

Development and Growth Curve of the Pine Cones of *Araucaria angustifolia* (Bert.) O. Ktze, in the Region of Curitiba – PR

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ABSTRACT

The objectives of this work were to describe the development and growth rate of the pine cones of *Araucaria angustifolia* during and after the pollination period, to identify the period of maximum growth of the cones and the period of pollination and maturation of the pine nuts. The adult individuals were found at the Setor de Ciências Agrárias of the UFPR, in Curitiba – PR. Collections and measurements of pine cones were made in 2003 and 2005. The diameter and the length of the pine cones were measured 15 different times in both the years. In the studied environmental conditions, the period between the pollination and maturation of the pine nuts was 20 months. The maximum pine cone growth was achieved between October and January after the pollination, and between October and April of the following year.

Key-words: parana-pine, strobili, pollination

INTRODUCTION

Araucaria angustifolia is economically the most important native species of gymnosperm in Brazil. Its occurrence characterizes the Araucária forest, which occurs mainly in the southern states of Brazil, but also occurring in the states of São Paulo, Minas Gerais and Rio de Janeiro and neighbouring countries like Argentina and Paraguay (Koch and Corrêa, 2002). And the araucaria is a dióica plant pollen is carried from the male strobili (androstrobilus) to the female strobili (ginostrobili). After the pollination, the pines grow until the seeds are mature and fall (Shimoya, 1962; Solórzano-filho, 2001). The inflorescences develop at the apical region of the

branches of adult the plants. The ginostrobilus is made of several carpelares leaves distributed along a common conical axe, known as "pinha". The androstrobilus are less developed estrobilus, known as "mingotes", have several scales distributed along an elongated axe which carry the pollen sacs where the pollen grain grow (Mattos, 1972; Ferri, 1983).

In *A. angustifolia* the formation of the androstrobilus starts in November and all the estrobilus of each individual plant usually are at the same developmental stage. Between September and October of the following year, the pollen is released in a cycle of 10 to 11 months (Anselmini, Zanette and Bona, 2006). The initial formation and development of the ginostrobili of

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A. angustifolia is internal, shield by the terminal leaves of the branches. The reproductive branches are formed in November, at the same time as the androstrobilus. In September, the "terminal leaves" of the reproductive branches open and expose the ginostrobilo, already with its modified fertile and sterile leaves formed. The pollination occurs from September to October, subsequently the pines start to grow so that the maturation and the fall of the seeds occur approximately 20 months later, from April to September. Due to this extended reproductive cycle of more than on year, the pines can be found at three different developmental stages of the same individual plant (Anselmini, Zanette and Bona, 2006).

The main goal of the present work was to accurately describe the development/growth of the pine cones of *A. angustifolia* during and after the pollination, identifying the period of maximum pine growth and the period of pollination and maturation or the seeds in the studied region (Curitiba – PR).

METHODS

This study was conducted on the adult *Araucaria* plants, more than 30 years old, during 2003 and 2005. The observations and ginostrobilus collections were made every month on the female plants and three of these were also used to observe the pine cone growth. Two male plants were used to observe the development of the androstrobilus. The pine cones measurement started after the pollen was released by the androstrobilus, beginning of the pollination season. The diameter and the length of the pine cones were measured with a "packimeter" to establish their growth rate. An elevating platform (18m high) was used to reach the top of the trees. Three adult plants, with 20 pine cones each were used. The pine cones were individually marked. The measurements were done on the following dates: 23/10/2003, 28/11/2003, 18/12/2003, 22/01/2004, 17/02/2004, 05/04/2004, 04/05/2004, 01/06/2004, 03/08/2004, 28/09/2004, 12/11/2004, 14/12/2004, 24/01/2005, 22/02/2005 and 05/04/2005, when the mature pine cones, which presented differences in colour, were finally collected.

RESULTS AND DISCUSSION

The individuals of both the sexes produce a new estróbilos every year. In the male plants, all the androstrobilus were at the same developmental stage and before the new structures start to be formed with an overall cycle of less than one year (Solórzano-filho, 2001; Anselmini et al., 2006). In contrast, in the female plants, new estróbilos were formed every year and in the same plant ginostrobili of two to three different developmental stages can be found simultaneously (Anselmini, Zanette and Bona, 2006). The formation of the reproductive branches was observed during November in 2003 and 2004, generally at the third or fourth verticilo after the last fructification. The formation and initial development of the ginostrobili of *A. angustifolia* occurred while they were entirely protected by the terminal leaves of the branches. The formation of the parts of the ginostrobili, like the modified fertile leaves and the infertile leaves also occurred in the same period. Hundreds of the modified leaves can be seen when the protective leaf layer was removed from the reproductive branches (see also Mattos, 1972 and Hertel, 1980). For the environmental conditions of Curitiba in 2003 and 2004, the modified leaves in the ginostrobilus started to be formed in January. In March, the fertile scale started to appear at the base of these leaves (Anselmini, Zanette and Bona, 2006). In August, after nine months of the beginning of the development of the ginostrobilus, the terminal leaves started to open, exposing the modified reproductive leaves, which then received the pollen (transported by the wind) (Fig. 1-A). In 2004, the pollination occurred from the second half of September to the end of October. During this period, the pollen was released from 30% of the androstrobilus of one of the male plants studied. After the pollination period, the therm pine cone was used instead of the ginostrobili. The pine cone growth starts and in width and length after the female reproductive "button" was open during the pollination period. It lasted for 20 months, until the full maturation and fall of the pine seeds (Fig. 1-BCDEF). Similar were recorded by Burlingame (1914), and Mantovani et al., (2004) at the Campos do Jordão region. However these events were different from those observed by Shimoya (1962) and Solórzano-Filho (2001), which reported a period longer than 20 months.

A notable size increase of the pine cones occurred between October and January 2003/04 (Fig. 2).

From February 2004, the growth rate decreased considerably up until August when another period of marked growth starts.

For the Curitiba region, the months of August and February correspond to a more favourable period of the year, with increased luminosity and

temperature, which allow a higher vegetative growth rate. Shimoya (1962) reported that in the region of Viçosa in the state of Minas Gerais, two distinct periods on the development cycle of *A. angustifolia* can be observed. One between October and December, when the pollination and fertilization of the ginostrobilus occurred.

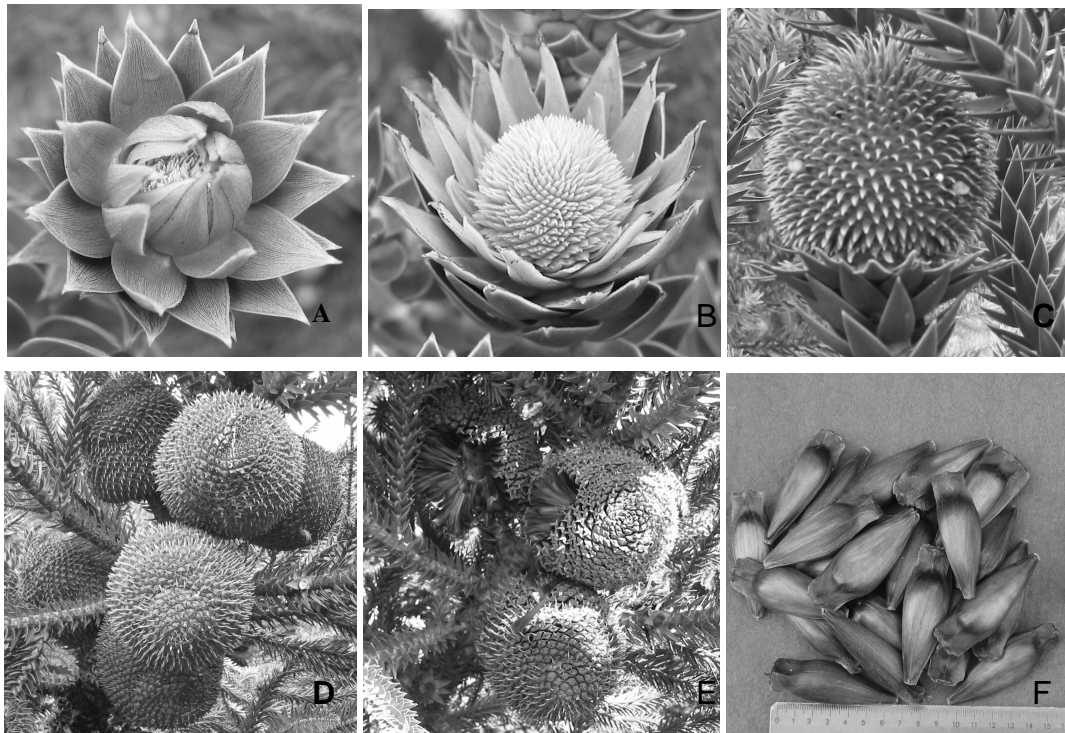


Figure 1 - Phenology evolution and growth of the pine cones. A) Ginostrobilus the terminal leaves start to open; B) Ginostrobilus during pollination period; C and D) Growth of the pine cones after the pollination period; E) Maturation of the seeds period and F) Mature seeds.

The second period, between May and July, corresponded to a resting period when no significant reproductive events occurred. However when the óvulos of *A. angustifolia* were fertilized yet remained to be determined. It has been suggested that the time lag between the pollination and fertilization approximately ranged between 12 to 14 months (Burlingame, 1913; Shimoya, 1962). This period encompassed the growth of the pollen tubes, fertilization and the formation of the do pro-embryo. After the fertilization the beginning of the zygotic embryogenesis is characterized by the

intense mitotic activity and the end is characterized by the accumulation for reserve (von Arnold et al., 2002). Observing the growth curve of the pines, the second growth peak appears one year after pollination, so that it could represent the period of the fertilization and the accumulation of reserve substance. After April, the pine size remained constant. During the second phase of the marked growth (February 2005), the pine cones were on average 118 mm wide and 133 mm long. The mature pine cones collected the year before presented a very similar size (average width = 120

mm, average length = 152 mm). The pine cones maintained their oval shape throughout the development. Mattos (1972) and Koch and Corrêa (2002) suggested that the period of the seed fall lasted for approximately six months (from March

to August). However, in the case the seed fall was during April and September and in two plants, the maturation of the seeds occurred during September and December.

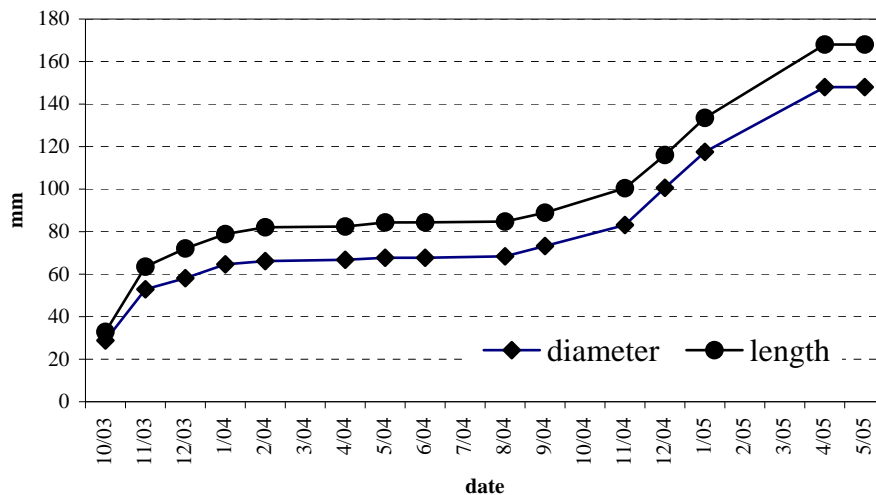


Figure 2 - Growth curve of the pine cones of *Araucaria angustifolia*, in the 2003 and 2005, Curitiba – PR.

CONCLUSION

The period between the pollination and maturation of the pine cones is of approximately 20 months. Two growth peaks of the pine cones were observed, one between October and January, after pollination and another between August and April of the following year.

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RESUMO

O objetivo deste trabalho foi descrever o desenvolvimento e o crescimento das pinhas da *Araucaria angustifolia* durante e após o período de polinização, identificando os períodos de maior crescimento das pinhas, a época de polinização e maturação dos pinhões. As plantas adultas

pesquisadas situam-se no Setor de Ciências Agrárias da UFPR, em Curitiba – PR. Para o acompanhamento do crescimento das pinhas foram realizadas coletas e medições de pinhas durante os anos de 2003 a 2005. O diâmetro e o comprimento das pinhas foram medidos em 15 datas, durante os três anos. Para as condições ambientais de Curitiba, o período compreendido entre a polinização das pinhas e a maturação das sementes foi de 20 meses. Há dois picos de crescimento das pinhas, um de outubro a janeiro, logo após a polinização, e outro de outubro a abril do ano seguinte.

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