THE CULTIVATION OF TITAN ARUM (*AMORPHOPHALLUS TITANUM*) – A FLAGSHIP SPECIES FOR BOTANIC GARDENS

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One of the most exciting plant species is the Titan Arum, *Amorphophallus titanum*, which can truly be regarded as a flagship species for botanic gardens. Wild populations suffer from an increasing pressure on their natural habitat, but botanic gardens can play an important role in the *ex-situ* conservation of the species. The cultivation of *A. titanum* is not easy but it offers an irresistible challenge for any keen horticulturist. The University of Bonn Botanic Gardens (Germany) has more than seventy years of experience in the cultivation of this giant and the purpose of this paper is to help the botanic garden community to achieve success in the cultivation of this fascinating plant.

INTRODUCTION

The Titan Arum (*Amorphophallus titanum*) is one of the most prominent plants in the plant kingdom. It was discovered in Sumatra (Indonesia) in 1878 by Odoardo Beccari who sent seeds to the botanic gardens in Florence and Kew. It took 11 years before the first plant flowered in 1889 at the Royal Botanic Gardens, Kew. For the next 100 years flowering events of Titan Arum in botanic gardens were extremely rare; only 21 flowerings were recorded worldwide until 1989 – three of them in Bonn (1937, 1940, 1987). In 1998 Barthlott & Lobin published a comprehensive monograph on *Amorphophallus titanum*.

Gandawija *et al.* (1983) provide an overview on various flowering events of *A. titanum.* According to Fayyaz (2006, internet presentation) there are approximately 100 plants that produce flowers in cultivation worldwide. Field observations are published by Giardano (1999), Hetterscheid (1994) and Symon (1994).

Since 1990 approximately 80 *A. titanum* plants have bloomed in botanic gardens – six of them in Bonn (two in 1996, 1998, 2000, 2003, 2006). It is not only the architectural structure but also its gigantic blooms with mal odour that are a magnet for thousands of visitors when it is in flower. It is worth noting that scientists from

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the field of bionics are becoming increasingly interested in the structure of the inflorescence.

The University of Bonn Botanic Gardens can reflect on a long tradition in the cultivation of this species. The first Titan Arum bloomed in 1937, followed by eight further occasions, the last in 2006 (see Table 1).

Date	Weight (kg)	Height (m) Measured from soil surface
21 April 1937	22.5	1.81
July 1940	/	/
8 April 1987	21,5	1.61
8 May 1996	32	2.33
30 May 1996	50	1.69
30 April 1998	27	1.72
7 July 2000	36	2.575
22 May 2003	78	2.74
13 and 16 May 2006	117	2.595; 2.22; 1.665

Table 1: Flowering of *Amorphophallus titanum* in the University of Bonn Botanic Gardens

Naturally over such a long period of time a considerable amount of horticultural observations and data have been accumulated and a general overview was published by Hetterscheid *et al.* (1998). The former horticulturist in charge at Bonn, M. Koenen (retired), and now M. Neumann have gained considerable practical experience in cultivating *A. titanium* and this now deserves to be shared with the wider botanic garden community.

Anatomical research in plant structure is one of the major activities at the affiliated Nees Institute. The structure of the 1987 inflorescence was examined thoroughly by scientists from different fields and the results were published by Barthlott & Lobin (1998). In this publication a general review of available literature covering the species can be found. The revision of the African species of *Amorphophallus* was carried out in the Nees Institute also, using plant material from the gardens (Ittenbach, 2003). Finally, Hejnowicz & Barthlott (2005) reported on *A. titanum* as an ultra light construction.

One of the specimens currently held at Bonn not only produced the tallest flower in 2003, but it also flowered in three consecutive years, in 2000, 2003 and 2006. This is unusual, since most Titan Arums do not survive the stress of flowering in cultivation and die soon after their first flowering. The most outstanding flowering event was the one in 2003 when the plant developed an inflorescence of 3.06m measured from tuber surface and it entered the Guinness Book of World Records. The same plant also produced the biggest ever recorded tuber of 117kg. In May 2006 this produced three individual blooms at the same time, opening within one week (Fig. 10). Multiple blooms of Titan Arum had not been observed before this time.

MORPHOLOGY, HABITAT AND LIFE STRATEGY

Titan Arum occurs throughout the Barisan mountain Range in West Sumatra, Indonesia. Its main distribution centre covers approximately 300 x 100km on the western slopes in secondary rainforests from sea level 1200m. It prefers humid soils and open places where it grows in groups of individuals at all stages of development (Hetterscheid, 1998). In the description that follows, the life cycle of Titan Arum is described in order to provide a better understanding of its growth characteristics (Fig. 4).

The plants grow at intervals interrupted by periods of dormancy. It produces either one gigantic leaf or, having reached critical tuber size (see below), inflorescences. The tuber produces only one leaf at a time. This can reach an impressive size and resembles a small tree. The petiole of a mature plant may grow up to three meters in height. White circular marks on the petiole resemble lichens, and this phenomenon of mimicry is described in detail in Barthlott (1995).

The lamina is at least 3 times dissected and the one on a recent leaf of a mature Titan Arum at Bonn was 5.2m in diameter. It covers an area of 22m² and a leaf may last for 9 to 24 months. Young plants keep their leaves for only for 6 months.

The tuber is capable of doubling its weight during the vegetative period. When it has reached approximately 15kg it is mature and can produce either a leaf or an inflorescence after dormancy. Table 2 presents an overview of weight increase of an *A. titanum* tuber. The Titan Arum that bloomed in 2000, 2003 and 2006 more than doubled its tuber weight between 2000 and 2003 from 36kg to 78kg. Within 12 months, from 2003 to 2005 the tuber grew from 78kg to 117kg. – a net weight increase of 39kg within one and a half years. After the triple bloom in May 2006 the tuber went into dormancy with a weight of 94kg and so, during the triple bloom, the tuber lost some 23kg.

Weight (kg)	**Diameter (millimetres)**	**Height (millimetres)**	**Estimated age in years**	**Year of measurement**
Various *A. titanum*				
5	230	150	7	
32	490	/	9	1996
50	490	380	imported	1996
Same plant of titan arum				
36	490	230	11	2000
78	650	340	14	2003
117	830	370	16	2006
94	800	370	17	2007

Table 2. Dimensions of tubers of *Amorphophallus titanum*

The inflorescence has gigantic dimensions. It consists of a spathe which forms a tube at its base where tiny female flowers are arranged below the small male flowers. The spathe opens during the afternoon and during the first night the female flowers bloom. A strong smell of carrion is released at short intervals but only for a short period of time during the first night, when the plant is in its female stage. Towards the end of the first night the spathe may close a little or more. During the second night, the male flowers bloom producing masses of yellow pollen. On the second day the inflorescence closes completely and may stay upright for about another day. Then the spadix collapses. In cultivation the flowers are normally not pollinated unless artificial pollination is carried out (see below). Any unpollinated inflorescences will wither in the following weeks. After pollination the Titan Arum will develop an infrutescence with orange red berries.

CULTIVATION

The cultivation of the Titan Arum in botanic gardens is very specific. It requires a conservatory with a roof height of at least 5 meters and it needs to maintain a high temperature and humid conditions (see below). The cultivation of Titan Arum is therefore not particularly suitable for the beginner, amateur or botanic gardens with minimal glasshouse facilities.

Containers and Potting

The size of the container should be 2.5 times larger than the diameter of the tuber. For example, if the tuber is 100mm in diameter the pot provided should be 250mm across. The best containers for Titan Arums are made of plastic and they should be wider than they are deep. Bearing in mind that the tuber of a mature plant may weigh up to 75kg or more, a container of approximately 1.4m diameter will be required. Tuber, container, compost and water add up to a weight of more than one ton and, therefore, once potted the container can only be moved with extreme difficulty so it has to be placed in the location where it might eventually flower.

During dormancy the tuber should not be taken out of the pot and it must be stored in a warm place. The best time for potting is towards the end of dormancy when the central bud starts to swell. The roots should not be in growth or only very slightly and should not be damaged by repotting the tuber.

When large tubers are taken out of the soil they should not be allowed to lie directly on a hard surface because their own weight may cause damage to the lower part of the tuber (Fig. 5). In order to avoid any damage it is best to place the tuber on a 200mm layer of compost that will later be used for potting. A normal container is placed upside down above the tuber to avoid desiccation and keep it away from light. If roots have already developed at this stage, a wet tissue should be placed above the bud and the roots. The duration of storage should be as short as possible as in its natural habitat the tuber never dries out completely. Small tubers will die within 10 days if kept dry outside the compost.

The compost has to be changed completely. It is important to plant the tuber fairly deep because approximately 90% of the roots develop on the upper surface of the tuber next to the central bud and the remaining 10% develops around the rest of the tuber. The width between the tuber and rim of the container should therefore be wide enough so that the roots can reach the compost beneath. The size of young and old tubers vary greatly; larger tubers (more than 10kg) should have at least 200mm of soil on their upper surface, medium sized ca. 100mm, and small ones 30 to 40mm.

Compost

The key for successful cultivation of the Titan Arum is plant hygiene. Therefore, all compost needs to be free of pathogens and thus should be steamed before use. The recommended compost is a mixture of 75% Einheitserde ED73 (Balter) and 25% washed sand. Einheitserde ED73 (Balter) consists of 70% peat, 30% claydust, pH 5.8, fertilizer (N:P:K ratio 14-16-18) and slow-release fertilizer (N:P:K ratio 20-10-15). At the bottom of each container a layer of gravel should be placed for drainage – lava, pumice or limestone are suitable materials. This drainage should cover about 10% of the depth of the pot.

Watering

Titan Arum requires regular watering and it has to be cultivated under very humid conditions, which can generally only be reached in appropriate conservatories.

Directly after the tuber has been potted, it has to be watered thoroughly to ensure that the compost is completely wet. With larger tubers of 500mm diameter or more, watering has to be carried out very carefully, because larger tubers prevent the soil beneath them from becoming wet. The compost should never dry out after potting and at the start of leaf development, in particular, the young plants are sensitive to drying out. Plants will die if not watered well and experience has shown that it is better to water more rather than keeping the plant too dry. Good drainage as described above is absolutely necessary for successful cultivation. Clogged drainage or 'wet feet' will kill the plant in due course.

Once the Titan Arum starts to bloom and the spathe opens it is necessary to water the container carefully on that day and only then will the inflorescence open completely. Personal observation has shown that the supply of ample amounts of water at this period are essential for the complete opening of the spathe. In the 1998 bloom the container seemed to be wet enough and was not watered while the spathe opened, but then the inflorescence did not open completely.

Critical attention also has to be given to air humidity. *A. titanum* suffers particularly in summer and if air humidity falls under a critical level the leaf edges start to drop down. Experience has shown that air humidity should be 80–90%. Air humidity is especially important during antheses, because the spathe will wither faster, if air moisture is too low. It should be as high as possible, with a minimum of 80%. This may be difficult to maintain, when visitors queue to see the plant and when there is regular opening and closing of access doors.

Fertilizer

Titan Arum requires high levels of fertilizer to be applied on a regular basis. Liquid fertilizer should be applied every fortnight starting immediately after potting with 0.3% of 8% N, 8% K, 6% P. In winter (December to March) fertilizer application is reduced to 0.2% every 3 weeks. No more fertilizer is applied once the leaves start to wither.

In contrast to general horticultural practice during the development of the inflorescence fertilizer is applied in the quantities described above. Just before the spathe opens the application of fertilizer should cease.

Temperature

Titan Arum requires high temperatures at stable levels similar to its natural habitat. They should be 28°C during the day and 26°C during the night. The minimum temperature should not be lower than 25°C, and the maximum temperature not higher than 32°C. The plants may survive lower or higher temperatures for short periods, but will be significantly damaged for that vegetative phase.

Light

Titan Arum requires ample amounts of light. Shade should only be given during the hottest time in the year around noon. The Titan Arum at Bonn is not supplied with additional lighting.

Pests and diseases

Hygiene is most important for successful cultivation of the Titan Arum, because the tuber is easily infected. The most serious problem is caused by nematodes (mostly *Meloidogyne incognita*) that are present in warm conservatories in the majority of botanical gardens. In most cases they are the cause for the short life span of the Titan Arum in botanic garden cultivation.

Very often nematode infected tubers develop tubercles around the tuber surface. These areas consist of soft tissue and are not associated with accessory buds. In due course they will start to rot and leave crater-like scars which then serve as entrance ports for secondary infections. Unfortunately, It is nearly impossible to kill any infections because nematodes live in the intercellular spaces. The best way to prevent infections is by only using sterile compost, drainage material and pots. Experience has shown that tuber rotting only occurs if the drainage is insufficient or nematodes are present.

It is good horticultural practice to keep *Amorphophallus* pots well away from direct contact to the ground by placing them on bricks or pots turned upside down. This means that nematodes cannot enter the pots.

Sometimes mealy bugs that feed on the tuber appear during dormancy. However, this is not a serious problem because they disappear once the plant is in growth.

The leaves are usually not affected by any pests or diseases. Aphids may occur if plants are not healthy but they are easily controlled with Neudosan™ which contains Potassium salts with fatty acids, or by general biological pest control.

PROPAGATION

A. titanum is under threat in its natural habitat and extensive collection puts the species under serious pressure. As part of any conservation activities it is important to understand the propagation protocol of the species. It should not be imported into botanic gardens from the wild, and botanic gardens should share only self propagated plant material.

Propagation by seed

There are eight records of cultivated Titan Arums producing seeds (see Table 3). Up until the present time all plants in cultivation have died after setting fruit but it is unknown whether plants survive fruiting in nature.

Name	Year
Palmengarten, Frankfurt	1992
University Botanic Gardens, Bonn	1996
Huntington Botanical Garden, California	1999
Palmengarten, Frankfurt	2000
Fairchild Tropical Garden, Florida	2003
Botanic Garden University of California, Davis	2004
Botanic Garden University of Washington, Seattle	2004
Royal Botanic Gardens, Kew	2005

Table 3 Records of infrutescence of *Amorphophallus titanum*

In cultivation *A. titanum* sets seed only after artificial and successful pollination and fertilization. The plants are proterogyn, meaning that pollen only becomes ripe when the female phase of flowering has finished and according to the literature at least, self-pollination is not possible.

Pollen of another plant has usually been used for artificial pollination. Pollen should be stored because it is unlikely that any garden would have two plants flowering at the same time. It can be stored deep-frozen in liquid nitrogen or kept cool in a refrigerator at 5°C, the latter for up to six weeks. Both methods of storage are equally effective.

Stored pollen from Bonn and freshly harvested pollen from Palmengarten in Frankfurt were used for artificial pollination in Bonn in 1996. The bloom was divided into 4 sections and every sector was pollinated with differently stored pollen. The result showed that there was no difference in the number of fruits, the contents of seeds in each fruit or in the germination rate between the treatments. It seems that *A. titanum* is rather unspecific in its fertilization requirements and even the application of unripe pollen will result in successful fertilization. This has been shown at Huntington Botanic Garden on one occasion in 2000. Self-pollination using unripe pollen took place (BBC, 2000 internet presentation) and resulted in an infrutescence with viable seeds.

After successful pollination the peduncle begins to elongate and the ovaries start to swell. It reaches up to 1.5m with the infrutescence measuring about 500mm. Spathe and appendix then wither leaving scars. The ca. 500 orange red berries ripen simultaneously and they are 40mm long, 25mm in diameter and weigh 5 to 15kg (Fig. 7). Each berry contains 1 to 3 seeds, with 2 seeds being most frequent (66%).

In Bonn fruits were harvested in December 1996 and in January 1997 following artificial pollination in May 1996. Fruits were ripe 7–8 months after pollination.

Seeds were first cleaned of the fruit pulp and then sown straight away. Some were sown in the same compost as for potting and some were placed on sand. However, there was no difference in germination behaviour between the different treatments. Most were covered with 10mm of compost but some with less. It is important to note this because most of the seeds that were not fully covered with soil rotted away. Soil temperature was 26°C and air temperature 29°C. It should be especially noted that it is important to remove the pulp because it contains germination inhibitors. The best practice is to sow the seeds as soon as possible after harvest. They should not be stored because they dry out very quickly.

Practical experience has shown that the length of germination varies greatly. The first seeds germinated after 30 days, the last seeds after 157 days. The germination rate was 82% out of 361 seeds sown. Cultivation requirements of seedlings are very similar to those of adult plants. After germination the young plants produce one single leaf followed by the other (Fig. 6), interrupted by periods of dormancy. The duration of this period of dormancy is irregular. Seedlings may develop a new leaf while the old one is still present. The tuber of older plants can rest for 2 to 15 months. Size and shape of the first leaf depends on the quality of the seed itself. The first leaf can be divided into 3 or 5 segments. The subsequent growth rate of seedlings does not follow a uniform pattern. Some grow very slowly, others much faster. The first of the Bonn seedlings flowered after 8 years on 16 July 2005 in the Botanic Garden of Marburg University. Other botanic gardens report that their plants took 10 to 12 years to reach flowering size.

Tissue culture

Tissue culture is a sophisticated but possible method of propagating the Titan Arum. Professor Hans Kohlenbach from the University of Frankfurt successfully attempted *in vitro* propagation by tissue culture in 1985 and 1986 (Kohlenbach, 1998). Two of the Bonn specimens were obtained from this source.

Leaf cuttings

Another method of propagation is to take leaf cuttings, as described by Upton (1998). Experience has shown, that the leaf should be completely developed but not older than 4 months. Cuttings should be taken from the petiole above the triple division. Each branching further on is usable for cuttings and it is the Y-shaped leaf veins that are used. The propagation material ought to be 250 to 300mm long. All excess leaf blade material should be cut off leaving only just a few parts. The proximal part should be dipped in general rooting powder and then the propagule can be placed in a propagation compost such as a mixture of 50% peat and 50% washed sand.

Pots should be placed in a humid atmosphere with bottom heat (26°C). The light quantity and quality should be the same as for adult plants. Within 3 months tuber tissue should have developed at the proximal end of the cuttings. It then takes a further 6 months until the first leaves are visible. After this time the cuttings are completely rotten and only the tuber tissue is left. In Bonn 5 out of 10 cuttings taken failed to root. Most of the thinner cuttings (20mm) survived; all of the thicker (60 to 70mm) cuttings died. The first leaves were small and it took a significant time to grow them on. After 7 years one vegetatively produced specimen produced a leaf of only 1.2m.

During field observations in South East Asia one of the authors (MN) discovered that other species of *Amorphophallus* seemed to have the ability to self-generate by some form of leaf cutting. Along a footpath in Thailand vegetation had been hand cleared. Among the cut plants, leaf debris of two species of *Amorphophallus* was discovered. Examination of this material showed that tuber tissue developed at the proximal base of the petiole. One of the two species was identified as *A. paeonifolius*, the other could not be identified. This observation indicates the likelihood of other species also being able to self-generate by the formation of callus tissue around their petiole.

Tuber propagation

Other *Amorphophallus* species have the natural ability to self-regenerate from bulbils which develop on the leaf near the Y-shaped branchings along the veins in the centre of the leaves (as in *A. bulbifer* and *A. oncophyllus*). In other species rhizome-like offsets develop from the tuber. These may separate to form new plants in species such as *A. konjac* and *A. krausei*. There are no indications that the Titan Arum self-propagates in this way.

PRACTICAL CONSIDERATIONS

Differential diagnostics of a flower bud and leaf bud

Once the tuber of Titan Arum has developed a new bud it is exciting to predict whether it will be a leaf or an inflorescence. There is a significant difference between a flower bud and a leaf bud. The leaf bud is arrow shaped, perfectly round in diameter and the tip of the cataphyll is exactly in the centre (Fig. 8). A bud from an inflorescence is bell shaped, irregularly rounded and the tip of the cataphyll is clearly placed more laterally, making it look as if the bud is 'pregnant' (Fig. 9). For an experienced gardener this difference is recognizable even in the very early stages when the bud is about 60mm in diameter but it becomes more obvious when the bud extends by more than 100mm above the soil level.

Growth pattern of the flowering bud

The daily growth pattern of the various blooms at Bonn have been accurately recorded. The daily height increase of the 2006 inflorescence is shown in Figure 1. The columns show a rather slow but steady growth increase. However, a significant increase can be seen after the third week until approximately 5 days before the spathe opens.

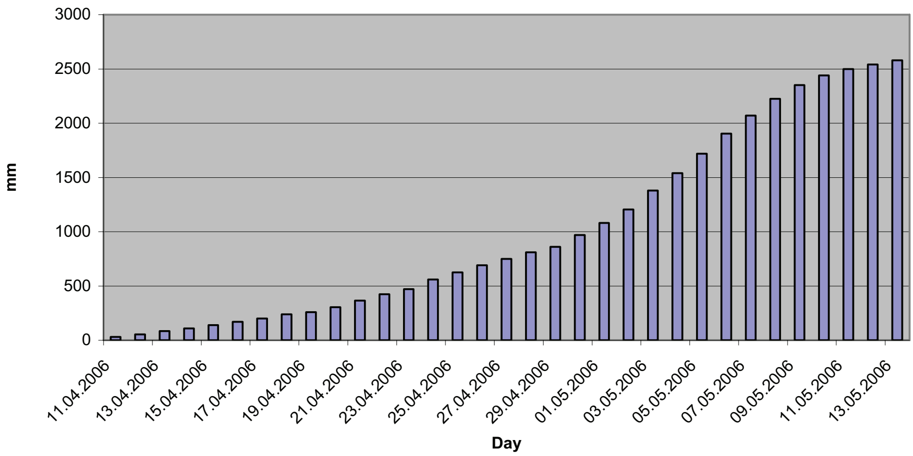

Fig. 1 From bud to flower – daily height of inflorescence of *Amorphophallus titanum* in millimetres above ground from April to May, 2006.

The daily growth pattern of inflorescences are characterised by a slow increase in the beginning. Afterwards it changes into a rapid growing phase and in the last days before opening the growth rate slows down significantly (Fig. 2).

It is possible to predict the opening date of the bloom by analysing the growth statistics. The daily growth rate is even and there is no difference between day and night growths (Fig. 3), therefore the temperatures should be maintained at a constant level throughout the day and night.

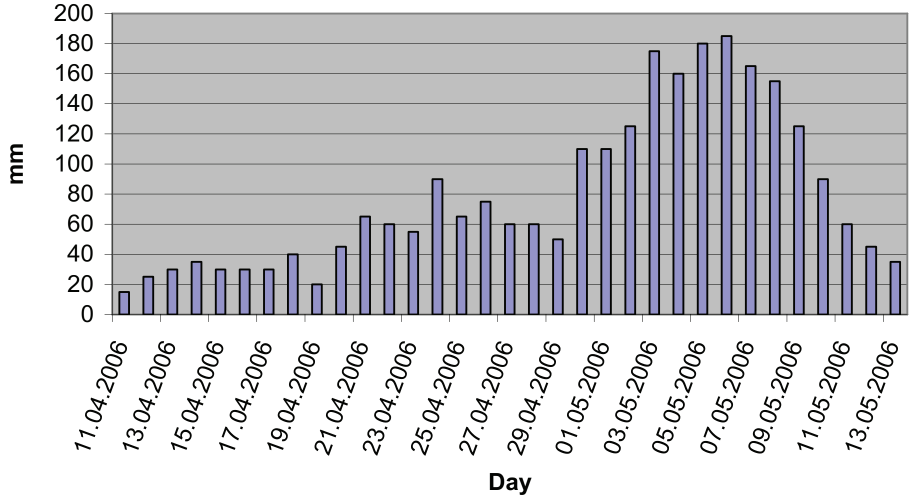

Fig. 2 Daily growth rate of inflorescence of *Amorphophallus titanum* in millimetres from April to May, 2006

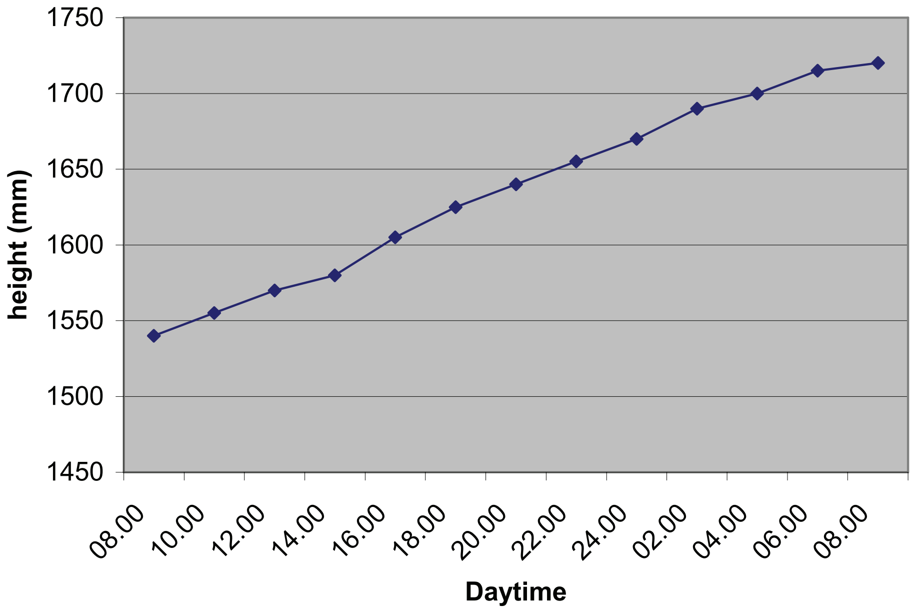

Fig. 3 Distribution of the growth rate of the inflorescence of *Amorphophallus titanum* during 24 hours on 4 and 5 May 2006

When does the bloom really open?

There are several key considerations to consider when it comes to predicting the day when the bloom opens. It is helpful to know roughly the opening day, because numerous preparations need to be made before the flowering spectacle starts (see below). One of the most important tasks is to calculate the duration from the first visible bud until the opening of the bloom. It is difficult to predict the exact moment when the spathe opens but there are some hints which may help to ease the forecast. The following observations are based on experience from several blooming events at Bonn but are described most specifically from the 2006 event.

Table 4 presents the time span of various titan arums from first bud until bloom. The time varies from 25–46 days and, naturally, the taller the inflorescence the longer it takes to develop the bloom. Experience has also shown that there is hardly any difference in the development time between an inflorescence and a leaf.

Bud visible	**Spathe opening**	**Days**	**Height (m) Measured from soil surface**
22.3.1996	08.5.1996	46	2.33
02.5.1996	30.5.1996	28	1.67
01.4.1998	30.4.1998	29	1.72
30.5.2000	06.7.2000	37	2.57
14.4.2003	22.5.2003	38	2.74
09.4.2006	13.5.2006	34	2.59
15.4.2006	13.5.2006	28	2.22
22.4.2006	16.5.2006	24	1.66

Table 4. Time needed for the inflorescence to develop from a bud

Once the daily growth rate (see above) exceeds 100mm within 24 hours the rapid growing period starts. This happened in Bonn in 2006, 13 days before the spathe opened and lasted for approximately 10 days. After this period of rapid growth, the daily increase slows down rapidly within 4 days to a few centimetres in 24 hours. This is the first secure indication that the opening of the spathe will follow within the next few days.

On the afternoon before the spathe opens, and especially on the morning of that day, a secretion pours out of the closed bud where the spathe overlaps and runs down the peduncle. Sometimes this is accompanied by a slight mal odour of the appendix.

REMARKS ON THE LIFECYCLE

The lifecycle of Titan Arum has been described above and some conclusions and observations are described below.

Professor Kohlenbach from the University of Frankfurt donated a specimen of Titan Arum to the University of Bonn Botanic Gardens on 8 June 1988, the plant having been propagated by tissue culture 1985. It subsequently flowered three times, in 2000, 2003 and 2006. The tuber increased in weight from 36kg (2000) to 78kg (2003) and then up to 117kg (2006). Until then the heaviest tuber reported was of 72.6kg (Bogner, 1981).

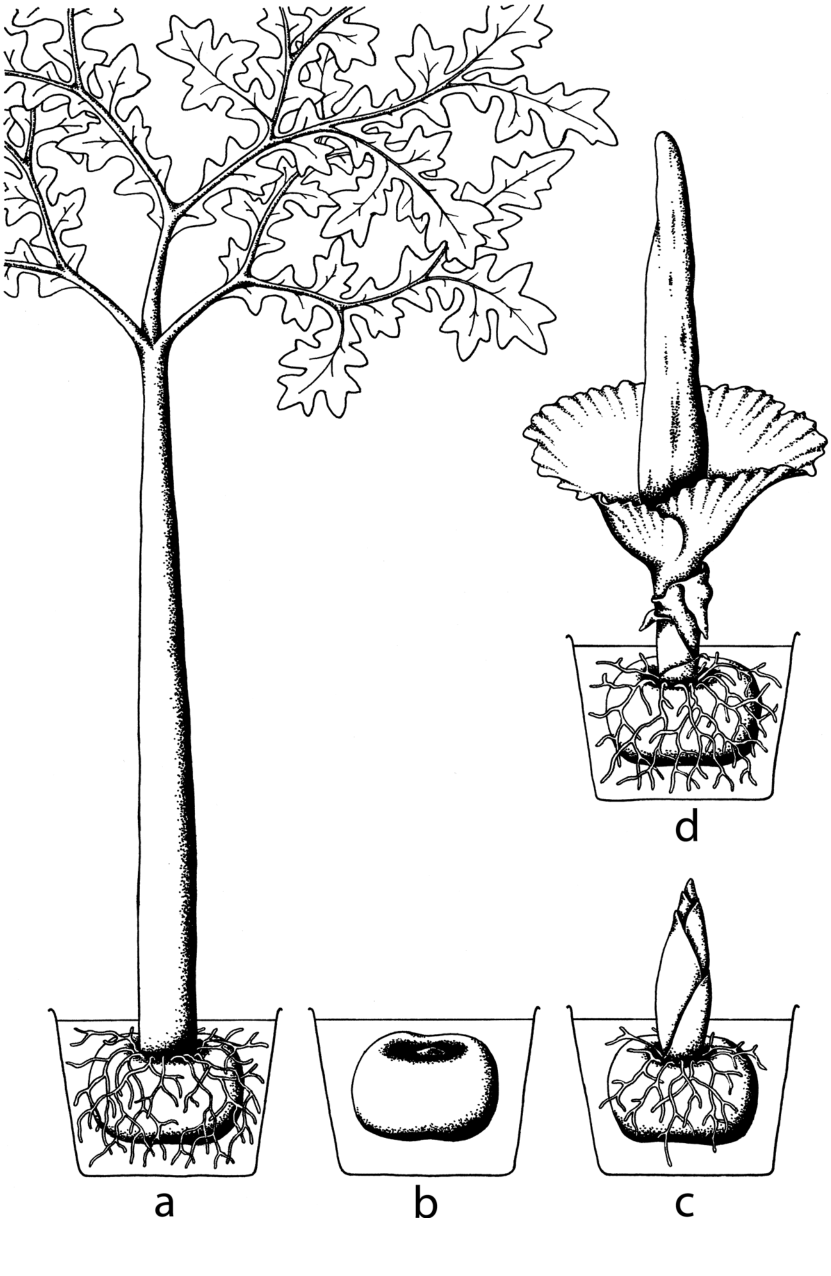

Fig. 4 Lifecycle of Titan Arum (*Amorphophallus titanum*):
a) Tuber with leaf; b) tuber at dormancy; c) bud; d) inflorescence; usually after dormancy several periods with leaves occur until an inflorescence is produced.
Drawing: Nils Köster.

Fig. 5 The tuber is moved from its container for inspection. The tuber weighed 117kg. Photo: Markus Radscheit.

Fig. 6 The young generation of Titan Arum is growing in 1997. The young seedlings are developing after successful hand-pollination. Photo: Wilhelm Barthlott.

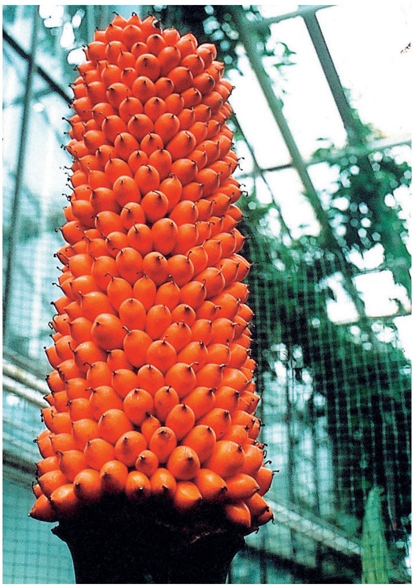

Fig. 7 This infrutescence developed after hand-pollination in 1996. Approximately 500 berries could ripen. Photo: Wilhelm Barthlott.

Fig. 8 Typical leaf-bud of Titan Arum, which is arrow shaped, perfectly round in diameter and the tip of the cataphyll is exactly in the centre. Photo: Wilhelm Barthlott.

Therefore, it seemed unlikely that the 2003 weight of 78kg would ever be superseded. The same tuber produced an inflorescence of 2.575m in height in 2000, with 2.74m (3.06m height measured from the tuber is the world record) in 2003 and three inflorescences in 2006 (Fig. 10). Two opened on 13 May 2006 and the third on 16 May 2006. It is the first time that one tuber of *A. titanum* has produced more than one inflorescence. J. Bogner (pers. comm.) and personal observations report that the phenomena of multiple blooms has occurred before in *A. konjac*. Those plants also developed three leaves afterwards and at that time there were already three small new tubers visible.

Our observations, especially those made during the flowering and post flowering phase in 2003 and 2006, lead us to the assumption that *A. titanum* behaves as most other *Amorphophallus* species. Once the plant exceeds a critical size more than one inflorescence and leaf can be produced. Finally the tuber will divide into smaller units and normal life cycle resumes.

DORMANCY AND STORAGE

The leaf should be left on the plant tuber until it detaches itself. The lower part of the petiole may decay into a mud-like liquid on the tuber and the petiole can easily be removed. This liquid should remain on the tuber and must not be removed, otherwise it may result in injury of the tuber. During dormancy the tuber has to be stored in the compost, where it should not dry out. Larger containers keep enough moisture for a long period but small pots tend to dry out fast. Smaller units therefore need to be kept evenly moist. Once a week the tubers need to be checked for signs of new growth and this is easily observed through the hole in the compost created by the petiole.

MANAGING THE SPECTACLE

There are very few occasions in botanic gardens that attract as many visitors as when a Titan Arum comes into bloom. The media potential is enormous and therefore the event needs to be well prepared. Experience has shown that Titan Arum blooms are a magnet for visitors of all age groups. The critical point is the clear diagnosis of whether the bud will develop into a flower or leaf (see above). As described above there are only around 30 days to prepare for the flowering spectacle in the gardens (see above, Table 4). However, the final day when the spathe opens cannot be clearly predicted (see above).

The flowering event is a great chance to present the botanic garden to a wider audience as thousands of visitors can be expected over a short period of time. During the past flowering events at Bonn more than 10,000 people visited the garden on each occasion, queuing for up to 2.5 hours. Even bad weather did not distract the interested masses. At Bonn some 16,000 visitors were attracted over four rainy days to see the bloom in 2003.

Although the prediction can be made quite precise there are still pitfalls that may cause a problem. On the morning of 23 May 2003 the press was informed that the bloom

Fig. 9 Bud from an inflorescence of Titan Arum. The typical asymmetrical shape can be seen. Photo: Wilhelm Barthlott.

Fig. 10 In 2006, Titan Arum surprised with three inflorescences from one tuber.
This has never happened before.
Photo: Wilhelm Barthlott.

Fig.11 The show is over, 4 days after opening, the spadix collapses.
Photo: Markus Radscheit.

would not open until the following day. However, in the early afternoon of the same day, the bloom started to unfold causing problems of how to manage both the media and public.

It has proved to be very useful to have an internet camera, telephone hotline and regular press releases to cope with the interest from the public at Bonn. It also helped greatly during the management of such a public event to have informed the local traffic police and other authorities at an early stage.

The careful selection of a site where the container can sit is extremely important. This site not only needs to fulfil the horticultural requirements of the plant but also needs to be located so that large visitor masses can easily view the bloom. The installation of a top view camera or a simple mirror is a good idea as it allows visitors to look into the bloom.

All human and technical capacities are needed to cope with the enormous public interest but this is amply paid back by the enthusiasm of the visitors who will admire your Titan Arum open mouthed.

CONCLUSION

A. titanum has fascinated many thousands of visitors to botanic gardens worldwide. This remarkable plant, however, is facing enormous pressure from habitat destruction and over-collection. In cultivation the Titan Arum requires highly sophisticated cultivation protocols. It is not easy to cultivate over long periods of time and is a challenge for any keen horticulturists. Therefore botanic gardens with their various capacities and opportunities can make a significant contribution towards the long term *ex-situ* conservation of this remarkable and charismatic species.

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