Ege Üniv. Ziraat Fak. Derg., 2007, 44 (3):1-12
ISSN 1018-8851

Hermaphroditism in *Pistacia atlantica* Desf. : A New Report from Izmir/Turkey

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Abstract: The members of the ***Pistacia*** genus are all dioecious plant species, and some of them are known to be economically important. In this report, the inflorescence features of an exceptional monoecious ***Pistacia atlantica*** Desf. tree having hermaphrodite flowers found in the Barbaros Plain of Izmir/ Turkey were exhibited. The distribution of staminate and pistillate inflorescences on the canopy was highly complex in examine tree. Most of the branches bore pistillate inflorescences. Several branches bore only staminate inflorescences or inflorescences belonging to both sexes concurrently. Also, there were some weak branches having mixed clusters that comprised individual flowers of both sexes separately or hermaphrodite flowers in which the pistil and stamen concurrently appeared. In hermaphrodite flowers, defected or imperfect floral organ formations were prominent.

Key words: ***Pistacia***, inflorescence, hermaphrodite, monoecious

Pistacia atlantica Desf.'deki Hermafroditizm: İzmir/Türkiye'den Yeni Bir Rapor

Öz: ***Pistacia*** cinsine giren türlerin tamamı dioik bitkiler olup, bazılarının ekonomik öneme sahip oldukları bilinmektedir. Bu çalışmada, İzmir'in Barbaros Ovası'nda bulunan, hermafrodit çiçeklere sahip olağan dışı bir monoik ***P. atlantica*** Desf. ağacının infloresens özellikleri ortaya koyulmuştur. İncelenen ağaçta, dişi ve erkek infloresensin taç üzerindeki dağılımı oldukça karmaşıktır. Dalların çoğunda dişi infloresens hakimdir. Az sayıdaki dalda ise sadece erkek veya her iki cinse ait infloresens bir arada bulunmaktadır. Aynı zamanda, bazı zayıf dallarda her iki cinsiyete sahip çiçeklerin yanı sıra, pistil ve stamenin bir arada olduğu hermafrodit çiçekleri içeren karışık salkımlar da yer almaktadır. Hermafrodit çiçeklerde kusurlu veya gelişmemiş organ yapılanmaları çok belirgindir.

Anahtar kelimeler: ***Pistacia***, infloresens, hermafrodit, monoik

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Introduction

The genus ***Pistacia*** (***Anacardiaceae***) comprises eleven species, some of which are of high economic and cultural importance in Mediterranean and Asian countries. All the species are dioecious and their flowers are unisexual, naked and anemophilous (Zohary, 1952). Both staminate and pistillate inflorescences are panicles bearing up to several hundred individual flowers. Flower buds occur laterally on one-year old wood (Crane and Iwakiri, 1981).

Up to now, very few cases were reported on exceptional gender types and flower distribution of ***Pistacia*** trees by several scientists.

First, two hermaphrodite trees (with male and female organs borne in same flower) were reported in the vicinity of Antep Province of Turkey. It was estimated that these trees were either seedlings of ***Pistacia vera***, or hybrids between ***P. vera*** and ***P. terebinthus*** (Ozbek, and Ayfer, 1958). In the second case, three trees with unusual inflorescence characteristics were described as follows: (1) a branch bearing staminate flowers on a female individual tree of ***P. atlantica***, (2) a hybrid between ***P. vera*** and ***P. atlantica*** bearing nearly equal numbers of pistillate and staminate inflorescence, mostly on separate branches, and (3) a similar hybrid, predominantly staminate, but with several branches bearing pistillate inflorescences (Crane, 1974). Thirdly, a group of nine ***P. atlantica*** trees with monoecious traits were found in the Yunt Mountains of Manisa Province in Turkey. One of the trees was fully monoecious, i.e., all branches bore a mixture of male and female inflorescences (Type I); Three of them had several branches with only staminate flowers, while the rest of the branches bore pistillate inflorescences (Type II); Five other trees had inflorescences of both sexes on several branches, and pistillate inflorescences on the remaining branches (Type III) (Kafkas et al., 2000). Recently, some monoecious ***P. terebinthus*** trees were found in Rodopi Mountains of Bulgaria, a region that is quite distant from the natural distribution area of this species. The inflorescence characteristics of the trees were described as follows: Male flowers were carried on one-year-old shoots, and originated directly from the basal rachis; Female flowers were carried on one-year-old shoots and originated about 5 cm from the peduncle insertion; female and male flowers were present in the same inflorescence (Avanzato and Quarta, 2004).

The exceptional sex types of ***Pistacia*** species are of importance in relation with pistachio breeding. It was suggested that a

monoecious or hermaphrodite pistachio cultivar would eliminate the need for male (pollinator) trees in the orchard and increase the yield per hectare by about 10% (Ozbek and Ayfer, 1958; Kafkas et al., 2000; Avanzato and Quarta, 2004). Despite, the need of a long-term conventional breeding procedure with a number of backcrosses, the transfer of monoecious genetic trait to cultivated pistachio would be of high benefits theoretically.

Anatolia is a major center of diversity for the genus ***Pistacia,*** and there are approximately 66 millions wild ***Pistacia*** trees belonging to six taxa spread out in the four main geographical regions and transitional zones of Turkey (Kaska et al., 1995; Atli et al., 1998). Aegean region is also very rich and diverse in ***Pistacia*** genetic resources. In this region, the most common taxon is ***P. atlantica***. It can be found particularly in Manisa (Yunt Mountains), and to a lesser extent, in Aydın, Mugla and Izmir Provinces (Kaska et al., 1995). In some localities, they are top-worked with pistachio cultivars.

In this report, the morphological traits of a monoecious ***P. atlantic****a* tree, also bearing hermaphrodite flowers found in Barbaros Plain of Izmir Province were presented.

Materials and Methods

In the course of the field observations and seed collection works, an isolated and rich population of ***P. atlantica*** trees was explored in the Barbaros Plain about 50 km west of Izmir city.

Our examinations on 9 April 2005 resulted in the discovery of an exceptional ***P. atlantica*** tree bearing both staminate and pistillate inflorescences. The existing tree, growing in an unprotected, uncultivated location was located by a GPS device (GARMIN-12) at 38°19’30.6”N, 26°34’02.7”E-165 m asl.

The tree, on this date, exhibited blooming during observation. In general, pollen shedding started in staminate clusters as vegetative buds broke. Cluster distribution of both sexes on the tree appeared highly complex and variable.

Shoot samples with flower clusters were collected and stored at 4 °C, under humid conditions. During dissection, flower bracts and bractlets were carefully discarded by a needle or a surgical blade for three-dimensional study of the floral organs. Micro-anatomical examination of floral structures was performed with a stereo microscope (OLYMPUS SZ61), and documented with digital camera system.

Results

The tree was multi-stemmed, nearly upright and 5 m in height with a canopy spread equal to its height (Figure 1).

Figure 1. Multistemmed *P. atlantica* tree.

Inflorescence types and distribution

Observations showed the blooming was protandrous (male clusters bloomed about one week before female clusters).

Three types of inflorescences were distinguished on branches.

Male inflorescence

They are conical in shape, compact, later loosening, and reddish before pollen shedding. Some of them take place as unmixed clusters on several branches. Incidence of such pure branches was very scarce on the canopy. Also, male clusters have rarely coexisted with the female ones on some branches.

Female inflorescence

Female inflorescences were less conical, compact and longer than the male inflorescences. They were yellowish-green in colour, the perianth contained a single lanceolate and hairy bract with several sepals. Stigmas were prominent, bright pink, unequally long and strongly recurved. Female clusters occur on one-year old wood like male clusters. Female clusters were located mostly on the outer canopy and generally but not always, unmixed (Figure 2).

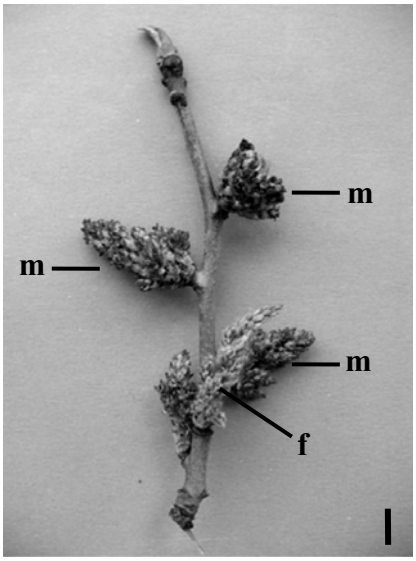

Figure 2. Female and male clusters on one-year old wood, f: female, m: male, bar=1 cm

Mixed inflorescence

The mixed inflorescence was more similar in appearance to the female inflorescence as opposed to the male. The mixed inflorescence was conical, compact in shape and light green in color. Occurrence of mixed clusters originated from one-year old wood of the weak lateral branches in a narrow part of the canopy on the south side of the tree (Figure 3).

The mixed inflorescences occurred mostly unmixed with other types (Figure 4), but rarely appeared with male clusters on several branches (Figure 5). Organ morphology of the mixed inflorescences occurring on the same branch with male inflorescences was complex and uneven.

Floral structure of mixed inflorescence

The mixed clusters not only comprised the individual flowers of both sexes separately, but also bore hermaphrodite flowers in which the pistil and stamen concurrently occurred (Figure 6).

In general, pistillate flower formation was predominant in mixed clusters, whereas the number of staminate and hermaphrodite flowers was rather low. However, the occurrence of staminate flowers was more frequent in several clusters.

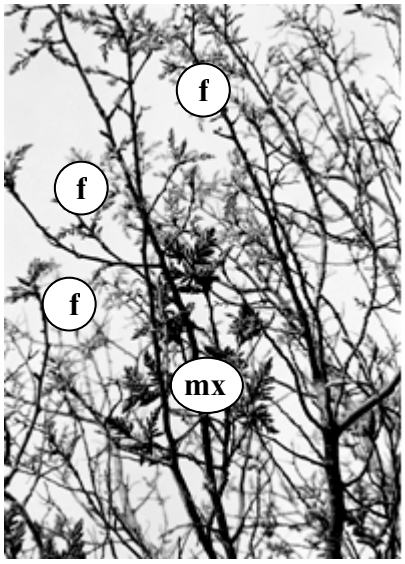

Figure 3. Female and mixed clusters on canopy, f: female, mx: mixed.

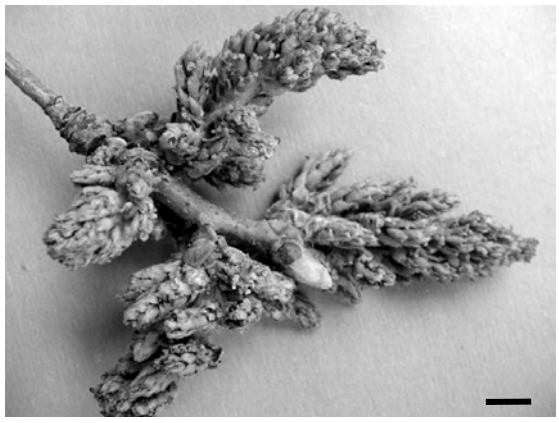

Figure 4. Mixed clusters on one-year old wood, bar=1 cm

In mixed clusters, defected or imperfect floral organ formation was highly extensive. Individual male flowers on lateral branches generally carried one or rarely two anthers in contrast to normal male flowers which had more anthers. On the other hand, anther formation was usually more or less defected in shape or at least one of the two anthers was even rudimentary in staminate flowers. It was observed that some clusters bore more staminate flowers than usual and have more anthers. Such flowers had a lot of malformed and rudimentary anthers, besides some pistil-like odd structures as well (Figure 7).

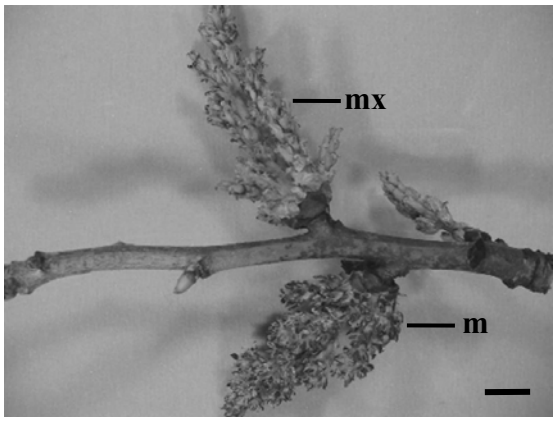

Figure 5. Male and mixed cluster on one-year old wood, m: male, mx: mixed, bar=1 cm

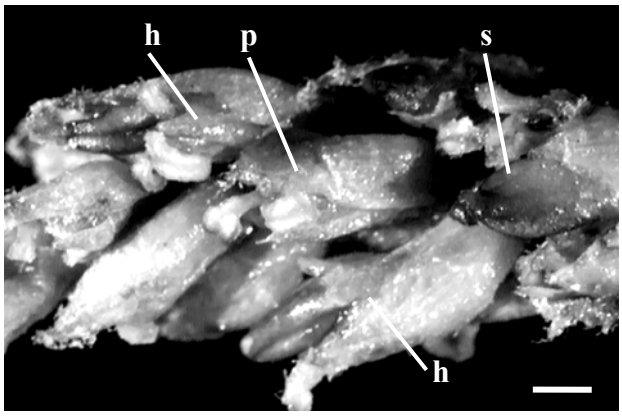

Figure 6. Floral structure of mixed inflorescence, h: hermaphrodite, p: pistillate, s: staminate flower, bar=1mm

As for the pistillate flowers, uneven pistil formations were frequently detected. Unlike the globular shaped ovaries in normal pistils, asymmetrically halved or cylindrical ovaries with over split or closed stigmas were common (Figure 8). Double ovaries were rarely observed in some pistillate flowers.

In hermaphrodite flowers, malformation of floral organs was more prominent than unisexual flowers. Most of them have one anther and a pistil is contiguous with each other. On the other hand, anther numbers of the flowers were markedly high on the terminal point of clusters.

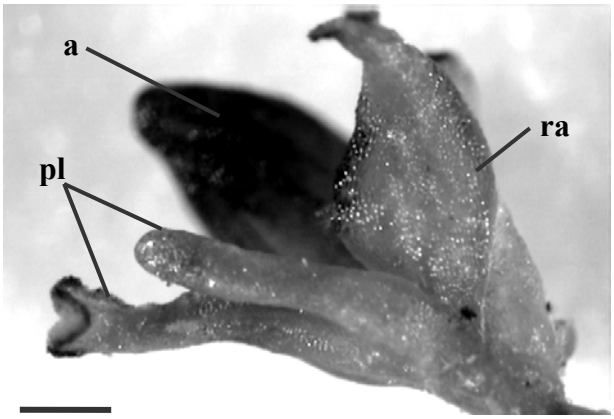

Figure 7. Malformed organs in staminate flower, a: anther, pl: pistil-like structure, ra: rudimentary anther, bar=500µ

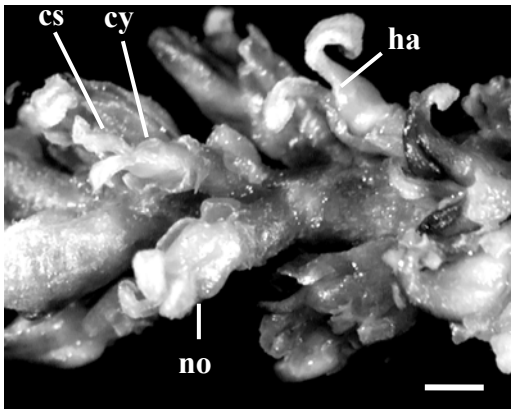

Figure 8. Abnormal pistil formations, cy: cylindirical, ha: halved and no: normal ovary, cs: closed stigma, bar=1 mm

In such flowers, a rudimentary or less developed pistil was surrounded by several anthers (Figure 9). Defected pistil formation was more prominent than stamen formation in hermaphrodite flowers. Ovaries were asymmetrically elongated, nearly halved rather than globular shape. Stigmas were unequal. Anthers were not well developed or formed as those observed in usual staminate flowers. Some of the anthers have stigmas or stigma-like structures (Figure 10).

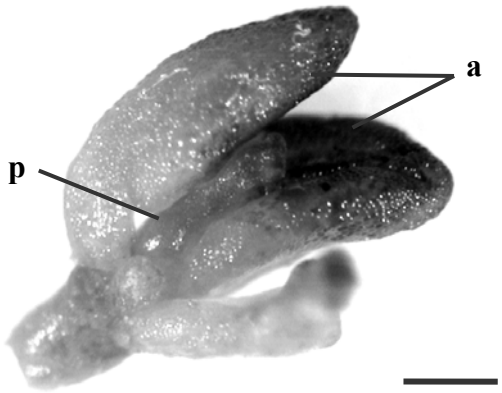

Figure 9. Terminal hermaphrodite flower, a: anther, p: pistil, bar=500µ

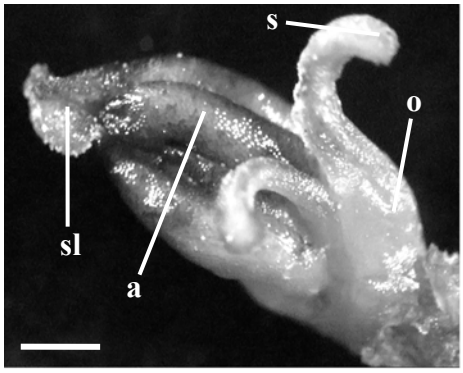

Figure 10. Floral organs in hermaphrodite flower, a: anther, s: stigma, sl: stigma–like structure, o: ovary, bar=500µ

Discussion

Observations showed the examined tree was multi stemmed and quite small contrasted with the general appearance of the other ***P. atlantica*** individuals scattered over the area. The tree appears to have originated from sucker regrowth after the original tree was cut down at some time in the past. In fact, intact ***P. atlantica*** trees in this area have one stem and generally a very large habit.

At the time of blooming, growth and development of male and female clusters were not synchronous. The tree seemed to have protandrous dicogamy and male clusters bloomed about one week before female ones. Protandrous ***P. atlantica*** trees were observed previously (Grundwag, 1975; Kafkas et al., 2000).

Morphological examinations showed the presence of three different inflorescence types with diverse distribution patterns on

branches. Male inflorescences were differed from female inflorescences with their different morphology. However, general morphology of inflorescences belonging to both sexes matched with the findings of previous studies on ***P. atlantica*** trees (Zohary, 1952; Grundwag, 1976). On the other hand, female clusters occurred on one-year old wood like the male ones. They were located predominantly on the outer canopy as unmixed branches. Also, they have rarely coexisted with male clusters on some branches (Figure 2). This type of inflorescence distribution was also reported for the Type II and Type III trees found in the Yunt Mountains in which the pistillate cluster was predominant (Kafkas et al., 2000).

As for the mixed inflorescences, they rather resemble female inflorescences or exhibit an intermediate morphology between the inflorescences belonging to both sexes. Occurrence of such clusters was limited to a narrow part of the canopy on the south side (Figure 3). The mixed inflorescences were born on one-year old wood as unmixed in general, but they rarely occurred together with male ones on several branches.

The degree of growth and development in mixed clusters appeared to be less than those found in female ones at the time of sampling. It was thought that the occurrence of such mixed clusters might partially link with either different source allocation within the tree or position of bearing branches on the canopy.

In this work, the presence of hermaphrodite flowers in mixed clusters was also shown. Hermaphrodite flowers were formerly reported in an early work in ***P. vera*** (Ozbek and Ayfer, 1958) and recently in ***P. terebinthus*** (Avanzato and Quarta, 2004). But micro-morphology of floral structures had not exhibited in both cases. Apart from unusual hermaphrodite flowers, malformed floral organs frequently occurred in mixed clusters. For instance, anther numbers of individual male flowers on mixed clusters did not exceed two, while the male flowers of normal inflorescences had more anthers. As a matter of fact, stamen number that ranged between 5 and 7 was reported in male flowers of ***P. atlantica*** (Zohary, 1952).

Examinations also showed that uneven organ formations were highly extensive in pistillate flowers of mixed inflorescences (Figure 8). Moreover, double ovary formation was also detected in some pistillate flowers. Double ovary formation was not reported for the members of ***Pistacia*** so far. It is an unacceptable characteristic for nut crops from the pomological point of view.

Organ formation disorders were more expressed in hermaphrodite flowers than unisexual ones. But defected or rudimentary pistillate structures were more abundant than the staminate ones in this type of flowers was observed. Post-pollination studies also showed the ovules of most hermaphrodite flowers were not perfect and main structures were uneven compared to normal pistillate flowers.

Conclusion

Results of this study proved the floral morphology of monoecious ***P. atlantica*** was far more complex. Former reports on the unusual gender types in ***Pistacia*** generally emphasized the various cases of inflorescence distribution without regarding the micro-morphology of floral structures. However, our examinations did expose that the incidence of defected or rudimentary floral organ formations could reach to a large extent in a monoecious ***Pistacia*** tree. In general, the expression of monoecious traits may give rise to hermaphroditism together with malformation of floral structures in ***P. atlantica***. In pistachio breeding, mentioned problems of floral biology would more or less affect the final yield. So they have to be considered as potential risks in transferring the monoecious traits.

Our works will more focus on the clarification of inflorescence characteristics and breeding value of examined tree in the coming years.

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