Altitudinal changes in photosynthetic pathways of floristic elements in southern Sinai, Egypt

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Abstract

High altitude profoundly influenced plant diversity and distribution on mountains of southern Sinai (Egypt). Plants exhibiting the C3-mode of photosynthesis were widely distributed along the altitudinal transect. Plants exhibiting the C4-mode were restricted below an altitude of about 1400 m above sea level. The transition from C3-dominated areas to C4-dominated areas occurred between 1200 and 1400 m a.s.l.

Additional key words: C3, C4, ecophysiology.

Introduction

Sinai is part of the Saharo-Arabian desert with a climate influenced by the Mediterranean in the north and high altitude in the south. Mountains of southern Sinai (Egypt) are characterised by outcrops of smooth-faced granite rocks, and landforms (slopes, terraces, and ridges). This area is floristically rich with 419 species of which 28 are endemic (Danin 1983, 1986, El-Ghareeb and Shabana 1990, Mostafa and Klopatek 1995, Boulos 1997). In this area, photosynthetic pathways and distribution of plant species have been studied (Winter and Troughton 1978, Winter 1981, Ziegler et al. 1981, Vogel et al. 1986, Batanouncy et al. 1988). However, although several studies describing plant distribution along altitudinal gradients in different parts of the world exist in the literature (Tieszen et al. 1979, Earnshaw et al. 1987), no attention has been given to the effects of high altitude on the flora of southern Sinai. This is why we describe altitudinal changes in photosynthetic pathways of the flora of Mount Musa (Saint Catherine area, southern Sinai, Egypt).

Materials and methods

The study site of Mount Musa, 2285 m a.s.l., is one of the highest mountains in Egypt. Records of temperature, humidity, precipitation, and evaporation for 20 years (1974-1994) supplied by the Authority of Meteorology were used to calculate variability coefficient of rainfall, annual thermal amplitude (Willert et al. 1992), and aridity (Sayed 1998). Work was carried out early in the dry season (mid-June) and included only perennial species prevailing at that time of year. Air (50 cm above ground) and soil (5-cm depth) temperatures were measured using a digital thermometer, and humidity was measured using a digital hygrometer (Maplin Electronics, Manchester, U.K.). Soil water potential was determined using a psychrometer (Wescor, Logan, Utah, U.S.A.). Carbon isotope discrimination ratio (δ13C values) in the ranges −24 to −31 %, and −10 to −15 % were considered indicative of C3 and C4 modes of photosynthesis, respectively (Griffiths 1993). Quadrats (1 m²) were set at designated altitudes, plant species were identified (Zohary 1966, 1972, Töckholm 1974, Feinbrun-Dothan 1978, 1986, Boulos 1995, El-Hadidi and Fayed 1995, Boulos 1999), and diversity and evenness were calculated (Magurran 1988). Measurements were routinely repeated and standard error was calculated.

Results

For January and June, air temperature was −5 and 35 °C, relative humidity 58 and 29 %, evaporation 5.7 and 17.5 mm, respectively, and a mean annual rainfall of 45 cm y⁻¹ occurred partly as snow during the period Novem-
ber-March. Calculations based on these records revealed that the study site had a variability coefficient of rainfall of 12, an annual thermal amplitude of 15 K, and an aridity of 8.6 mm °C⁻¹.

Soil and air temperatures and vapour pressure deficit decreased with increased altitude (Fig. 1A,B). Soil water potential remained almost unchanged, but was slightly higher at 1200 and 1800 m a.s.l. (Fig. 1C). A total of 33 perennials belonging to 15 families were recorded (Table 1). Five species (Anabasis articulata, Atriplex halimus, Calligonum polygonoides, Heliotropium strigosum, and Salsola tetrandra) had Kranz anatomy and δ¹³C values characteristic of C₄ plants, whereas others had δ¹³C values characteristic of C₃ plants. Diversity and evenness increased with increasing altitude, with diversity being slightly higher at 1200 and 1800 m a.s.l. (Fig. 2 A,B). The number of C₃ species increased, whereas that of C₄ species decreased with increased altitude (Fig. 2C).

While C₃ species were widely distributed along the altitudinal transect, C₄ species were restricted below 1400 m a.s.l. (Table 2). Diversity correlated well with vapour pressure deficit and altitude (Fig. 3).

**Discussion**

Although most of Sinai is of Saharo-Arabian phytogeographical characteristics (McGinnies et al. 1968), high mountains of Saint Catherine area are dominated by Irano-Turanian and endemic plant species (Mostafa and