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ABNORMAL CONES IN *CUPRESSUS SEMPERVIRENS*

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ABSTRACT

Abnormal cones found in *Cupressus sempervirens* include bisexual cones and double female and male cones. They are very infrequent, but there are individual trees with a tendency to produce such cones. We suggest that these cones reflect changes in normal hormonal balance.

Key words: *Cupressus sempervirens*, bisexual cones, cones.

INTRODUCTION

All conifers, which belong to the gymnosperms, normally have unisexual cones. The male cones are simple, made of one branch, and the female cones are compound, made of several branches (Gifford and Foster 1989). Very infrequently, bisexual cones are formed, especially in the Pinaceae (Goebel 1905; Chamberlain 1935). Natural occurrence of bisexual cones in the genus *Cupressus* has been reported only in *C. macrocarpa* Hartw. ex Gord. (Lemoine-Sebastian 1972), but bisexual cones have been artificially induced in *C. arizonica* Greene by gibberellin application (Pharis and Morf 1967). Double (bifurcated) cones are even more infrequent. Double male cones were reported in *Cedrus libani* A. Rich (Masters 1869), *C. deodara* (Roxb. ex Lamb.) G. Don (Khoshoo 1949), and *Pinus ponderosa* Dougl. ex. Laws. (Bingham et al. 1969), and double female cones in *P. monticola* Dougl. ex. D. Don (Bingham et al. 1969).

In this note I show that various types of bisexual and double cones are formed by *Cupressus sempervirens* L. trees.

MATERIALS AND METHODS

The cones of several thousand trees 5–60 years old of *Cupressus sempervirens* were observed as part of a study on the reproductive biology of Mediterranean conifers. About 350 of these trees, from five to nine years old, were observed regularly every year from their first year of cone formation in 1984 until 1989. More than 100 of these trees were marked; thus, trees which formed bisexual cones could be individually visited. Altogether, about 50,000 young female, 20,000 mature female, and 20,000 male cones were observed, and bisexual and double cones were found. Several bisexual cones were coated with gold and studied under a Jeol JSM 840 A scanning electron microscope, to examine their structure.

RESULTS

Bisexual cones were found on four *Cupressus sempervirens* trees, three of which grew in Tel Aviv and one in Lehavim (Israel). One of the trees formed bisexual cones during four successive years. The tree in Lehavim formed only one bisexual

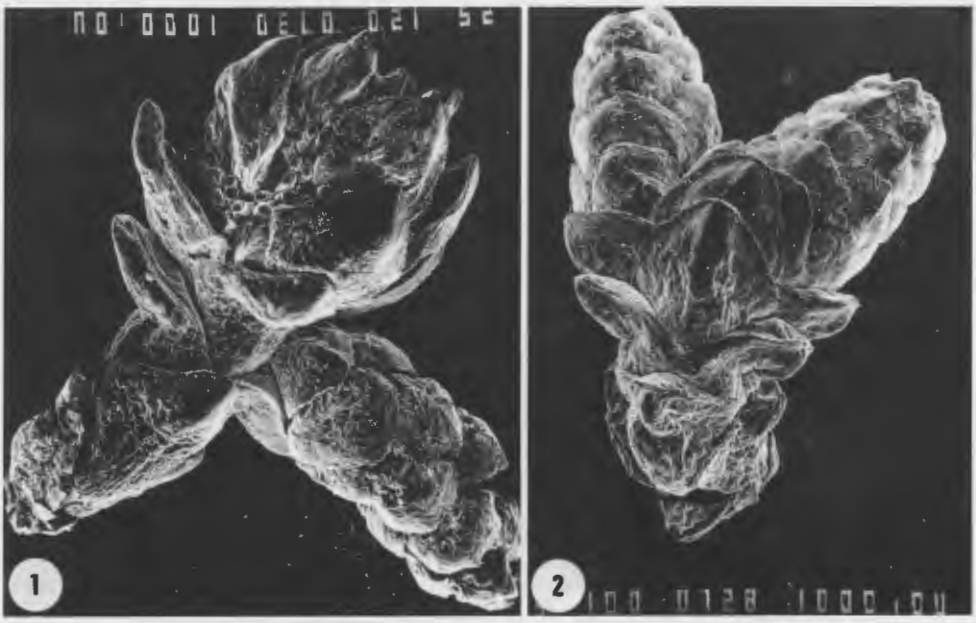

Fig. 1–2. Abnormal cones of *Cupressus sempervirens*. — 1. A bisexual cone showing a round female part and an elongated male cone emerging from the base (×35). — 2. A bisexual cone which has a bifurcated upper male part (×35).

cone, one tree in Tel Aviv formed one bisexual cone, another formed three, and the third tree, 22. Altogether, 27 bisexual cones (0.054%) were found, versus about 50,000 young female and 20,000 male cones. Of the 27 bisexual cones, 23 had a female base and a male top, three had a male cone as a lateral appendage (Fig. 1), one had a bifurcated male top (Fig. 2). When the female cone was normal (complete), with a male appendage, the female part had normal ovules, and the male part was also normal, and shed pollen. The bisexual cones appeared in lateral branches, at the center of the crown. Their position on the branch was among female cones, but close to the male zone.

In addition, a total of five partially bifurcated mature female cones (0.025%) were found in three trees: one in Lehavim (Fig. 3), and three on one tree and one on another, growing in Yoqneam.

Finally, two trees in the Tel Aviv population carried male cones above the female cones in the young growth, which usually carries female cones, of several branches.

DISCUSSION

Natural occurrence of bisexual cones is commonly the outcome of an unknown environmental setting (see review by Tosh and Powell 1986), but in *Pinus monticola* (Bingham et al. 1969), and *Larix laricina* (Du Roi) K. Koch (Tosh and Powell 1986), some trees form bisexual cones regularly, and this seems to indicate a genetic basis (Bingham et al. 1969; Tosh and Powell 1986).

Initiation of cones starts after a hormonal stimulation of the growth apices. In conifers, male cones are induced by various gibberellins (Pharis, Ruddat, Phillips,

Fig. 3. An abnormal, partially bifurcated, mature female cone (×1.3).

and Heftman 1965; Pharis and Morf 1967; Ross and Pharis 1987). Less is understood about the induction of female cones. Accumulated experimental evidence, and the zonation of cones in the crown: female cones in upper, lateral, young parts, and male cones in lower and inner parts (Pharis and Morf 1968; Marquard and Hanover 1984; Lev-Yadun and Liphschitz 1987), led to a suggestion that auxin may be involved in female cone induction in addition to gibberellin (Pharis and Morf 1968; Pharis and King 1985).

Both bisexual and double cones in *Cupressus sempervirens* are very infrequent. Most previous reports on bisexual and double cones are from the Pinaceae (see review in Tosh and Powell 1986), and only a few instances of bisexual cones have been reported in *Cupressus* (Lemoine-Sebastian 1972; Pharis and Morf 1967). In *C. sempervirens* bisexual cones were found in a zone where female and male cones were close together, e.g., less than 5 cm apart, and thus in such cases the usual zonation of gender in the crown of *C. sempervirens* (Lev-Yadun and Liphschitz 1987) was blurred at the meeting zone. Since hormonal regulation is involved in bisexual cone production (Pharis and Morf 1967, 1968; Marquard and Hanover 1984; Longman 1985), it seems that the blurred situation resulted from an intermediate hormonal balance in the contact between female and male zones. The inverse position of male and female cones in *C. sempervirens* (male distal to female on the branch) seems to reflect a temporary disorder in hormonal balance. The reasons for this disorder are not known.

The formation of double (bifurcated) cones probably results from changes in the growth apex, or follows release of a dormant bud from suppression. Since female cones are compound branches (Gifford and Foster 1989), it is not surprising that sometimes dormant branches will proliferate and result in double cones.

Actually, their extremely low frequency seems to indicate a very strong apical dominance in the cones. The same is true for male cones, in which dormant buds should exist above the base of every microsporophyll.

The relationships between female and male cones found here support the hypothesis that female cones are compound, and male cones are simple. Compound branches can form simple branches from a dormant bud, as happens in bisexual cones that have a female base (the compound part), with the male addition either at the tip or in a lateral position. Male cones, which are simple, do not carry female cones.

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