidyas. Of about 1400 species of vascular plants reported from the alpine region of Uttarakhand, at least 350-400 species are known to have one or other kind of medicinal use (Rawat, 2005).

Table-1 List of some important MAPs reported in the alpine and sub-alpine region of Western Himalaya, India

S. No.	Scientific Name	Local Name	Altitudinal Range	Part Used	Use/Cure
1.	*Aconitum atrox* (Bruhl.) Mukherjee	Mitha	3400-3900	Roots	Deadly poisonous, small quantity used as Anti-arthritic and sedative
2.	*Aconitum heterophylum* Wall.	Atis	3300-4500	Roots	Aphrodisiac,tonic
3.	*Allium wallichi* Kunth.	Gopka	3300-4200	Leaves	Indigestion
4.	*Angelica archangelica* L.	Rickchoru	3300-3600	Rhizome, Seed	Stimulant, expectorant
5.	*Angelica glauca* Edgew.	Chora	3000-3800	Rhizome, Whole plant	Dysentery, bronchitis, constipation
6.	*Arnebia benthamii*	Balchhari	3300-3800	Root	Hair tonic, fever, headache,

	(Don) Johnston				cuts and wounds
7.	*Artemisia gmelinii* Webb. Ex Stechm.	Purcha	2500-3000	Whole plant	Insecticide
8.	*Bergenia ciliata* (HK.f. & Th.) Engler	Silphar	1000-3000	Root	Stone, fébrifuge, digestive
9.	*Betula utilis* Don	Bhoj pat	2400-3000	Seed	Abortifacient
10.	*Carum carvi* L.	Kala jeera	2000-3800	Seed	Local spice, appetizer, cold and cough
11.	*Cirsium wallichii* DC.	Shyam Kanya	300-3000	Leaves, Root	Hepatic and spleen trouble, scorpion stings, chest pain
12.	*Dactylorhiza hatagira* (Don) Soo	Hatha jari	2800-4000	Tubers	Tonic, astringent, Ayruvedic formulations
13.	*Fagopyrum esculentum* (L.) Moench	Palthi	1200-4100	Whole plant	Health food
14.	*Fritillaria roylei* Hk.	Ksheer kakoli	2700-4000	Whole plant	Ayurvedic formulations, general tonic
15.	*Gaultheria trichophylla* Royle	Tunglu	2000-4000	Fruits	Appetizer
16.	*Hippiphae salicifolia* D.Don	Tarbu	2000-3600	Fruit	Appetizer, source of vitamin C
17.	*Malaxis muscifera* (Lindl.) Kuntz.	Jeevak	1600-3600	Tubers	Tonic
18.	*Nardistachys grandiflora* DC.	Jata mansi	3600-4800	Rhizome	Incense, Stimulant, Heart tonic
19.	*Origanum vulgare* L.	Ban tulsi	1000-4000	Whole plant	Tonic, bronchitis, hysteria
20.	*Picrorhiza kurrooa* Benth.	Kutki	1500-3000	Whole plant	Fever, stomachache
21.	*Plantago major* L.	Lahuriya	1500-3000	Whole plant	Dysentery
22.	*Podophyllum hexandrum* Royle	Van kakri	3000-4000	Root, Fruit	Roots to treat Sceptic wounds
23.	*Polygonatum cirrhifolium* (Wall.) Royle	Maida	1600-3600	Root	Cold, Cough
24.	*Polygonatum verticillatum* (L.) All.	Mahamaida	1400-4000	Root	Urino-genital disorders, nerve tonic
25.	*Potentilla fulgens* Wall. ex Hk.f.	Bajra Danti	2700-4300	Root	Astringent
26.	*Primula macrophylla* D.Don	Ram Jayan	1800-4500	Flower	Urinary ailments
27.	*Rheum emodi* Wall. Ex meissn	Archa	3300-5200	Rhizome	Purgative and astringent tonic
28.	*Rheum moorcroftianum* Royle	Dolu	2700-3500	Rhizome	Dysentry, internal injury
29.	*Rhododendron anthopogon* Don	Kooti	3000-3800	Whole plant	Incense, giddiness, antidote to Aconite poison
30.	*Ribes alpestre* Decne.	Kontilo	3200-3800	Fruit	Source of Vitamin C
31.	*Rumex acetosa* L.	Chukil jhar	1500-3000	Whole plant	Cuts and wounds, tonic
32.	*Saussurea costus* (Falc.) Lipsch.	Kooth	3000-4000	Whole plant	Lumbar pain, menorrhea, headache
33.	*Saussurea obvallata* (DC.) Edgew.	Brahma Kamal	4000-5600	Whole plant	Cough
34.	*Swertia ciliate* Burtt	Chiraita	1200-3500	Whole plant	Blood diseases, purifier
35.	*Taxus wallichina* Zucc.	Thuner	1100-3650	Leaves, Bark	Tonic, anti-cancerous

Table-2 Status of some important MAPs in the alpine and sub-alpine region of Western Himalaya, India

S. No.	Scientific Name	Local Name	IUCN Status (Global)	Status in UK (Regional)*
1.	*Aconitum balfourii*	Mitha	Vulnerable	Vulnerable
2.	*Aconitum heterophyllum*	Atees	Critically Endangered	Critically Endangered
3.	*Allium wallichii*	Lhadum	-	-
4.	*Angelica archangelica*	Rickchoru	Endangered	Endangered
5.	*Angelica glauca*	Choru	Endangered	Endangered
6.	*Bergenia ciliata*	Pasanbhed	-	Near Threatened
7.	*Betula utilis*	Bhojpatra	-	Near Threatened
8.	*Carum carvi*	Kala Jira	-	-
9.	*Dactylorhiza hatagirea*	Hatha jari	-	Critically Endangered
10.	*Hippophae salicifolia*	Tarbu	-	-
11.	*Nardostachys grandiflora*	Mansi	-	Critically Endangered
12.	*Picrorhiza kurrooa*	Kutki	-	Critically Endangered
13.	*Podophyllum hexandrum*	Van Kakri	-	Vulnerable
14.	*Polygonatum verticillatum*	Maha Maida	-	-
15.	*Rheum emodi*	Archa	Endangered	Endangered
16.	*Rheum moorcroftianum*	Dolu	-	Near Threatened
17.	*Rhododendron anthopogon*	Kooti	Near Threatened	-
18.	*Ribes alpestre*	Kontilo	-	-
19.	*Saussurea obvallata*	Brahma Kamal	Endangered	-
20.	*Swertia ciliata*	Chiraita	-	-

**Regional status as per the Shimla CAMP* (Ved *et. al.*, 2003)

Owing to the rapid rate of destruction of forests precious herbal medicines are becoming rate day by day. Some of these medicinal plants are much threatened and others are vanishing rapidly. So, it is indispensable to take necessary steps to protect the plant from degeneration (Dobhal and Bhandari, 2006). Considering the increasing demand for herbal drugs in general and Himalayan medicinal plants in particular and consequent depletion of several species, it is imperative to initiate urgent steps for conservation (Nautiyal et al., 2001).

There is a need to establish a systematic and organized collection of valuable medicinal plants of the region. Cottage industries should be established for preparation of crude medicines, powders etc. The survey of medicinal plants in their natural habitats should be priority for research work. Studies should be carried out with in two or three years for screening the importance and status of the medicinal plants. On account of ignorance and unemployment, the valuable herbs of the area disappearing as an alarming rate. Greedy herb contractors with the help of local people also play great role in the exploitation and depletion of this great strength.

Palte-1-(a-j): **Some important endangered medicinal plants of Western Himalaya;** **(a)***Podophyllum hexandrum,* **(b)** *Angelica archangelica* **(c)** *Angelica glauca* **(d)***Fritillaria roylei* **(e)** *Rheum moorcroftianum* **(f)** *Nardostachys grandiflora* **(g)***Aconitum balfourii* **(h)** *Aconitum heterophyllum* **(i)** *Dactylorhiza hatagirea* **(j)***Picrorhiza kurrooa*

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Taxonomic Studies On The Family Polypodiaceae (Pteridophyta) Of Nainital Uttarakhand

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ABSTRACT: The present account deals with the members of the family - Polypodiaceae (Pteridophyta) from Nainital. In the present work, 9 genera and 14 species have been collected and studied i.e. *Arthromeris, Colysis, Goniophlebium* and *Microsorum* (1 species each), *Drynaria* and *Phymatopteris* (2 species each), *Lepisorus, Polypodiodes* and *Pyrrosia* (3 species each). Some of the taxa of ferns reported earlier from Nainital by previous workers based on wrong identification have been placed under the heading excluded / doubtful species giving only botanical name and the reasons of their being excluded / doubtful species are based on Khullar (1994, 2000 & 2001). [New York Science Journal. 2009;2(5):47-83]. (ISSN: 1554-0200).

Keywords: Pteridophytes, polypodiaceae, Uttarakhand

Introduction

The Uttarakhand state is situated between 77°45'-81°E longitude, 29°5'-31°25'N latitude. The state constitutes the central part of the Himalaya and is rich in pteridophytic vegetation, due to varied climatic conditions and topography.

Nainital is a well known summer hill resort of India and is situated on the outer hills of Kumaun Himalaya. It harbours a rich and varied flora very different from the vast

plains of India. The rich and varied flora of this place is a special attraction for a large number of tourists who visit this hill station for the sake of making plant collections. Although the flora of Nainital is very well known today, but the ferns and fern-allies have not received due attention. This may be probably due to the lack of interest or the difficulties involved in their identification. The study area encompassing a total area of 208.5 km^2, lies within the latitudes of 29° 19' - 29° 28' North and longitudes of 79° 22' - 79° 38' East. It includes the main portion of the famous lake region lying along the south-central sections of district Nainital. Within the region, therefore lie the well known lakes of Nainital, Khurpatal, Sat tal, Bhimtal and Naukuchiatal. From the highest altitude around Nainital valley, the drainage radiates to almost all directions. The principal drainage outlet from the lake of Nainital ultimately forms a major river known as Ballia which traverse the region in the south-eastern direction and ultimately joins the Gola river near Ranibagh. It is here again that the drainage emerging from the Sat tal and Naukuchiatal area converges and ultimatel joins the main river Gola. To the north of Nainital, the region is drained by the tributaries of the Kosi river which also marks the boundary of the region for some distance. Towards north-west, there are number of seasonal streams that take rise from the outermost ranges of the Siwalik and flow in a generally south-west to north-east direction before emerging into foothill zone of Bhabar.

Physiographically the Southernmost narrow belt called the Siwalik hills and with ranges averaging elevations of 1500-1600 m makes a geologically different area from the rest of this region lying northwards which falls within the Lesser Himalaya. The Siwalik comprising of tertiary and pleistocene deposits. The principal rock types of this group include such sedimentary rocks as fine-grained sandstone with interbedded shale bands and conglomerates. This zone constitutes the youngest part of the Himalayan system and the constituent rocks are friable and prone to erosion.Towards the north, the Lesser Himalaya, with elevation ranging from 1200-2611 m is a distinct geological unit generally with crystalline and metamorphic rocks such as granites, gneisses and schists. The lesser Himalaya are separated from the Siwaliks by a fault called Main Boundary Fault-which is tectonically active zone characterised by landslides and such other landscape changes.

The publication of very comprehensive account of plant collections from Kumaun and

adjacent parts of Garhwal by Sir Richard Strachey and J.E. Winterbottom between the years 1846-1849 followed the classical works. The original catalogue was published in 1852 in *Atkinson's Gazetteer of Himalayan Provinces and Oudh.* This original catalogue of Strachey and Winterbottom was later revised and supplemented by J.F. Duthie (1906), which is known as *Catalogue of the Plants of Kumaun and of the adjacent portions of Garhwal and Tibet based on the collections made by Strachey and Winterbottom during the years 1846-1849* and on the catalogue originally prepared by Sir Richard Strachcy in 1852, by adding the results of previous and subsequent botanical explorations. This catalogue still functions as a milestone for the floristic works including pteridophytes. For the entire Kumaun Himalaya, Pangtey and Punetha (1987) attempted for the first time after Duthie (1906) to enumerate all the pteridophytes then known to them based on their collections coupled with previous records. It was followed by the compilation of a list of ferns of Kumaun by Pande (1990).

Herbarium specimens of plants drawan are deposited in the Herbarium, Department of Botany, D. S. B. Campus, Kumaun University, Nainital. The figures of the whole plant or frond or part of it are natural size, while for the detailed drawings the following magnifications have been used; dermal appendages (x 17.5), magnified portion (x 100), spores (x 450), part of lamina to show venation and arrangement of sori (x 150), indusia (x 17.5) following Khullar (1994).

Family : **POLYPODIACEAE** Berchtold & Presl

Prirozen. Rostl. **1**: 272 (1820); *emend.* Ching, Sunyatsenia **5**: 257 (1940).

Rhizome long or short-creeping, cylindrical or dorsiventrally compressed, much branched, dictyostelic, scaly; scales peltate, clathrate or non-clathrate. Fronds isomorphic or dimorphic. Stipes articulate to a short phyllopodium, in two dorsal rows on the rhizome. Lamina simple or pinnate, margin entire or variously lobed; veins free or reticulate, areolae with or without free oftern branched swollen included veinlets. Sori exindusiate, superficial, rounded, sometimes elongated or acrostichoid, distributed all over or partly lower surface of the lamina. Spores bilateral, monolete, perinate or non-perinate, smooth or verrucose or tuberculate or spinulose.

Type: *Polypodiurn* L., Sp. PI. **2**: 1082 (1753); *emend.* Ching, Contrib.Inst. Bot. Nat. Acad. Peiping **2**: 31 (1933).

KEY TO GENERA

A. Sori linear, elongated, oblique to the costa ..... 2. **Colysis**

A. Sori rounded or oval ..... B

B. Fronds dimorphic ..... 3. **Drynaria**

B. Fronds isomorphic C

C. Lamina simple, margin entire ..... D

C. Lamina margin deeply lobed or lamina pinnate ..... F

D. Stellate hairs present on the lower surface of the lamina; sporangia acrostichoid, distributed over a larger portion of the lower surface of the lamina; soral

paraphyses absent……..9. **Pvrrosia**

D. Stellate hairs absent; sporangia aggregate into small Sori, which are present in either one or many rows on either side of the rachis and 2-3 between main lateral veins……..E

E. Sori in a single row on either side of the rachis: soral paraphyses irregular or ovatelaneeolate or subrhomboidal, umbrella-shaped, peltately or non-peltately fixed……5. **Lepisorus**

E. Sori in many rows on either side of the rachis and 2-3 between main lateral

Veins; soral paraphyses simple ..... 6. **Microsorum**

F. Veins anastomosing to form many irregular areolae, included veinlets simple or forked……..G

F. Veins anastomosing to form a single row of areolae on either side of the costa, costal areolae with one included veinlets. marginalveins free H

G. Lamina simple, deeply pinnatifid (simple, trifid, palmatifid) or pinnate; margin deeply lobed to the rachis; areolae with or without free included veinlets with swollen tips: sori in a row on either side of main vein and one between the

lateral veins or irregularly biseriate .....7. **Phymatopteris**

G. Lamina pinnate; arcolae with simple or forked included veinlets, running on all sides; sori in 1 or 1-2-seriate between each

pair of main lateral veins ..... 1. **Arthromeris**

H. Lamina pinnate at least in the major lower half

Of lamina, the remaining upper pinnatifid ..... .4. **Goniophlebium**

H. Lamina simple, deeply pinnatifid, margin deeply lobed to the rachis, sometimes the

lower 1-2 pairs of lobes free .....8. **Polypodiodes**

1. ARTHROMERIS

Arthromeris (Moore) J. Smith, Hist. Fil.: 110 (1875).

Polypodium D.Don, Prodr. Fl. Nepal.: 3 (1825), *pro parte.*

Phymatodes Presl, Tent. Pterid. : 195 (1836), *pro parte.*

Drynaria J. Smith, Bot. Mag. 72 Comp. : 14 (1846), *pro parte.*

Polypodium sect. *Phymatodes* Hook., Sp. Fil. 5: 90 (1853).

Pleopeltis sect. *Arthromeris* Moore, Index Fil. : 77 (1857).

Rhizome long-creeping, thick, somewhat fleshy, densely scaly; scales brown, peltate, non-clathrate, luminae elongate, narrow, lanceolate, attenuate. Fronds isomorphic. Stipes rather distant, long, articulated to short podophylla. Lamina pinnate, imparipinnate, glabrous; pinnae opposite or alternate, usually sessile, prominently articulated to rachis, lanceolate, margin entire, cartilaginous or with a broad hyaline membrane, lower pinnae usually the largest; terminal pinnae similar to lateral ones; veins main lateral veins distinctveinlets anastomosing to form many irregular areolae, included veinlets simple or forked, running on all sides. Sori exindusiate, without paraphyses, 1 or 1-2-seriate, between each pair of main lateral veins, superficial. Spores bilateral, monolete, non-perinate, exine more or less spinulose.

Type: *Arthromeris Juglandifolia* (D.Don) J. Smith, Hist. Fil. : 111 (1875).

Arthromeris wallichiana (Spreng.) Ching, Contrib. Inst. Bot. Nat. Acad. Peiping **2**: 92 (1933); Chandra, J. Bombay nat. Hist. Soc. **74**: 649 (1979); Dhir, Biblioth. Pterid. **1**: 129 (1980); Dhir & Sood, Biblioth. Pterid. **2**: 94 (1981); Pangtey *et al.*, Him. Res. & Dev. **1**: 157 (1982); Trivedi *et al.*, J. Indian Bot. Soc. **62**: 94 (1983); Dixit, Census Indian Pterid.: 35 (1984); Singh *et al.*, Indian J. For. **9**: 6 (1986); Pangtey & Punetha in Westem Him. **1**: 410 (1987); Pande & Dashila, Indian Fem J. **5**: 87 (1988); Geobios new Reports **8**: 108 (1989); Indian Fern J. **7**: 145 (1990); Pande & Basera, Indian Fern J. **5**: 158 (1998); Pande, Khullar *et al.*, Ferns Nainital: 158 (1990); Khullar, Him. Res. & Dev. **7**: 60 (1988); Ill. Fern Fl. West Him. **1**: 70. t. 26 (1994); Chandra, Ferns India: 410 (2000).

Polypodium wallichianum Spreng., Syst. Veg. *ed.* 16, **4**(1): 53 (1827); Mehra, Ferns Muss.: 26 (1939); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 169 (1942).

Polypodium juglandifolium D.Don, Prodr. Fl. Nepal.: 3 (1825); Hook., Syn. Fil.: 368 (1867); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 566 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 96 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906).

Pleopeltis juglandifolia Moore, Index Fil: 78 (1857); Bedd, Handb. Ferns Brit. India: 368 (1883); Handb. Ferns Brit. India Suppl: 98 (1892); Marten, J.Bombay nat. Hist. Soc. **19**: 182 (1909).

Rhizome long-creeping, very thick, somewhat fleshy, densely scaly; scales brown, cuspidate-subulate, base broad, margin distantly toothed, apex acuminate, stramineous to pale brown, glaucous, glabrous, narrowly lanceolate, fimbriate-hairy. Stipes up to 30 cm long, stramineous to pale brown, thick, glabrous. Lamina pinnate, up to 40 x 30 cm, ovatelanceolate, texture coriaceous, glossy, glabrous; pinnae *c* 8 pairs, 15 x 4 cm, opposite but lower ones alternate, sessile, lanceolate, base cuneate or rounded, lower surface pale green or bluish-green, margin with a thick cartilaginous line, generally strongly repando-undulate, basal pinnae the largest, other pinnae gradually decrescent towards the terminal one; terminal pinna similar to the lateral ones; lateral veins prominent, reaching the margin, almost parellel, smaller veins anastomosing to form many irregular areoles; areoles with simple or forked free veinlets. Sori large, round, a single sorus between the main lateral veinlets, in a row on either side of the costa. Spores dark-brown, 28.0-35.0 x 45.5-52.5 µm, non-perinate, exine densely tuberculate and granulose.

HABITAT: Grows on humid rocks in shade and also as an epiphyte.

DISTRIBUTION: Scattered from 1500-2700 m altitude.

UTTARAKHAND: NAINITAL: below Dhobighat.

INDIA: Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland; Manipur; Tripura.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; China; Thailand; Vietnam; Myanmar.

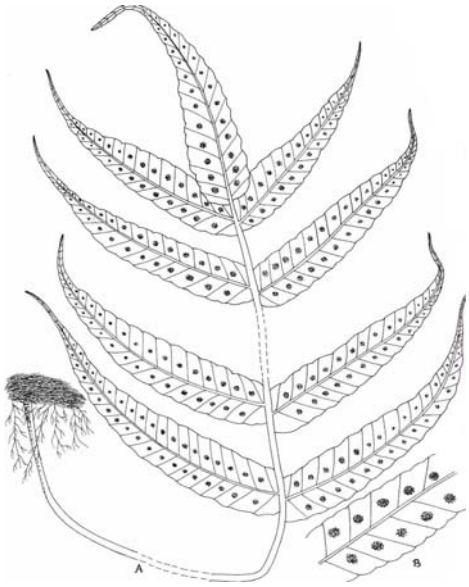

PLATE 1 A

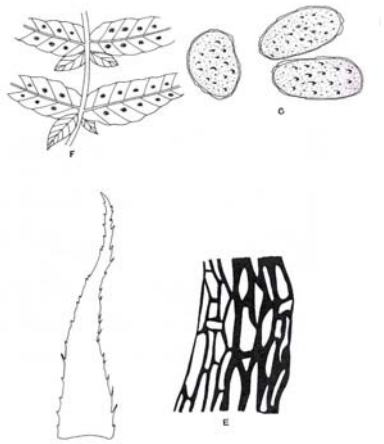

PLATE 1 B

PLATE 1 A: **Arthromcris wallichiana** (Spreng.) Ching: A = Plant: B = **Magnified part of lamina**

PLATE 1 B: **Arthomeris wallichiana** (Spreng.) Ching: C= Spores; D= Rhizome scale; E= Magnified part of rhizome scale; F= Part of lamina.

2. **COLYSIS**

Colysis C. Presl, Epim. Bot.: 146 (1851); Fee, Gen. Fil.: 172 (1850-1852), *non* J. Smith (1875).

Grammitis Hook. & Grev., Icon. Fil.: t. 6 (1827), *non* Sw.(1801).

Grammitis sect.Diagramma Blume, Enum. Pl. Java: 118 (1828).

Selliquea Bory, Dict. Class. d'hist. Nat. **6**: 587 (1824); Presl, Tent. Pterid. : 216 (1836); Bedd., Handb. Ferns Brit. India :389 (1883), *pro parte.*

Gymnogramme sect. *Selliquea* Hook., Sp. Fil. **5**: 161 (1964); Hook. & Baker, Syn. Fil.: 387 (1868), *pro parte.*

Polypodium Mett., Polyp. : 214 (1857).

Polypodium sect. *Pleopeltis* Diels in Engler & Prantl, Nat. Pflanzenfam. *Pleopeltis* : 316 (1899), *pro parte.*

Rhizome long-creeping, thin, subhypogeaous, scaly; scales ovate-acuminate, thin, clathrate, luminae clear, large. Stipes far apart, articulated to the Rhizome. Lamina simple with margin entire or deeply pinnatitid or even palmately lobed or pinnate, texture thin, herbaceous; pinnae adnate to the rachis; veins rather poorly developed; veinlets anastomosing irregularly in two rows of areolae, free included veinlets clavate. Sori linear, elongate, continuous or sometimes interrupted, one between each pair of main lateral veins, oblique to the costa, rarely subcostal, exindusiate. Spores light-brown to yellowish, bilateral, monolete, non-perinate, exine smooth.

Type: *Colysis hemionitides* Presl, Epim. Bot.: 147 (1849).

Colysis elliptica (Thunb.) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 333 (1933): Dixit, Census Indian Pterid.: 36 (1984); Chandra, Ferns India: 397 (2000).

Polypodium ellipticum Thunb., Fl. Jap. : 335 (1784); Chowdhery, Pterid. Fl. Upper Gangetic Plain: 70 (1973).

Colysis elliptica (Thunb.) Ching var. *pothifolia* (Ham. *ex* D. Don) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 334 (1933); Dhir, Biblioth. Pterid. **1** : 130 (1980); Bir *et al.*, Pterid. Fl. Garhwal Him.: 23 (1983); Dixit, Census Indian Pterid.: 36 (1984).

Hemionitis pothifolia Ham. *ex* D.Don, Prodr. Fl. Nepal.: 13 (1825).

Selliguea pothifolia J. Smith, J. Bot. **3**: 399 (1841).

Gymnogramma elliptica Hook. & Baker, Syn. Fil.: 389 (1868); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 570 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 102 (1903).

Selliguea elliptica (Thunb.) Bedd., Ferns Brit. India: Index (1870).

Colysis pothifolia (Ham. *ex* D.Don) H. Ito, J. Jap. Bot. **11**: 89 (1935); Dixit, Census Indian Pterid.: 37 (1984); Pangtey *et al.*, J. Bombay nat. Hist. Sc. **83**: 683 (1986); Pangtey & Punetha in Western Him. **1**: 409 (1987); Pande; Indian Fern J. **7**: 145 (1990); Khullar *et al.*, Ferns Nainital: 159 (1991); Khullar, Him. Res. & Dev. **7**: 60 (1988); Ill. Fern Fl. West Him. **1**: 73. t. 27 (1994); Chandra, Ferns India: 399 (2000).

Rhizome long-creeping, thick, woody, scaly; scales dark-brown, concolorous, lanceolate, margin entire, apex acuminate. Stipes 30-60 cm long or longer, stramineous, thick, glabrous; rachis stramineous, broadly winged or quite wingless, glabrous. Lamina simple, 30 - 45 x 15 - 30 cm; texture subcoriaceous, glabrous, margin deeply lobed into 4-10 pairs of lobes or occasionally subpalmately divided into 3-5 lobes or even simple; lobes 14.0 x 2.0-2.5 cm, alternate, linear-oblong, dries green, base broadly decurrent, apex acuminate, teeminal lobe almost as long as lateral ones; main veins of the lobes stout, prominent, other lateral veins anastomosing to form areolae, areolae unequal, free, included; veinlets with clavate ends. Sori exindusiate, linear, oblique, extending from the costae but not reaching the margin, punctiform, paraphyses light-brown, small, 1-2 celled. Spores light-brown or yellowish, 31.5 - 38.5 x 35.0 - 45.5 µm, non-

perinate, exine smooth.

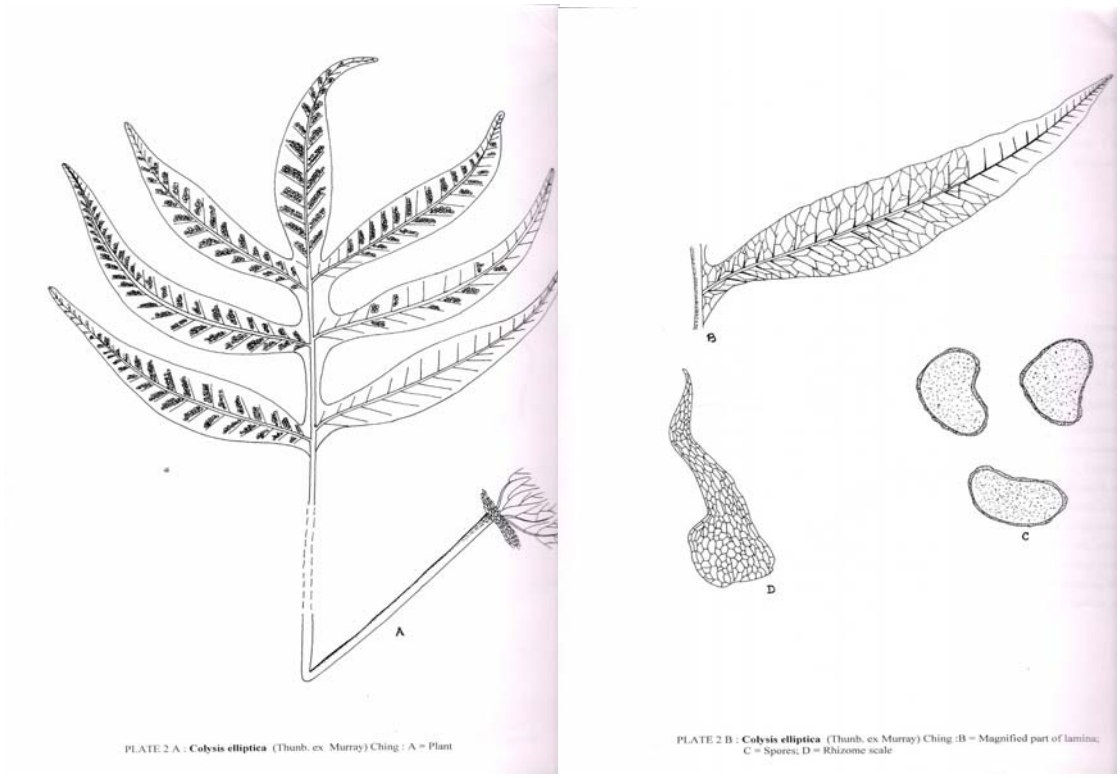

PLATE 2 A : **Colysis elliptica** (Thunb. ex Murray) Ching : A = Plant

PLATE 2 B : **Colysis elliptica** (Thunb. ex Murray) Ching :B = Magnified part of lamina; C = Spores; D = Rhizome scale

HABITAT: Grows in dark humid places.

DISTRIBUTION: Rare from 700-1200 m altitude.

UTTARAKHAND: NAINITAL: behind Jeolikote along the streams in oak-pine mixed forest, below Patuwadangar.

INDIA: Sikkim; Darjeeling; Meghalaya; Nagaland.

GENERAL DISTRIBUTION: Nepal; Bhutan; China; Taiwan; SW Japan; Vietnem; Korea; Philippines; Malaysia; Myanmar; Queensland.

2. **DRYNARIA**

Drynaria (Bory) J. Smith in Hooker J. Bot. **4**: 60 (1841) *nom. cons.*

Polypodium subgenus *Drynaria* Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 555 (1825); Hope, J. Bombay nat. Hist. Soc. **15:** 89 (1903)

Rhizome long-creeping, thick, densely scaly; scales brown, usually concolorous, occasionally with a central dark streak, lanceolate, peltate, non-clathrate, margin variously fimbriate, filamentous projections short or long, apex long acuminate. Fronds dimorphic. Sterile fronds usually much shorter than the fertile ones, persistent, dry; rachis prominent, brown, hairy or scaly or glabrous. Lamina simple, pinnatifid, ovate or lanceolate, deeply lobed, usually much shorter than the fertile ones, persistent, dry, hairy or glabrous; veins main lateral veins prominent, protruding on the lower surface, a well formed almost continuous row of areolae with or without free included veinlets. Fertile fronds: stipes prominent, usually winged due to the decurrent lamina bases, upper surface of rachis grooved, hairy; lamina simple, pinnatifid, but margin deeply

lobed almost to the rachis, lobes usually decurrent on stipe; veins profusely anasomosing as in sterile fronds, but costal areolae not as prominent as in the sterile ones. Sori exindusiate, small, round, close to costa, usually on the costal areolae, in a row on either side of the costa and one between each main lateral vein; paraphyses absent or 2-celled. Spores bilateral, monolete, light-brown, nonperinate, exine variously ornamented.

Type: *Drynaria quercifolia* (L.) J. Smith, J. Bot. **3**: 392 (1841).

KEY TO SPECIES

A. Margin of Rhizome scale fimbriate with long filamentous projections; lower lobes in the fertile fronds not reduced but of the same size as those in the middle of the lamina; veins forming 4-5 series of primary large areolae with

smaller included areolae .....2. **D. propinqua**

A. Margin of Rhizome scales with short teeth like projections; lower lobes much reduced, almost half the length of the

middle lobes; veins forming 3-4 series of uniform areolae .....1. **D. mollis**

1. **Drynaria mollis** Bedd., Ferns Brit. India: t. 216 (1867); Handb. Ferns Brit. India: 341. t. 190 (1883); Marten, J. Bombay nat. Hist. Soc. **19**: 182 (1909); Mehra, Ferns Muss.: 26 (1939); Verma & Khullar, Fern. Gaz. **12**: 87 (1980); Dhir, Biblioth. Pterid. **1**: 130 (1980); Pangtey *et al.*, Him. Res. & Dev. **1**: 158 (1982); Bir *et al.*, Pterid. Fl. Garhwal Him.: 23 (1983); Dixit, Census Indian Pterid.: 58 (1984); Satija & Bir. Aspects Pl. Sci. **8**: 87 (1985); Pande & Kandpal, Acta Botanica Indica **14** (Suppl.): 121 (1986); Singh *et al.*, Indian J. For. **9**: 9 (1986);

Drynaria rivale (Mett. ex Hook.) Christ, Bull. Boiss. **7**: 6 (1899).

Polypodium rivale Mett. *ex* Hook. & Baker, Syn. Fil.: 368 (1867); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 556 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 90 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906).

Drynaria tibetica Ching & S.K. Wu in C.Y.Wu Fl. Xizangica **1**: 342 (1983); Khullar *et al.*, Ferns Nainital: (1991); Khullar, Ill. Fern Fl. West Him. **1**: 81. t. 29 (1994)

Rhizome long-creeping, thick, densely scaly; scales light to mid-brown, rarely darker, apex long acuminate. Fronds dimorphic, approximate. Sterile fronds: stipes short or none at all, winged, base scaly; scales brown, lanceolate, margin fimbriate, apex long acuminate; rachis brown, hairy, hairs hyaline, 3-4 celled, scaly, scales as on stipe. Lamina simple, pinnatifid, 10-15 x 6-8 cm, elliptical ovate, deeply lobed, lobes 1.5-3.5 x 0.8-1.0 cm, lanceolate, herbaceous, brown, glossy, margin entire, apex acute, margin entire, hairy, texture herbaceous, brown, glossy; veins prominent. Fertile fronds : stipes 3-7 cm long, light-brown, sparsely scaly, base densely scaly, scales as on sterile fronds, winged almost to the base; rachis light-brown, hairy. Lamina simple, deeply pinnatifid, 25-30 x 12 cm, ovate, margin deeply lobed almost to the rachis; lobes 2.0-5.5 x 1.0 cm, margin entire, hairy, apex acute; texture herbaceous, lower lobes generally much reduced in size, lowermost lobe decurrent on stipe; veins anastomosing to form 3-4 pairs of reticulate uniform sizes areolae between margin and costa, with or without free, simple included veinlets. Sori small, round, nearer to costa, usually on the first areolae towards the costa, in one row and one between the lateral veins; paraphyses short, about 2-celled. Spores brown, 24.5-35.0 x 31.5-56.0 µm, exine spinulose.

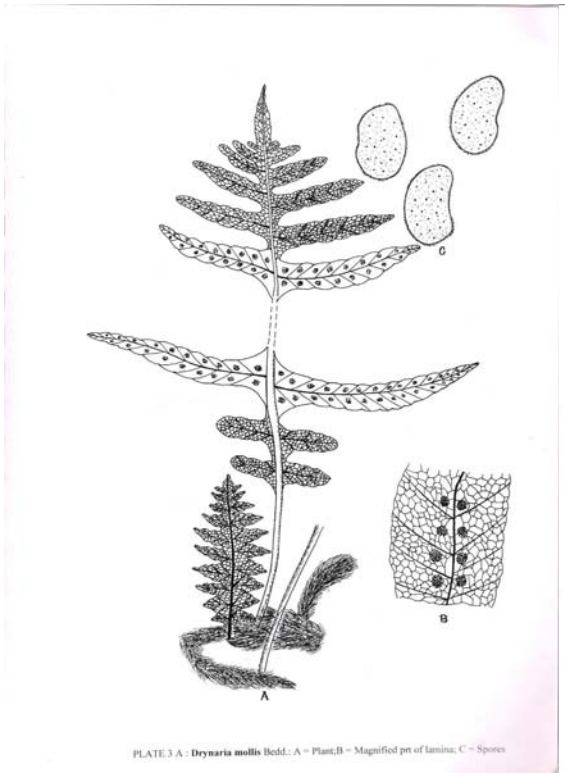

PLATE 3 A : **Drynaria mollis** Bedd.: A = Plant;B = Magnified prt of lamina; C = Spores

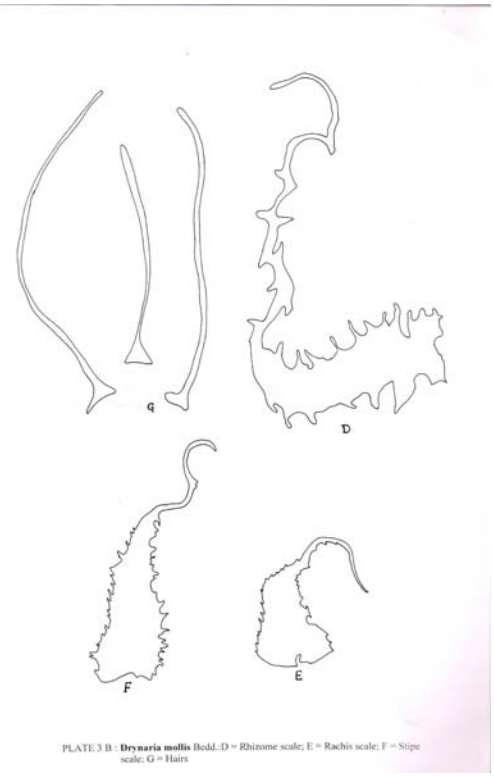

PLATE 3 B : **Drynaria mollis** Bedd.:D = Rhizome scale; E = Rachis scale; F = Stipe scale; G = Hairs

HABITAT: Generally grows as an epiphyte on oaks and rhododendrons *etc.*

DISTRIBUTION: Restricted between 2000 and 3000 m altitude and quite common to abundant.

UTTARAKHAND: NAINITAL: Nainital, Cheena peak, Kilbury, Pangtey's Gorge, Mukteshwar, towards Land's end, Dorothy seat, Lariakanta.

INDIA: Himachal Pradesh; Sikkim; Darjeeling hills.

GENERAL DISTRIBUTION: Tibet; Nepal; Bhutan.

2. **Drynaria propinqua** (Wall. *ex* Mett.) J. Smith, J. Bot. **4**: 61 (1841); Pangtey *et al.*, Him. Res. & Dev. **1**: 158 (1982); Trivedi *et al.*, J. Indian Bot. Soc. **62**: 95 (1983); Dixit, Census Indian Pterid.: 58 (1984); Singh *et al.*, Indian J. For. **9**: 9 (1986); Khullar *et al.*, in Western Him. **1**: 355 (1987); Pangtey & Punetha in Western Him. **1**: 409 (1987); Punetha & Kaur, J. Econ. Tax. Bot. **9**: 285 (1987); Pande & Basera, Indian Fern J. **5**: 158 (1988); Pande, Geobios new Reports **8**: 108 (1989); Indian Fern J. **7**: 146 (1990); Khullar *et al.*, Ferns Nainital: 161 (1991);

Polypodium propinquum Wall. *ex* Mett., Abh. Senckenb. Natur. Ges. **2**: 120. t. 3. f. 50 (1857); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 556 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 89 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906).

Drynaria prolifera P. & H. Pande, Indian Fern J. **11**: 97 (1994), *nom. nud.*

Rhizome long-creeping, thick, scaly; scales russet to mid-brown, linear-lanceolate, margin fimbriate, filamentous projections very long, apex acuminate. Frond dimorphic, 3-5 cm distant on Rhizome. Sterile fronds: stipes very short or none, winged, brown, thick, scaly; scales deciduous, linear-lanceolate, fimbriate, filamentous projections long; rachis brown, scaly; scales as on the stipe but smaller. Fertile fronds: lamina simple, pinnatifid, 25-60 x 16-30 cm, ovate-oblong, margin entire, apex acute, upper segments ascending, lower deflexed, herbaceous, brown, hairy; veins prominent; costae and costules scaly; scales small. Fertile fronds: stipes 7-25 cm long, thick, sparsely scaly, base densely scaly, winged due to the decurrent lowernost lamina

lobes; rachis brown, grooved, scaly. Lamina simple, pinnatifid, 25-60 x 16-30 cm, ovate-oblong, deeply lobed to the rachis; lobes 7.0-16.0 x 1.0-1.5 cm, lanceolate, margin entire, not reduced; texture subcoriaceous, usually hairy, hairs short or 3-5-celled long; veins profusely anastomosing to fom1 3-5 primary large areolae with smaller included areolae which may contain free, simple or branched included veinlets; costae ans costules scaly. Sori small, round on the costal areolae, one between each main lateral vein; paraphyses small, 2-celled. Spores yellowish-brown, 24-35 x 49-59 µm, exine spinulose.

PLATE 4 A : **Drynaria propinqua** (Wall. ex Mett) J. Smith : A = Plant; C = Spores

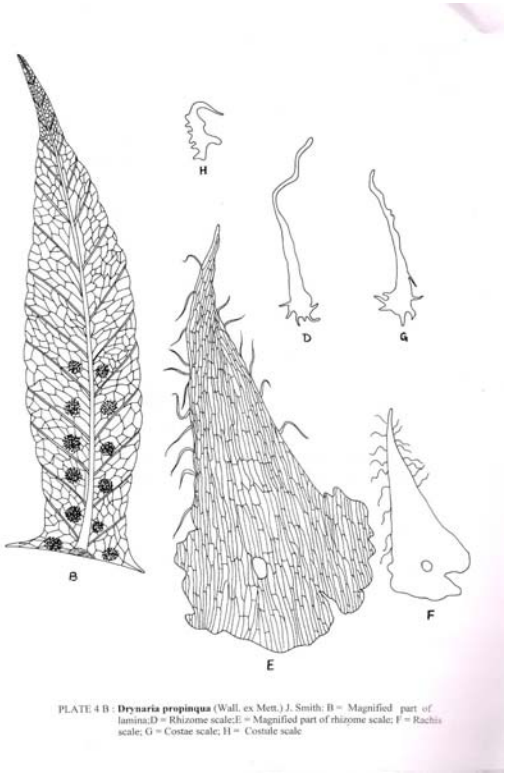

PLATE 4 B : **Drynaria propinqua** (Wall. ex Mett.) J. Smith: B = Magnified part of lamina;D = Rhizome scale;E = Magnified part of rhizome scale; F = Rachis scale; G = Costae scale; H = Costule scale

HABITAT: Grows as an epiphyte as well as a lithophyte.

DISTRIBUTION: Fairtly common in Kumaun but becomes rarer further west between 1300 and 3000 m altitude.

UTTARAKHAND: NAINITAL: Bajoon, Patuwadhangar.

INDIA: Sikkim; Darjeeling; Assam; Meghalaya; Nagaland; Manipur; Tripura.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; S & C China; Vietnam; Thailand; Malaysia; Myanmar.

4. **GONIOPHLEBIUM**

Goniophlebium (Blume) Presl, Tent. Pterid.: 185. t. 7 (1836).

Polypodiatrum Ching, Acta Phytotax. Sin. **16**: 29 (1978).

Rhizome long-creeping, dictyostelic, often glossy, scaly; scales dak-brown, small, deciduous at maturity, clathrate, base ovate, apex acuminate. Fronds isomorphic. Stipes distinct on Rhizome. Lamina pinnate or at least a major lower half of lamina pinnate, the remaining upper pinnatifid; pinnae sessile, articulated to the rachis, lower ones free and very shortly petiolate, middle ones with often ± adnate base, distal ones confluent; veins anastomosing to form a single row of areolae on either side of the costa but marginal veins free; areolae with a free included veinlet. Sori superficial, not immersed; paraphyses triangular, pehate, clathrate, long stalked,

fugaceous. Spores light-brown or yellowish, bilateral, monolete, perinate.

Type: *Goniophlebium argutum* (Wall. ex Hook.) J. Smith in Hooker Gen. Fil. ad t.51 (1840).

Goniophlebium argutum (Wall. *ex* Hook.) J. Smith in Hook. Gen. Fil.: ad t. 51 (1840); Bedd., Ferns South. India: t. 69 (1863); Handb. Ferns Brit. India: 323 (1883): Bir ***et*** *al.,* New Botanist **1**: 152 (1974); Chandra, Ferns India: 390 (2000).

Polypodium argutum Wall. *ex* Hook., Sp. Fil. **5**: 32 (1863); Dhir, Biblioth. Pterid. **1**: 121 (1980); Dhir & Sood, Biblioth, Pterid. **2**: 91 (1981); Goel & Bhattacharyya, Indian J. For. **4**: 36 (1981); Pangtey *et al.*, Him. Res. & Dev. **1**: 159 (1982).

Polypodiastrum argutum (Wall. *ex* Hook.) Ching, Acta Phytotax. Sin. **16**(4): 28 (1978); Dixit, Census Indian Pterid.: 51 (1984); Pangtey & Punetha in Western Him. **1**: 408 (1987); Pande & Basera, Indian Fern J. **5**: 159 (1988); Pande, Geobios new Reports **8**: 109 (1989); Khullar *et al.*, Ferns Nainital: 179 (1991);

Rhizome long-creeping, thick, scaly; scales dark-brown to blackish, spreading, ovate-lanceolate or linear-lanceolate, margin fimbriate with short projections, apex hair pointed. Stipes 1.0-2.5 cm distant on rhizome, articulated on phyllopodia, *c* 10 cm long, light-brown, thick, glossy, sparsely hairy, hairy, hairs light-brown, few, multicellular, scaly; scales dark brown, short, fimbriate with long projections. Lamina pinnate or major lower half pinnate and the distal c 1/4 deeply pinnatifid, 30-50 x 15-25 cm; texture herbaceous, glabrous; pinnae many, 10.0-15.0 x 1.5-2.0 cm, lower ones opposite, upper alternate, sessile, patent, more or less adnate and decurrent, lanceolate, base broad, auricled or nearly round, apex acute, basiscopic side prominently auricled on both sides, margin serrate, terminal pinna similar to lateral ones but longer than the preceding 2-3 pairs below: main lateral veins prominent running mid-way to margin, anastomosing to form a series of large costal areolae, with simple included veinlets, marginal veins all free or rarely united, vein ends thickened, not reaching the margin, glabrous; costae very sparsely scaly, scales dark-brown, small caducous. Sori superficial, round, at the ends of free included veinlets in the costal areolae, in a single row on either side of costa and one between each main lateral vein, pamphyses peltate, clathrate, margin stellate, also simple,

PLATE 5 A : **Goniophlebium argutum** (Wall. ex Hook.) J. Smith : A = Plant

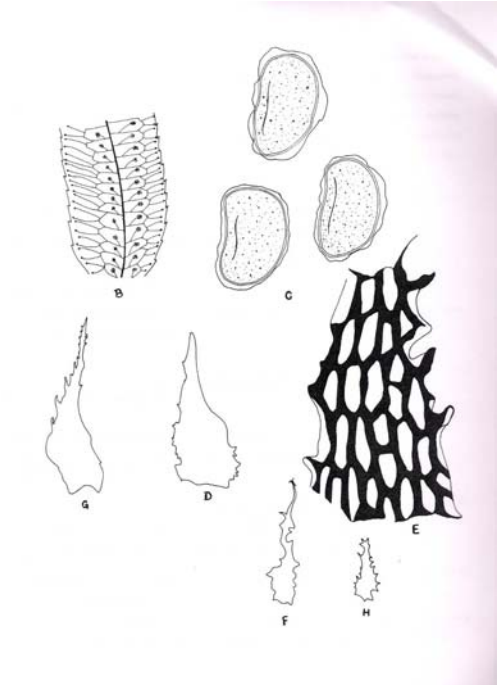

PLATE 5 B : **Goniophlebium argutum** (Wall. ex Hook.) J. Smith : B = Magnified part of lamina;C = Spores; D =Rhizome scale; E = Magnified part of rhizome scale; F = Rachis scale; G = Stipe scale; G = Costae scale

2-6-celled ones. Spores yellowish, 28-38 µm.

HABITAT: This fern grows in the forests as an epiphyte / lithophyte.

DISTRIBUTION: Occasional between 1800 and 2700 m altitude.

UTTARAKHAND: NAINITAL: way to Kilbury, Lariakanta, Dhobighat.

INDIA: Himachal Pradesh; Darjeeling; Meghalaya; Nagaland.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; China; Taiwan; Vietnam; Laos; Thailand; Philippines; Myanmar.

5. **LEPISORUS**

Lepisorus (J. Smith) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 56 (1933).

Drynaria sect. *Lepisorus* J. Smith, Bot. Mag. 2. Compend. 13 (1824); Fee, Gen. Fil.: 272 (1852).

Pleopeltis Hook., Exot. Fl. **1**: t. 63 (1823); Gen. Fil. : t.18 (1838); Sp. Fil. **5**: 57 (1864); Bedd., Ferns South. India : 57(1873); Handb. Ferns Brit. India : 344 (1883). *pro parte.*

Phymatodes C. Presl, Tent. Pterid. : 196 (1836), *excl. type. nom. nud.*

Polypodium sect. Pleopeltis (Hook.) Christ, Farnkr. d. Erde : 102 (1897); C. Chr., Index Fil.: 506 (1906), *pro parte.*

Polypodium sect. *Phymatodes* (C. Presl) Hook., Syn. Fil.: 353 (1865); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 557 (1880); Hope, J. Bombay nat. Hist. Soc. **15:** 90 (1903).

Rhizome long or sometimes short-creeping, thick or thin, branched, scaly; scales concolorous or bicolorous with the central cells generally dark - coloured with thick walls and marginal cells light-coloured, luminae opaque or clear, generally small, peltate, attached towards the base, ovate-acuminate or ovate-lanceolate or linear-subulate, base broad, margin entire or erosed or fimbriate (with long filamentous projections), apex acute or long acuminate, clathrate. Fronds generally in 2-rows on rhizome. Stipes articulated to the rhizome, approximate or distantly placed, generally short, often winged due to the decurrent lamina base, glabrous or scaly; scales generally deciduous; rachis often prominent on lower side, glabrous or scaly. Lamina simple, lanceolate or linear-lanceolate, base cuneate and often decurrent on stipe, apex acute, long acuminate or abruptly attenuated, margin entire, revolute in a few; texture thick or thin, coriaceous to subcoriaceous or herbaceous, glabrous or scaly; scales lanceolate; veins prominent or obscure forming series of areolae with or without free single or forked included vein lets. Sori exindusiate, when young densely covered with imbricate fuscous easily deciduous scales, round, oblong or elongate, medial or submedial in a single row on either side of the rachis, situated on the plexes of radiate veinlets; paraphyses isomorphic or dimorphic: (i) umbrella - shaped, peltate, clathrate, (ii) hair-like, 2-celled. Spores hyaline to yellowish, bilateral monolete, non-perinate, exine smooth or tuberculate or verrucose.

Type: *Lepisorus thunbergianus* (Kaulf.) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 88 (1933).

KEY TO SPECIES

A. Lamina turning bright brown on drying;

spores yellow, minutely verrucose ..... 1. **L. mehrae**

A. Lamina turning green on drying; spores light-yclow, papillate and

tuberculate or tubereulate-granulose……B

B. Lamina 6.0-25.0 x 0.5-1.0 cm, narrowly linear-lanceolate, apex long acuminate;

texture thick, fleshy; veins obscure .....2. **L. nudus**

B. Lamina 15.0-50.0 x 1.5-4.0 cm, linear

to broadly lanceolate, apex acute; texture

herbaceous, membranaceous; veins distinct.. ..... 3. **L. sesquedalis.**

1. **Lepisorus mehrae** Fras.-Jenk., New Sp. Syndrome Indian Pterid. & Ferns Nepal: 159 (1997); Chandra, Ferns India: 380 (2000).

Lepisorus kashyapii (Mehra) Mehra, Res. Bull. Panjab Univ. (n. s.) **13**: 23 (1962); Bir & Trikha, Bull. Bot. Surv. India **11**: 211 (1969); Chandra, J. Bombay nat. Hist. Soc. **74**: 648 (1979); Khullar *et al.*, in Western Him. **1**: 355 (1987); Pangtey & Punetha in Western Him. **1**: 407 (1987); Punetha & Kaur, J. Econ. Tax. Bot. **9**: 284 (1987); Pande & Basera, Indian Fern J. **5**: 158 (1988); Pande & Pande, Vegetos **3**: 57 (1990); Pande, Indian Fern J. **7**: 147 (1990); Khullar *et al.*, Ferns Nainital: 166 (1991).

Polypodium kashyapii Mehra, Ferns Muss.: 248 (1939), *nom. nud.;* Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942).

Pleopeltis kashyapii (Mehra) Alston & Bonner, Candollea **15**: 208 (1956).

Lepisorus kashyapii (Mehra) Mehra var. *minor* Bir & Satija, Amer. Fern J. **71**: 55 (1981); Satija & Bir. Aspects Pl. Sci. **8**: 23 (1985); Khullar. Him. Bot. Res.: 386 (1991); Khullar *et al.*, Ferns Nainital: 169 (1991).

Lepisorus kashyapii (Mehra) Mehra var. *major* Bir & Satija. Amer. Fern J. **71**: 55 (1981); Satija & Bir, Aspects Pl. Sci. **8**: 23 (1985); Khullar, Him. Bot. Res.: 386 (1991); Khullar *et al.*, Ferns Nainital: 169 (1991).

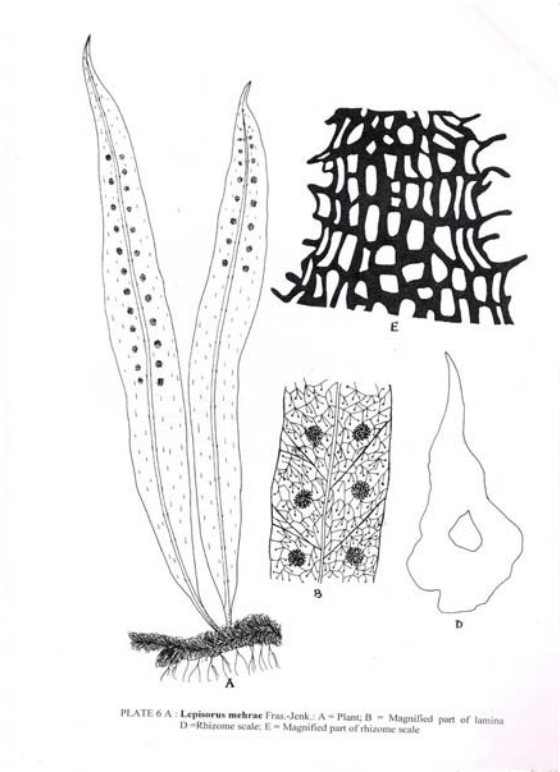

PLATE 6 A : **Lepisorus mehrae** Fras.-Jenk.: A = Plant; B = Magnified part of lamina D =Rhizome scale; E = Magnified part of rhizome scale

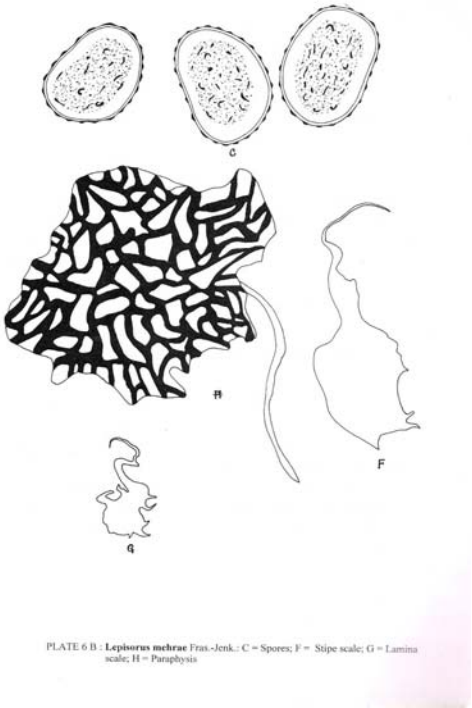

PLATE 6 B : **Lepisorus mehrae** Fras.-Jenk.: C = Spores; F = Stipe scale; G = Lamina scale; H = Paraphysis

Rhizome long-creeping, thick, loosely attached to the substratum by long straight robust roots, scaly; scales brown, base broad, margin toothed or fimbriate (with long filamentous projections), apex acuminate. Stipes 1-2 cm, distant on rhizome, usually clustered towards growing tip, forming a basket-like structure, stramineous to yellowish, scaly; scales brown, margin in the basal

part toothed, rest with long filamentous projections, lanceolate with a broad base and a long drawn out apex; rachis prominent on lower surface, stramineous, scaly, scales dark-brown, decreasing in size towards the apex, margin with prominent filamentous projections, apex acuminate, long drawn out. Lamina (12.0)-15.0 x 35.0 (-40.0) x 1.5-3.5 (-5.5) cm, broadly lanceolate, base gradually decurrent on stipe, apex acute, margin entire or slightly wavy; texture thick, subcoriaceous, bright brown on drying, lower surface scaly, scales dark-brown, contorted, deciduous; veins inconspicuous, anastomosing to form many irregular areolae with free simple or forked included veinlets. Sori not deeply immersed, round, large, submedial; paraphyses peltate, clathrate, subpersistent. Spores yellowish, 35 - 42 x 49 - 59 µm, exine minutely verrucose.HABITAT: Commonly grows as a lithophyte, occasionally as an epiphyte. DISTRIBUTION: Fairly common from 2100-2500 m altitude.

UTTARAKHAND: NAINITAL: Nainital, Lariakanta, Khurpatal Tiffin Top, Pangtey's Gorge, Kilbury.

INDIA: Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland.

GENERAL DISTRIBUTION: Nepal.

2. **Lepisorus nudus** (Hook.) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 83 (1933): Bir & Trikha, Bull. Bot. Surv. India **11:** 265 (1969); Awasthi & Sharma, Proc. Indian Acad. Sci. (Pl. Sci.) **89**: 309 (1980); Dhir, Biblioth. Pterid. **1**: 124 (1980); Dhir & Sood, Biblioth. Pterid. **2**: 84 (1981); Verma & Khullar, Fern Gaz. **12**: 87 (1980); Goel & Bhattacharyya, Indian J. For. **4**: 36 (1981); Pangtey *et al.*, Him. Res. & Dev. **1**: 159 (1982); Bir *et al.*, Pterid. Fl. Garhwal Him.: 19 (1983); Pande *et al.*, Him. Res. & Dev. **3**: 40 (1984); Dixit, Census Indian Pterid.: 41 (1984); Satija & Bir, Aspects Pl. Sci. **8**: 18 (1985); Singh *et al.*, Indian J. For. **9**: 7 (1986); Khullar *et al.*, in Western Him. **1**: 356 (1987); Pangtey & Punetha in Western Him. **1**: 407 (1987); Punetha & Kaur. J. Econ. Tax. Bot. **9**: 284 (1987); Pande & Dashila, Indian Fern J. **5**: 87 (1988).

Pleopeltis nuda Hook., Exot. Fl.: t. 63 (1823); D.Don, Prodr. Fl. Nepal.: 3 (1825); Alston & Bonner, Candollea **15**: 208 (1936); Sledge, Bull. Brit. Nat. Hist. Soc. Bot. **2**: 135 (1960); Pande, Indian For. **99**: 52 (1973).

Polypodium nudum (Hook.) Kunze, Linnaea **23**: 281 (1850), *non* Forssk. (1786); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942); Chowdhury, Pterid. Fl. Upper Gangetic Plain: 69 (1973).

Pleopeltis linearis sensu Bedd., Handb. Ferns Brit. India: 346. t. 180 (1883), *non* Thunb. (1784); Mehra, Ferns Muss.: 75 (1939).

Pleopeltis wightiana (Thunb.) Bedd., Ferns Brit. India: 60. t. 180 (1863).

Polypodium lineare sensu Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 558 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 96 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906).

Lepisorus gyirongensis Ching & S.K. Wu in C.Y.Wu Fl. Xizangica **1**: 304 (1983); Punetha & Kholia, New Botanist **16**: 117 (1989).

Lepisorus intermedius Ching & Khullar, Indian Fern J. **1**: 74 (1984).

Lepisorus tenuipes Ching & Khullar, Indian Fern J. **1**: 91 (1984); Pande & Kandpal, Acta Botanica Indica **14** (Suppl.): 121 (1986); Khullar *et al.*, in Western Him. **1**: 357 (1987); Pangtey & Punetha in Western Him. **1**: 408 (1987); Pande & Pande, Acta Botanica Indica **15**: 103 (1987); Pande & Basera, Indian Fern J. **7**: 148 (1990); Pangtey *et al.*, New Botanist **18**: 220 (1991); Khullar *et al.*, Ferns Nainital: 172 (1991).

Lepisorus parvus Khullar, Him. Res. & Dev. **7**: 59 (1994), *nom. nud.*

Lepisorus pseudolinearis Ching & Khullar, Him. Res. & Dev. **7**: 60 (1988), *nom. nud.*

Lepisorus birii Khullar, Him. Res. & Dev. **7**: 60 (1988), *nom. nud.*

Rhizome long-creeping, thin, scaly; scales dark-brown, concolorous, luminae uniform, clear, isodiametric, base broad, margin toothed towards apex, almost entire below, often loosing the apex when scales are older, apex acuminate or acute. Stipes 0.5-1.5 cm distant on rhizome, short, 0.5-3.0 cm long, sparsely scaly, scales as on rhizome; rachis prominent, sparsely scaly, scales deciduous. Lamina 6.0-25.0 x 0.5-1.0 cm, apex long acuminate, narrowly linear-lanceolate, base gradually attenuated and decurrent on stipe, apex long acuminate; texture; texture thick, fleshy, glabrous; veins obscure, anastomosing to form 2- 3 areolae, areolae with free simple or forked included veinlets. Sori round, large, medial but closer to the rachis, often confluent, covering the entire lamina between margin and rachis, more than half of the lamina fertile; paraphyses peltate, clathrate Spores hyaline to yellowish, 35-49 x 59-70 µm, exine smooth or minutely rugose.

HABITAT: Grows as an epiphyte as well as a lithophyte.

DISTRIBUTION: Not uncommon between 1000 and 3000 m altitude.

UTTARAKHAND: NAINITAL: Snow view, Nainital-Bhowali road, Khurpatal, Mangoli, Bajoon, Patuwadangar, Sattal, Bhimtal, Naukuchiatal, Jeolikote, Dogaon.

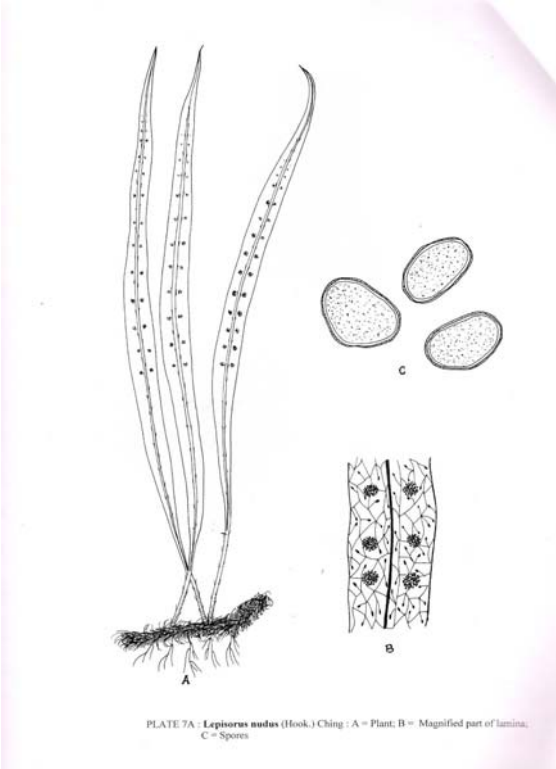

PLATE 7A : **Lepisorus nudus** (Hook.) Ching : A = Plant; B = Magnified part of lamina; C = Spores

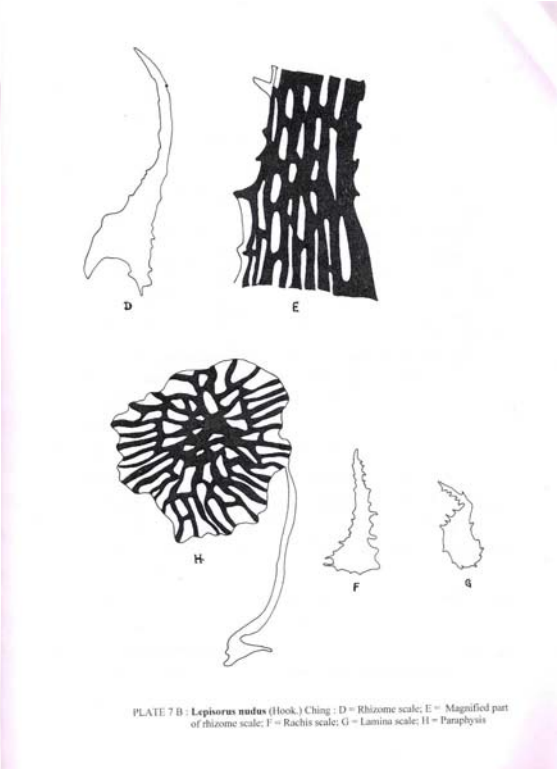

PLATE 7 B : **Lepisorus nudus** (Hook.) Ching : D = Rhizome scale; E = Magnified part of rhizome scale; F = Rachis scale; G = Lamina scale; H = Paraphysis

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland; south India.

GENERAL DISTRII3UTION : Pakistan; Nepal; Bhutan; China; Japan; Thailand; Sri Lanka.

3. **Lepisorus sesquipedalis** (J. Smith) Fras.-Jenk., Bot. Helv. **102**(2): 153 (1992), *non Lepisorus sesquipedalis* (Wall. *ex* J. Smith) Fras.-Jenk., Pakistan Syst. **5**: 91 (1991); Khullar, Ill. Fern Fl. West Him. **1**: 109. t. 41 (1994); Chandra, Ferns India: 383 (2000).

Drynaria sesquipedalis J. Smith, Bot. Mag. 72 Comp.: 13 (1846).

Polypodium sesquipedale (J. Smith) Mett., Mem. Fam. Foug. **1**: no. 162 (1856).

Polypodium scolopendrium Buch.-Ham. *ex* D.Don. Prodr. Fl. Nepal.: **1** (1825), *nom. illeg. non*

Polypodium scolopendrium Burm. (1768).

Polypodium excavatum auct. India, non Bory (1810); Mehra, Ferns Muss.: 23 (1939); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942).

Polypodium lineare Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 558 (1880), *pro parte.*

Pleopeltis simplex Bedd., Handb. Ferns Brit. India: 347 (1883).

Lepisorus excavatus auct. Western Himalaya, *non* (Bory) Ching (1933); Bir & Trikha, Bull. Bot. Surv. India **11**: 273 (1969); Bir & Trikha, Amer. Fern J. **64**: 56 (1974); Chandra, J. Bombay nat. Hist. Soc. **74**: 648 (1979); Pangtey *et al.*, Him. Res. & Dev. **1**: 150 (1982); Bir *et al.*, Pterid. Fl. Garhwal Him.: 18 (1983); Pande *et al.*, Him. Res. & Dev. **3**: 40 (1984).

Lepisorus excavatus Bory var. *scolopendrium* (Ham. *ex* D. Don) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 69 (1933); Loyal & Verma, J. Bombay nat. Hist. Soc. **57**: 488 (1960); Dixit, Census Indian Pterid.: 40 (1984).

Lepisorus scolopendrium (Ham. *ex* D.Don) Mehra & Bir, Res. Bull. Panjab Univ. (n.s.) **15**: 168 (1964), *nom. nud.;* Pangtey & Punetha in Western Him. **1**: 408 (1987); Pande & Dashila, Indian Fern J. **5**: 87 (1988); Pangtey *et al.*, New Botanist **18:** 220 (1991); Khullar. Him. Res. & Dev. **7**: 60 (1988); Khullar *et al.*, Ferns Nainital: 170 (1991).

Lepisorus leiopteris auct. Western Himalaya, *non* (Kunze) Bir & Trikha, Amer. Fern J. **64**: 54 (1974); Pande & Kandpal, Acta Botanica Indica **14** (Suppl.): 121 (1986); Pangtey & Punetha in Western Him. **1**: 407 (1987).

Lepisorus excavatus Bory var. *mortonianus* Bir & Trikha, Amer. Fern J. **64:** 56 (1974); Dixit, Census Indian Pterid.: 40 (1984); Satija & Bir, Aspects Pl. Sci. **8**: 27 (1985); Pande, Indian Fern J. **7**: 147 (1990).

Lepisorus excavatus Bory var. *himalayensis* Bir & Trikha, Amer. Fern J. **64:** 58 (1974); Dixit, Census Indian Pterid.: 40 (1984); Pande, Indian Fern J. **7**: 147 (1990).

Pleopeltis mortonianus (Bir & Trikha) Love & Love, Taxon **26**: 324 (1977).

Lepisorus scolopendrium var. *himalayensis* (Bir & Trikha) Pangtey & Punetha in Western Him. **1**: 408 (1987).

Lepisorus scolopendrium var. *mortonianus* (Bir & Trikha) Pangtey & Punetha In Western Him. **1**: 408 (1987).

Lepisorus himalayensis (Bir & Trikha) Khullar, Him. Res. & Dev. **7**: 60 (1988); Him. Bot. Res.: 386 (1991).

Lepisorus mortonianus (Bir & Trikha) Khullar, Him. Res. & Dev. **7**: 60 (1988); Him. Bot. Res.: 386 (1991).

*Lepisorus krameri*i P. & H. Pande, Indian Fern J. **11**: 97 (1994), *nom. nud.*

Rhizome long-creeping, thick, woody, scaly; scales dark-brown, concolorous, central cells with dark coloured walls, uniformly thick, lanceolate, margin entire or slightly erosed, apex acuminate, luminae clear. Stipes *c* 0.2-2.0 cm distant on rhizome, 0.5-4.0 cm long, stramineous, sparsely scaly; scales as on rhizome, adpressed, deciduous; rachis prominent, scales as on stipe, adpressed, gradually decreasing in size. Lamina 15.0-50.0 x 1.5-4.0 cm, linear to broad lanceolate, base decurrent on stipe, apex acute, margin entire or slightly convolute; texture herbaceous, membranaceous when dry, lower surface scaly, scales darkbrown, small; veins distinct, anastomosing to form 4-5 areolae between margin and rachis, areolae with free simple or forked included veinlets. Sori immersed forming pustules on the surface, round, submedial, one between each main lateral vein; paraphyses peltate, clathrate. Spores yellowish-brown, 35.0-45.5 x 52.5-63.0 µm, exine sparsely tuberculate.

HABITAT: Grows as an epiphyte as well as a lithophyte in the forest.

DISTRIBUTION: A very common fern between 1800 and 3000 m altitude.

UTTARAKHAND: NAINITAL: Kilbury, Pangote, Pangtey's Gorge, Cheena peak, Snow View, Lariakanta, Dhobighat, Camels back, Land's end, Tiffin top, Khurpatal, Mangoli, Patawadhangar.

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland; Tripura.

GENERAL DISTRIBUTION: Tibet; China; Nepal; Bhutan; N Thailand.

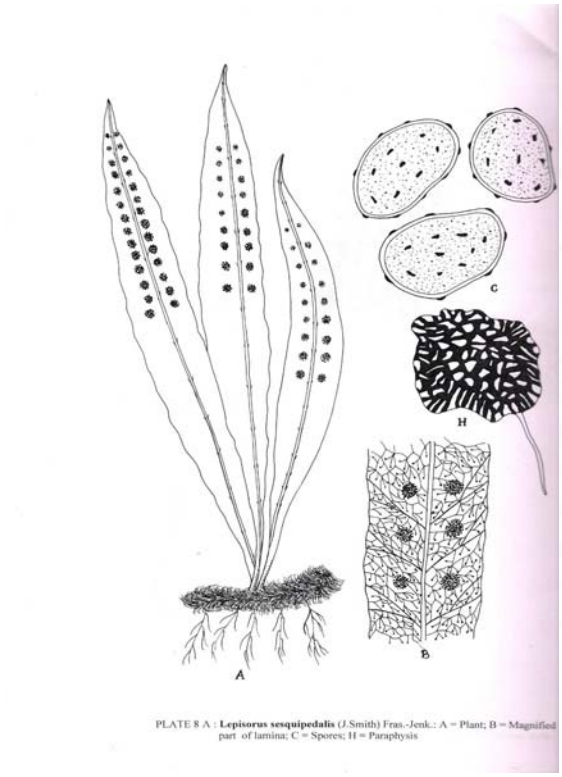

PLATE 8 A : **Lepisorus sesquipedalis** (J.Smith) Fras.-Jenk.: A = Plant; B = Magnified part of lamina; C = Spores; H = Paraphysis

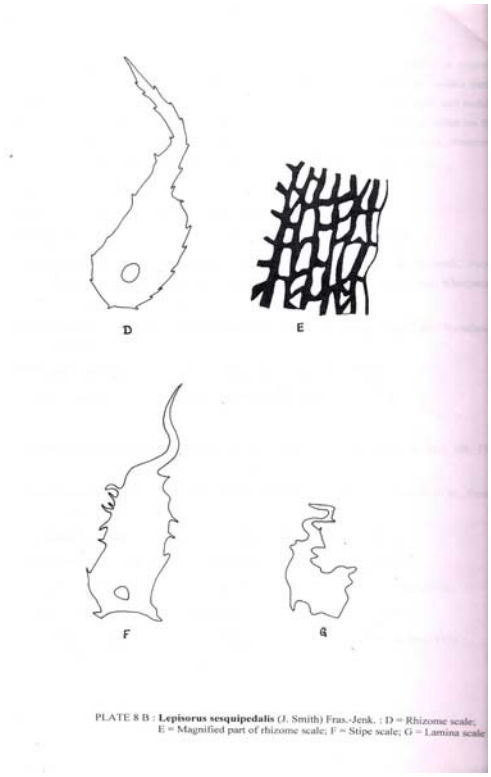

PLATE 8 B : **Lepisorus sesquipedalis** (J. Smith) Fras.-Jenk. : D = Rhizome scale; E = Magnified part of rhizome scale; F = Stipe scale; G = Lamina scale

Excluded / Doubtful Species

1. **Lepisorus amaurolepidus** (Sledge) Bir & Trikha, J. Bombay nat. Hist. Soc. **68**: 192 (1971).

2. **Lepisorus birii** Khullar, Him. Res. & Dev. **7**: 60 (1988), *nom. nud.;* Khullar *et al.*, Ferns Nainital: 164 (1991).

3. **Lepisorus excavatus** *auct.* Western Himalaya, *non* (Bory) Ching (1933).

4. **Lepisorus jakonensis** (Blanf.) Ching, Acta Bot. Yunnanica **5**: 5 (1883).

5. **Lepisorus kuchenensis** (Wu) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 89 (1933).

6. **Lepisorus leiopteris** (Kunze) Bir & Trikha, Amer. Fern J. **64**: 54 (1974).

7. **Lepisorus oligolepidus** (Bak.) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 66 (1933).

8. **Lepisorus scolopendrius** (Buch.-Ham. *ex* D.Don) Mehra & Bir, Res. Bull. Panjab Univ. (n.s.) **15**: 168 (1964).

9. **Lepisorus suboligolepidus** Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 77 (1933).

10. **Lepisorus tenuipes** Ching & Khullar, Indian Fern J. **1**: 91 (1984).

11. **Lepisorus ussuriensis** (Regel & Maack) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 91

(1933).

12. **Platygyria variabilis** Ching & S. K. Wu, Acta Bot. Yunnanica **5**: 21 (1983), *non Lepisorus variabilis* Ching & S.K. Wu in C.Y. Wu (= *Lepisorus clathratus).*

13. **Pleopeltis macrocarpa** (Bory *ex* Willd.) Kaulf., Berlin Jahrb. Pharm. **21**: 41 (1820).

6. MICROSORUM

Microsorum Link, Hort. Reg. Bot. Berol. **2**: 110 (1833); *emend.* Ching, Bull. Fan Mem. Inst. Biol.Bot. **4**: 295 (1933).

Acrostichum L., Sp. Pl. **2**: 1067), *pro parte.*

Phymatodes Presl, Tent. Pterid.: 195 (1836); Nakai, Tokyo Bot. Mag. **43**:505 (1929), *pro parte.*

Drynaria J. Smith, J. Bot. **4**: 60 (1841), *pro parte.*

Polypodium D. Don, Prodr. Fl. Nepal.: 1 (1825); Mett., Polyp. : 86 (1857), *pro parte.*

Polypodiwn sect. *Phymatodes* Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 557 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 1903), *pro parte.*

Pleopeltis Moore, Index Fil. : 77 (1857); Bedd., Ferns Southern India (1864); Ferns Brit. India (1865); Handb. Ferns Brit. India: 357 (1883), *pro parte.*

Rhizome long or short-creeping, thick or thin, scaly but older portions becoming glabrous; scales dark-brown or black, lanceolate or ovate, peltate or basally attached, clathrate, margin entire or shortly toothed. Fronds isomorphic. Stipes approximate or distant, articulated to phyllopodia, long or short or even absent, lower surface rounded or grooved, upper f1at, glabrous or hairy or scaly; rachis similar to stipe. Lamina simple, entire or deeply lobed, membranaceous or thick, herbaceous or subcoriaceous, glabrous or lower surface hairy; veins usually prominent, smaller transverse veins anastomosing to form areolae which contain smaller included areolae, ultimate areolae with free, simple or branched clavate, included veinlets in all directions, glabrous or hairy. Sori exindusiate, scattered or in 2-3 regular rows between lateral veins and several between margin and rachis, slightly or prominently sunk in the lamina; paraphyses filamentous, uniseriate, small, 2-4 celled, often with a terminal glandular cell, peltate clathrate scales absent. Spores bilateral, monolete, yellowish-brown, exine smooth or finely granulate, granulations arranged in a reticulate fashion.

Type: *Microsorum irregulare* Link, Hort. Reg. Bot. Berol. **2**: 110 (1833).

Microsorum membranaceum (D. Don) Ching, Bull. Fan Mem. Inst. Biol. Bot. **4**: 309 (1933); Pangtey *et al.,* Him. Res. & Dev. **1**: 159 (1982); Bir *et al.,* Pterid. Fl. Garhwal Him.: 23 (1983); Pande *et al.,* Him. Res. & Dev. **3**: 40 (1984); Dixit, Census Indian Pterid.: 45 (1984); Pande & Kandpal, Acta Botanica Indica **14** (Suppl.): 121 (1986); Khullar *et al.*, in Western Him. **1**: 357 (1987); Pangtey & Punetha in Western Him. **1**: 409 (1987); Punetha & Kaur, J. Econ. Tax. Bot. **9**: 285 (1987); Khullar *et al.,* Ferns Nainital: 173 (1991); Pangtey *et al.,* New Botanist **18**: 220 (1991); Khullar, Him. Res. & Dev. **7**: 60 (1988); Ill. Fern Fl. West Him. **1**: 121. t. 45 (1994); Chandra, Ferns India: 406 (2000).

Polypodium membranaceun D.Don, Prodr. Fl. Nepal.: 2 (1825); Clarke, Trans Linn. Soc. Lond. II (Bot.) **1**: 560 (1880); Hope, J. Bombay nat Hist. Soc. **15**: 93 (1903); C. Chr., Index Fil. **3**: 544 (1906); Mehra, Ferns Muss.: 26 (1939); Sterwart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942);

Pleopeltis membranacea Moore, Index Fil.: 191 (1860); Bedd., Handb. Ferns Brit. India: 335 (1883); Marten, J. Bombay nat. Hist. Soc. **19**: 182 (1909).

Pleopeltis grandifolia sensu Bedd., Ferns South. India: t. 177 (1864).

Rhizome short-creeping, thick, densely scaly but older portion glabrous; scales blackish

to dark - brown, lanceolate, margin entire, apex acuminate. Stipes 0.5-1.0 cm distant on rhizome or approximate, *c* 2-15 cm long or lamina decurrent almost up to the base, thick, stramineous, base scaly, rest glabrous; rachis rigid, prominent on lower surface, glabrous. Lamina simple, 30-100 x (2-) 4-6(-15) cm, lanceolate or oblanceolate, base gradually decurrent on stipe, apex attenuate, margin entire or wavy; texture thin, membranaceous, glabrous; veins distinct, lateral veins alternate, almost parallel reaching up to margin, glabrous, transverse veinlets many anastomosing to form many primary areolae which further contain smaller, irregular areolae, included veinlets many, free.

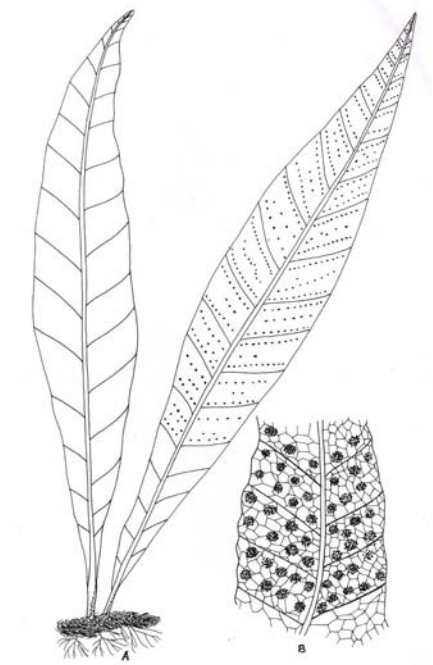

PLATE 9 A: **Microsorum membranaceum** (D.Don) Ching : A = Plant; B = Magnified part of lamina

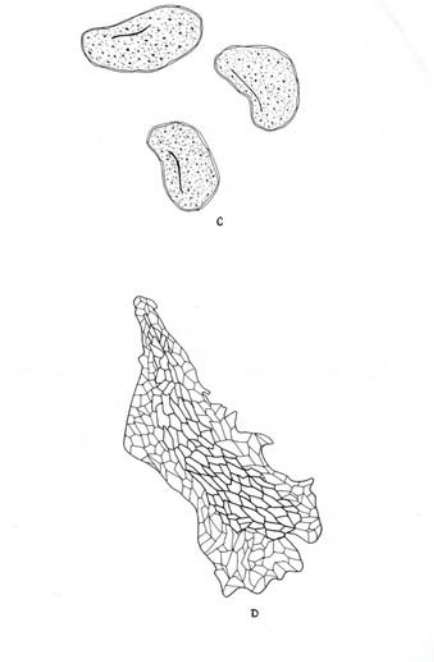

PLATE 9 B: **Microsorum membranaceum** (D.Don)Ching:C= Spores;D=Rhizome scale

Sori numerous, scattered, usually in 2 (-3) - 4(-7) parallel (or irregular) rows, 6-9 between margin and rachis, more or less irregularly subcontluent; paraphyses filamentous, uniseriate, short, 2-3 celled. Spores yellowish-brown, 28.0-38.0 x 44.5-52.5 µm, exine minutely granulate.

HABITAT: Grows as a lithophyte on wet rocks along river banks and besides water-falls or in forest as an epiphyte.

DISTRIBUTION: Fairly common from 1500-2700 m altitude.

UTTARAKHAND: NAINITAL: Dhobighat, Jeolikote, Bhimtal, Mangoli, Bajoon, Dogaon.

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Assam; Arunachal Pradesh; Meghalaya; Nagaland; Manipur; central India; Pachmarhi hills; south India: Mahabaleshwar; Khandala; Purandar.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; China; Taiwan; Vietnam; Thailand; Philippines; Sri Lanka.

7. PHYMATOPTERIS

Phymatopteris Pich. Serm., Webbia **28**: 460 (1973).

Phymatopsis J. Smith, Hist. Fil. : 104 (1875).

Rhizome long-creeping, dictyostelic, thick or thin, fleshy, scaly; scales brown, generally

bicolorous, linear-lanceolate or broad lanceolate or suborbicular or subulate peltate, attched towards base, margin fimbriate with very long (ciliate) projections. Fronds isomorphic, rarely dimorphic. Stipes articulated to the rhizome, stramineous to light-brown; rachis usually glabrous or sometimes scaly. Lamina simple, deeply pinnatifid (or simple, trifid, palmatifid or pinnate), deeply lobed to the rachis; texture coriaceous or herbaceous, lower surface glabrous, bluish-green, sometimes hairy, upper glabrous, often glaucous, glabrous; main and lateral veins distinct; veinlets anastomosing to form irregular areolae with or without free included veinlets with swollen tips. Sori exindusiate, large, distinct, oval or round, in a row on either side of the main vein and one between the lateral veins or irregularly biseriate, superficial or slightly sunk; paraphyses simple, 2-7 celled, terminal otten glandular. Spores bilateral, monolete, non- perinate, exine smooth, granulate or spiny.

Type: *Phymatopteris palmata* (Blume) Pich. Serm., Webbia **28**: 460 (1973).

KEY TO SPECIES

A. Lamina lobes triangular lanceolate, bases broad, margin minutely serrate or minutely serrulate lower pair generally downwardly deflexed .....1. **P. oxyloba**

A. Lower lobes linear lanceolate, bases decurrent, margin entire, lowest pair ascending or deflexed .....2. **P. quasidivaricata**

1. **Phymatopteris oxyloba** (Wall. *ex* Kunze) Pich. Serm., Webbia **28**: 464 (1973); Pande *et al.*, Him. Res. & Dev. **3**: 40 (1983); Bir *et al.*, Pterid. Fl. Garhwal Him.: 22 (1983); Dixit, Census Indian Pterid.: 50 (1984); Satija & Bir, Aspects Pl. Sci. **8**: 62 (1985); Khullar *et al.*, in Western Him. **1**: 358 (1987); Pangtey & Punetha in Western Him. **1**: 409 (1987); Pande & Pande, Acta Botanica Indica **15**: 103 (1987); Pande & Dashila, Indian Fern J. **5**: 88 (1988).

Polypodium oxylobum Wall. *ex* Kunze, Linnaea **24**: 255 (1851); Hope, J. Bombay nat. Hist. Soc. **15**: 94 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta 2: 169 (1942).

Pleopeltis oxyloba (Wall. *ex* Kunze) Bedd., Ferns South. India: t. 175 (1863).

Polypodium hastatum (Thunb.) Pich. Serm. var. *oxyloba* (Wall. *ex* Kunze) Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 563 (1880).

Polypodium trifidum D.Don. Prodr. Fl. Nepal.: 3 (1825), *non* Hoffm. (1790); Hook. & Baker, Syn. Fil.: 363 (1868).

Pleopeltis trifida (Smith) Bedd., Handb. Ferns Brit. India Suppl.: 96 (1892).

Phymatodes oxyloba (Wall. *ex* Kunze) Ching, Contr. Inst. Bot. Nat. Acad. Peiping **2**: 67 (1933); Bir & Devi, Bull. Bot. Surv. India **10**: 207 (1968); Loyal & Verma, J. Bombay nat. Hist. Soc. **57**: 488 (1960); Verma & Khullar, Fern Gaz. **12**: 88 (1980); Dhir, Biblioth. Pterid. **1**: 127 (1980);

Crypsinus oxylobum (Wall. *ex* Kunze) Sledge. Bull. Brit, Mus. Nat. Hist. Bot. **2**: 145 (1960).

Phymatopsis oxylobus (Wall. *ex* Kunze) Ching, Acta Phytotax. Sin. **9**: 190 (1964).

Rhizome long-creeping, thick, scaly; scales bicolorous, linear-lanceolate, margin fimbriate with long projections, apex acuminate. Stipes *c* 2 cm distant on rhizome, 9-11 cm long, never longer than the lamina, stramineous, firm, erect, glabrous but extreme base scaly; scales as on rhizome; rachis glabrous. Lamina simple, pinnatifid, 15 -50 x 15 - 25 cm, ovate-lanceolate, base decurrent, margin deeply lobed, 0.5-1.0 cm to the rachis; texture subcoriaceous, glabrous; lobes linear-lanceolate, apex acuminate, margin not cartilaginous, entire, terrninal lobe 6-9 x 1 -2 cm, as long as the lateral ones, 3-5 (-8) pairs, alternate 9.0-11.0 x 2.5 (-5.0), lowest pair or the one above it is the largest, ascending or deflexed; sinus 1.0-1.5 cm; veins anastomosing, areolae with or without included veinlets. Sori round, submedial, in a row on either side of the main vein

and one in between the lateral vein lets. Spores yellowish-brown, 31.5-35.0 x 56.0-66.5 µm, non-perinate, exine spinulose.

HABITAT: Grows as an epiphyte as well as a lithophyte.

DlSTRIBUTION: An occasional in the west, but common to abundant in Kumaun between 1300 and 3600 m altitude.

UTTARAKHAND: NAINITAL: Bhowali, Kainchi, Bhimtal, Sattal, way to Ratighat, Bajoon, Mangoli, Patuwadangar, Jeolikote.

INDIA: Himachal Pradesh; Sikkim; Darjecling; Meghalaya; Nagaland.

GENERAL DlSTRIBUTION: Nepal; Bhutan; SW China; Nepal; Bhutan; Taiwan; Vietnam; Thailand.

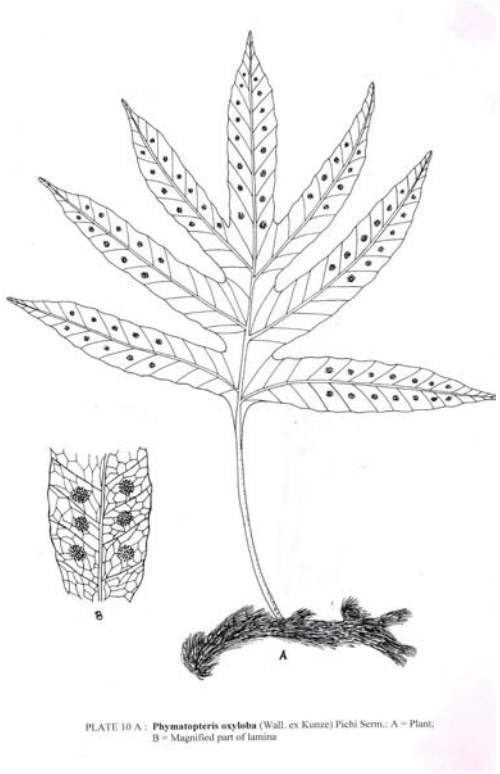

PLATE 10 A : **Phymatopteris oxyloba** (Wall. ex Kunze) Pichi Serm.: A = Plant; B = Magnified part of lamina

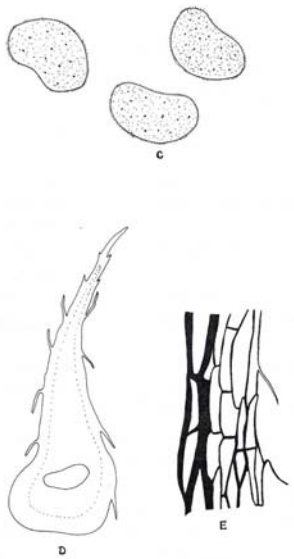

PLATE 10 B : **Phymatopteris oxyloba** (Wall. ex Kunze) Pichi Serm.: C = Spores; D= Rhizome scale; E = Magnified part of rhizome scale

2. **Phymatopteris quasidivaricata** (Hayata) Pich. Serrn., Webbia **28**: 464 (1973); Dixit, Census Indian Pterid.: 50 (1984); Chandra, Ferns India: 417 (2000).

Polypodium quasidivaricatum Hayata, J. ColI. & Univ. Tokyo **30**: 446 (1911). *Phymatopsis quasidivaricata* (Hayata) H.Ito, J. .lap. Bot. **11:** 100 (1935).

Crypsinus quasidivaricatus (Hayata) Copel., Gen. Fil.: 266 (1947).

Phymatopteris stracheyi (Ching) Pich. Serm., Webbia **28**: 464 (1973); Bir *et al.*, Pterid. Fl. Garhwal Him.: 22 (1983); Dixit, Census Indian Pterid.: 50 (1980); Satija & Bir, Aspects Pl. Sci. **8**: 59 (1985); Singh *et al.*, Indian J. For. **9**: 8 (1986); Khullar *et al.*, in Western Him. **1**: 358 (1987); Pangtey & Punetha in Western Him. **1**: 409 (1987); Punetha & Kholia, New Botanist **16**: 118 (1989).

Phymatodes stracheyi Ching, Contr. Inst. Bot. Nat. Acad. Peiping **2**: 83 (1933): Bir; & Devi, Bull. Bot. Surv. India **10**: 204 (1968); Chandra, J. Bombay nat. Hist. Soc. **74**: 648 (1979);

Dhir, Biblioth. Pterid. **1**: 127 (1980); Verma & KhuIlar. Fern Gaz. **12**: 88 (1980).

Polypodium stracheyi Ching in C. Chr., Index Fil. Suppl. **3**: 159 (1934); Stewart. 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 169 (1942).

Phymatopsis stracheyi Ching, Acta Phytotax. Sin. **9**: 195 (1964).

Crypsinus stracheyi Panigr. & Patnaik, Proc. Nat. Acad. Sci. India **34B**: 482 (1964).

Rhizome long-creeping, thin, scaly; scales bicolorous, lanceolate, soft, margin fimbriate with long projections, apex acuminate. Stipes 1-2 cm distant on rhizome, 8-10 long, stramineous, thin, firm, glabrous but extreme base scaly, scales as on rhizome; rachis glabrous. Lamina simple, pinnatifid, 10-15 x 10-15 cm, deltate or narrowly elongate, lanceolate, margin long, deeply lobed; texture subcoriaceous, glabrous; lobes triangular lanceolate, base broad, apex acuminate, margin minutely serrate or serrulate, teeth neither mucronate nor spinescent, terminal lobe 7-9 x 1 cm, as long as lateral ones, lateral pairs 3-4 pairs, opposite to alternate, lowest pair downwardly deflexed, acuminate; veins anastomosing forming 2-3-series of areolae with free included veinlets. Sori round, close to the main vein, in a row on either side of it; paraphyses small, 2-celled, simple, hair-like. Spores dark - brown, 24.5-35.0 x 42.0-56.0 µm, non-perinate, exine granulose.

HABITAT: Grows both as an epiphyte and lithophyte.

DlSTRIBUTION: Rare around 1800 m altitude and above.

UTTARAKHAND: NAINITAL: Nainital-way to Kilbury.

INDIA: Himachal Pradesh; Sikkim; Darjeeling.

GENERAL DISTRIBUTION: Tibet; China; Taiwan.

PLATE 11 : **Phymatopteris quasidivaricata** (Hayata) Pichi Serm.:A= Plant; B = Magnified part of lamina; C = Spores; D = Rhizome scale; E = Magnified part of rhizome scale

Excluded / Doubtful Species

1. **Phymatopteris hastata** (Thunb.) Pich. Serm., Webbia **28**: 462 (1973).

8. POLYPODIODES

Polypodiodes Ching, Acta Phytotax. Sin. **16(4)**: 26 (1978).

Polypodium L., Sp. Pl. 2: 1082 (1753), *emend.* Ching, Contrib. Inst. Bot. Nat. Acad. Peiping **2**: 31(1933).

Polypodium sect. *Eupolypodium* Hook. ex Baker, Syn. Fil.: 319 (1868); C.Chr., Index Fil. : 506 (1905).

Goniophlebium (Blume) C. Presl, Tent. Pterid.: 185 (1836); Bedd., Ferns Brit. India: t. 87.(1866-69); Ferns Brit. India Suppl. :1867); Handb. Ferns Brit. India: 317 (1883).

Polypodium sect. *Goniophlebiun* Blume, Fl. Jav. Fil. : 132 (18280; Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 550 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 85 (1903).

Rhizome long-creeping, dictyostelic, brown or dark-brown, densely scaly becoming glabrous with age; scales dark-brown to blackish, ovate-lanceolate or subulate-lanceolate, glaucous, cells moderately large, clear, almost isodiametric, basifixed or peltate with a broad lower half, margin entire or fimbriate with a short or long projections, apex acute or sometimes long hair pointed. Fronds isomorphic. Stipes distant on rhizome, articulated to the rhizome with prominent pseudopodia; rachis hairy and / or scaly or glabrous. Lamina simple, pinnatifid, imparipinnate, triangular-lanceolate to linear-lanceolate; texture herbaceous to subcoriaceous, glabrous or more or less hairy; lobes simple, confluent at their bases, lower 1 or 2 rarely free, reduced, distant towards deflexed, broadly adnate, articulated or not to the rachis pinnae; veins forked, free or generally anastomosing to form one (rarely two) rows of costal areolae; areolae subhexagonal with one free simple excurrent veinlet, marginal veins free. Sor exindusiate, generally in a row on either side of the costa, round or oblong, glabrous or with dimorphic paraphyses (simple or peltate). Spores light-brown or yellowish, bilateral, monolete, subreniform or ovoid, perinate or non-perinate, smooth or slightly tuberculate.

Type: *Polypodiodes amoena* (Wall. ex Mett.) Ching, Acta Phytotax. Sinica **16**: 27 (1978).

KEY TO SPECIES

A. Fronds large, robust; rhizome thick, dia. 0.4-0.5 cm; lamina lobes more than 8 cm long; texture thick,

subcoriaceous: rachis generally scaly throughout ..... 1. **P. amoena**

A. Fronds small, delicate; rhizome thin, dia. 0.1-0.2 (-0.4) cm; lamina lobes not more than 2.5 cm long; texture thin, herbaceous; rachis sparsely scaly;

scales restricted to lower half ..... B

B. Rhizome scales hair-like, many black; lamina lobes

numerous, often more than 30 ..... 2. **P. lachnopus**

B. Rhizome scales narrow but not hair-like, all

brown; lamina lobes seldom more than 30 ..... 3. **P. microrhizoma**

1. **Polypodiodes amoena** (Wall. *ex* Mett.) Ching, Acta Phytotax. Sin. **16**(4): 27 (1978); Khullar *et al.*, in Western Him. **1**: 358 (1987); Pangtey & Punetha in Western Him. **1**: 408 (1987); Pande, Geobios new Reports **8**: 109 (1989); Indian Fern J. **7**: 149 (1990); Khullar *el al.*, Ferns Nainital: 182 (1991); Pangtey *el al.*, New Botanist **18**: 220 (1991).

Polypodium amoenum Wall. *ex* Mett., Uber Farngatt. **1**: 80 (1857); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 550 (1880); Hope, J. Bombay nat. Hist. Soc. **14**: 85 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906); Mehra, Ferns Muss.: 21 (1939); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 169 (1942); Bir *et al.*, New Botanist **1**: 149 (1974); Chandra, J. Bombay nat. Hist. Soc. **74**: 649 (1979);

Polypodium aureum D.Don. Prodr. Fl. Nepal.: 3 (1825), *non* L (1753).

Goniophlebium amoenum J.Smith in Hook. Gen. Fil.: ad t. 50 (1840); Bedd., Handb. Ferns Brit. India: 317 (1883); Marten, J. Bombay nat. Hist. Soc. **19**: 182 (1909); Singh *et al.*, Indian J. For. **9**: 7 (1986); Chandra, Ferns India: 389 (2000).

Polypodium valdealatum Christ. Bull. Herb. Boiss. **7**: 4 (1899).

Polypodium amoenum Wall. *ex* Mett. var. *latedeltoideum* Christ. Bull. Acad. Georg. Bot.: 142 (1907).

Polypodium amoenum Wall. *ex* Mett. var. *xerophyticum* Mehra & Bir, Res. Bull. Panjab Univ. (n.s.) **15**: 166 (1964).

Polypodium amoenum Wall. *ex* Mett. var. *pinnatifidum* Dhir, Biblioth. Pterid. **1**: 119 (1980), *nom. nud.*

Rhizome long-creeping, thick, densely scaly; scales dark-brown, adpressed, ovate-acuminate or lanceolate-subulate, base broad, margin entire or slightly erosed. Stipes distant on rhizome, *c* 30 cm long, stramineous to light-brown, thick, robust, scaly at extreme base, rest glabrous, scales as on rhizome; rachis stramineous or brown, lower surface scaly throughout, scales as on rhizome, but smaller; upper surface hairy, hyaline. Fronds robust. Lamina pinnatifid, large, up to 60 x 25 cm, triangular-lanceolate, apex acuminate; texture thick, herbaceous to subcoriaceous; lobes many, *c* 40 pairs, 10 x 1 cm, horizontal, lanceolate, base broad, apex acuminate, margin distantly dentate-serrate or irregularly lobed, lower most lobes generally free, horizontal or downwards deflexed; veins prominent, anastomosing to form a row of costal areolae, sometimes in two rows in larger fronds, costal arches of rachis continued nearly or quite to the base of the fronds, costal arches of the man rachis continued nearly or quite to the base of the frond; costa lower surface scaly, upper hairy; costules upper, surface hairy, lower glabrous. Sori round or oval, medial, on the included veinlet in the costal areolae, in a single row on either side of the costa; paraphyses peltate. elathrate, short stalked.. Spores light-yellow; 24.5 - 38.5 x 45.5 - 66.8 µm, exine minutely tuberculate.

PLATE 12 : **Polypodiodes amoena** (Wall. ex Mett.) Ching : C = Spores; D = Rhizome scale; E = Magnified part of rhizome scale; F = Rachis scale; G = Stipe scale; H = Costae scale

HABITAT: Grows as a lithophyte; sometimes as a foot epiphyte.

DISTRIBUTION: Common and sometimes ahundant hetween 1800 and 2400 m altitude.

UTTARAKHAND: NAINITAL: Cheena peak, Kilhury, Pangtey's Gorge, Dhohighat, Lariakanta, Tiffin top, Camel's back.

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland; Manipur.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; China; Taiwan; Vietnam; Philippines; Myanmar; N Thailand.

2. **Polypodiodes lachnopus** (Wall. *ex* Hook.) Ching, Acta Phytotax. Sin. **16**(4): 27 (1978); Dixit, Census Indian Pterid.: 52 (1984); Singh *et al.*, Indian J. For. **9**: 8 (1986); Khullar *et al.*, in Western Him. **1**: 358 (1987); Pangtey & Punetha in Western Him. **1**: 408 (1987); Pande, Geobios new Reports **8**: 109 (1989); Indian Fern J. **7**: 150 (1990); Khullar *et al.*, Ferns Nainital: 183 (1990); Pangety *et al.*, New Botanist **18**: 220 (1990).

Polypodium lachnopus Wall. ex Hook., Icon. Pl.: t. 952 (1854): Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 551 (1880); Hope. J. Bomhay nat. Hist. Soc. **15**: 86 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906); Mehra, Ferns Muss.: 22 (1939); Bir *et al.*, New Botanist **1**: 150 (1974); Loyal & Verma, J. Bombay nat. Hist. Soc. **57**: 488 (1960); Chandra. J. Bombay nat. Hist. Sac. **74**: 649 (1979); Verma & Khullar, Fern Gaz. **12**: 88 (1980); Dhir, Biblioth. Pterid. **1**: 121 (1980).

Polypodium vulgare D.Don, Prodr. Fl. Nepal.: 2 (1825), *non* L. (1753).

Goniophlebium lachnopus (Wall. *ex* Mett.) J. Smith in Hook. Gen. Fil.: ad t. 51 (1840); Bedd., Handb. Ferns Brit. India: 319 (1883); Marten, J. Bombay nat. Hist. Soc. **19**: 182 (1909); Pande, Indian For. **99**: 52 (1973); Chandra, Ferns India: 391 (2000).

Rhizome long-creeping, thin, densely scaly; scales black, iridescent with oblongovate base, subulate, margin fimbriate with prominent short and long projections, apex long, spreading,

hair pointed. Stipes 0.5-2.0 cm distant on rhizome, short, 6.0-15.0 cm long, stramineous, thin, sparsely hairy, hairs hyaline, short, 2-3-celled, very sparsely scaly, scales few, as on rhizome; rachis hairy, hairs on the lower surface short, 1-2-celled, upper surface more hairy, hairs longer, moderately scaly, scales nearly orbicular, apex long, cuspidate or setiform. Lamina simple, pinnatifid, 15-50 x 3-7 cm, linear-lanceolate, margin deeply lobed nearly to the rachis; texture herbaceous, hairy, hairs as on rachis; lobes many, 30-60 pairs (rarely below 30), 1.0 - 2.5 x. 5.0 - 0.8 cm, margin remotely crenate-serrate, apex subacuminate, lower most lobes at times free and downwards deflexed; veins anastomosing to form a series of large costal areolae with simple included veinlets, marginal veins free rarely united, such marginal areolae without free included veinlets; costae and costules hairy, hairs hyaline, short, costa scaly, scales short, orbicular.. Sori small, round, in a single row on either side of the costa and one between each costal areolae; paraphyses peltate, clathrate, long stalked, margin stellate. Spores pale, 31.5 - 42.0 x 52.0 - 66.0 µm, perinate, perine smooth.

HABITAT: Grows as an epiphyte and as a lithophyte.

DISTRIBUTION: Fairly common between 1800 and 2400 m altitude.

UTTARAKHAND: NAINITAL: Nainital, Land's end, Nainital-Bhowali road, Dhobighat,

Pangtey's Gorge, Kilbury.

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland; Manipur.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; China.

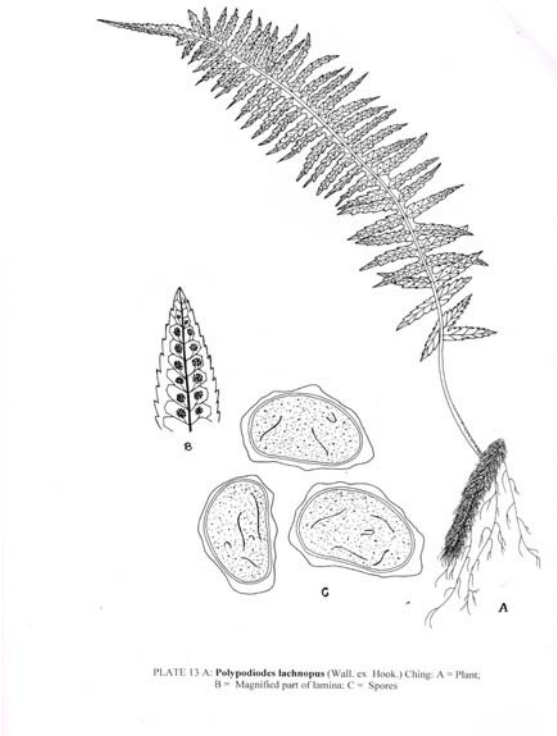

PLATE 13 A: **Polypodiodes lachnopus** (Wall. ex Hook.) Ching: A = Plant; B = Magnified part of lamina; C = Spores

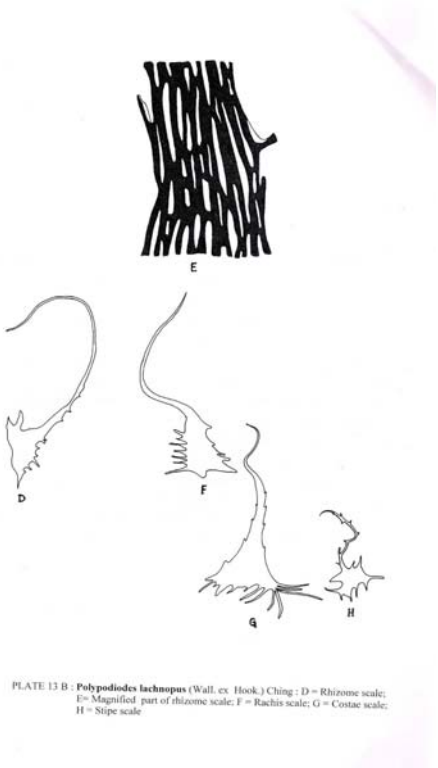

PLATE 13 B : **Polypodiodes lachnopus** (Wall. ex Hook.) Ching : D = Rhizome scale; E= Magnified part of rhizome scale; F = Rachis scale; G = Costae scale; H = Stipe scale

3. **Polypodiodes microrhizoma** (Clarke *ex* Baker) Ching, Acta Phytotax. Sin. **16**(4): 27 (1978); Dixit, Census Indian Pterid.: 52 (1984); Singh *et al.*, Indian J. For. **9**: 8 (1986); Khullar *et al.*, in Western Him. **1**: 359 (1987); Pangtey & Punetha in Western Him. **1**: 408 (1987); Pande, Geobios new Reports **8**: 109 (1989); Indian Fern J. **7**: 130 (1990); Pande & Pande, Vegetos **3**: 57 (1990); Pangtey *et al.*, New Botanist **18**: 220 (1991).

Polypodium microrhizoma Clarke *ex* Baker in Hook. & Baker Syn Fil *ed.* **2**: 511 (1874); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 551 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 86 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906); Mehra, Ferns Muss.: 22 (1939); Bir *et al.*, New Botanist **1**: 147 (1974).

Goniophlebium microrhizoma (Clarke *ex* Baker) Bedd., Ferns Brit. India Suppl.: 21. t. 384 (1876); Handb. Ferns Brit. India: 322 (1883); Loyal & Verma, J. Bombay nat. Hist. Soc. **57**: 488 (1960); Chandra, Ferns India: 392 (2000).

Polypodium taliense Christ, Bull. Soc. Bot. Fr. Mem. **1**: 14 (1905).

Polypodium microrhizoma Clarke *ex* Baker var. *xerophyticum* Mehra, Ferns Muss.: 22 (1939), *nom. nud:* Dhir, Biblioth. Pterid. **1**: 120 (1980); Bir *et al.*, Pterid. Fl. Garhwal Him.: 17 (1983); Satija & Bir, Aspects Pl. Sci. **8**: (1985).

Rhizome long-creeping, thin, scaly; scales dark-brown, lanceolate, margin fimbriate with short projections, apex acuminate. Stipes 2-4 cm distant on rhizome, 10-20 cm long, stramineous or castaneous brown, thin, glaucous, glabrous; rachis castaneous brown or stramineous, glaucous, generally glabrous or occasionally very sparsely scaly, scales few scattered, brown, small, lanccolate. Lamina simple, pinnatifid, 15-20 x 5-8 cm, linear, narrow, lanceolate, apex acuminate, deeply lobed almost to the rachis; texture membranaceous, herbaceous, glabrous; lobes 20-25 pairs, 3.0-4.0 x 0.3-0.5 cm, lanceolate, margin serrate or distantly incised, lower most lobes sometimes free, distant, slightly smaller than the next two or three pairs above; veins anastomosing to form a single series of costal areolae but free towards apex of the lobes, costal arches of the main rachis usually broken at least in the lower half of the lamina; costae and costules glabrous, costa rarely with a few scales but generally glabrous. Sori round or oval,

medial on the included or free veinlets, nearer the costa, in a single row on either side of costa; paraphysespeltate, clathrate, also simple 2-celled ones. Spores light-yellowish, 24.5-31.5 x 49.0-56.0 µm, perinate, perine narrow, smooth.

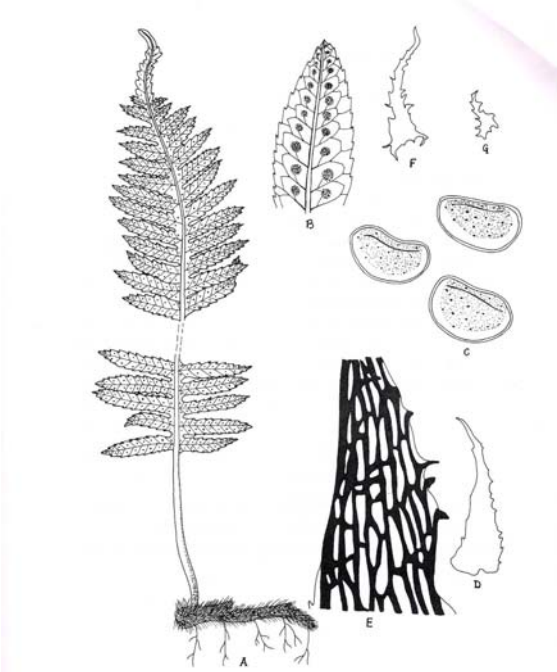

PLATE 14 : **Polypodiodes microrhizoma** (Clarke ex Baker) Ching : A = Plant; B = Magnified part of lamina; C = Spores; D = Rhizome scale; E = Magnified part of rhizome scale; F = Rachis scale; G = Costae scale

HABITAT: Grows as an epiphyte and as a lithophyte.

DISTRIBUTION: Very common or abundant from 1500- 2700 m altitude.

UTTARAKHAND: NAINITAL: Dhobighat, Lariakanta, Snow View, Cheena peak range, Tiffin top, Khurpatal, Patuwadhangar, Jeolikote, Bhimtal, way to Ratighat.

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Nagaland.

GENERAL DISTRIBUTION: Nepal; Bhutan; Tibet; SW China; Taiwan; Thailand; N Myanmar.

Excluded / Doubtful Species

1. Polypodiodes subamonea (Clarke) Ching, Acta Phytotax. Sin 16(4): 27 (1987).

Polypodium subamoenum Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 550 t. 82. f. 2 (1880). *Goniophlebium subamoenum* (Clarke) Bedd., Handb. Ferns Brit. India: 317 (1883); Chandra, Ferns India: 394 (2000).

9. **PYRROSIA**

Pyrrosia Mirbel in Lamarch & Mirbel Hist. Pl. **4**: 70 (1803); Hist. Nat. Veg. **5**: 91 (1803).

Polypodium Sw. in Schard. J. Bot. **1800**(2): 21 (1801).

Cyclophorus Desv., Berl. Mag. **5**: 30 (1811).

Niphobolus Kaulf., Enum. Fil.: 24 (1824), *nom. superfl.;* Bedd., Ferns Southern India: t. 240 (1863); Ferns Brit. India: t. 161 (1865-1870); Handb. Ferns Brit, India: 324- 332 (1883).

Polypodium sect. *Niphobolus* Hook., Sp. Fil. **5**: 43 (1863); Clarke, Trans. Linn. Soc. Lond II (Bot.) **1**: 552 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 87 (1903).

Rhizome long or short-creeping, thick or thin, densely scaly; scales concolorous or bicolorous, generally paleate. Fronds isomorphic, rarely dimorphic. Stipes distant or clustered, articulate at base, or stipe indistinct, hairy; hairs stellate, generally caduceus; rachis usually prominent, at times sunken, hairy. Lamina simple, linear-lanceolate or ovate, margin entire, rarely hastately or palmately lobed; texture generally and glossy with age, provided with pit-like or punctuate hydathodes arranged in rows, lower surface hairy, hairs generally brown or hyaline, stellate, uniform or dimorphic, generally in two layer of straight, acicular (thin), curly and interwined or lanceolate (thick), broad and flat, stalked, lower layer of irregularly coiled arms; hairs lighter coloured or hyaline, arms long, coiled or hairs mixed (both type or arms on the same hair), their number in a hair variable; veins generally obscure or lateral veins prominent, copiously anastomosing, areolae with many free simple branched or unbranched included veinlets; veinlet ends clavate. Sori exindusiate, in one, two or three or multiseriate rows between rachis and margin, acrostichoid, distributed over a large area of the lower surface, superficial or partly immersed in pits, round, rarely oblong; paraphyses absent. Spores bilateral, monolete, generally large, exine thin, smooth or sparsely verrucose, occasionally the thin outer layer of exine may become loose on soaking and peel off.

Type: *Pyrrosia chinensis* Mirbel. Hist. Nat. Veg. **5**: 92 (1803).

KEY TO SPECIES

A. Stipes distinct. 5-20 cm long, lamina base rounded or unequally hastate, both halves decurrent to a

short distancc on stipe ..... 1. **P. floccolosa**

A. Stipes indistinct or very short, rarely up to 2 cm long; lamina base gradually tapered,

decurrent on stipe .....B

B. Rhizome scale margin entire, smooth ..... 2. **P. mannii**

B. Rhizome scale margin loothed or timbriate ..... 3. **P. porosa**

I. **Pyrrosia flocculosa** (D.Don) Ching, Bull. Chinese Bot. Soc. **1**: 66 (1935); Mehra, Ferns Muss.: 26 (1939); Loyal & Verma, J. Bombay nat. Hist. Soc. **57**: 488 (1960); Bir *et al.*, Pterid. Fl. Garhwal Him.: 20 (1983); Pande *et al.*,. Him. Res. & Dev. **3**: 40 (1984); Satija & Bir. Aspects Pl. Sci. **8**: 43 (1985); Hovenkamp, Leidcn Bot. series **9**: 179 (1986); Pangety & Punetha in Western Him. **1**: 407 (1987); Pande & Dashila, Indian Fern J. **5**: 86 (1988); Pande, Geobios new Reports **8**: 169 (1989); Indian Fern J. **7**: 151 (1990); Khullar *et al.*, Ferns Nainital: 187 (1991); Ill. Fern Fl. West Him. **1**: 160. t. 59 (1994); Chandra; Ferns India: 365 (2000).

Polypodium flocculosum D.Don, Prodr. Fl. Nepal.: 1 (1825); Hooker & Baker, Syn. Fil.: 351 (1867); Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 554 (1880); Hope, J. Bombay nat. Hist. Soc. **15**: 88 (1903); Duthie, Cat. Pl. Kumaun: 230 (1906).

Polypodium tomentosum Roxb. in Griff., Calc. J. Nat. hist. **4**: 483 (1844), *non* Thomas, *nec* Bory.

Niphobolus detergibilis (Hook.) Bedd., Ferns Brit. India: t. 162 (1863).

Polypodium detergibile Hook., Sp. Pl. **5**: 49 (1863).

Niphobolus flocculosus (D.Don) Spreng., Syst. Veg. **4**: 45 (1827); Bedd., Ferns Brit. India: t. 62 (1866); Handb. Ferns Brit. India: 331. t. 180 (1883).

Cyclophorus flocculosus (D.Don) C. Chr., Index Fil.: 199 (1905); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942); Chowdhury, Pterid. Fl. Upper Gangetic Plain: 73

(1973).

Rhizome short-creeping, thick, densely scaly, scales brown, lanccolate, margin entire or slightly fimbriate, apex acuminate, hair pointed. Stipes approximate 0.3-0.5(-1.0) cm distant on rhizome, 5-20 cm long, shorter than lamina, stout, thick, densely hairy; hairs light brown, arms needle-like, size variable, stalked, stalk 3-4-celled, armed hairs hyaline, arms closely coiled; rachis hairy, hairs as on stipe. Lamina simple, 7-25 (-35) x 2-3 (-8) cm, lanceolate or oblong-lanceolate, base rounded or unequally hastate, one-half ending before the other or both halves decurrent on stipe, apex acuminate, margin entire or undulate; texture succulent-coriaceous, lower surface brown or greyish - white, densely hairy, upper surface bright-green, hairy; veins immersed; costules indistinct, main lateral veins faintly raised on lower surface, oblique, anastomosing 10 form 10-15 areolae on either side of rachis. Sori immersed, many, round, small or slightly spreading along veinlets, in distinct regular rows between main lateral veins. Spores yellowish, 52.5-59.5 x 66.5-87.5 µm, exine smooth or faintly verrucose.

HABIT AT: Grows both as an epiphyte as well as lithophyte.

PLATE 15: **Pyrrosia flocculosa** (D. Don) Ching : A = Plant; B = Magnified part of lamina; C = Spores; D = Rhizome scale; E = Magnified part of rhizome scale; F & G = Hairs

DISTRIBUTION: Common in the region from 1300-2100 m altitude.

UTTARAKHAND:. NANITAL: Nainital, Khurpatal, Jeolikote, Gogaon, Ranobagh, Kathgodam, Bhimtal area, Mangoli, Bajoon, way to Ratighat.

INDIA: Jammu (Kathua); Himachal Pradesh; Sikkim; Darjeeling; Siliguri; Assam; Arunachal Pradesh; Meghalaya; Nagaland; Manipur; Tripura.

GENERAL DISTRIBUTION: Nepal; Bhutan; Thailand; Vietnam; Myanmar; Bangladesh.

2 **Pyrrosia mannii** (Gies.) Ching, Bull. Chinese Bot. Soc. **1**: 55 (1935); Dhir, Biblioth. Pterid. **1**: 117 (1980); Satija *et al.*, Bull. Bot. Surv. India **25**: 81 (1983); Dixit, Census Indian Pterid.: 55 (1984); Satija & Bir, Aspects Pl. Sci. **8**: 44 (1985); Hovenkamp, Leinden Bot. series **9**: 212 (1986); Pangtey & Punetha in Western Him. **1**: 407 (1987); Pande, Indian Fern J. **7**: 151 (1990); Khullar, Him. Res. & Dev. **7**: 61 (1988); Ill. Fern Fl. West Him. **1**: 165. t. 61 (1994); Khullar *el al.*, Ferns Nainital: 188 (1991); Chandra. Ferns India: 369 (2000).

Niphobolus mannii Gies., Farngatt. Niph.: 107 (1801).

Polypodium fissum sensu Clarke, Trans. Linn. Soc. Lond. II (Bot.) **1**: 554 (1880); Duthie, Cat. Pl. Kumaun: 230 (1906), *non* (Blume) Baker in Baker & Hooker (1867).

Niphobolus fissus sensu Hook., Sp. Fil. **5**: 48 (1863); Bedd., Handb. Ferns Brit. India: 330 (1883), *pro parte, non* Blume (1828).

Niphobolus floccigerus sensu Bedd., Ferns Brit. India Suppl.: 22. t. 386 (1876), *non* Blume (1828).

Pyrrosia fissa sensu Mehra, Ferns Muss.: 26 (1939), *non* (Bl.) Mehra. (1939). *Cyclophorus porosus* C.Chr., Index Fil.: 200 (1905). *pro parte;* Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942).

Rhizome short-creeping, thick, scaly; scales brown, concolorous, lanceolate, margin entire, apex acuminate. Stipes approximate, 0.1-0.3 cm distant on rhizome, very short, c 1 cm long or none, light-brown, hairy; hairs light-brown to dark-brown, arms acicular, size variable, stalked, stalk long, *c* 8-celled, coiled-armed hairs light-brown to almost hyaline, mixed hairs with very short straight arms and a few long coiled ones; rachis hairy, hairs ason stipe. Lamina 15.0-45.0 x 1.0-1.5 cm, oblanceolate or lanceolate or linear lanceolate, base long attenuate gradually narrowed and extending almost to the very base of stipe, apex acute or acuminate, margin entire, sometimes irregular or even pinnately lobed; texture herbaceous, lower surface densely hairy, upper surface sparsely hairy; veins indistinct; veinlets anastomosing to form *c* 8-areolae on either side of rachis; areolae with 36 free, mostly unbranched included veinlets. Sori immersed, round, scattered in irregular rows. Spores yellowish, 38.5-52.5 x 52.5-84.0 µm, exine almost smooth or with sparse subglobose verrucae.

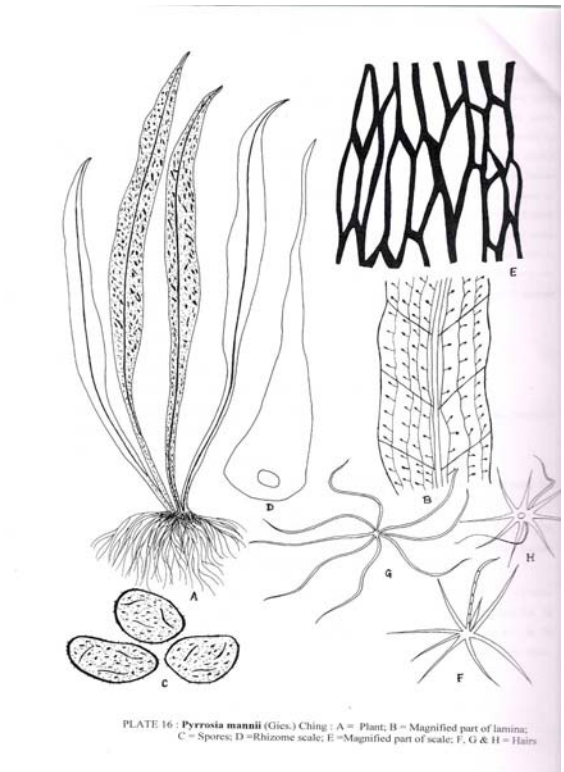

PLATE 16 : **Pyrrosia mannii** (Gies.) Ching : A = Plant; B = Magnified part of lamina; C = Spores; D =Rhizome scale; E =Magnified part of scale; F, G & H = Hairs

HABITAT: Grows as an epiphyte.

DISTRIBUTION: Occasional between 800 and 1500 m altitude.

UTTARAKHAND: NAINITAL: below Dhobighat, Dogaon to Jeolikote, Sattal, Bhimtal area, Mangoli-Kaladhungi road, Ramgarh.

INDIA: Sikkim; Darjeeling; Meghalaya; Nagaland; Tripura.

GENERAL DlSTRIBUTION: Nepal; Bhutan; China; Thailand; Malaysia; Myanmar; Sri Lanka.

3. **Pyrrosia porosa** (Presl) Hovenkamp, Blumea **30**: 208 (1984); Leiden Bot. Ser. **9**: 226 (1986); Fraser-Jenkins, Pakistan Syst. **5**: 91 (1992); New Sp. Syndrome Indian Pterid. & Ferns Nepal: 232 (1997); Chandra, Ferns India: 372 (2000).

Pyrrosia stictica (Kunze) Holtt., Novit. Bot. Inst. Carol. Prag. **1968**: 31 (1969); Verma & Khullar, Fern Gaz. **12**: 88 (1980); Satija *et al.*, Bull. Bot. Surv. India **25**: 76 (1983); Dixit, Census Indian Pterid.: 56 (1984); Satija & Bir, Aspects Pl. Sci. **8**: 50 (1985); Hoyenkamp. Leiden Bot. series **9**: 218 (1986); Khullar *et al.*, in Western Him. **1**: 359 (1987); Pangtey & Punetha in Western Him. **1**: 407 (1987); Pande & Dashila, Indian Fern J. 5: 86 (1988); Pande, Indian Fern J. **7**: 151 (1990); Khullar *et al.*, Ferns Nainital: 189 (1990); Pangtey *et al.*, New Botanist **18**: 220 (1991); Khullar, Him. Res. & Dev. **7**: 61 (1988); III. Fern Fl. West Him. **1**: 169. t. 63 (1994).

Niphobolus sticticus Kunze, Linnaea **24**: 257 (1851).

Polypodium sticticum (Kunze) Mett., Polyp.: 128 (1856).

Polypodium porosum (Presl) Wall. *ex* Mett., Polyp.: 128 (1856).

Niphobolus fissus sensu Bedd., Ferns Brit. India: II (1870); Handb. Ferns Brit. India: 330 (1883). *non* Blume (1828).

Niphobolus porosus Presl. Tent. Pterid.: 200 (1836).

Niphobolus mollis senSu Nayar & Chandra, Canad. J. Bot. **45**: 615-634 (1967). non Kunze (1848); Chandra, Ferns India: 369 (2000).

Cyclophorus porosus (Presl) Presl, Epim. Bot.: 130 (1851); Stewart, 150th Ann. Vol. Royal Bot. Gard. Calcutta **2**: 170 (1942).

Cyclophorus sticticus (Kunze) C.Chr., Index Fil.: 201 (1905).

Pyrrosia mollis sensu Nayar & Chandra, Bull. Nat. Bot. Gard. Lucknow **117**: 67 (1965); Canad. J. Bot. **45**: 615-634 (1967); Dhir, Biblioth. Pterid. **1**: 116 (1980); Dhir & Sood, Biblioth. Pterid. **2**: 85 (1981); Pangtey *et al.*, Him Res. & Dev. **1**: 160 (1982); Satija *et al.*,. Bull. Bot. Surv. India **25**: 76 (1983); Dixit, Census Indian Pterid.: 55 (1984); Singh *et al.*, Indian J. For. **9**: 9 (1986); Punetha & Kaur, J. Econ. Tax. Bot. **9**: 283 (1987).

Pyrrosia nayariana Ching & Chandra, Amer. Fern J. **54**: 62 (1964); Satija *et al.*, Bull. Bot. Surv. India **25**: 81 (1983); Dixit, Census Indian Pterid.: 55 (1984); Satija & Bir, Aspects Pl. Sci. **8**: 49 (1985); Khulllar *et al.*, Ferns Nainital: 188 (1991); Khullar, Him. Res. & Dev. **7**: 61 (1988); III. Fern Fl. West Him. **1**: 167. t. 62 (1964).

Rhizome short-creeping, thin, scaly; scales dark-brown with an almost blackish central region, lanceolate, surface hairy, margin fimbriate, filamntous projections long, basal part toothed, apex acuteor acuminate, not hair pointed. Stipes approximates very short or none or not clearly demarcated, light-brown, hairy; hairs persistent, light-brown; rachis hairy, hairs as on stipe. Lamina simple, 10.0 - 18.0 (-30.0) x 0.5 - 1.0 (-2.0) cm, oblanceolate or lanceolate or linear-lanceolate, base long attenuated gradually narrowed and extending almost to the very base, nearly as long as rest of the lamina, apex acute, margin entire; texture herbaceous or succulent-coriaceous, lower surface light-brown to dark-brown, densely hairy, upper surface deeply punctuate, bright green, glossy at maturity, hairy, hairs as on rachis; veins indistinct; veinlets anastomosing to form 3-5-areolae on either side of rachis, areolae with 2 or 3 free unbranched veinlets. Sori immersed, comparatively large, round, scattered in irregular rows. Spores yellowish, large, 42.0-66.5 x 84.0-94.5 µm, verrucose, verrucae subglobose, non-perinate.

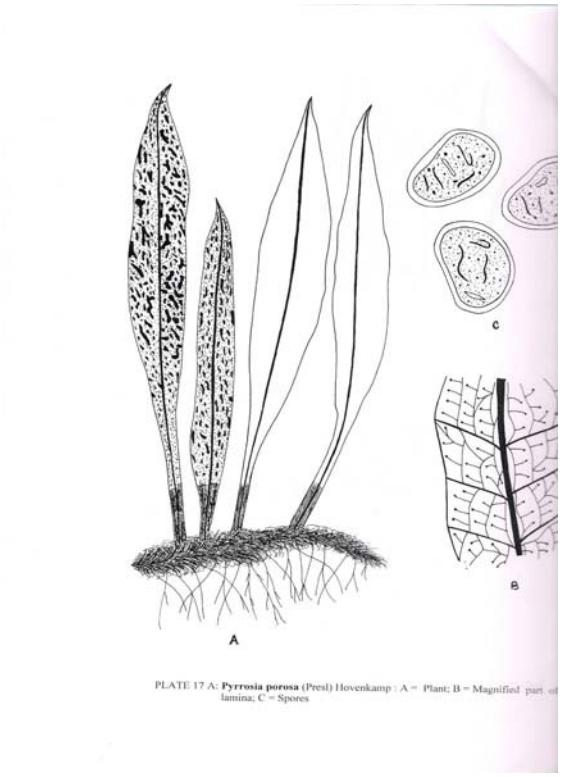

PLATE 17 A: **Pyrrosia porosa** (Presl) Hovenkamp : A = Plant; B = Magnified part of lamina; C = Spores

HABITAT: Grows as an epiphyte or occasionally as a lithophyte. DISTRIBUTION: A rather common fern from 1500-2200 m altitude.

UTTARAKHAND: NAINITAL: Mangoli-Kaladhungi road, Gola valley, Dogaon, between Dogaon and Jeolikote, Bhujiaghat, way to Ratighat.

INDIA: Jammu & Kashmir; Himachal Pradesh; Sikkim; Darjeeling; Meghalaya; Manipur; Tripura; Tamil Nadu; Kodaikanal; Nilgiri hills; Kerala.

GENERAL DISTRIBUTION: Pakistan; Nepal; Bhutan; China; Taiwan; S Japan; Thaialnd; Vietnam; Laos; Myanmar; Sri Lanka.

Excluded/Doubtful Species

I. **Pyrrosia mollis** (Kunze) Ching, Bull. Chinese Bot. Soc. **1**: 53 (1935). *Niphobolus mollis* Kunze, Bot. Zeit. **6**: 121 (1848).

2. **Pyrrosia nayariana** Ching & P. Chandra, Amer. Fern J. **54**: 62 (1964).

3. **Pyrrosia pannosa** (Mett. *ex* Kuhn) Ching, Bull. Chinese Bot. Soc. **1**: 58 (1935). *Polypodium pannosum* Mett. *ex* Kuhn, Linnaea **36**: 141 (1869).

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Electric Energy Supply In Nigeria, Decentralized Energy Approach

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Abstract: The analysis of Nigeria's electricity supply problems and prospects was done. The electricity demand in Nigeria far outstrips the supply which is epileptic in nature. The acute electricity supply hinders the country's development notwithstanding the availability of vast natural resources in the country. Nigeria is endowed with abundant renewable energy resources, the significant ones being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies. Decentralized Energy (DE) is the production of electricity at or near the point of use, irrespective of size, fuel or technology. The adoption of renewable energy technologies in a Decentralized Energy (DE) manner especially for rural communities and in stand-alone applications will improved electricity supply and enhance the overall economic development. [New York Science Journal. 2009;2(5):84-92]. (ISSN: 1554-0200).

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1. Introduction

With its rich supply of natural resources, Nigeria has become, quite naturally, heavily dependent on fossil fuels. But while thermal plants supply about 60 percent of our stationary energy grid and petroleum products help meet our transportation needs, we must continue to find ways to both reduce our dependence on fossil fuels and make our consumption of them less harmful to the environment.

Replacing fossil fuels with renewable energy is the ultimate goal, but as they currently account for 80% of global energy demand, it is not yet possible to do so and sustain even a basic standard of living. Indeed, although the volume of renewable is increasing at an enormous rate, it is still being outstripped by rising energy demand [1].

Electricity plays a very important role in the socio-economic and technological development of every nation. The electricity demand in Nigeria far outstrips the supply and the supply is epileptic in nature. The country is faced with acute electricity problems, which is hindering its development notwithstanding the availability of vast natural resources in the country. It is widely accepted that there is a strong correlation between socio-economic development and the availability of electricity.

The history of electricity in Nigeria dates back to 1896 when electricity was first produced in Lagos, fifteen years after its introduction in England. Despite the fact that its existence in the country is over a century, its development has been at a slow rate. In 1950, a central body was established by the legislative council, which transferred electricity supply and development to the care of the central body known then as the Electricity Corporation of Nigeria. Other bodies like Native Authorities and Nigeria Electricity Supply Company (NESCO) have licenses to produce electricity in some locations in Nigeria. Another body known as Niger Dams Authority (NDA) was established by an act of parliament. The Authority was responsible for the construction and maintenance of dams and other works on the River Niger and elsewhere generating

electricity by means of water power, improving and promoting fish brines and irrigation. The energy produced by NDA was sold to the Electricity Corporation of Nigeria for distribution and sales at utility voltages.

For over twenty years prior to 1999, the power sector did not witness substantial investment in infrastructural development. During that period, new plants were not constructed and the existing ones were not properly maintained, bringing the power sector to a deplorable state. In 2001, generation went down from the installed capacity of about 5,600MW to an average of about 1,750MW, as compared to a load demand of 6,000MW [2].

Nigeria Electric network grid is shown in Figure 1 below.

Figure 1. Nigeria Electric Grid Network. Source: Global Energy Network Institute (GENI)

2. Resources for Electricity Generation in Nigeria

Nigeria is a country that is blessed with a lot of resources that can be used to generate electricity such as coal, natural gas, oil, hydro and other renewable energy sources.

2.1 Coal

Coal was first discovered in Nigeria in 1909. Coal mining in Nigeria began in 1916 with a recorded output of 24,500 tons. Production rose to a peak of 905,000 tonnes in the 1958/59 with a contribution of over 70%

to commercial energy consumption in the country. Available data show that coal of sub-bituminous grade occurs in about 22 coal fields spread in over 13 States of the Federation. The proven coal reserves so far in the country are about 639 million tonnes while the inferred reserves are about 2.75 billion tonnes. Following the discovery of crude oil in commercial quantities in 1958 and the conversion of railway engines from coal to diesel, production of coal fell from the beginning of the sixties to only 52,700 tonnes in 1983 and contributed about 0.02% to commercial energy consumption in the country in 2001.

2.2 Oil

Oil exploration in Nigeria witnessed steady growth over the past few years. The nation had a proven reserve of 25 billion barrels of predominantly low sulphur light crude in 1999. This substantially increased to 34 billion barrels in 2004 and currently is about 36.5 billion barrels. The growth in reserves is attributable to improved funding of Joint Venture operations, timely payment of cash call arrears, introduction of an alternative funding scheme, the emergence of new production sharing arrangements and the opening up of new frontier and deepwater / offshore blocks. Based on various oil prospects already identified especially in the deepwater terrain and the current (2006) development efforts, it is projected that proven reserves will reach about 40 billion barrels by year 2010 and potentially 68 billion barrels by year 2030. Oil production in the country also increased steadily over the years; however, the rate of increase is dependent on economic and geopolitics in both producing and consuming countries. Nigeria's current production capacity is about 2.4 million barrels per day even though actual production is averaging around 2.4 million barrels per day partly due to the problems in the Niger Delta and OPEC production restriction. Average daily production is projected to increase to 4.0 million barrels per day by 2010 and potentially to over 5.0 million per day in year 2030.

In the downstream oil sub-sector, Nigeria has four refineries with a total installed capacity of 445,000 barrels per day and 5001 km network of pipeline from the refineries to 22 oil depots. The Federal Government also established petrochemical and fertilizer plants. The capacity utilization of these plants and facilities has been considerably low, due to the high level of decay arising from poor maintenance and operating conditions, under -funding, vandalization especially on the pipelines, and the various companies' lack of management autonomy for efficient operation. Consequently, annual domestic demand for petroleum products is not fully met by internal production and has to be supplemented by imports.

2.3 Natural Gas

Nigeria's proven natural gas reserves, estimated at about 187.44 trillion standard cubic feet in 2005, are known to be substantially larger than its oil resources in energy terms. Gas discoveries in Nigeria are incidental to oil exploration and production activities. Consequently, as high as 75% of the gas produced was being flared in the past. However, gas flaring was reduced to about 36% as a result of strident efforts by the Government to monetize natural gas. Domestic utilization of Natural gas is mainly for power generation which accounted for over 80% while the remaining are in the industrial sector and very negligible in the household sector. Given the current reserves and rate of exploitation, the expected life-span of Nigerian crude oil is about 44 years, based on about 2mb/d production, while that for natural gas is about 88 years, based on the 2005 production rate of 5.84 bscf/day.

2.4 Renewable Energy

Nigeria is endowed with abundant renewable energy resources, the significant ones being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies. The estimated capacity of the main renewable energy resources.

Except for large scale hydropower which serves as a major source of electricity, the current state of exploitation and utilization of the renewable energy resources in the country is very low, limited largely to pilot and demonstration projects.

The main constraints in the rapid development and diffusion of technologies for the exploitation and utilization of renewable energy resources in the country are the absence of market and the lack of appropriate policy, regulatory and institutional framework to stimulate demand and attract investors. The comparative low quality of the systems developed and the high initial upfront cost also constitute barriers to the development of markets.

2.4.1 **Hydropower**

Essentially, hydropower systems rely on the potential energy difference between the levels of water in reservoirs, dams or lakes and their discharge tail water levels downstream. The water turbines which convert the potential energy of water to shaft rotation are coupled to suitable generators.

The hydropower potential of Nigeria is very high and hydropower currently accounts for about 29% of the total electrical power supply. The first hydropower supply station in Nigeria is at Kainji on the river Niger where the installed capacity is 836MW with provisions for expansion to 1156 MW. A second hydropower station on the Niger is at Jebba with an installed capacity of 540 MW. An estimate for rivers Kaduna, Benue and Cross River (at Shiroro, Makurdi and Ikom, respectively) indicates their total capacity to stand at about 4,650 MW. Estimates for the rivers on the Mambila Plateau are put at 2,330MW. The overall hydropower resources potentially exploitable in Nigeria are in excess of 11,000MW [3].

Indeed small-scale (both micro and mini) hydropower systems possess the advantage, over large hydro systems, that problems of topography are not excessive. In effect, small hydropower systems can be set up in all parts of the country so that the potential energy in the large network of rivers can be tapped and converted to electrical energy. In this way the nation's rural electrification projects can be greatly enhanced.

2.4.2 **Solar Energy**

Solar radiation is the radiant energy that is emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy. The knowledge of the amount of solar radiation in a given location is essential in the field of solar energy physics. This in effect helps us to have a fair knowledge of the insolation power potential over the location [4].

Solar energy is the most promising of the renewable energy sources in view of its apparent limitless potential. The sun radiates its energy at the rate of about 3.8 x 1023 kW per second. Most of this energy is transmitted radially as electromagnetic radiation which comes to about 1.5kW/m^2 at the boundary of the atmosphere. After traversing the atmosphere, a square metre of the earth's surface can receive as much as 1kW of solar power, averaging to about 0.5 over all hours of daylight. Studies relevant to the availability of the solar energy resource in Nigeria have fully indicated its viability for practical use. Although solar radiation intensity appears rather dilute when compared with the volumetric concentration of energy in fossil fuels, it has been confirmed that Nigeria receives 5.08 x 1012 kWh of energy per day from the sun and if solar energy appliances with just 5% efficiency are used to cover only 1% of the country's surface area then 2.54 x 106 MWh of electrical energy can be obtained from solar energy. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day.

Solar energy technologies are divided into two broad groups namely solar-thermal and solar photovoltaic. In solar thermal applications, solar energy, as electromagnetic waves, is first converted into heat energy. The heat energy may then be used either directly as heat, or converted into 'cold', or even into electrical or mechanical energy forms.

Typical such applications are in drying, cooking, heating, distillation, cooling and refrigeration as well as electricity generation in thermal power plants.

In solar photovoltaic applications, the solar radiation is converted directly into electricity. The most common method of doing this is through the use of silicon solar cells. The power generating unit is the solar module which consists of several solar cells electrically linked together on a base plate. On the whole the major components of a photovoltaic system include the arrays which consist of the photovoltaic conversion devices, their interconnections and support, power conditioning equipment that convert the dc to ac and provides regulated outputs of voltage and current; controller, which automatically manages the operation of the total system; as well as the optional storage for stand alone (non-grid) systems.

2.4.3 **Biomass**

Biomass energy refers to the energy of biological systems such as wood and wastes. Biomass energy is an indirect form of solar energy because it arises due to photosynthesis. The biomass resources of Nigeria can be identified as wood biomass, forage grasses and shrubs, residues and wastes (forestry, agricultural, municipal and industrial) as well as aquatic biomass.

Wood, apart from being a major source of energy in the form of fuel wood is also used for commercial purposes in various forms as plywood, sawn wood, paper products and electric poles. For energy purposes, Nigeria is using 80 million cubic metres (43.4 x 109 kg) of fuel wood annually for cooking and other domestic purposes. The energy content of fuel wood that is being used is 6.0 x 109MJ out of which only between 5 - 12% is the fraction that is gainfully utilized for cooking and other domestic uses.

2.4.4 **Wind Energy**

Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. Seasonal variations in the energy received from the sun affect the strength and direction of the wind. The ease with which wind turbines transform energy in moving air to rotary mechanical energy suggests the use of electrical devices to convert wind energy to electricity. Wind energy has also been utilized, for decades, for water pumping as well as for the milling of grains.

A study on the wind energy potentials for a number of Nigerian cities shows that the annual wind speed ranges from 2.32 m/s for Port Harcourt to 3.89 m/s for Sokoto. The maximum extractable power per unit area, for the same two sites was estimated as 4.51 and 21.97 watts per square metre of blade area, respectively. When the duration of wind speeds greater than 3 m/s is considered than the energy per unit area is 168.63 and 1,556.35 kWh per square metre of blade area, again for Port-Harcourt and Sokoto.

Although use of wind energy for water supply has been known and used for hundreds of years, in recent times efforts have been directed largely towards the use of wind power for the generation of electricity and in the past twenty years or so rapid changes in technology have occurred and major wind powered generating plants have been installed, especially in the rural areas of the developed countries.

3. Inefficient and Unreliable Energy Supply System

In electric energy supply efficiencies of existing thermal plants are low. They are as low as 12% whereas efficiencies of up to 40% are attainable with modern technologies. Also substantial electricity is lost during transmission and distribution. These losses are sometimes more than 30% of the total electricity generated. Apart from these inefficiencies the reliability and availability of existing installed electric generation system is low. There is the serious problem of power unreliability over the years such that most industrial establishments and upper income households install very expensive generating sets amounting to over half of the total installed grid capacity. This constitutes huge economic losses to the Nigerian economy.

The major factors contributing to the above unreliability and inefficiency in the power sector are:

(i) Frequent breakdown of generating plants and equipment due to inadequate repairs and maintenance;

(ii) Lack of foreign exchange to purchase needed spare parts on time

(iii) Obsolete transmission and distribution equipment which frequently breakdown

(iv) Lack of skilled manpower

(v) Inadequacy of basic industries to service the power sector.

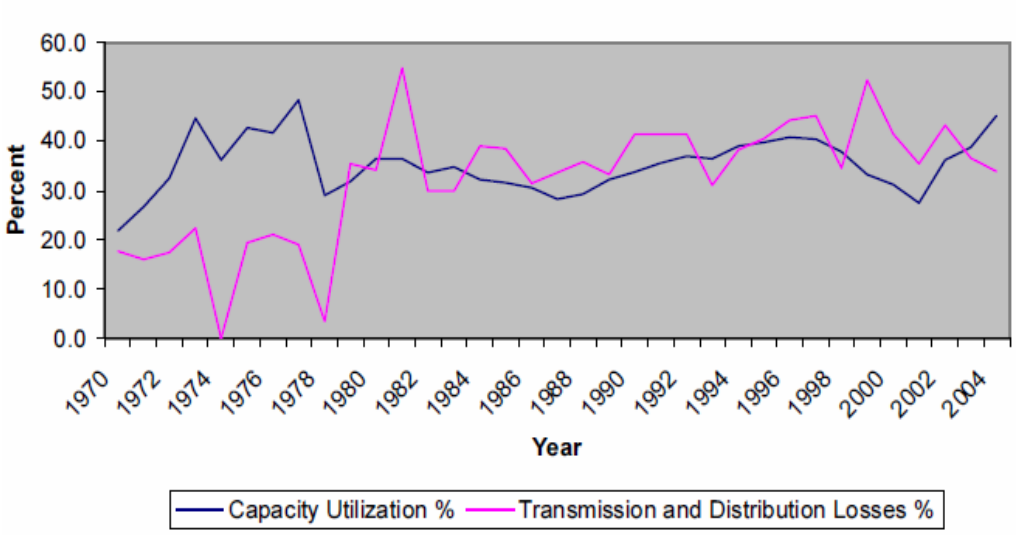

Figure 2. Indicator of Electricity Crisis in Nigeria 1970 to 2004 (Source: Iwayemi [6])

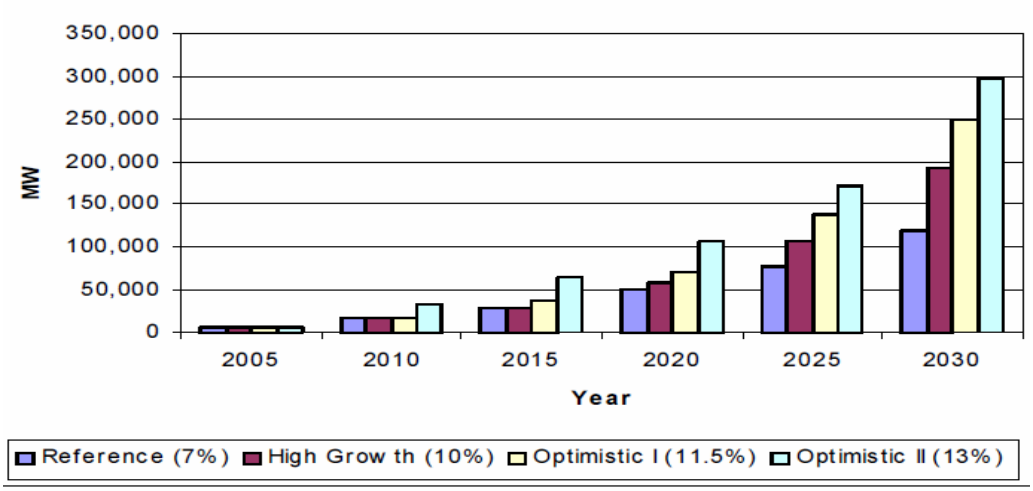

Figure 3. Electricity Demand Projection in Nigeria (Source: Sambo [2])

4. Decentralized Energy

Decentralized Energy (DE) is the production of electricity at or near the point of use, irrespective of size, fuel or technology. DE can be on-gird or off-grid and can be powered by a wide variety of fossil fuels [5]. It is an energy system that supplies an individual or small group of energy loads.

Currently, industrial countries generate most of their electricity in large centralized facilities, such as coal, nuclear, hydropower or gas powered plants. These plants have excellent economies of scale, but usually transmit electricity long distances.

Most plants are built this way due to a number of economic, health and safety, logistical, environmental, geographical and geological factors. For example, coal power plants are built away from cities to prevent their heavy air pollution from affecting the populace; in addition such plants are often built near collieries to minimize the cost of transporting coal. Hydroelectric plants are by their nature limited to operating at sites with sufficient water flow. Most power plants are often considered to be too far away for their waste heat to be used for heating buildings.

Low pollution is a crucial advantage of combined cycle plants that burn natural gas. The low pollution permits the plants to be near enough to a city to be used for district heating and cooling.

Distributed generation or Decentralized Energy (DE) is another approach. It reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used. This also reduces the size and number of power lines that must be constructed.

Typical distributed power sources in a Feed-in Tariff (FIT) scheme have low maintenance, low pollution and high efficiencies. In the past, these traits required dedicated operating engineers, and large, complex plants to pay their salaries and reduce pollution. However, modern embedded systems can provide these traits with automated operation and clean fuels, such as sunlight, wind and natural gas. This reduces the size of power plant that can show a profit.

What determines whether electricity generation is DE is not so much how electricity is generated rather where power is generated. DE technologies generate electricity where it is needed. Central generation on the other hand generates electricity in large remote plants and power must then be transported over long distances at high voltage before it can be put to use. It does not matter what technology one employs, whether it is used in connection with an existing grid or in a remote village, or whether the power comes from a clean renewable source or from burning fossil fuel: if the generator is 'on-site' it is DE. This means that, strictly speaking, DE could imply technologies that are not necessarily cleaner for the environment such as diesel generators without heat recovery. More often that not, however, DE is synonymous with cleaner electricity- indeed that is one of DE's main benefits.

Renewable DE is clean, and provides benefits not only to the individual investor but also to society on a whole. Like DE in general it can provide significant benefits: environmental, economic, efficiency, resource conservation, reliability and security.

What makes renewable DE distinct is that renewable DE technologies, as the name suggests, employ sources of energy to make electricity that can be replenished or that do not run-out over time. Sun and wind are perpetual and biomass is another word for fuel that comes from things that grow back including wood waste, agricultural residues etc.

However, just because a technology is renewable does not mean it can be considered DE. There is a strong argument that to use renewable electricity technologies optimally they should be used in a decentralized application but this is not always the case. Certainly renewable resources naturally occur in a decentralized manner: every year, the sun pours the equivalent of 19 trillion toe of energy onto the earth's surface a small fraction of which would be sufficient to meet all the world's energy demand (~9 billion toe per year) several times over. The energy the sun shines down however is not concentrated- rather spread evenly around the world. The case is similar with other renewable resources such as wind, hydro, geothermal and biomass. Renewable energy, therefore, can be used in DE applications and non DE applications but it is used optimally in DE applications.

DE can be broken into two main divisions:

(i) High efficiency cogeneration of heat and power, with capacities ranging from 1 kW to over 400 MW and which include reciprocating engines, gas turbines, steam turbines, fuel cells and micro turbines. Cogeneration, also known as combined heat and power or CHP, is a proven and reliable concept that recycles heat that is a byproduct of all combustion-based electrical generation and has been used widely in industry and buildings throughout the world.

(ii) On-site renewable energy systems and energy recycling technologies that capture otherwise wasted energy. These can include photovoltaic and biomass systems, on-site wind and water turbine generators, plus systems powered by gas pressure drop, exhaust heat from industrial processes, and low energy content combustibles from various processes.

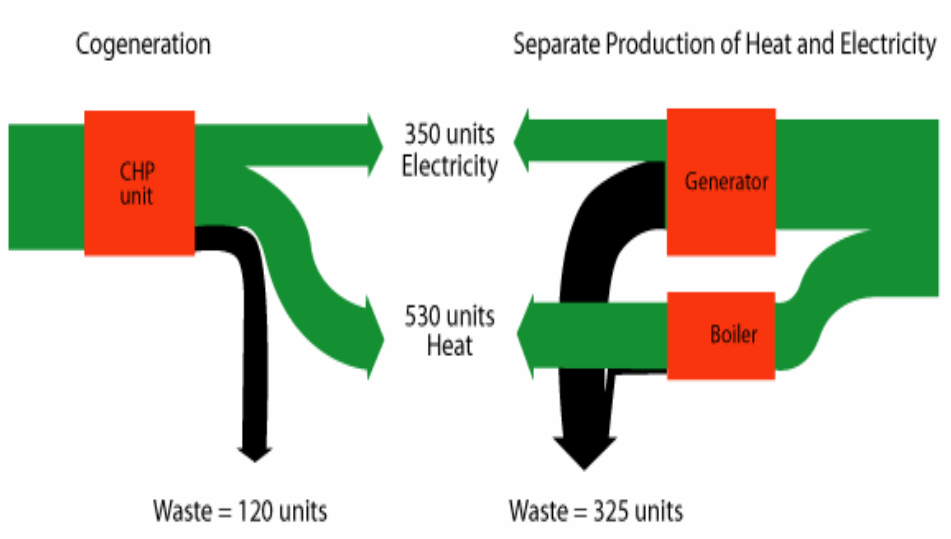

Figure 4. Cogeneration of Heat and Power (Source: WADE [5])

Figure 5. Comparison of Decentralized and Centralized Renewable Wind Technologies (Souce: WADE [5])

5. Electricity Supply Mix

Large hydro accounted for about 31.30% of grid electricity generation by 2005 while natural gas accounted for the balance of 68.30%. An analysis of the country's energy resource base clearly show that the nation stands to benefit immensely by ensuring that petroleum products are made to last for as many years to come as possible so they continue to serve as revenue earners and fuel the industrial sector for as many years as possible.

This can only be realized after the adoption of as many energy types as possible within the energy mix of the country in a Decentralized Energy (DE) manner. The clear and practical approach is to adopt the renewable energy sources of solar, biomass, wind energy and small-scale hydropower plants for as many applications as possible. This approach is supported by the fact that all or at least two renewable energy sources are available in all parts of the country, the technology for their use is mostly simple and for which the capacities exist; their use does not require the heavy financing and they are not associated with serious environmental implications.

Table 1. Nigeria Future Installed Electricity Generation Capacity by Fuel (%). (Source: Sambo [2])

Fuel Type	**2010**	**2015**	**2020**	**2025**	**2030**
Coal	0.0	9.9	13.8	15.3	15.6
Gas	78.6	48.5	53.5	53.0	59.0
Hydro	21.3	18.9	13.6	10.7	8.6
Nuclear 0.0	9.4	5.3	8.3	6.7	
Solar	0.1	13.1	11.0	10.4	8.3
Wind	0.0	0.1	2.9	2.3	1.8

6. Conclusions

Nigeria is blessed with abundant resources of fossil fuels as well as renewable energy resources. There is the urgent need to encourage the evolvement of an energy mix that will emphasize the conservation of petroleum resources in such a manner that will lead to their continued exportation for foreign exchange earnings for as many years to come as possible. The adoption of renewable energy technologies in a Decentralized Energy (DE) manner especially for rural communities and in stand-alone applications will surely lead to reduced internal consumption of petroleum products.

The major advantages of the renewable energy technologies include the simplicity of the technologies, ease of maintenance as well as their enhanced environmental friendliness over fossil fuel systems. There is clear evidence of the use of renewable energy technologies at the moment. However there is the necessity to increase the use of the system especially for rural development.

In view of the apparent reluctance of local entrepreneurs to adopt the mature and proven renewable energy systems for mass production and subsequent commercialization there is need to actively promote the training of local craftsmen on the design, construction, operation and maintenance of appropriate energy end - use devices. After such training programmes soft loans could be made available to the craftsmen so they can commence the production and subsequent sale of the devices.

There is a growing worldwide acceptance that decentralized electric generation will reduce capital investment needs compared to central generation with its supporting transmission and distribution systems. In addition, decentralized generation can lower the cost of electricity, reduce pollution, reduce production of greenhouse gas, and decrease vulnerability of the electric system to extreme weather and militants attacks. While DE is unlikely to replace central power entirely, it is believed that the share of DE in global power generation will increase dramatically in coming years, with important benefits to all segments of the population and significant environmental benefits.

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5-O-Glycosylated Flavonols from *Cheilanthes grisea*

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Abstract: *Cheilanthes grisea* Blanford, a rare fern of Kumaun hills, is a member of psinopteridacea family of leptosporangiate group of ferns. The fern fronds of *Cheilanthes grisea* (Voucher species No. 21) was collected from Pithoragarh district of Kumaun hills, Uttarakhand (India) altitude ranging 2800-3000m. About 500gm air dried fern fronds were extracted sequentially with 80%MeOH and 60%MeOH by cold percolation methods for six days. The two extracts were combined and concentrated under reduced pressure until only H_2O layer remained. It was partitioned with CH_2Cl_2:H_2O (1:1). The CH_2Cl_2 soluble was evaporated to dryness and residue was chromatographed on cellulose CC using 50%HOAc as an eluent. A blue fluorescent band observed between two dark purple fluorescent bands on CC with UV light. It was eluted and collected separately by monitoring CC with UV light. The eluent of blue fluorescent band was concentrated and chromatographed on Whatman No. 3 PC using 30%HOAc as an eluent. Three blue fluorescent bands observed on PC, representing Frac-1, Frac-2 and Frac-3 at Rf 45, 52 and 56 were eluted separately and gave three flavonoidal compound [1], [2] and [3] respectively. On the basis of chromatographic behaviour, hydrolytic method (acid, enzymatic and HI), H_2O_2 oxidation, UV, MS and ^{1}HNMR studies, compounds [1], [2] and [3] were identified as quercetin-3-OCH_3-5-O-β-D glucoside, kaempferol-3-OCH_3-5-O-β-D-glucoside and quercetin-3, 4'-dimethyl ether-5-O-β-D glucoside respectively. [New York Science Journal. 2009;2(5):93-95]. (ISSN: 1554-0200).

Keywords: *Cheilanthes grisea*, rare species, Kumaun Himalaya

Introduction

Cheilanthes Swartz, a group of leptosporangiate ferns of family psinopteridaceae, distributed widely in temperate and humid regions of Indian Himalayas. Nine species of *Cheilanthes* have been reported from the hills of central Himalayas (Pande, 1990). Various species of *Cheilanthes* have widely been recommended as medicines of traditional uses (Chopra *et al.,* 1958).

Therefore, *Cheilanthes* species have been screened for various biological activities (Banerjee and Sen, 1980). *C. grisea* Blanford is a rare species of Kumaun Himalaya. Literature survey revealed that the species of fern has neither been investigated for biological activities nor for active constituents. Present communication reveals the isolation and identification of flavonoidal compounds from *Cheilanthes grisea.* The extracts derived from other medicinal plants have widely been investigated for various Biological activities (Khetwal and Verma, 1983, 1984, 1986, 1990; Khetwal *et al*., 1985, 1986; Mishra and Verma).

Material and method

Cheilanthes grisea Blanford, family psinopteridacea, was collected from the hills of Pithoragarh district (Uttarakhand), altitude ranging, 2800m to 3000m. The authentification of species was made by Prof. P. C. Pande, Department of Botany, Kumaun University, SSJ Campus, Almora, Uttarakhand (India). Its voucher species No. 21 has been deposited in the Chemistry Department of Kumaun University SSJ Campus, Almora, Uttarakhand (India).

Extraction and isolation of flavonoidal compounds

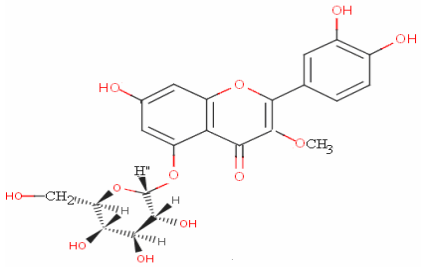
About 500gm of fern fronds of *C. grisea* was extracted sequentially with 80%MeOH and then 60%MeOH by cold percolation methods for six days. Two extracts were combined and reduced pressure until H_2O layer remained. It was partitioned with CH_2Cl_2: H_2O (1:1). The CH_2Cl_2 fraction was chromatographed on cellulose CC using 50%HOAc as an eluent. A broad blue fluorescent band was observed on CC under UV light. It was eluted separately. The eluent was dried under reduced pressure and residue was further chromatographed on Whatman No. 3 PC using 30%HOAc. Three blue fluorescent bands were observed on PC at Rf, 45, 52 and 56, representing Frac-I, II and III. Each fraction was cut and eluted separately gave

compounds [1], [2] and [3] respectively. The eluent of each fraction was re-chromatographed in BAW and finally purified on Sephadex LH-20 CC.

Results and discussion

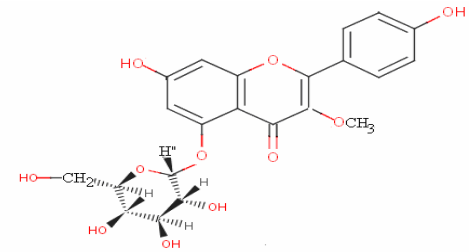
A blue fluorescent band derived from 30%HOAc fractionation of CH_2Cl_2 soluble on cellulose CC, afforded three compounds [1], [2] and [3]. They were isolated by the RPPC followed by their final purification on Sephadex LH-20 CC. The compound [1] a blue fluorescent on PC, gave a molecular ion at m/z 447 $[M-H]^-$ in FABMS (-ve) calculated for $C_{22}H_{22}O_{12}$ and other prominent ion observed at m/z 315 $[M\text{-glucosyl}]^-$, represent an aglycone. The blue fluorescent spot turned to orange after spraying with methanolic solution of Naturstoffreagenz A (NA) reagent, indicating the presence of ortho-di-hydroxyl group in the B-ring. UV spectra of compound [1] in MeOH ($\lambda_{max,}$ nm) gave two absorption bands at 255 (band II) and 353 (band I) and shifts obtained with diagnostic shift reagents, NaOMe (267, 401); NaOAc (268, 379); NaOAc+H_3BO_3 (260, 372); $AlCl_3$ (245, 378) and $AlCl_3$+HCl (251, 352), indicating the presence of free hydroxyls at C-3', C-4' and C-7 (Markham, 1982). The positive $AlCl_3$ shift which returned to neutral on addition of HCl indicated that the 5-hydroxyl was substituted (Mabry *et al.*, 1970).

Acid hydrolysis of [1] gave an aglycone, [1(a)] and glucose (CoPC). The aglycone was identified as quercetin-3-OCH_3 by MS studies: Mass spectra indicated the values m/z at 316$[M]^+$ 100%, 315(71%), 301$[M\text{-}CH_3]^+$, 298$[M\text{-}H_2O]^+$, 287$[M\text{-}HCO]^+$, 285$[M\text{-}OMe]^+$, 273$[M\text{-}CoMe]^+$, 153$[A+H]^+$ 137$[B_2]^+$. Hydrolysis of compound [1] with HI in presence of $NaHSO_3$, gave quercetin (CoPC). Finally, the compound [1] was identified as quercetin-3-OCH_3-5-O-β-D-glucoside by ^{1}HNMR studies in DMSO-d_6, 400 MHz: ^{1}HNMR showed five signals in aromatic region at δ 6.40 (1H, d, J=2.0Hz), δ 6.70 (1H, d, J=2.0Hz), δ 6.90 (1H, d, J=8.5Hz), δ 7.50 (1H, dd, J=8.5 and 2.0Hz) and δ 7.69 (1H, d, J=2.0Hz) attributed to H-6, H-8, H-5', H-6' and H-2' respectively of quercetin. The anomeric proton appeared as doublet at δ 4.78 (J=7.2Hz) and remaining protons of sugar appeared as multiplet at δ 3.0-4.20. A singlet appeared at δ 3.86 (3H, s), assignable to OCH_3 group attached at C-3.



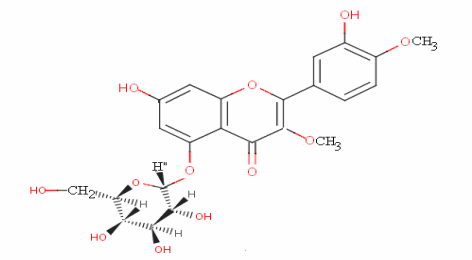
Quercetin-3-OCH_3-5-O-β-D-glucoside

The compound [2], a blue fluorescent on PC under UV light, gave a molecular ion m/z at 461$[M-H]^-$ in FABMS (-ve) and other prominent ion observed at 299$[M\text{-glucosyl}]^-$. On the basis of color reactions, compound [2] has free hydroxyls at C-4' and C-7 (Markham, 1982). The positions of free hydroxyls have also been supported by UV spectra in MeOH ($\lambda_{max,}$ nm): MeOH (257sh, 341); NaOMe (267sh, 319, 395); NaOAc (269, 311,376); NaOAc+H_3BO_3 (257sh, 343); $AlCl_3$ (256sh, 340) and $AlCl_3$+HCl (257sh, 341), indicating a flavone with disustituted at C-3 and C-5 (Mabry *et al.*, 1970). Acid hydrolysis of compound [2], gave kaempferol-3-O-CH_3 (CoPC) and glucose (CoPC). In ^{1}HNMR the sugar region of the compound [2] was found similar to the corresponding sugar region of compound [1]. Thus, the compound [2] was identified as kaempferol-3-O-CH_3- 5-O-β-D-glucoside.



Kaempferol-3-OCH_3-5-O-β-D-glucoside

FABMS (-ve) of compound [3] gave a molecular ion m/z at 491 $[M-H]^-$ and prominent ion observed at 329 $[m/z\ 491\text{-glucosyl}]^-$, represent an aglycone. Acid hydrolysis of compound [3], gave quercetin-3, 4'-dimethyl ether and identified by ^{1}HNMR studies in DMSO-d_6, 400 MHz: ^{1}HNMR showed four signals in aromatic region at δ 6.18 (1H, d, J=2.0Hz), δ 6.38 (1H, d, J=2.0Hz), δ 7.08 (1H, d, J=9.0Hz) and 7.50-7.60 (2H, m for H-2' and H-6'). Two singlet at δ 3.87 (3H, s) and 3.96 (3H, s) represent OCH_3 groups attached and C-5 position. Thus, aglycone was identified as quercetin-3, 4'-di-OCH_3 (CoPC). ^{1}HNMR studies in DMSO-d_6, 400MHz of compound [3] gave δ 6.63(1H, d, J=2.0Hz), δ 6.75 (1H, d, J=2.0Hz), δ 7.09 (1H, d, J=9.0Hz) and δ 7.50 to 7.61 (2H, m) represent H-6, H-8, H-5', H-2' and H-6' respectively. The anomeric proton singlet appeared at δ 4.80 (1H, d, J=7.5Hz). Thus, the compound [3] was identified as quercetin-3, 4'- dimethyl ether-5-O-β-D- glucoside.



Quercetin-3, 4'- dimethyl ether-5-O-β-D- glucoside

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关于压强涨落的疑难

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内容提要：在计算压强的涨落时，吉布斯的系综理论遇到了困难：从这个理论不能导出准热力学方法的压强涨落公式；不仅如此，当否勒应用系综理论计算理想气体的压强涨落时，得出一些不合理的结论。本文证明：诸如此类的困难都是由一个疏忽引起的。只要选择了合理的相变量，有关的问题将迎刃而解。[New York Science Journal. 2009;2(5):96-101]. (ISSN: 1554-0200).

关键词：吉布斯系综理论；否勒；系综理论；哈密顿函数；压强涨落的疑难；特征相变量

1. 引言

物理学中有许多历史遗留问题，其中之一是“关于压强涨落的疑难”，王竹溪教授[1]在他写的《统计物理学导论》一书中，把这一疑难表述为：“如何从系综理论推导出准热力学方法的压强涨落公式来，还不是很清楚的。”本文将解决这一问题。

2. 三个问题

吉布斯的系综理论把一个热力学体系的微观状态理解为一个理论力学的系统，由该系统的哈密顿函数来描述。该函数除了表示系统微观状态的“相变量”（正则变量）以外，还含有一组“外参量”，它们是热力学中的“几何位形变量”。

为了计算压强涨落，我们仅需考虑H(q, p; V)这种形式的哈密顿函数，其中(q, p)是全体“相变量”的略写，体积V则是它唯一的外参量。对于这一系统，任一热力学量ϕ的微观值是某一“相函数”f(q, p; V)，用[f(q, p; V)]表示f(q, p; V)的“系综平均值”则有：

$$\phi = [f(q, p; V)]。$$

例如，内能U的微观值是哈密顿函数H(q, p; V)，从而

$$U = [H(q, p; V)]; \tag{1}$$

而压强P的微观值则是偏导数$-(\frac{\partial H}{\partial V})_{qp}$，从而

$$P = [-(\frac{\partial H}{\partial V})_{qp}]。 \tag{2}$$

此外，热力学量ϕ的“涨落”的定义是

$$Flu(\phi) \equiv [(f - [f])]^2 = [f^2] - [f]^2。$$

令

$$\pi(q, p; V) \equiv -(\frac{\partial H}{\partial V})_{qp}, \tag{3}$$

则压强的涨落的定义是

$$Flu(P) \equiv [\pi^2] - [\pi]^2。 \tag{4}$$

根据系综理论，从(3)式与(4)式可得到

$$Flu(P) = kT\{[(\frac{\partial \pi}{\partial V})_{qp}] - (\frac{\partial P}{\partial V})_T\}。 \tag{5}$$

和其他热力学函数的涨落公式相比，这一公式显得格格不入，表现为如下三个问题：

第一，(5)式中的$[(\frac{\partial \pi}{\partial V})_{qp}]$不能用热力学函数来表示。

第二，对于正则系综，体积和分子数没有涨落，在这一条件下，用准热力学方法得到的压强涨

落公式是

$$\mathrm{Flu}(P) = kT\{(\frac{\partial P}{\partial V})_S - (\frac{\partial P}{\partial V})_T\}。 \tag{6}$$

从系综理论理应能导出(6)式，但如何从系综理论推导出(6)式来，还是一个问题。

第三，英国物理学家否勒[2]（R. H. Fowler）把(5)式应用于理想气体，得出了极为不合理的结论。

下面，我们将依次考察这些问题。

3. 否勒的烦恼

首先考察第三个问题。否勒考虑如下系统：容器中盛有N个相同的单原子分子组成的理想气体，单个分子的状态由相对地面的直角坐标 (x, y, z)及其共轭的动量 (p_x, p_y, p_z) 来描写。为了在计算相函数的平均值时，把外参量从“相宇”的“积分域”移至哈密顿函数中，否勒引进一个势函数，当某一分子在容器内时，这个势函数取值零，当该分子在容器外时，这个势函数取值无穷大。为了言简意赅，我们称该势函数为对应的容器的“域势”。

考虑一个直角六面体容器 C，其六个面的方程分别为：

$$x = 0，x = 1，y = 0，y = 1，z = 0，z = V，$$

从而其底面的面积为 1，高为 V，容器的容积为 V。

引进“壁势”

$$\xi(x) \equiv \begin{cases} 0, & 当 x > 0， \\ +\infty, & 当 x < 0; \end{cases}$$

以及

$$\eta(x) \equiv \xi(x) + \xi(1 - x);$$
$$\zeta(x, y, z) \equiv \eta(x) + \eta(y) + \eta(z),$$

则对于气体的任一分子 a，有

$$\zeta(x, y, \frac{z}{V}) = \begin{cases} 0, & 当分子\ a\ 在容器\ C\ 内， \\ +\infty, & 当分子\ a\ 在容器\ C\ 外， \end{cases}$$

可见 $\zeta(x, y, \frac{z}{V})$ 就是容器C的域势。

于是单个分子的哈密顿函数表成：

$$\varepsilon = \frac{p^2}{2m} + \zeta(x, y, \frac{z}{V})。$$

其中，

$$p^2 \equiv p_x^2 + p_y^2 + p_z^2。$$

对气体的 N 个分子进行编号，则其中的第 k 个分子的哈密顿函数表成

$$\varepsilon_k = \frac{p_k^2}{2m} + \zeta(x_k, y_k, \frac{z_k}{V})。$$

为了书写方便，我们把上式的右边写成 $\{\frac{p^2}{2m} + \zeta(x, y, \frac{z}{V})\}_k$。于是气体的哈密顿函数表成

$$H(q, p; V) = \sum_{k=1}^{N} \varepsilon_k = \sum_{k=1}^{N} \{\frac{p^2}{2m} + \zeta(x, y, \frac{z}{V})\}_k, \tag{7}$$

其中的相变量 (q, p) 由 N 个分子的位置坐标与动量坐标组成。

根据(3)式与(7)式，压强的微观表达式为

$$\pi(q, p; V) = -(\frac{\partial}{\partial V})_{q,p} \sum_{k=1}^{N} \{\zeta(x, y, \frac{z}{V})\}_k。$$

可见为了计算压强涨落，必须计算“壁势”$\xi(x)$的导数，可是$\xi(x)$却不能求导。否勒把$\xi(x)$改成某一陡峭的连续函数，得出了一个压强涨落公式，不幸的是，按照否勒的这种思路，气体压强的涨落与容器壁的性能有关，这是不合理的。

此外，按照否勒的公式，压强的相对涨落与能量的相对涨落数量级不同，而其他热力学函数的相对涨落的数量级都是一样的。

关于否勒的公式，王竹溪教授在《统计物理学导论》一书中还提到另一位作者[3]的工作，这位作者承认否勒导出的结论是不合理的，但建议用改变“压强涨落”的定义来解决这一问题。诚然，如果允许在遇到不顺心的结果时就适当修改定义，则物理学将不再有任何疑难，正因为如此，这种方法在任何情况下都是不可取的。

4. 特征相变量

我们看到，从吉布斯开始，用系综理论计算压强涨落的工作可谓一路坎坷，问题一个接一个。为什么会这样呢？是前人有某种疏忽，还是在这里有某种隐蔽的物理学规律有待发现呢？为了回答这一问题，让我们用系综理论来计算一个已知的广义力。

考虑由N个相同的单原子分子组成的理想气体，置于一个离地面高度为h的容器中，则当容器的高度有变更δh时，对应的广义力W将克服重力作功$W\,\delta h$，其结果是诸分子的重力势能增加$Nmg\,\delta h$，根据功能原理，有

$$W = Nmg。$$

它是将盛在容器中的气体在重力场中举起时的“举力”，与气体诸分子所受的总重力$-Nmg$大小相等，方向相反。这个广义力的微观值与宏观值是一样的。

为了用系综方法计算广义力 W，必须给出容器的域势。为此，设容器是一正立方体，对于相对于地面的坐标系，其六个面的方程分别为

$$x = 0，\ x = 1，\ y = 0，\ y = 1，\ z = h，\ z = h + 1，$$

从而容器的域势可表成$\zeta(x, y, z - h)$，整个气体的哈密顿函数则表成

$$H(q, p; h) = \sum_{k=1}^{N} \{\frac{p^2}{2m} + mgz + \zeta(x, y, z - h)\}_k。 \tag{8}$$

其中 h 是这个哈密顿函数唯一的外参量，它是容器的底部离地面的高度。

根据系综理论，

$$W = (\frac{\partial H}{\partial h})_{qp}。 \tag{9}$$

(8)式与(9)式给出

$$W = \sum_{k=1}^{N} \frac{\partial}{\partial h}\{\zeta(x, y, z - h)\}_k。$$

于是我们又一次遇到对“壁势”$\xi(x)$求导的问题。如果按照否勒的思路从上式计算W，则不仅得不出$W = Nmg$，而且还会得出气体分子所受的重力依赖于容器壁的性能这一荒谬绝伦的结论来。

问题何在呢？原来我们忽略了一个细节：(8)式中的相变量(q, p)是描写诸分子的“状态”的变量，从而(9)式中的偏导数要求(q, p)不变本来是要求诸分子的“状态”保持不变，特别是“诸分子都在容器之内”这一条件保持不变。但按照容器的域势$\zeta(x, y, z - h)$，当h足够大时，分子就不能留在容器之内。另一方面，固定(8)式中(q, p)让H对h的偏导，意味着诸分子相对地面的位置不变而改变容器的高度，这是根本不可能实现的。诚然，我们并没有意识到自己提出了这一要求，但我们确实不自觉地通过一个未经考察的数学公式表述了这一要求。这实在太粗心大意了，只要我们稍加注意，就肯定能避免这一疏忽。

在这里，只要用条件“诸分子相对容器的位置不变”来取代“诸分子相对地面的位置不变”，一切问题就都迎刃而解。换句话说，为了用系综理论求广义力 W，我们必须采用相对于容器的坐标系，从而必须作如下坐标变换

$$x' = x，\quad y' = y，\quad z' = z - h，$$

并取对应的动量坐标。把变换以后的正则变量记作 (q', p')，再引进

$$J(q', p') = \sum_{k=1}^{N} \{\frac{(p')^2}{2m} + \zeta(x', y', z')\}_k。$$

则哈密顿函数 H(q, p; h) 变换为

$$H(q', p'; h) = J(q', p') + \sum_{k=1}^{N} mg(z'_k + h)。$$

这样就立刻得到

$$W = (\frac{\partial H}{\partial h})_{q', p'} = Nmg。$$

由此可见，只要取诸分子相对于容器的位置坐标与动量坐标作为相变量，则系综理论给出的广义力 W 的表达式将与“功能原理”的结论一致。

一般地说，对于给定的哈密顿函数H(q, p; h)，如果对相变量 (q, p) 作一次包含参变量h的正则变换，变到新的相变量 (q', p')，则偏导数 $(\frac{\partial H}{\partial h})_{q', p'}$ 与 $(\frac{\partial H}{\partial h})_{qp}$ 将是不同的相函数，这两个相函数不可能都表示广义力W。由此可见，(9) 式仅对于一组特定的相变量才成立，我们称这一组相变量为外参量h的“特征相变量”。以前我们的疏忽在于，没有注意到最初采用的相变量并不是特征相变量。

我们看到，对于 (8) 式中的相变量 (q, p)，域势含有外参量h，而且外参量正是通过域势引进哈密顿函数的。而对于特征相变量来说，当外参量改变时，“诸分子都在容器之内”这一条件保持不变。这就意味着域势中不含外参量，从而在我们对外参量求偏导时，不再遇到对壁势求导的问题，不会得出对应的广义力依赖于容器壁的性能的荒谬结论。

5. 否勒的疏忽

回到压强涨落的问题，要计算压强的涨落，首先要给出压强的微观表达式，而只有对外参量 V 的“特征相变量”，(3) 式的偏导数才是压强的微观表达式。于是问题归结为怎样得到这组 V 的“特征相变量”。

设有由N个相同的单原子分子组成的理想气体，盛在一个正立方体容器中。取相对于地面直角坐标 (x, y, z)，容器的六个面的方程分别为

$$x = 0，\ x = a，\ y = 0，\ y = a，\ z = 0，\ z = a，$$

其域势为 $\zeta(\frac{x}{a}, \frac{y}{a}, \frac{z}{a})$，从而气体的哈密顿函数则表成：

$$H(q, p; V) = \sum_{k=1}^{N} \{\frac{p^2}{2m} + \zeta(\frac{x}{a}, \frac{y}{a}, \frac{z}{a})\}_k。$$

为了保证当 a 改变从而气体被压缩时，诸分子都仍然在容器之内，我们取如下“随动坐标”：

$$x' = \frac{x}{a}，\quad y' = \frac{y}{a}，\quad z' = \frac{z}{a}。$$

把x'的共轭动量记作p_x'，则有$p_x' = ap_x$，气体的哈密顿函数表成

$$H(q', p'; V) = \sum_{k=1}^{N} \{\frac{(p')^2}{2ma^2} + \zeta(x', y', z')\}_k。$$

考虑到$V = a^3$，并略去实际上不起作用的域势，则气体的哈密顿函数表成

$$H(q', p'; V) = V^{-2/3} \sum_{k=1}^{N} \{\frac{(p')^2}{2m}\}_k。$$

两端取对数再对 V 求偏导，可得到

$$(\frac{\partial H}{\partial h})_{q', p'} = -\frac{2H}{3V}。$$

从而有

$$\pi = \frac{2H}{3V}。$$

对于系综理论，体积 V 没有涨落，因此上式表明压强的相对涨落等于能量的相对涨落。

于是我们看到，否勒的烦恼是由于他选错了相变量。更确切地说，他根本没有想到在这里还有一个选择相变量的问题。这是他的疏忽，也是其他物理学家们的疏忽。

6. 一个关键的定理

在第二节，我们提到(5)式有三个问题，上面我们已经解决其中的最后一个问题。现在考察其他两个问题。

对于V的特征相变量 (q, p)，(2)式成立。比较(2)式与热力学关系

$$P = -(\frac{\partial U}{\partial V})_S,$$

再考虑(1)式，我们有

$$[(\frac{\partial H}{\partial V})_{qp}] = (\frac{\partial [H]}{\partial V})_S。$$

对于哈密顿函数 H(q, p; V)，上式给出了求“系综平均值”与求“对 V 的偏导”两个运算交换次序的法则。如果这一法则也适用于其他相函数。即如果有如下定理：

A 如果 (q, p) 是V的特征相变量，则对任意相函数f(q, p; V)，有

$$[(\frac{\partial f}{\partial V})_{qp}] = (\frac{\partial [f]}{\partial V})_S。 \tag{10}$$

则其他两个问题也迎刃而解。

事实上，将定理A应用于压强，我们得出结论：如果 (q, p) 是V的特征相变量，则有

$$[(\frac{\partial \pi}{\partial V})_{qp}] = (\frac{\partial P}{\partial V})_S。 \tag{11}$$

这样就把 $[(\frac{\partial \pi}{\partial V})_{qp}]$ 表成了热力学函数，从而解决了第一个问题。而有了(11)式

(5)式就过渡到(6)式，第二个问题也解决了。

于是全部问题归结为证明命题 A，而该命题可证明如下：

如果 (q, p) 是V的特征相变量，则H(q, p; V)是系统的能量的微观值，正是这个H(q, p; V)给出正则系综的分布函数 ρ(q, p; V, T)，而 ρ(q, p; V, T)给出任意相函数f(q, p; V)的系综平均值：

$$[f(q, p; V)] = \int f(q, p; V)\rho(q, p; V, T)\,d\Omega。$$

在这里，积分域是全相宇，dΩ 是相宇的体元。

设在某一无穷小可逆过程中，系统的体积变更 δV，对应地，[f]的变更为

$$\delta[f] = \int \rho\,\delta f\,d\Omega + \int f\,\delta\rho\,d\Omega。$$

根据系综理论，在可逆绝热过程（$\delta S = 0$）中，对应的分布函数保持不变（$\delta\rho = 0$）。因此，上式给出

$$(\delta[f])_S = \int \rho\,\delta f\,d\Omega。 \tag{12}$$

考虑到

$$(\delta[f])_S = (\frac{\partial [f]}{\partial V})_S\,\delta V$$

和

$$\int \rho\,\delta f\,d\Omega = \int \rho\,(\frac{\partial f}{\partial V})_{qp}\,\delta V\,d\Omega = [(\frac{\partial f}{\partial V})_{qp}]\,\delta V,$$

可从(12)式得到(10)式，定理 A 证完。

于是，我们得出结论：只要 (q, p) 是V的特征相变量，就可以从系综的压强涨落的定义得到准热力学方法的压强涨落公式，从而实现了王竹溪教授的遗愿，彻底消除了困扰了物理学数十年的“关于压强涨落的疑难”。

7. 结束语

由于疏忽，吉布斯的系综理论遇到了挫折，出现了“关于压强涨落的疑难”，并且长期遗留下来，为什么数十年来谁也解决不了这一问题呢？这是耐人寻味的。

我想，当一位物理学家着手写一本统计物理学专著时，难免会遇到这一问题，但作者未必有兴趣研究它，即使他研究，也肯定会浅尝辄止，原因有二：

第一，在物理学家们看来，凡是物理学中的久攻不克的问题，都蕴含某种大自然的隐蔽规律，这种规律只有通过某种匪夷所思的“新颖观念”才能发现。这种发现凭借的是“大胆而丰富的想象力”，而不是严格的推理与谨慎的计算。他们做梦也想不到，这个使得一代又一代统计物理学家束手无策的难题，竟然是由一个令人啼笑皆非的疏忽引起的。因此，按照人们已经习惯了的思想方法，这一问题根本就无从入手。

第二，在物理学领域里，只有研究前沿问题才能出成果，而像这样的历史遗留问题，尽管长期以来一直困扰着人们，即使解决了，也算不上成果。人们不愿把自己的时间与精力用在这种“费力不讨好”的工作上。

在物理学的这种大环境下，能像王竹溪教授那样承认自己对这个问题无能为力是需要勇气的，大多数作者会明智地回避这一问题。例如，前苏联物理学家兰道为物理学写了一套百科全书式的教程。对于涨落问题，他用“准热力学方法”计算了各种热力学量的涨落，也用系综理论计算了某些热力学量的涨落，唯独回避了用系综理论计算压强涨落的问题。

从这个例子我们看到一个事实：在物理学领域里有一种机制，任何一位物理学家只要偶然犯了一个错误，就会在这个领域里沉积下来，成为物理学的组成部分。不难想象，经过数世纪的日积月累，物理学所沉积的错误已经相当可观，堪与希腊神话中的奥革阿斯的牛圈中的牛粪相比。

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The Knotty Problem about Pressure Fluctuation

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Abstract：Computing the pressure fluctuation, Gibbsian ensemble theory came up against a difficulty: from this theory it is impossible to obtain the pressure fluctuation formula resulted from para-thermodynamics method; moreover, applying ensemble theory and calculating the pressure fluctuation of ideal gas; R. H. Fowler received some unreasonable outcomes. Herein, it is proved that such difficulty is resulted from a careless step; all knotty problems above will be solved smoothly provided a set of right phase variables is adopted. [New York Science Journal. 2009;2(5):96-101]. (ISSN: 1554-0200).

Key words：Gibbsian ensemble theory; R. H. Fowler; Hamilton function; the knotty problem about pressure fluctuation; characteristic phase variables

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为什么狄拉克不能从他的“大数假说”得出正确的结论

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内容简介: 20 世纪初, 有一些学者曾对引力常数 G 值是一个恒量表示怀疑. 1937 年，英国最富想象力的物理学家狄拉克曾提出“大数假说”. 他说:“自然界中出现的没有量纲的非常大的数是彼此相关的.” [1] “自然界中任何两个没有单位的大数,可以用简单的数学运算联系起来.”[2] 他根据这个假说, 直接得出了两个结论: 【1】. 万有引力常数 G 值反比于宇宙时间 t_b 的增加,即 $G \propto t_b^{-1}$. 【2】. 宇宙物质量 M_b 和物质粒子总数 N_p 随宇宙时间 t_b 的平方的增加而增加,即 $M_b(N_p) \propto t_b^2$.总的结果就是: $G \propto t_b^{-1}$, $M_b(N_p) \propto t_b^2$. 显然，他的意图是給 1929 年哈勃定律所发现的宇宙膨胀作一种规律性的解释。然而,他的结论是不对的。现在，只有用黑洞理论才可以证实狄拉克“大数假说”中所导出的上述错误结论。本文根据霍金黑洞理论的观点和公式所作的详细的计算表明：: G 仍然是常数而不是变数，$M_b(N_p) \propto t_b$. [New York Science Journal. 2009;2(2):102-107]. (ISSN: 1554-0200).

关键词：狄拉克的“大数假说”，G 是常数不是变数，哈勃定律，宇宙黑洞，

I. 狄拉克“大数假说”中 $G \propto t_b^{-1}$ 的思想产生的由来

按照狄拉克“大数假说”的思想, 将静电力场作用力 F_e 与引力场的作用力 F_g 加以比较.

以宇宙中实际的氢原子为例. 质子的质量 $m_p = 1.66\times10^{-24}$g, 电子的质量 $m_e = 9.11\times10^{-28}$g, 两个带电质点的电量 $e = -e = 1.602\times10^{-19}$ C , r 为两点电荷间的距离.

$G = 6.67\times10^{-8}cm^3/s^2{*}g$, $k = 9.0\times10^9$ N•m^2/C^2,对于万有引力场，

$F_g = Gm_pm_e / r^2 = 6.67\times10^{-8}\times1.67\times10^{-24}\times9.11\times10^{-28}/ r^2 = 101\times10^{-60}/ r^2$

对在真空中静电力场,

$F_e = k e^2/ r^2 = 9.0\times10^9$ N•m^2/C$^2\times (1.6\times10^{-19}C)^2/ r^2 = 9.0\times10^9\times10^5\times10^4\times (1.6\times10^{-19}C)^2/ r^2$

$= 23\times10^{-20}/ r^2$

令 $\eta = F_e/ F_g = k e^2/ Gm_pm_e = 23\times10^{-20}/101\times10^{-60} = 2.3\times10^{39}$ **(1)**

或者 $1/\eta = F_g/ F_e = 4.348\times10^{-40}$

在上面(1)中, 我们只能采用如氢原子中 2 个正反带电体间的吸引力.而如果采用两个相同电体间的排斥力,则在 $F_g = G m_pm_e / r^2$ 中, m_pm_e 就会变成 m_p^2 或者 m_e^2,而使(1)中的结果必然是η大于或者小于 2.3×10^{39} 的 1840 倍, 从而使(1)式和狄拉克的“大数假说”的数值相差太大而失去其存在的意义. 狄拉克以基本力的引力和电磁力的比值 $\eta = 2.3\times10^{39}$ 为基本条件, 他更进一步以宇宙的年龄 t_b 与原子时间(光通过电子经典半径 R_e 的时间) t_e 之比为单位来测算,其所得出数值也几乎是 $\eta = 10^{39}$。

取经典电子半径: $R_e = ke^2/ m_e C^2 = (4.803\times10^{-10})^2/(9.11\times10^{-28}\times9\times10^{20}) = 2.8179\times10^{-13}$ cm, 则光通过电子经典半径的时间 t_e, （以 esu 为单位，取 $e = 4.803\times10^{-10}$ 时，则 k=1），

∴ $\mathbf{t_e = R_e/C = 2.82\times10^{-13}\ cm/C = 2.8\times10^{-13}/3\times10^{10} = 0.934\times10^{-23}s,}$ (1a)

设取 $t_b/t_e = 2.3\times10^{39} = \eta$, 结果,

$t_b = 2.3\times10^{39}\times0.934\times10^{-23}s/3.156\times10^{7}=6.8\times10^{8}yrs$ (1b)

但宇宙时间$t_b = 6.8\times10^{8}$yrs不符合 1937 年时对宇宙观察的数据。

温柏格: “在 1930 和 1940 年代, 哈勃常数 H_0 被认为要大得多, 约为 170 公里/秒/百万光年, 这样, 宇宙的年龄 t_b 就大约是 20 亿岁(根据 170 公里/秒/百万光年，实算应当是 17.6 亿岁). 如果将引力制动考虑在内, 还应更小. ” [3]

假定狄拉克在 1937 年取， $t_b = 20\times10^{8}$yrs, 于是，$\eta_b = t_b/t_e = 20\times10^{8}yrs\times3.156\times10^{7} / (0.934\times10^{-23}s) = 6.76\times10^{39}$
$=2.94(2.3\times10^{39}) = 2.94\eta$

于是 $\eta_b = t_b/t_e = 6.76\times10^{39} = 2.94\eta \approx \eta$ (2)

因此，**$t_b = 20\times10^{8}$yrs 大约是狄拉克在 1937 年提出“大数假说”所采用的数值。**

从（1）和（2）式，狄拉克按照他的“大数假说” 在 1937 年近似地得出,

$$k e^2/ Gm_pm_e \approx t_b/t_e \quad (3)$$

在(3)式中, 因为 k, e, m_p ,m_e , 和 t_e 都是常数，他臆想地推测出,

$$G \propto t_b^{-1} \quad (4)$$

但是我们宇宙现今的实际年龄$t_r=137\times10^{8}$yrs, 所以. $t_r \approx 7\, t_b$，即是狄拉克在 1937 年所取年龄t_b的 7 倍。因此. **狄拉克的$t_b = 20\times10^{8}$yrs 只不过是一个估计数值，它与宇宙的实际年t_r相差太大。**如果G 是一个变数，从$t_b = 20\times10^{8}$yrs到 $t_r = 137 \times 10^{8}$yrs, 宇宙的年龄已经增加了近 7 倍。那么，现在的G 值就应当相应地比 1937 年减少 7 倍而变成 $G = 6.67\times10^{-8}cm^3/s^2{*}g/7 = 10^{-8}cm^3/s^2{*}$ g. G 的这种变化为什么没有能被测量出来呢？可见，$G \propto t_b^{-1}$ 是一个不可靠的结论。因此，狄拉克的“大数假说”中所选取宇宙时间$t_b = 20\times10^{8}$yrs的数值在当时虽然可以勉强被接受, 现在看来，实际上不过是数值的近似相等的巧合或者凑合.可见,由他的“大数假说”而建立的近似公式$k e^2/ Gm_pm_e \approx t_b /t_e$ 不是必然而是偶然成立的.**狄拉克是把数值的巧合当作为一般的规律**。所以实际上 $$k e^2/G\, m_pm_e \neq t_b /t_e \quad (5)$$

II. 狄拉克是如何得出宇宙物质量 M_b 和物质粒子总数（质子数）$N_p = (t_b/t_e)^2$?

人所共知，在 1937 年, 狄拉克**只能**从哈勃常数 H_0 计算出 M_b 和 N_p，从上面可知， 当 $H_0 \approx 170$km/s/Mly 时。相应地 $t_b \approx 20\times10^{8}$yrs, 于是, 相应地宇宙的密度$\rho_c$, M_b ， N_p 为，

$$\rho_c = 3\, H_0^2/8\pi\, G = 5.8\times10^{-28}\, g/cm^3 \quad (6)$$

$$M_b = 4\pi\rho_c R^3/3 = 4\pi\rho_c C^3 t_b^3/3 = 1.649\times10^{55}\, g \quad (7)$$

$$N_p = M_b/1.67\times10^{-24} = 9.87\times10^{78} = (3.14\times10^{39})^2 \quad (8)$$

$m_p = 1.66\times10^{-24}$ 为质子的质量。因此，**下面的等式(9)是极其符合狄拉克在 1937 年提出“大数假说”时的结果的**。设宇宙物质粒子总数为 N_p,

$N_p = (3.14\times10^{39})^2$, 由 (2) 式。$t_b/t_e = 6.76\times10^{39}$, 则 $(t_b/t_e)^2 = (2.6\times10^{39})^2$,

$$\therefore\ \mathbf{N_p = M_b/m_p \approx (t_b/t_e)^2} \quad \mathbf{(9)}$$

讨论： §1. 虽然(9)式在数值的相等上大致符合狄拉克的“大数假说”所需要的结果，即$N_p = (t_b/t_e)^2$ **和** $N_p \propto t_b^2$ ，但它绝对不是一个普遍的数学等式和方程式，**因为(9)式只有在$H_0 \approx 170$km/s/Mly 即$t_b \approx 20\times10^{8}$yrs的条**

件下，(9) 式才可以存在和成立。因此， (9)式只能是一种数字的巧合。但是上面 (7)式可直接转变为:

$M_b = 4\pi\rho_c R^3/3 = 4\pi(3H_0^2/8\pi G)C^3t_b^3/3 = 4\pi(3H_0^2/8\pi G)C^3t_b/3H_0^2 = C^3 t_b/2G$ (10)

(10)式才是一个完全的等式，它准确地证明了$M_b \propto t_b$. 狄拉克是不知道(10)式还是不愿意采用 (10) 式? 狄拉克可能为了他的“大数假说”的需要，有选择性地忘记或不采用 (10)式，而采用它的(9) 式，即$M_b \propto t_b^2$。

§2. 狄拉克对$N_p = t_b^2$也可以从他的$t_b G$ = 常数的假设中直接推导出来

如果按照狄拉克的“大数假说”的需要，G 是一个变数，从 (3)式可得,

$k e^2 t_e/m_p m_e = t_b G = \text{constant} = 1.42\times10^9\ cm^3/s*g$ (11)

从 (6),(7), (11) 和 (1a)式，以及 $H_0 t_b = 1$ 和 $t_e = ke^2/m_eC^3 = 0.934\times10^{-23}s$ (k=1)，可得，

$M_b = C^3 t_b^2/2Gt_b = C^3 t_b^2/2 (k e^2 t_e/m_p m_e) = 0.95\times10^{22}g\times t_b^2$ (12)

$N_p = M_b/m_p = 0.95\times10^{22}g\times t_b^2/1.67\times10^{-24} = 0.57\times10^{46} t_b^2$ (13)

(12) 和(13)式应当是狄拉克在 1937 年从 (11) 和(6) ，(7)式在 $Gt_b = \text{constant} = 1.42\times10^9\ cm^3/s*g$ 的条件下可以直接推导出来的. 这表明(9) 和 (13) 是用两种不同的方法得到了 $N_p = (t_b/t_e)^2$. 虽然狄拉克在 1937 年从(13) 式得到了“大数假说”中所需的较好的结果，但这并不能证明我们宇宙的实际演变和膨胀过程就能符合 (11), (12) 和 (13)式.

§3. 现在，让我们用最近科学家们观察和计算出来的较准确的宇宙年龄的数值 A_o 来检验 (11) 和 (13) 式的正确性。根据 WMAP 卫星的观测, 宇宙的准确年龄 A_o =137±1.3 亿年，误差大约 1%.[7] 于是,从 (10)式，宇宙现在的**实际质量** M_r ，

$M_r = C^3 t_b/2G = 0.875\times10^{56}g.$ (14)

而且，数值 $A_o = 137\times10^8$yrs 和 $M_r = 0.875\times10^{56}$g 还可以得到其它最近观测数据的旁证，例如, 哈勃常数 最近较准确的数值是 H_o = 73km/s/Mpc, 据此可得出 $A_o = 134\times10^8$yrs 和 $M_r = 0.856\times10^{56}$g.

现在用 (11) 和 (12)式来检查狄拉克的宇宙质量得出 $M_b = 0.95\times10^{22} t_b^2$(137 亿年) = 18×10^{56}g. 结果是:

$$\mathbf{M_b = 21\ M_r.} \quad (15)$$

再从(11)式, $G = 1.4\times10^9/t_b$. 由此可见，我们宇宙年龄从狄拉克在 1937 年所估计的 20×10^8yrs 到现在的 137×10^8yrs,年龄 增加了 13.7/2 =6.85 倍, 而引力常数也应减少 6.85 倍. 更何况,假如回首考察宇宙在大爆炸诞生的瞬间，即 $t_b = 10^{-43}$s 时, 从(11)式, $G = 1.4\times10^{52}\ cm^3/s^2*g$, 和(12)式, $M_b = 1.835\times10^{-64}$g. 于是可得, $M_b < 10^{-59}10^{-5}$ g，10^{-5}g 是普郎克质量，这表示 M_b 已经大大地深入到也许人类永远也不可能探知的普郎克领域。这是不可避免会从狄拉克“大数假说”得到的荒谬结果。

§4. 在狄拉克的 1937 年想象中，也许会把宇宙质量和粒子数的增加所表示的宇宙膨胀而产生的“物质创生” M_b (N_p) $\propto t_b^2$类比为与细胞的分裂随时间的增加相类似，因而在他当时看来，宇宙粒子数 N_p 随宇宙时间平方 t_b^2 的增加就是比较合理的。因为他的“大数假说”就是用类比法想象出来的。同时，由(7)式可知，在 1937 年的狄拉克年代，宇宙总质量($M_b=10^{55}$g)与质子质量之比约为 1.2×10^{78}，约为 10^{39} 的平方,这种错觉也可能误导了狄拉克坚信宇宙物质的总量是按照质子的平方的增加而增长的。

III. 狄拉克在 1937 年提出 “大数假说” 时,他当然不会知道以后发现的白矮星中子星,更不会知道黑洞. 因此狄拉克“大数假说”作为当时探讨宇宙的膨胀和演变中的奥秘还是有重要的启示作用的，因为 G值 随宇宙时

间 t_b 的增加而减少至少給哈勃在 1929 年所发现宇宙的膨胀给以某种勉强的解释。或者在自然界，无因次的大数之间存在某种联系，但由狄拉克“大数假说”所推导出的(11), (12) 和(13)则是完全错误的。 **现在，运用黑洞（BH）理论结合宇宙较准确的最新观察数据**，对宇宙从大爆炸到至今的的膨胀过程作计算和比较，其结果是非常一致和协调的。根据作者以前的论证,“我们的宇宙在大爆炸时诞生于许许多多**原始的最小引力黑洞(MGBH，$m_b=10^{-5}g$)**的碰撞和合并.宇宙现在仍然是一个超级巨大黑洞(UBH), **哈勃定律所展示的宇宙膨胀规律就是宇宙黑洞的膨胀规律。**宇宙今后也是黑洞並以黑洞的衰亡形式为终结”.[4][5][6] 因此,以黑洞的产生变化发展的数据来说明分析我们的宇宙的膨胀和发展规律是正确可靠的.[4][5][6] **宇宙大爆炸时的原始最小引力黑洞（MGBH = $m_b=10^{-5}g$)的数值计算如下:** [4][5][6]

原始最小引力黑洞质量 $m_b=10^{-5}g$, 它即是普郎克质量，从施瓦兹恰尔德解, $C^2/2=Gm_b/r_b$,

其完全膨胀后的半径（即视界半径） $r_b=1.5\times10^{-33}cm$,

取 $t_{bb}=r_b/C$ 为光通过原始最小引力黑洞的时间，$t_{bb}=1.5\times10^{-33}/C=0.5\times10^{-43}s$,

T_{bo} 是 MGBH 的温度, 从 $\mathbf{T_{bo}=(C^3/4GM_b)\times(h/2\pi\kappa)\approx 0.4\times 10^{-6}M_\theta/M_b}$，$T_b=0.65\times10^{32}k$.

黑洞内相当于质子质量的粒子数 $n_p=m_b/m_p=10^{-5}/1.67\times10^{-24}=0.6\times10^{19}$

现今观察和计算的我们宇宙的超级巨大黑洞（UBH）的数值计算如下: [4][5][6]

我们宇宙黑洞的精确年龄$A_o=13.7\times10^9$年，从$C^2/2=GM_b/R_b=GM_b/CA_o$。

我们宇宙质量$M_b=8.75\times10^{55}g$,

其完全膨胀后的半径（即视界半径）$R_b=CA_o=1.297\times10^{28}cm$,

光通过宇宙黑洞的时间$t_b=A_o=0.432\times10^{18}s$(即 137 亿年)。

黑洞的质子数$N_p=8.75\times10^{55}/1.66\times10^{-24}=5.23\times10^{79}$ 宇宙黑洞的温度$T_b=0.9\times10^{-29}k$,

根据上面原始最小引力黑洞(MGBH) 和现今宇宙的超巨大黑洞（UBH）对应项的比值如下:

对应的质量比值$R_m=M_b/m_b=8.75\times10^{55}/10^{-5}=8.75\times10^{60}$,

对应的黑洞视界半径比值$R_r=R_b/r_b=1.297\times10^{28}/1.5\times10^{-33}=8.65\times10^{60}$,

对应的时间比值$R_t=t_b/t_{bb}=0.432\times10^{18}/0.5\times10^{-43}=8.64\times10^{60}$,

对应的温度比值$R_T=T_b/T_{bo}=0.9\times10^{-29}/0.65\times10^{32}=13.85\times10^{-60}$,

黑洞的质子数的比值$R_n=N_p/n_p=5.23\times10^{79}/0.6\times10^{19}=8.72\times10^{60}$

IV. 分析与 结论:

§1. 上面 5 组比值的数值几乎完全相等，这完全表明运用黑洞（BH）理论结合宇宙较准确的最新观察数据来解释宇宙膨胀规律和宇宙物质M_b 以及质子数N_p 随时间准确地按正比例的增加是真正有效和可靠的。**5 组比值的数值的一致性同时证明只有在G = 常数的条件下，我们宇宙的各种膨胀数值才能达到真正的协调一致。**因此，可以完全正确地得出，

$$\mathbf{M_b\propto N_p\propto R_b\propto 1/T_b\propto t_b,\ G=常数,} \qquad (4a)$$

因此，狄拉克的结论 "宇宙物质M_b 以及粒子数N_p 随时间的平方的增加而增加，i.e. **$M_b(N_p) \propto t_b^2$ 和Gt_b = 常数**." **是不对的**. **因为他的这组公式只有在$H_0 \approx 170$km/s/Mly 即$t_b \approx 20\times10^8$yrs的特定条件下才可以勉强地存在和成立，而没有普遍的意义。**

§2. **为什么我们宇宙的膨胀规律与黑洞的膨胀规律完全一致**？从施瓦兹恰尔德对广义相对论（GTR）的解可得， $C^2/2 = GM_b/R_b$, 这是黑洞存在的必要条件。因 $R_b = CA_0 = Ct_b$, 于是，

$$\mathbf{M_b = C^3 t_b /2G} \qquad (4b)$$

由黑洞推导出的 (4b)式与由哈勃定律推导出的(10) 式是完全相等的。这清楚地证明哈勃定律所定义的宇宙的膨胀规律就是我们宇宙黑洞（UBH）的膨胀规律.

§3. 有趣的是，霍金在 1971 年指出宇宙中有一种特殊的黑洞--原初宇宙小黑洞 m_{bo}[4]，其质量大约是$\approx10^{15}$g 的数量级。设我们宇宙现今的年龄 τ_{b0}= 137 亿年，**如果 $\mathbf{m_{bo}}$ 现今尚能存在于宇宙中**，其质量按照霍金黑洞的寿命公式应该是：

$$\tau_{b0} \approx 10^{-27}\, \mathbf{m_{bo}}^{3}{}_{(s)} \text{ [4][8]} \qquad (4c)$$

$$\mathbf{m_{bo} \geq (10^{27}\times137\times10^8\times3.156\times10^7)^{1/3} = 0.756\times10^{15}g} \text{ [4]} \qquad (4d)$$

m_{bo} 内的质子数 $n_{bo} = \mathbf{m_{bo}}/m_p = \mathbf{0.756}\times10^{15}/1.67\times10^{-24} = 0.45\times10^{39}$. 同时该黑洞 **$m_{bo}$** 的视界半径 $r_{bo} = 2G\,\mathbf{m_{bo}}/C^2 = 10^{-13}$cm = 等于经典电子半径 R_e [参见 (1a)式], i.e， $r_{bo} = R_e \approx 10^{-13}$ cm, 于是, 光通过 r_{bo} 的时间 t_{bo} 等于 t_e [参见 (2)式]，即 $t_{bo} = t_e = R_e/C \approx 0.934\times10^{-23}$s。而黑洞的寿命 $\tau_{bo} \approx 10^{-27}(\mathbf{0.756\times10^{15}})^3 = 0.43\times10^{18}$s $\approx$ 137 亿年 = 宇宙现今年龄。于是，$\tau_{bo}/t_e = 4.6\times10^{40}$.

因此，该黑洞 m_{bo} 的明显特征是，

$$n_{bo} \approx \tau_{bo}/t_e \approx (10^{39}\sim10^{40}) \approx \mathbf{F_e/F_g = k\,e^2/Gm_pm_e} \qquad (4e)$$

(4e)式正表明狄拉克 "大数假说"中的等式(3)和(9)只是一个哈勃常数在$H_0 \approx 170$km/s/Mly 即$t_b \approx 20\times10^8$yrs的条件下的一个特例，而不可以普遍地运用。**只有黑洞的碰撞合并和吞噬外界能量-物质所产生的宇宙膨胀规律才完全符合哈勃定律，这是对哈勃定律的唯一的正确解释。** [4]作者也曾指出，m_{bo}这种黑洞也不可能残存在现今宇宙空间。[4]

§4. 从上面的分析和计算中，可以清楚地看出为什么狄拉克不能从 "大数假说"得出正确结论

【1】。. 在 1937 年, 无人知道黑洞（BH），霍金的黑洞理论和公式尚未出现。**而狄拉克仅仅知道原子和哈勃定律以及当时错误的哈勃常数**.他可能想象为我们宇宙只来源于原子，而宇宙随时间t_b的膨胀导致 "宇宙物质创生" 的M_b 和原子数N_p 的增加像细胞分裂那样地快速增加。并以$(t_b/t_e)^2$ 或 t_b^2 去量度M_b 和N_p 的增加。但从 (1)式 到 (9)式，**他采用了当时错误哈勃常数值H_o=170km/s/Mly 而相应的在 1937 年得出t_b = 20×10^8yrs,** 狄拉克并进而从错误数值的近似相等得出两个错误的结论: Gt_b = 常数,和 (9)式, $N_p = (3.14\times10^{39})^2$, $(t_b/t_e) \approx 6.76\times10^{39}$, $(t_b/t_e)^2 = (2.6\times10^{39})^2$, **然而我们宇宙现今的实际年龄是$A_o = 13.7\times10^9$yrs**, 据此，如按照狄拉克的(13)式,则推算出 $N_{p137} = 20.5\times10^{80} = (4.5\times10^{40})^2$, $t_{b137}/t_e = 4.5\times10^{40}$, 于是, $(t_{b137}/t_e)^2 = (2.15\times10^{40})^2$. 由此可见，比值 $N_p/(t_b/t_e)^2$ 从狄拉克 1937 年 3.14/2.6 = 1.2 到现在的 4.5/2.15 =2.11 已经增加了将近 1 倍。

【2】. **然而，狄拉克用t_b/t_e 为标准以量度M_b 和 N_b 的猜测思想还是很有意义的。首先，**通过公式(1)和(2)

的计算而得出$\eta = k e^2/ Gm_pm_e \approx t_b / t_e \approx 10^{40}$在宇宙学上具有深远的意义。[9] 但是这不能否定G作为常数在长期宇宙演化中真实作用。“如果G值和现在的数值有 1/10 的差异，它就会对恒星演化时消耗核燃料的速度产生重大的影响。，，，结果，太阳就会大大的缩短演化时间进入红巨星阶段。如果真的如此，地球就会在生命还没有得到充分发展之前就消失的无影无踪了。”[9] **其次，如果把光通过经典电子半径R_e 的时间t_e改换成光通过黑洞视界半径r_b的时间t_b，**按照黑洞理论，就可以算出如上所述正确的结果，即$R_t = t_b/t_{bo} = 8.64\times10^{60}$, $R_m = M_b /m_b = 8.75\times10^{60}$ 和 $R_n = N_p /n_p = 8.72\times10^{60}$, 于是，**$M_b /m_b = N_p /n_p = t_b/t_{bo} \approx 8.75\times10^{60}$. 由此可见，这些按照黑洞理论计算出的比率在G = 常数的条件下达到了完美的一致和协调，毫无巧合的痕迹。这也再次证明以黑洞理论解释宇宙的膨胀是正确可靠的。**由于在 1937 年没有发现黑洞和出现黑洞理论，这使得**狄拉克无法知道和运用 $t_b/t_{bo} = 8.64\times10^{60}$, 从而导致狄拉克从他的$t_b/t_e \approx 10^{39}$得出$G \neq$ 常数和$N_p = (t_b/t_e)^2$**的**错误结果。**

【3】. 重要的是，狄拉克用两个无因次大数的近似相等的巧合而建立普遍方程的思路是不对的。仅仅用两个特例就建立一组普遍公式的作法是不符合数学归纳法的规则的。

====全文完====

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Why Couldn't Paul Dirac Derive Out The Correct Conclusions From His "Large Number Hypothesis"?

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Abstract: In the beginning of 20 century, a number of scientists had some doubts to the gravitational constant G as a constant value. In 1937, Pual Dirac, a most imaginative scientist in England, proposed a "large number hypothesis" (LNH), **he might intend to give a reasonable explanation to Hubble's law got in 1929 with his LNH**. **However,** in 1937, the wrong numerical values of Hubble's constant (H_o=170km/s/Mly) led to a wrong universal time $t_b = 20\times10^8$yrs. In addition, nobody knew BH and Hawking's theory about BH in 1937, it led Dirac to derive some wrong conclusions from his LNH: Gt_b = constant, i.e. $G \propto t_b^{-1}$, and $N_p \approx (t_b / t_e)^2$, i.e. $N_p \propto t_b^2$, but **Dirac's idea of measuring M_b and N_b with t_b/t_e has still had significant,.** In this article, according to the detailed calculations with theories and formulas about black holes (BH), the correct results can be derived: G is not a variable, but still a constant, and $M_b \propto t_b$.

Key Words: Paul Dirac's "Large Number Hypothesis"; G is not a variable; Hubble's law; universal black hole;

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美国走出危机的根本出路

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摘要：美国的金融危机经济危机已经蔓延到全世界。根据美国目前的社会状况，危机的实质就是人类自私贪婪的本性没有得到适当的协调，导致社会中支出大于产出，即每天消费掉的东西少于新创造的东西。所以，关于美国走出危机的战略思路，可以归纳四点：1.低成本制造实际产品，制造成本尽可能低，起码要低于世界平均成本。2.大数量制造实际产品，制造数量尽可能大，起码要大于消耗数量。3.小数量消耗社会财富，消耗财富尽可能少，起码要小于创造数量。4.合理的分配社会财富，财富分配尽可能合理，起码要保证基本合理。美国走出危机的战略思路必须从以上四点为纲。[New York Science Journal. 2009;2(5):108-112]. (ISSN: 1554-0200).

关键词：美国；金融危机；经济危机；世界；支出；产出；财富；分配

美国政府财政赤字（联邦债务）已经超过十万亿美元，对外则仅欠中国就接近2万亿美元以上(宋鸿兵2007)。美国的金融危机严重的影响了美国的社会现状，影响了所有的美国人，并且已经蔓延到全世界。作为当今世界第一超级大国，世界首强首富，尤其是1万枚核武器的军事存在及其毁灭整个地球的军事能力，美国走出危机走向健康发展关系世界上每一个人的利益，不管你是不是美国人。

关于发自美国影响世界的经济危机，从政客精英，到商贾学人，到亿万百姓，人人关心，也涌现大量的举措与探讨。现在的救市措施与论点，比如美国政府所谓7000亿救市(证券时报,2008)，等，都只能是战术上的措施，没有从战略角度加以思考，缺乏战略思路。甚么次贷、杠杆、CDS、马列主义政治经济学等，对目前的美国经济危机，都不能表明实质。其实目前的美国社会状况，实质很简单，就是人类自私贪婪的本性没有得到适当的协调，导致社会中支出大于产出，即每天消费掉的东西少于新创造的东西。想一想，如果美国政府现在财政盈余十万亿美元而不是赤字，对外则顺差几十万亿人民币元或几亿欧元，美国现在还会有金融危机吗？绝对不会像现在这样焦头烂额。

所以，关于美国走出危机的战略思路，可以归纳四点：

1. 低成本制造实际产品，制造成本尽可能低，起码要低于世界平均成本。
2. 大数量制造实际产品，制造数量尽可能大，起码要大于消耗数量。
3. 小数量消耗社会财富，消耗财富尽可能少，起码要小于创造数量。
4. 合理的分配社会财富，财富分配尽可能合理，起码要保证基本合理。

美国之所以最近出现如此明显的金融危机经济危机，其根本原因就是以上四点问题严重，走出危机的战略思路自然也必须从以上四点为纲。

1. 走出危机，应低成本制造实际产品，制造成本尽可能低，起码要低于世界平均成本。

道理很简单，是人，就要吃喝拉撒，就要消耗物质产品，不管你是富豪还是贫民。人们所消耗的物质产品，主要还是人制造的。现代这个商品社会，每个人制造产品不是为了自己直接的消费，而是用来交换，然后得到自己消费所需要的各种产品。要成功的完成商品交换，价格是第一重要的。任何一个交换者，在进行交换时，首先考虑的是对方物品的价格问题。所以，要使自己的商品完成交换，即卖出去，自己的商品一定要有足够低的价格，起码是具有竞争力的低价格。价格高低的决定性因素是成本。在正常的交换中，只有价格高于成本，卖方才会有利可图。有低的成本，才会有低的销售价格。有了低的销售价格，才会有具有竞争力的销售。举个典型的例子，就是美国通用汽车公司及福特汽车公司。按照通用福特的财力、技术力量、产品市场（美国是最大的汽车市场）、历

史渊源、人脉关系等，都堪称世界数一数二。全世界其它汽车公司能生产的任何汽车产品，通用福特应该都有能力生产出来。但是，通用福特却连年巨额亏损，不但不能给美国这个车轮上的国家带来财政贡献，还成为需要国家救助的财政负担。为什麽呢？是美国不需要通用福特生产那麽多车吗？显然不是。通用福特产品滞销、连年巨额亏损的根本原因就是产品生产成本过高，原因是决定公司生产产品成本的场地使用、工资等都较高。中国可以生产奥拓售价每台两万七千元人民币。试想如果通用福特能够大量生产出成本低于两千美元的车，还会产品滞销？还会连年亏损吗？美国的产品很难在世界上卖出，但其它一些国家的产品很容易在美国销售，根本原因不是美国没有相应的技术或能力生产这样的产品，也不是美国的市场学家经济工作者运作方法上失误，更不是外国人（比如中国人）抵制美国货或美国人崇洋媚外不买本国货，而是美国的产品生产成本过高，所以定价就需要较高，所以卖不出去。按照现在人类生产的技术能力，一般来讲，除非出现像三鹿奶粉那样不法商人为提高蛋白质含量数据故意掺毒，各家产出的产品质量都可以被市场接受。人们购物时选择商品的首要因素是价格。在这里，一般来讲商品质量是第二重要的。比如，生产一只圆珠笔，即使产品质量再好，写字后十万年不褪色，但如果此圆珠笔生产成本一个一千美元，会有多少人会买呢？所以结论是，美国要想走出危机，首要的战略出路就是尽可能的降低生产成本，起码要降到低于世界平均成本。产品生产成本的主要构成有五部分，1为劳动力成本，2为场地使用，3为原材料消耗，4为资金与设备使用，5为产品的流通状况及其它成本，其中，劳动力成本与场地使用成本为最重要的硬成本。美国现在的现状是劳动力价格过高，高过很多国家与地区几十倍甚至数百倍，这样就自然而然的提高了产品的成本价格很多倍。同时，美国过高的房地产价格也是生产成本过高的直接原因。有此高的成本，企业要生存，只能制定较高的产品价格，但是消费者在购买时当然是要认真地比较欲购物的价格，比较后，价格较高的当然竞争力低、销售不畅。

2. 走出危机，应大数量制造实际产品，制造数量尽可能大，起码要大于消耗数量。

一个社会一个公司，生产出来的产品即使成本再低质量再好，如果数量太少，也不会产生足够的效益。如果一个社会创造的财富与消耗的财富数量上相等，这个社会应该是不倒退也不发展；如果这个社会创造的财富比消耗的财富还少，社会就会倒退；如果这个减少一直持续下去，最后将财富耗尽了，该社会就消亡了；一个社会只有创造的财富大于消耗的财富，这个社会才能有财富的积累与增加，才会发展。而现在美国的情况，由于产品成本过高，所以在目前全球化的形势下销售不畅。产品卖不出去就导致生产厂家不能大量或适量生产。同时，美国70%以上的经济收入来自服务行业（比如金融银行业），这些服务行业的工作虽然不能被认作不劳而获，但他们确实不直接创造物质财富。虽然服务行业的劳动也是社会必须，但他们的劳动成果只能算是分享了物质生产者所创造的财富价值。社会财富的创造最终来源于物质生产部门的劳动。美国现在70%以上的生产能力用于服务与分享不到30%的社会生产能力所创造的社会财富，造成当前美国财富创造低于消耗就不难理解，其结果就是大量欠债，社会财富负积累。

即使全世界包括美国到处是中国制造印尼等制造的产品，但美国人还是要存活，还要吃喝拉撒。尤其是美国作为世界首富首强，还要生活的比其它地方人好，要消耗更多的物质财富，要花费极其巨大的财富维持军费进行战争等（仅一个伊拉克战争每月就要耗费掉100亿美元）。尤其是那些不直接创造物质财富（只是分享财富）的劳动者，比如政客、金融银行部门工作者、房地产商、医生、律师等，他们的收入常常高出物质生产者的收入几十倍以上，即他们平均消费的社会财富高于其他人几十倍。这样，造成美国财富负增长，造成美国不断增加的财政赤字及贸易逆差，导致美国的纯财富（净财富）不断减少，危机随之自然产生。所以结论是，美国要想走出危机，战略出路的第二点就是就是尽可能的制造大数量的产品，起码要大于消耗数量。

3. 走出危机，应消耗财富尽可能少，起码要小于创造数量。

与第二点为同一个问题，但为另一个方面。一个社会，要求得向前发展，就应该制造出尽可能低成本并且尽可能大数量的产品，但由于自然资源、人力资源、技术能力、生产资料状况等因素所限，这种成本的降低及数量的增大是有限的。所以，为了求得更大更快的财富积累与社会发展，降低社

会消耗是极其重要的。由于人自私的本性，为了享受每个人都有绝对无法去除的对财富消耗（也就是享受财富）的无限追求。我们每个人对消耗（享受）财富的这种追求的无限欲望是无可非议的，这是生物的本能。但是，为了社会的稳定存在及继续发展，任何人的这种欲望都必须受到限制。具体的讲，就是整个社会消耗的财富必须小于该社会新创造的财富，作为个人一般来讲所消费的财富数量应该小于自己所拥有的财富数量（多余部分作为纳税或积累等），即应该只消费那些属于自己的财富。如果借贷，应该是在能够归还的起的尺度内借贷。借贷及提前消费是可以的，但是前提是借贷的数量一定是要控制在自己能够如期归还的程度内，否则就会出现麻烦，出现危机。人们不应该借还不起的债。但是，现在美国的情况是财富的消耗大于创造，并且到处借债欠钱，消费了大量的不属于自己的财富，所以就有了超过十万亿美元并继续不断增加的巨额财政赤字及超过两万亿美元并继续不断增加的巨额国际贸易逆差，CDS问题账务市场总值是62万亿美元。物质不灭，能量守恒，如果耗的多造的少，社会净财富不断减少，自然产生经济危机。设想一下，如果美国现在是十万亿美元的财政盈余，而不是财政赤字，如果美国对中国等国有数十万亿美元的贸易顺差，而不是逆差，美国现在会有金融危机吗？绝对不会有！

在美国，不论是百姓买房子，还是政府借外债或商品进口，都大量的发生明知还不起还要借债的情景。如果将美元贬值作为预谋的少还钱的策略，这就等同于预谋的赖账不还，即赖掉货币贬值的那部分价值，这是无赖行为，也是危险的，作为美国不该如此。大量发行美元的做法，完全是掠夺性的，不能持久，最终也是自杀性的。

一个社会在运转过程中，应该是尽量提高生活质量，同时降低生活成本，这样才能有利于社会的财富积累，才会有利于社会的不断地良性发展。美国近几年来，生活必须用品，比如蔬菜、牛奶、面包等，其价格成倍甚至数倍增长，这样就提高了整个社会的运转成本，也直接刺激劳动力成本相应提高（虽然劳动力价格的提高小于蔬菜牛奶等价格的提高），限制了社会的发展。这样是经济危机发生的重要原因之一。

4. 走出危机，应使财富分配尽可能合理，起码要保证基本合理。

合理的分配社会财富，这个问题也十分重要。自私是地球上所有生命体的本能。地球上所存在的所有生命物质，从细菌到动物植物到人类，无一不具有自私的本质，这是生命物质本身的固有物质属性。人的本性是自私的、贪婪的，对物质财富的追求是无限的，这产生自生物生命过程本身，也无可非议。自古以来，即使所有的帝王，也没有人嫌财富太多。嘉庆皇帝就以夺取何珅的巨额财产作为他一生中最得意的业绩。比尔盖茨恨不得自己的财富再增加亿万倍。平民百姓更不用说。无论是资产阶级还是无产阶级，无论是乔治布什还是侯赛因萨达姆，都具有尽量追求自己利益自私自利的生物本能。随着人类文明发展，人们创造财富治理社会的能力不断提高，同时，谋取不合理所得利益的能力也在不断提高，一个最典型最罪恶的方式就是依靠武力通过战争杀戮的行为强取豪夺，比如一战二战及现在还在地球上发生的战争。同时，在日常生活中，由于人自私贪婪及对物质财富无限追求的本性，社会中财富分配与占有的不合理无处不在，这种不合理严重到一定程度就成为导致危机的原因。现在美国社会中在财富分配与占有上的严重不合理程度也成为当前导致危机产生与家中的重要原因。美国当前的经济危机，直接诱因是金融危机，而这金融危机的直接诱因是房屋次级贷款。房地产价格的高低就直接关系到财富的分配。比如纽约法拉盛一栋房子十年前10万元，现在涨为100万元，这就是说十年前有人花费了10万元买了房子，现在增值为100万元，但是房子与土地还是原来的物质（如果忽略折旧）。对于房产拥有者，增加了10倍的财富，只要市场认可，挺好的，没有人有意见。但是，如果这个曾经升到100万元的房产，因为房市的低落而降回到10年前的 10万元的价钱，这就是房市危机吗？联邦政府就应该拿出数千亿美元的全社会纳税人的钱来救市？应该救市而让房地产价格保持不降吗？其实本来就绝对不应该这样救市。一栋房产经过几年从10万元涨价为100万元，为什麼就不能再降回10万元？值10万还是100万，绝对应该让市场根据供求关系及人们的购买力与购买意向来决定，绝不应该有政府去救市保值。这种救市实质救市那全民的钱给了那些房产拥有者。房市应该真正的市场化，房价过高造成社会成本升高，不利于社会的发展与竞争。如果房市下跌，就让它跌下去。物质不灭吗。一个现有的房地产的真正社会价值不会因这个地产

的市场现价而改变。房价高了低了，房子还是那座房子，占地还是原来的那麽大，其高低只会影响到钱财在买卖双方的分配，房价高卖的人多得钱，房价低买的人少出钱。政府拿全社会的税钱去就房市，是因为政府中掌权的人一般拥有的房产较多，所以房地产高价有利于这些政府中掌权者，其结果是用大家的钱为当权者服务，最后造成房市的价格不断升高，直至房屋的价格高出该房屋实际价值，从而产生房市危机。所以现在的出路应该是让房市按照市场供求关系去变动，而不是政府拿钱救房市。政府拿钱救房市将会加大不合理分配、加重危机。

华尔街金融公司的工作人员为什麽年收入就要30万美元？为什麽那些公司的高管年收入百万甚至千万美元？这些不从事物质生产的公司高管、律师、医生、议员、政客们，每个小时的收入相当于美国其他部门的工作者及中国等国家的工作者数百个小时的工作，他们每小时创造的价值就等于其他人数百个小时创造的价值吗？绝对不是如此。这是社会财富分配不公平不合理。这种不合理，直接造成美国很多人的收入与消费严重超出了他们劳动所创造的财富，造成社会整体财富过度消耗，也成为美国目前金融危机经济危机产生的重要原因。解决的办法，自然是合理调整财富分配。比如，金融公司的人员、大学金融经济院系的教工、律师、医生，等，其工资收入应该和其他受相似教育训练的工作者具有相似的工资收入，而不应该是现在这样的差别。

政府利用自己的权利，很多情况下政府工作人员对外办几分钟的手续，就收取数十元甚至数百元的办理费，应为只有政府拥有这样的权利来办理这类的手续，收取高价大家也得人了。这其实也是严重的腐败，是以权谋私。这样增加了政府的收入，保证了政府官员的高薪，也同时加大了人民的支出。羊毛出在羊生上，最终都是社会成本。政府很多部门人浮于事，高薪低效，也是经济危机产生的原因之一，需要努力改正。

还有，在美国，很多法律都定的很不合理。比如，有一个公司破产法，规定Corporation公司在破产时，受破产法保护，公司现有财产用于清债，而即使公司现有财产与所欠债务相差再多，公司所有人的私人财产也不能用于抵债。这就很不合理很不讲理，实际上是保护富人的不公平法律。举个例子，一个人注册一个Corporation公司，作投机冒险生意，第一年赢了1000万元，给自己豪发工资奖金，买豪宅置地产，转入了私人名下。第二年再同样冒险经营，赔了2000万元，清算财产，银行贷款一算，没钱了，受破产保护这就算了，上一年赢的1000万买成私人豪宅了，和公司无关？上一年赢的1000万转入私人帐下，今年亏的2000万由社会买单？这就是不合理的分配法律。公司赢利经营者将所赢利润用于买私人豪宅，无论这种赢利来自运气好还是天才努力，都无可非议。但是，如果公司经营赔了，公司财产不够用私人财产赔偿也是合情合理的。当然，现在社会文明提高了，不能像古代那样将欠债人变为奴隶或用欠债人的肉体器官来抵债，但如果用他们现有财产来抵债是合理的。那些赚过大钱成为富翁的人，在他们是富翁的时候，享受他们的财富是无可非议的。但是，如果以后他们赔了大钱，用他们现在拥有的财富去赔偿他们经营亏损的钱，当然也是无可非议的，即使如此他们成为了社会中最普通的贫民，也很正常。肉烂在锅里。如果他们亏损了巨款，他们不用自己的钱去赔，总得有资金去补偿这个损失。他们不赔，就得别人赔，或社会赔。所以，面对目前的经济危机，有企业破产了，企业现有资金不够赔的话，所有者个人财产应该拿来抵债，这也是解决危机的重要出路，也是个公平原则。贫民赚大钱了成为富翁，富翁赔大钱了成为贫民，可以是一夜之间，天经地义的。

关于美国的目前危机，有一篇署名YST的文章“一篇很全面准确的解析美国金融危机的文章”，值得一读（http://news.wenxuecity.com/messages/200810/news-gb2312-719184.html） (YST, 2009)。

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The Essential Way for USA Come out the Crisis

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Abstract: The financial crisis and economic crisis in the United States has spread to the world. According to the current social situation of US, the crisis is originally from the human nature of selfish. Right now, the essential problem of US is expensing too much and producing too little. So, the way to resolve the problem is to produce products as more as possible in the cost as low as possible, and to consume the social property as little as possible. Also, it is important to allot reasonably. [New York Science Journal. 2009;2(5):108-]. (ISSN: 1554-0200).

Keywords: the United States; financial crisis; economic crisis; world; product; consume

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