

## Inflorescence features of a new exceptional monoecious *Pistacia atlantica* Desf. (*Anacardiaceae*) population in the barbaros plain of İzmir/Turkey

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### Abstract

Unusual gender types in some *Pistacia* species are considered as useful material for pistachio breeding. In this report, the inflorescence characteristics of an exceptional monoecious *Pistacia atlantica* Desf. tree population were presented. The gender distribution was highly complex and variable among the trees. Some of the branches bore only female or male inflorescences. Also, some branches bore inflorescences belonging to both sexes concurrently. Besides, there were several branches having mixed clusters comprised the flowers of both sexes separately or hermaphrodite flowers in which the pistil and stamen concurrently appeared in some trees. In hermaphrodite flowers, defected floral organs were abundant.

**Keywords:** pistachio; Gender; hermaphrodite; pistil; stamen; ovule

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### Introduction

The genus *Pistacia* (*Anacardiaceae*) have eleven species, some of them are of high economic and cultural value in Mediterranean and Asian countries. All the species are dioecious and their flowers are unisexual, naked and anemophilous (Zohary, 1952). Both male and female inflorescences are panicles occurred laterally on one-year old wood (Crane and Iwakiri, 1981). So far, very few cases were reported on exceptional gender types and flower distribution in *Pistacia* species. All the examined trees were predominantly monoecious and some of them had also hermaphrodite (with male and female organs born in same flower) traits (Özbek and Ayfer, 1958; Crane, 1974; Kafkas et al., 2000; Avanzato and Quarta, 2004). It was hypothesized that a monoecious or hermaphrodite pistachio cultivar could eliminate the need for male (pollinator) trees in the orchard and augments the yield per hectare by about 10% (Özbek and Ayfer, 1958; Kafkas et al., 2000; Avanzato and Quarta, 2004). Despite the need of a long-term breeding protocol, the transfer of monoecious genetic trait to cultivated pistachio would provide high benefits theoretically.

Anatolia is an important center of diversity for the members of *Pistacia*. The Aegean region has also a large diversity of *Pistacia* genetic resources. In some regions, wild seedling trees are top-worked with pistachio cultivars (Atlı et al., 1998). In this report, the inflorescence features of an exceptional monoecious *P. atlantica* tree population, also bearing hermaphrodite flowers discovered in Barbaros plain of İzmir Province were presented.

### Materials and Methods

Our consecutive examinations in the springs of 2005-2008 resulted in the discovery of six *P. atlantica* seedling trees bearing both staminate and pistillate inflorescences. One of the trees was in an uncultivated location (Tree 1: 38°19'27.5"N, 26°34'34.7"E-165 m asl.) and the rest of them were standing as a group of border trees (Tree 2-6: Approx. 38°19'29.6"N, 26°34'37.2"E-166 m asl.). Observations were done during the blooming stages of trees. Fresh shoot samples with flower clusters were collected and stored at 4 °C, under humid conditions. Micro-anatomical examination of floral structures was performed with a stereo microscope (OLYMPUS SZ61) and documented with digital camera system.

### Results

Phenological observations for four years showed the blooming was more or less variable among the existing trees and also in different years. Blooming was generally protandrous in Tree 1, 3, 5, 6 (male clusters bloomed about one week before female clusters). But one of them (Tree 4) was protogynous and the other one (Tree 2) was homogamous. Peak blooming ranged between 4<sup>th</sup> week of March and 3<sup>rd</sup> week of April according to different trees and years.

Tree types of inflorescences showed different distribution patterns were distinguished on branches.

Male inflorescences were generally conical in shape, compact, later loosening, and reddish before pollen shedding. In Tree 1 and 2, male clusters rarely coexisted with female ones on some branches. Branches only with male inflorescences were very scarce on the canopies of Tree 1, 4 and 5. Rest of the trees had more male inflorescences evenly dispersed on their canopies. In Tree 1, they were some male inflorescences differed with their darker colors than normal ones. Such extraordinary clusters had many male flowers with defected or rudimentary anthers (Figure 1A).

Female inflorescences were less conical, less compact and longer than the male ones. They were located mostly on vigorous branches of outer canopy and generally but not always (e.g. Tree 1, 2) unmixed. In general, amount and distribution of female inflorescences appeared to be in balance with male ones on the canopies of Tree 2, 3 and 6.

The mixed inflorescences were only detected in Tree 1 and 2. They had an intermediate morphology between male and female inflorescences that sometimes could be more similar to each of gender (Figure 1B). Thus, they were categorized as male-like and female-like mixed inflorescences. Occurrence of mixed inflorescences originated from one-year old wood of the weak lateral branches in a narrow part of the canopy. They were mostly

unmixed, but rarely appeared with male inflorescences on several branches in Tree 1 (Figure 1C).

The mixed clusters not only comprised the individual flowers of both sexes separately, but also bore hermaphrodite flowers. Staminate flower formation was predominant in male-like clusters, whereas the appearance of pistillate and hermaphrodite flowers was very scarce. Most of the anthers had stigmas or stigma-like structures (Figure 1D). Pistillate flowers separately occurred on some clusters and all of them were even defected or rudimentary.

As for the female-like clusters, pistillate flowers were abundant, while the occurrence of staminate and hermaphrodite flowers was infrequent. In such clusters, defected or imperfect floral organ formations were highly extensive. Anther formation was usually more or less defected in shape or at least one of the two anthers was even rudimentary in staminate flowers. In pistillate flowers from female-like clusters, uneven pistil formations were frequently detected. Unlike the globular shaped ovaries in normal pistils (Figure 1E), cylindrical ovaries with over split or closed stigmas were not scarce (Figure 1F). Double ovary formations were rarely observed in some pistillate flowers (Figure 1G).

In hermaphrodite flowers, malformed floral organs were more prominent in female-like clusters. Most of them have one anther and a pistil is contiguous with each other (Figure 1H). Defected pistil formations were more common than stamen formation in hermaphrodite flowers. Ovaries were asymmetrical, nearly halved rather than globular shape and some of the anthers had stigmas or stigma-like structures as formerly described in staminate flowers of male-like clusters (Figure 1I).

Post-pollination examinations showed the ovule formation in most of the hermaphrodite flowers was more or less faulty compared to pistillate flowers from the normal female clusters (Figure 2A, B).

## Discussion

Despite the protogynous blooming behaviour of Tree 4, most of the trees (Tree 1, 3, 5 and 6) had protandrous dicogamy (Tree 2 was homogamous). Tendency towards earlier flowering of male individuals in *P. atlantica* was previously observed (Grundwag, 1975; Kafkas et al., 2000). But protogynous dicogamy was not reported so far in this species.

Occurrence and distribution of male, female and mixed inflorescences had diverse patterns among the trees. Male inflorescences mostly unmixed, but they rarely occurred together with female ones as observed in Tree 1 and 2 as formerly reported in the same species (Kafkas et al., 2000). Branches with only male clusters were very scarce and unevenly distributed on the canopies of Tree 1, 4 and 5. This type of gender distribution for monoecious *P. atlantica* trees was previously reported (Özbek and Ayfer, 1958; Crane, 1974; Kafkas et al., 2000).

Hermaphrodite flowers (comprising both male and female structures) were first reported in *P. vera* (Özbek and Ayfer, 1958). In another case, individual pistillate and staminate flowers occurred in same inflorescence in *P. terebinthus* (Avanzato and Quarta, 2004). Samples of Tree 1 and 2 appeared to have both of the gender distribution features of the other *Pistacia* species mentioned above and consequently they were more complex compared to other cases. The reasons of floral structures like rudimentary anthers, anthers

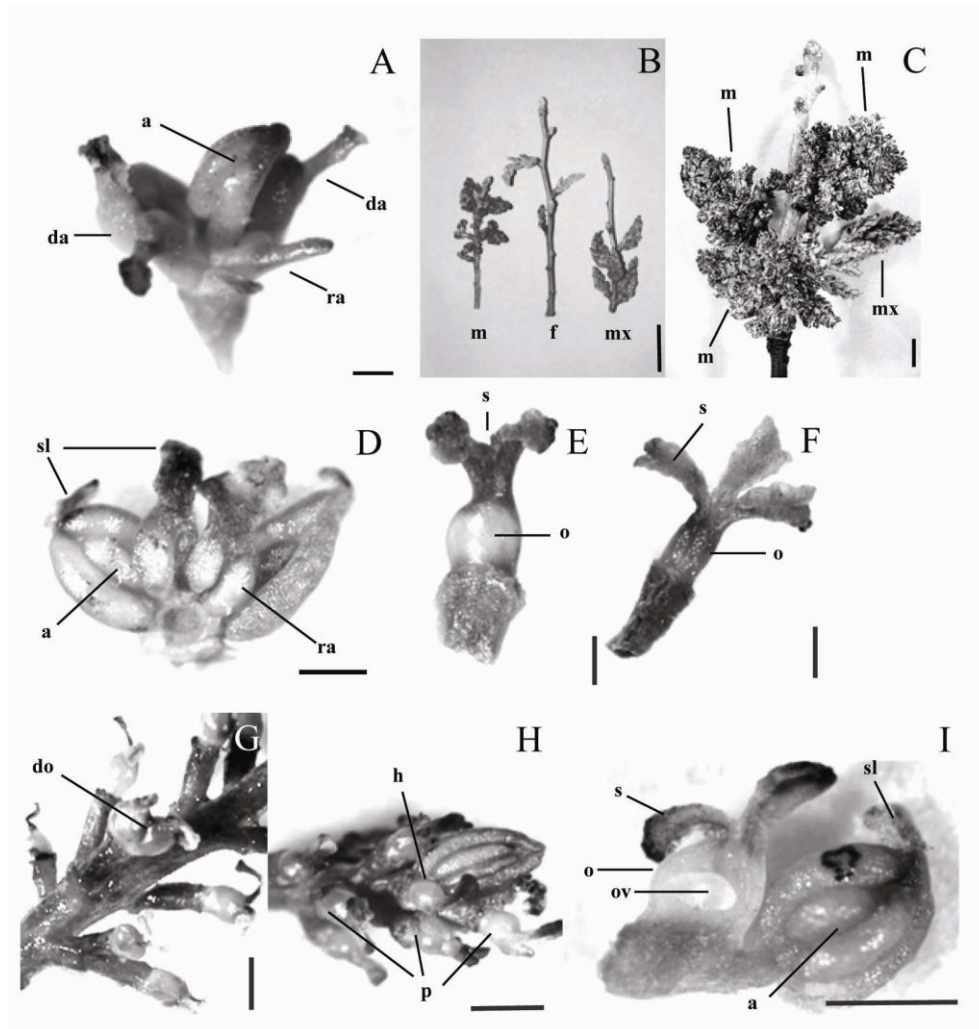


Figure 1. Malformed organs in staminate flower, a: anther, da: defected anther, ra: rudimentary anther, bar=500 $\mu$  (A). Comparison of three types of inflorescences on one-year old wood, f: female, m: male, mx: mixed, bar=5 cm (B). Male and mixed clusters on one-year old wood, m: male, mx: mixed, bar=1 cm (C). Staminate flower in male-like cluster, a: anther, ra: rudimentary anther, sl: stigma-like structure, bar=500 $\mu$  (D). Normal pistil, s: stigma, o: ovary, bar=500 $\mu$  (E). Abnormal pistil, s: stigma, o: ovary, bar=500 $\mu$  (F). Double ovary formation in pistillate flower, do: double ovary, bar=1mm (G). Hermaphrodite and pistillate flowers in female-like cluster, h: hermaphrodite, p: pistillate flowers, bar=1mm (H). Asymmetrical ovary (dissected) in hermaphrodite flower, a: anther, s: stigma, sl: stigma-like structure, o: ovary, ov: ovule, bar=500 $\mu$  (I).

with stigmas or stigma-like structures (Figure 1D) and also rudimentary pistils in male-like clusters of mixed inflorescences appeared to be obscure.

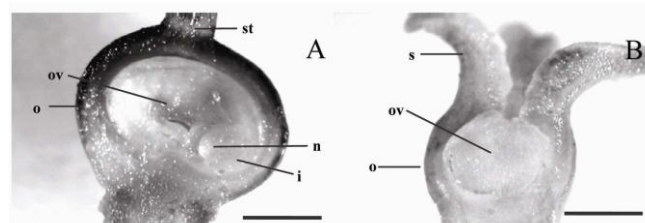


Figure 2. Ovule formation in normal pistillate flower, i: integument, n: nucellus, o: ovary, ov: ovule st: style, bar=500µ (A). Imperfect ovule formation in hermaphrodite flower, o: ovary, ov: ovule, s: stigma, st:style bar=500µ (B).

In female-like inflorescences, another number of individual staminate flowers was remarkably less compared with the staminate flowers of dioecious *P. atlantica* (Zohary, 1952). Besides, double ovary formation in pistillate flowers (Figure 1G) was not reported for the members of *Pistacia* so far. In hermaphrodite flowers, uneven ovary and stigma shapes were also very distinctive in pistillate structures. Such ovarian disorders might negatively affect the formation of healthy ovules. As a matter of fact, post-pollination examinations pointed out the faulty ovules in most of the hermaphrodite flowers dissected (Figure 2B). Insufficient seed setting is a common problem in *P. atlantica* species and did not exceed 28 % in wild (Grundwag, 1975; Grundwag, 1976). However, initial ovary and ovule morphology and development were not different in both fertilized and unfertilized flowers was reported (Grundwag, 1976). For this reason, many pistillate and hermaphrodite flowers from mixed inflorescences in examined trees will more likely fail to set seeds as a result of imperfect reproductive structures.

This work did expose the intensity of faulty organ formations could reach to a great extent in some monoecious trees. Expressions of monoecious traits may lead to hermaphroditism together with malformed floral structures in *P. atlantica*. In pistachio breeding, floral biology in monoecious types of the Barbaros Plain would be a useful information for further strategies.

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