

MORPHOLOGY AND PIGMENT CONTENT OF SPOROPHYTES AND GAMETOPHYTES OF TEN FERN SPECIES

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Abstract

The morphology and pigment contents of sporophytes and gametophytes of ten fern species were studied. In the morphological study, variations were found in stipe, texture, rachis, fronds and sori of these species. Photosynthetic pigment contents of sporophyte and gametophyte of ten species vary to a great extent. Even sporophyte and gametophyte of same species vary in pigment content. Sporophyte revealed higher chlorophyll content than gametophyte. The highest chlorophyll *a* and *b* were found in the gametophyte of *Cetarach officinarum*. Gametophyte of *Adiantum flabellatum* produced maximum anthocyanin whereas minimum anthocyanin content was found in the sporophyte of *Cetarach dalhousiae*. The highest carotenoid content was obtained from the gametophyte of *Cheilanthus albomarginata*. Altitudinal variations were also found to affect morphology and pigment content of sporophytes and gametophytes of ten fern species.

Introduction

Pteridophytes are evolutionally, in a pivotal position between bryophytes and seed plants (Pryer *et al.* 2001). A characteristic that distinguishes pteridophytes from other land plants is their independent sporophyte and gametophyte generations. Gametophytes of fern live on substrate surfaces as small individual plants and have no vascular system. However, sporophytes of ferns possess a vascular system that enables them to grow more than gametophytes that results in a large herbaceous plants (Wada 2007). It has been suggested that the distribution of ferns is mostly determined by factors of climate and habitat due to relatively low limitations in ferns for dispersal and establishment (Wild and Gagnon 2005). Many species are able to change the composition of their photosynthetic apparatus to optimize photosynthesis for the light environment in which they are growing. Chlorophylls play a very important role in photosynthesis; plants have additional pigments that participate in photosynthesis. Chlorophyll *a* and chlorophyll *b* show controlled changes in adapting to various growth conditions, enabling optimal utilization of available light. It is known that the chlorophyll *a* to *b* ratio is higher in high-light growth conditions than in low-light growth conditions. Thus the regulation of chlorophyll *b* synthesis is important for understanding the mechanisms of adaptation of plants to various light intensities. Other pigments that occur in plants are xanthophylls and carotenes (Taiz and Zeiger 2002). Though a lot of information is available about the photosynthesis and respiration of flowering plants but information about fern plant is meager. Hence, present project was undertaken to determine qualitative variations in the morphology of ten selected fern sporophytes belonging to same order and to measure photosynthetic pigment contents in ferns sporophytes and gametophytes.

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Materials and Methods

Ten species of ferns viz. *Adiantum capillus-veneris* (L), *A. caudatum* (Linn.), *A. fimbriatum* Christ, *A. flabellatum* L., *A. incisum*, *A. venustum* (Don) L., *Asplenium trichomanes* (L), *Ceterach dalhousiae* Hook, *C. officinarum* Willd, *Cheilanthes albomarginata* (Clarke) belonging to order Filicales were collected from District Muzaffarabad, Azad Kashmir according to randomized complete block design (RCBD) with four replicates. Experimental work was carried out in the laboratory, Department of Botany, University of Azad Jammu and Kashmir, Muzaffarabad. After morphological observations of the sporophyte, both sporophyte and gametophyte were subjected to measure pigment contents according to Arnon (1949). All the quantitative data obtained were subjected to analysis of variance (ANOVA) and then LSD at $p \leq 0.05$ was performed to compare the variations.

Results and Discussion

The morphology of ten fern species were studied and lots of variations were observed in the stipe, texture, rachis, fronds and sori of these species. Stipe of *Adiantum capillus-veneris* was found slender and suberect, *A. caudatum* tufted and wiry, *A. flabellatum*, *A. fimbriatum* and *Asplenium trichomanes* brown, dark brown and dark brown to dark purple, respectively. *Adiantum incisum* and *A. venustum* have proximate and hairy stipe while the stipe of *Ceterach dalhousiae* and *C. officinarum* was broad and lanolate. *Cheilanthes albomarginata* have smooth stipe and without any kind of scales.

Many variations were observed in the texture of studied ferns sporophyte. Sporophyte of *Adiantum capillus-veneris*, *A. fimbriatum*, *A. flabellatum*, *A. incisum* and *Cheilanthes albomarginata* was thin and herbaceous. Glabrous texture was observed in *Adiantum venustum*, *Asplenium trichomanes* and *Ceterach dalhousiae* whereas *Ceterach officinarum* and *Adiantum caudatum* revealed glossy and villose texture, respectively.

Rachis of *Adiantum capillus-veneris* was naked, of *Adiantum caudatum* with sparsely placed pinnae and of *Adiantum fimbriatum*, *A. flabellatum*, *A. incisum* and *A. venustum* with deltate, pinnate extended, hairy and petiolate, respectively. *Asplenium trichomanes*, *Ceterach dalhousiae* and *Ceterach officinarum* were found to have glabrous rachis whereas the rachis of *Cheilanthes albomarginata* was smooth.

Fronde, the special characteristic of ferns bears sporangia at maturity. Very little variations were observed in the physical appearance of fronds of the studied fern species. Almost all the studied fern species were found to have pinnately compound fronds. Fronds of *Adiantum capillus-veneris* were bipinnate with short terminal pinnae and of *Adiantum caudatum* were villose and pinnately compound. *Adiantum fimbriatum* was found having asymmetrically pinnate fronds and *Adiantum flabellatum* with pinnate fronds. *Adiantum incisum*, *A. venustum* and *Asplenium trichomanes* possessed pinnate, pinnately compound, pinnate linear lanceolate type fronds, respectively. Fronds of *Ceterach dalhousiae* were long glabrous, lanceolate and pinnately compound whereas of *Ceterach officinarum* and *Cheilanthes albomarginata* were pinnate with trichome and pinnate deltate, respectively.

Sori of *Adiantum capillus-veneris* were roundish, of *Adiantum caudatum* transversely oblong, of *Adiantum fimbriatum*, *A. flabellatum*, *A. incisum*, *A. venustum* and *Asplenium trichomanes* were indusiate. *Ceterach officinarum* possessed exindusiate sori whereas sori of *Cheilanthes albomarginata* were indusiate marginal.

In pteridophytes, chlorophyll content is both quantitatively and qualitatively similar to that of higher plants. Gametophyte generation is essential in the fern life cycle, however, very little is known about its ecology and physiology (Watkins *et al.* 2007). The photosynthetic pigments vary

from same species from different habitats. Photosynthetic pigments were determined from the sporophyte and gametophyte of ten selected fern species belonging to order Filicales and significant variations were observed in them. Sporophytes and gametophytes of same fern species vary in pigment contents. Decrease in pigment contents was observed from all the studied fern species from sporophyte compared to gametophyte. Gametophyte of the *Cetarach officinarum* revealed maximum chlorophyll *a* significantly followed by *Adiantum flabellatum* whereas minimum chlorophyll *a* was observed from sporophyte of *Adiantum caudatum* (Fig. 1).

Table 1. Morphological parameters of ten ferns belonging to order Filicales.

Species	Altitude (Feet)	Stipe	Texture	Rachis	Fronds	Sori
1 <i>Adiantum capillus-veneris</i> (L)	4900	Suberect rather slender	Pellucid herbaceous, thin	Naked	Bipinnate with short terminal pinnae	Roundish
2 <i>A. caudatum</i> (Linn)	4860	Tufted, wiry	Villose	Sparsely placed pinnae	Pinnately compound, villose	Transversely oblong
3 <i>A. fimbriatum</i> Christ	8250	Dark brown	Thin, herbaceous	deltate	Asymmetrical pinnate	Indusiate
4 <i>A. flabellatum</i> L.	3900	Brown, hairy	Herbaceous, slightly striate	Pinnate, extended	Pinnate	Indusiate
5 <i>A. incisum</i>	4750	Proximate	Herbaceous, slightly striate	Hairy	Pinnate	Indusiate
6 <i>A. venustum</i> (Don) L.	5200	Hairy	Glabrous	Petiolate	Pinnately compound	Ndusiate
7 <i>Asplenium trichomanes</i> (L)	6240	Dark-brown to dark-purple with narrow brown marginal wings	Coriaceous, glabrous	Glabrous	Pinnate, linear lanceolate	Indusiate
8 <i>Cetarach dalhousiae</i> Hook	4700		Long, glabrous, lanceolate,	Glabrous	Long, glabrous, lanceolate, pinnately compound	Exindusiate
9 <i>C. officinarum</i> Willd	4360	Broad lanceolate	Glossy	glabrous	Pinnate lamina with trichomes	Exindusiate
10 <i>Cheilanthes albomarginata</i> (Clarke)	6200	Without scales	Sub-coriaceous and herbaceous	smooth	Pinnate, deltate	Indusiate, marginal

Maximum chlorophyll *b* was found from gametophyte of the *Cetarach officinarum* which was followed by *Adiantum caudatum* and minimum chlorophyll *b* was revealed from sporophyte of *Adiantum incisum* (Fig. 2).

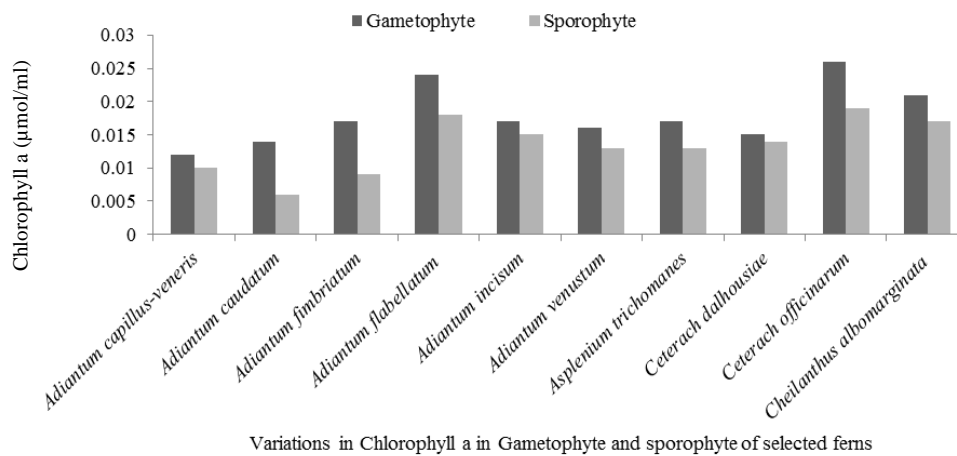


Fig. 1. Variations in Chlorophyll *a* of gametophytes and sporophytes of ten fern species belonging to Filicales.

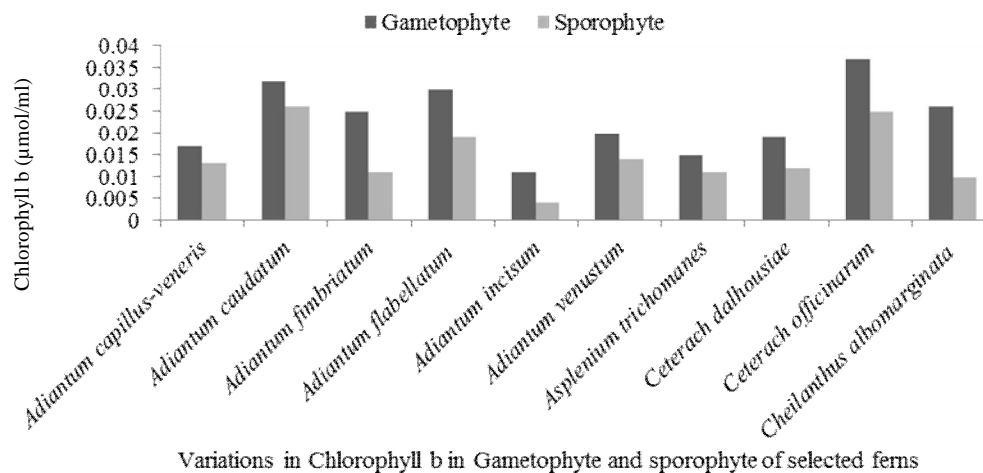


Fig. 2. Variations in chlorophyll *b* of gametophytes and sporophytes of ten fern species belonging to Filicales.

Gametophyte of *Cheilanthus albomarginata* revealed maximum anthocyanin whereas minimum anthocyanin content was observed in sporophyte of *Ceterach dalhousiae* which significantly varied from anthocyanin values of all other samples under study (Fig. 3).

Maximum carotenoid content was found in gametophyte of which was *Cheilanthus albomarginata* non-significantly followed by *Adiantum flabellatum* and minimum carotenoid content was revealed from the sporophyte of *Adiantum capillus-veneris* (Fig. 4). Other species showed intermediate carotenoid contents but in all the species a decrease in pigments was observed from sporophyte compared to gametophyte.

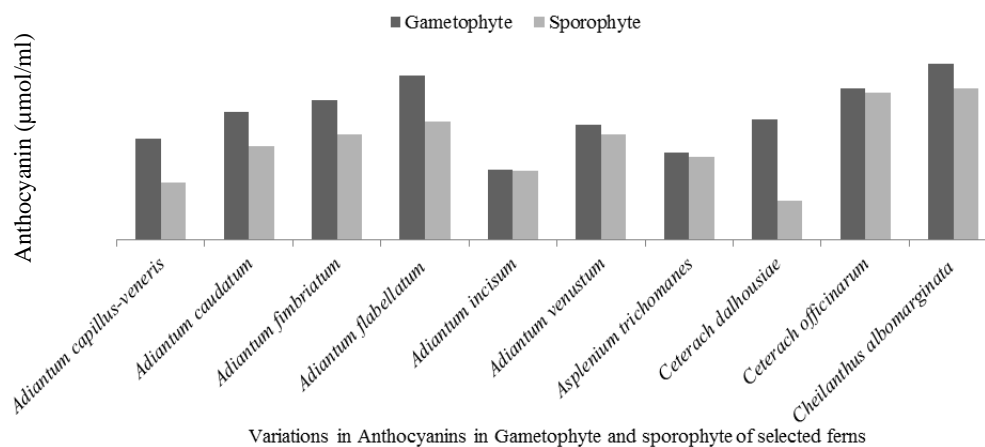


Fig. 3. Variations in anthocyanin of gametophytes and sporophytes of ten fern species belonging to Filicales.

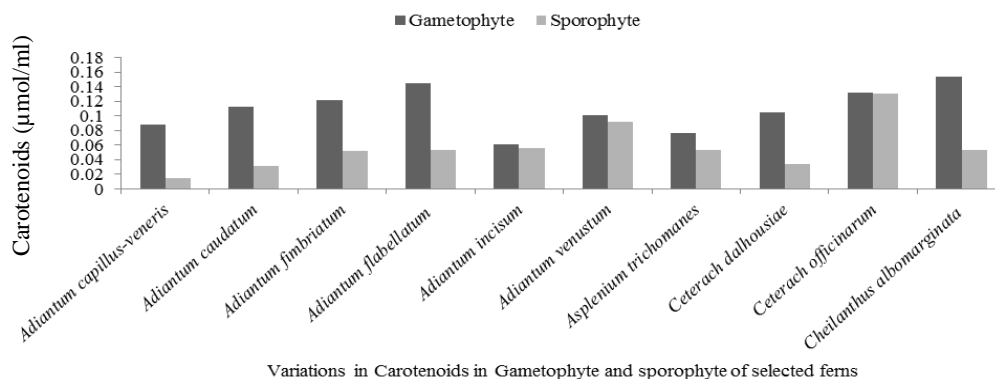


Fig. 4. Variations in carotenoids of gametophytes and sporophytes of ten fern species belonging to Filicales.

Many species are able to alter the composition of their photosynthetic apparatus to optimize photosynthesis for the light environment in which they are growing (Anderson *et al.* 1995). Although, the responses seen are complex with variations between species. In shade there was a tend to increase in the total amount of chlorophyll binding proteins relative to electron transport proteins and enzymes of the Calvin cycle (Yin and Johnson 2000). Amount of chlorophyll was higher in the shade ferns than the sun ferns (Nasrulhaq-Boyce and Mohamed 1987). The increase or decrease in chlorophylls depends on the available light. There was higher amount of chlorophylls and carotenoids in the terrestrial and epiphytic species than in the climbing species. Shaikh and Dongare (2008) showed that chlorophyll and carotenoids contents varied with microclimatic conditions in *Adiantum philippense*. Because of numerous factors concerned with nutrition, light and the plants sampled were growing under a variety of conditions which can influence chlorophyll content.

Carotenoids have two important roles in photosynthetic organisms. First, they act as accessory light harvesting pigments, effectively extending the range of light absorbed by the photosynthetic apparatus. Secondly, they perform an essential photoprotective role by quenching triplet state chlorophyll molecules and scavenging singlet oxygen and other toxic oxygen species

formed within the chloroplast. Sharma and Sharma (1992) reported that the variability in carotenoids from species to species is independent of ecological conditions and morphology of the plant. Gena (2002) found no relationship in between carotenoids and chlorophylls and in between dry to moisture loving species of pteridophytes.

It may be inferred that significant variation in pigment contents of gametophyte and sporophyte generations of the same fern species is present. Moreover, climatic conditions and altitudinal variations were found to affect fern morphology and photosynthetic pigments in gametophyte and sporophyte generations.

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