



Defying the elements, a lone windswept relict Cathaya silver fir stands proud in its Huaping refuge.

But how much longer can these “living fossils”, with an ancestry of tens-of-millions of years, survive the present near unprecedented rate of climate change, caused by the over-population of one species and its unsustainable burning of fossil fuels and decimation of forests and other ecosystems?

Cathaya argyrophylla, some little known facts

CHRIS CALLAGHAN of the Australian Bicentennial Arboretum (ABA) records some little known or often misreported facts about the ‘living fossil’ *Cathaya argyrophylla*, an endangered endemic tree of China.

Researching the affinities of ‘*Pseudocathaya*’ featured in the previous yearbook (Callaghan 2011), has made me realise that there are a number of key facts regarding its progenitor, the endangered endemic relict *Cathaya argyrophylla* that are in error in the literature authored by numerous conifer authorities, and even in *Flora of China* of all places!

These errors and some omissions in the records have obscured some interesting and little known details concerning this ‘living fossil’. For example, few people outside of, and probably within, China (including myself until recently), would know that the botanical discovery of *Cathaya*, recorded for 1955, was actually 17 years earlier and preceded that of *Metasequoia glyptostroboides*, the other more renowned Chinese ‘living fossil’ found by T. Kan in Hupeh Province in 1941, by three years.

I recently found on the informative '*Cathaya argyrophylla Archives*' website, which may be accessed at www.zgysbh.com/ysda/index.asp, that the real year for the discovery of *Cathaya* is 1938. This website contains many interesting articles with facts regarding the discovery and subsequent research of *Cathaya*, although the translation from Chinese to English by search engines can be extremely difficult to understand!

It is interesting to speculate that had *Cathaya* seeds or plants been brought out of China before the war, whether it would have shared some of the fame enjoyed by *Metasequoia* today, instead of sinking into virtual obscurity everywhere other than China. This was due to the Chinese authorities restricting the release of any plant material up until 1995, and then releasing only a small quantity of seed before 1998/1999.

To put things into an historical perspective, Yang Hsien-chin, at the time an adjunct professor at Shanghai's Fudan University (Prof. Tang Ya, pers. comm.), found the first unidentified tree of *Cathaya* on 18 April, 1938 at Jinfu Shan ('Golden Buddha Mountain'), in then SE Szechuan, while collecting for the Biological Laboratories of the Science Society of China, Nanking, after it, like Fudan University, became a refugee institution at Pei-pei, on the Kialing Jiang (river), c. 35km. north of Chungking, following the Japanese seizure of the then Chinese capital Nanking ('Southern Capital'), Kiangsu, in 1937.

The actual date of 18 April, 1938 has been determined by the present author by comparison with the collection dates of other specimens presently held at N. E. Forestry University, Harbin and Beijing Institute of Botany that were collected at Jinfu Shan during that month by Yang Hsien-chin (usually noted as Y. C. Yang^{F1}). For example, Yang's collection of *Rhododendron changii* at Jinfu Shan on that date is specimen 3161.

Yang's specimen 3163 (page 98) from the then unknown tree and with no collection date, found its way into the herbarium of the newly created Institute of Botany at Peking (Beijing or 'Northern Capital'), after its establishment as the seat of government by the victorious Communists in 1949.

There it languished until found in 1956 by the taxonomists Chun Woon-young and Kuang Ko-zen while researching specimens sent to them in summer by Professor Zhong Ji-xin. These had been collected at Wujiawan on Mount Hongya in Kwong Fuk Estate (now part of Huaping National Nature Reserve), Lungsheng County, Kwangsi on 16 May, 1955 [specimen 00198, branching shoot with old cones], by Deng Xian-fu and Li Zhi-you of the Kwangfu-Lingchu Expedition led by Professor Zhong, plus other specimens with old cones collected by Tan Hao-fu in the same region that autumn. Chun and Kuang noted some resemblance in the leaves to *Pseudotsuga sinensis* but differences in the male cones, so requested further specimens on which to make a determination. Thus they could examine shoots with flowers and

: F1 See photo, page 98 and Appendix, page 106 for alternative Chinese names of people and places.

recently fertilized cones collected by H. C. Lei and H. C. Chung in May and July 1956 [400044, 400046], plus cones with seeds collected by H. L. Hsu and H. F. Tan in October 1956 [700906]. (CA Archives website, Chun & Kuang 1958).

The Soviet botanist Sugatchey was shown the various specimens when he visited the herbarium and advised Chun and Kuang that they had many similarities to Tertiary fossils found in the Soviet Union, Poland and Germany, and the realization dawned that another 'living fossil' had been discovered (Tang 1987). Chun Woon-young presented the results of their research in a paper at a botanical forum in Russia in 1957 prior to its publication there the following year in the Soviet Journal of Botany (Chun and Kuang 1958), wherein they named two species in their formal description when establishing the new genus *Cathaya* in the Pinaceae.

These were *Cathaya argyrophylla*, with the type specimen 00198 collected at Huaping as above, and *C. nanchuanensis*, the type being Yang's specimen 3163, an infertile vegetative shoot only. However, they failed to designate which of the two species was the type of the genus, rectifying this oversight with their later redescription in Chinese (Chun and Kuang 1962), wherein they nominated *C. argyrophylla* as the type and sunk *C. nanchuanensis* into synonymy with it.¹

This followed advice c. 1960 from Cheng Wan-chun, the Chinese gymnosperm authority then researching the conifers for the future Chinese version of the Flora of China (delayed in completion by the outbreak of the Cultural Revolution—Cheng et al. 1978), that the distinctions between the two taxa were insufficient to retain them as separate species. This was after he had examined cone-bearing specimens gathered by Xiong Ji-hua, Zhou Zi-lin & Li Guo-feng at Jinfu Shan on 7 October, 1957 and Xiong & Zhou [64567] the following day.

In view of the above, it is interesting to learn of the recent creation of *Cathaya argyrophylla* subsp. *sutchuenensis* Silba based on specimen 8012 collected 9 July, 1980 by L. K. Fu at Jinfo Mountains, Szechuan, having apparently smaller leaves/cones than another specimen 3666 collected by S. Wang & W. Chub at Tian Ping Shan, Longsheng, Kwangsi which is designated *C. argyrophylla* subsp. *argyrophylla* Silba (Silba 2011).

Silba's statement that "one species of *Cathaya*" (viz. *C. nanchuanensis* in Chun & Kuang 1958) "was described from the northern locality in southern Sichuan based on fewer stomata lines on the undersides of the leaves and its smaller female cones" is not entirely correct, as there was no mention of the cones of this species by Chun & Kuang, since they based this species solely on Yang's 3163, the vegetative shoot without cones, and made no mention of any other specimens with cones.

The descriptions of *Cathaya argyrophylla* in all of the conifer books consulted understate the maximum height the tree reaches. It is either given as a "tree to 20m." or "tree to 24m" Likewise the majority list the diameter as 40cm d.b.h. or a few say 60cm d.b.h. In fact, trees in the wild are known to exceed

30m, an example being a tree at Dayao Shan, Guangxi, which was that height more than 20 years ago, at which time the highest at Huaping, Guangxi at 21.1m (Mao 1989), was possibly in reality over 30m high, as Tang Xiyang (1987) mentioned a Huaping tree at Wujiawan as “the largest Cathay silver fir in the world”. *Cathaya* trees were listed having trunks of 79.2cm/83cm d.b.h. at Dayao Shan/Huaping (Mao 1989), the Dayao Shan one being measured at 86.9cm d.b.h. in 2000, substantially more than noted in the literature. While it would be interesting to know, I have been unable to find out the present dimensions of these trees, or those in the other nature reserves where the trees are known to occur (see map/chart pp. 156/7, Callaghan 2007a). A 24m tree in Hunan Province has been dated at 390 years old.

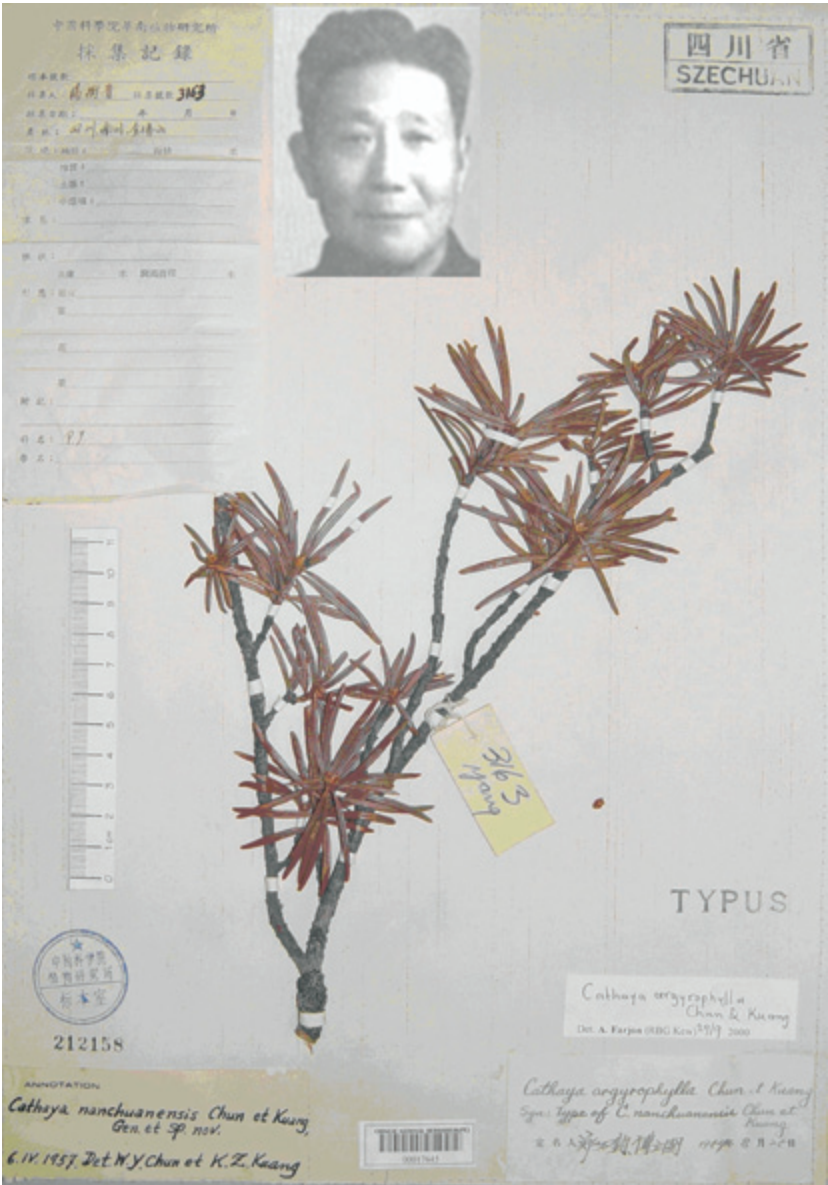
Another interesting fact often confused in the literature is the time taken for the seed cones of *Cathaya argyrophylla* to mature (**from pollination**). This is often erroneously stated as one year (“maturing in first year” – *Flora of China*, Fu et al. 1999) or as a single (growing) season. Inexplicably, the lead author for Pinaceae in *Flora of China*, Fu Li-kuo, had earlier stated “cones mature in the following year”, ie. second year (Fu et al. 1992). Some authors state that in Pinaceae, of which family *Cathaya* is a member, **only** *Pinus* and *Cedrus* have cones maturing in two years, with a few species of *Pinus* maturing in three years.

The reality for monotypic *Cathaya* is that the female strobili (see photo, page 76, Callaghan 2009) formed from pre-existing initials in the axils of a few of the lower leaves of the newly expanding shoots, open and are pollinated (mid-) late April to early May (Huang et al. 1985–see photo of receptive flowers, page 102), after which the flowers close. Fertilization takes place in the last ten days of June **the following year** (Wang & Chen 1974). After fertilization the 13-16 ovuliferous scales rapidly expand to cover the bracts (see photo, page 103) and the female cones enlarge to their mature size of 3-5cm by 1.5-2.5(-3)cm wide by October, at which time the scales open to release the mature seeds of the next generation. Hence the cones of *Cathaya* mature in 18 months spread over two calendar years.

The error concerning maturation of the cones has been perpetuated from the statement by the original authors Chun & Kuang (1962)² and repeated in Cheng, Fu & Chen (1978), that “cones mature that same year”, and as a consequence by many recent authors outside of, and some within, China. Wang (1990) mentions the original error by Chun & Kuang and confirms that “silver fir fruits never ripen in the same year”.

Incidentally, the TV documentary *Forest China* mentions the interesting finding that “a germ cell of a silver fir takes 31 months to grow into a mature seed.” (i.e. from the inception of a germ cell as an initial in the meristem through to a seed maturing, or $13 + 18 = 31$ months). [see Endnote 3 concerning male cones].

I should note the occurrence of rare hermaphroditic flowers of *Cathaya*



The undated, first ever collected specimen of *Cathaya* (*C. nanchuanensis* Chun et Kuang), Y. C. Yang's 3163 from Jinfu Shan, "Golden Buddha Mountain", Nanchuan county in then S. E. Szechuan. Label in lower right-hand corner is the opinion by Cheng Wan-chun and Fu Li-kuo (names in Chinese) on 1959-8-25 that *Cathaya nanchuanensis* is synonymous with *Cathaya argyrophylla*.

Inset, Yang Yen-chin, who at 25 years-of-age discovered *Cathaya*, the "pearl of the forest", in 1938, after which it slipped off the radar for another 17 years until rediscovered at Huaping, Guangxi in 1955.



Isotype number 00198 of *Cathaya argyrophylla* Chun et Kuang collected at Wujiawan, Kwong Fuk Estate, southern slopes of Hongya Shan, Lungsheng country, Kwangsi, 16 May 1955. [the holotype at IBSC was not made available for this article]

Inset. Prof. Zhong Ji-xin, leader of the Kwangfu-Linchu Expedition whose members Deng Xian-fu and Li Zhi-you discovered the tree from which the type specimens were collected.

mentioned by Chun & Kuang (1962) and Zhang (2011), a feature I was unaware of when writing about "*Pseudocathaya*" (Callaghan 2011). I can reveal here though that yet-to-be published '*Pseudocathaya cyanescens*' is no ordinary *Cathaya*, having unique features that set it apart from any other living conifer!

Finally, I'd like to say something about the much debated conservation status of *Cathaya argyrophylla*. Nothing I have become aware of since I advised five years ago (Callaghan 2007) that "perhaps the threatened status of *Cathaya argyrophylla* should be reviewed, and possibly revised upwards?" has altered my suggestion. In fact the evidence presented here would tend to reinforce the need for a review of its current status as 'Lower Risk, Conservation Dependent. Version 2.3' of 1994 (IUCN 2011).

The comparison I made in the 2006 article of c. 5400 *Metasequoia glyptostroboides* trees occurring in the wild compared to less than 4000 trees of *Cathaya argyrophylla* was without the knowledge that the majority of the *Metasequoia* were by then seed bearing individuals, many reaching maturity since H. H. Hu (1948) put their numbers at no more than 1,000 large and small trees. A 2001 count put *Metasequoia* numbers at 5750 large protected wild trees. One forestry station at Metasequoia Valley cultivated and distributed 445 million seedlings and 160 million cuttings of *Metasequoia* between 1979-2001 (Ma et al. 2004), a large percentage of the cuttings presumably replicating the wild genotypes (virtually impossible for *Cathaya* with its negligible strike rate! –Huang et al. 1985, Fu 1992).

The above contrasts with the situation for *Cathaya*, where at the time of a 1989 census of these trees (Mao 1989), I have calculated there to have been between 900 to 1000 mature individuals existing out of a total of 3266 wild trees. Regarding the remaining c. 2266-2366 seedlings and saplings, it is interesting to note that Tang Xizang (1987) mentioned that "in Huaping Reserve" (Guangxi) "one still sees seedlings and saplings, but in Sichuan, Hunan or Guizhou provinces one sees few seedlings or saplings. Without even the risk of human damage, these precious plants face the danger of extinction."

Since then however, the number of *Cathaya argyrophylla* seedlings under 20cm height found by surveys at Huaping, where Tang mentioned they were most prevalent, have plunged from **903 in 1979** when they accounted for almost 87% of the total 1040 *Cathaya* in the reserve (Mao 1989), to 97 in 2004, with **only 17 being found there in 2010!** The parent tree numbers over this 31 year period have increased from 70 to 71 mother trees (Zhang 2011), but are barely reproducing. During an authorized visit to the reserve in 2009, my arboretum colleague S. K. Png and I saw no seedling silver firs during our time there. The figures show that of the 69 saplings between 20cm and 5m counted in the 1979 census, plus the 903 seedlings, most have died, since allowing for expected mortalities due to reasons 8-13 listed below, both categories would have contributed by 2010 to a greater increase in the original total of 70 mother trees [classified as trees above 5 metres or c. 18 years of age]. Hence as the

mother trees die out over time, they are being replaced by only three or four trees in a century, which is not sufficient to maintain the long-term viability of the population at Huaping. Allowing for a corresponding decline in *Cathaya* numbers at the other reserves where little or no recruitment is taking place, could mean that this “giant panda of the plant kingdom” as it is dubbed by Chinese botanists, is declining significantly in numbers in the wild while its namesake, the giant panda of the animal kingdom is increasing [www.en.wikipedia.org for panda, accessed 3 March, 2012].

Tang’s prediction above appears to be moving closer to reality and the plant’s survival may be in a precarious state as older trees die and are not replaced. The lack of recruitment is due to a combination of the following adverse factors reported by Zhang (2011) and others:

1. Most trees have insufficient male flowers for adequate pollination.
2. The flowering season in April coincides with the rainy season, playing havoc with wind-borne pollination.
3. Flowering periods uncoordinated: male flowers open two weeks earlier than female flowers, resulting in low fruit formation of 15%.
4. Some researchers believe there is a possible undiagnosed problem with the floral structure, resulting in high rates of ovule abortion, or embryo death. Grimshaw & Bayton (2009) reports 12.2% of cones with no seed (parthenocarpic).
5. Nos. 3 and 4 are compounded by a poor seed germination rate of 15% in the wild at Huaping. Grimshaw & Bayton (2009) reports a seed germination rate of 21% (averaged across the various reserves?). [Tang Xiyang (1987) reported that initially only 4% could be germinated in cultivation].
6. Severe in-breeding is affecting natural regeneration.
7. Germination capacity of seeds is soon lost at normal temperatures due to a high oil content.
8. The seeds are eaten by rodents such as mountain rats which consumed the seeds of all but three of 102 cones under observation during a scientific study. Other predators of the silver fir seed are flying squirrels and silver pheasants. The silver pheasant also devours the seedlings.
9. Very poor natural regeneration is compounded by damping-off and the difficulty of seedling roots penetrating the thick moss layer prevalent in areas of *Cathaya* populations. Removal of the moss results in soil erosion, either dislodging seedlings or suffocating them under mud flows during rain periods.
10. Slow growing seedlings perish under leaf litter due to lack of light.
11. Seedlings initially need a certain amount of shade but once established after a year or so have, as a heliophyte, a high light requirement and dislike dense shady environments under the forest canopy, where they only survive one to two years. Seedlings protected from browsing animals

- beneath understorey shrubs such as evergreen rhododendrons rarely survive five years. Juvenile plants not in optimal light suffer dieback.
12. Seedlings suffer blight during the dry autumn season.
 13. The pine caterpillar *Dendrolimus kikuchii* is fond of silver fir foliage, consuming up to 30 leaves a day and can devour the leaves of a seedling in a short period, causing it to perish. It is a major threat to *Cathaya*, a modern day defoliator replacing the dinosaurs who probably fed on the foliage back in the Cretaceous when *Cathaya* occurred in at least Asia and North America (For the fossil record see Liu & Basinger 2000, for molecular evidence see Lin et al., 2010 and Wang 2000).

To say as some do that *Cathaya* is adequately protected in inaccessible areas is misinformed, as the Chinese consider “almost all extant *Cathaya argyrophylla* face serious threats and a high risk of extinction because of habitat deterioration and loss” (Wang et al., 2010. Am. J. Bot. 97: 17). The Huaping population which was the largest in the 1980s has been severely reduced as previously mentioned and as this population extends over only 15km, the entire population could be wiped out in a wildfire if the experience in Australia is anything to go by. Here, out-of-control firestorms in the last decade or so of drought and soaring temperatures as a result of global warming (no country is immune), have shocked people as they have raged at speeds in excess of 100kph over long distances. This means that Huaping or other populations could be

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Above, rarely observed receptive flowers of *Cathaya*, awaiting a dusting of pollen during spring from male strobili, on the older shoots below, **left**, or from an adjacent tree.



Photograph © Australian Bicentennial Arboretum (ABA)



Photograph © glib
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Left, goodbye bracts, hello scales! Fourteen months after pollination the finely-pubescent scales containing the now fertilised ovules commence to cover the pointed bracts.

Right, maturing cones containing the seeds of the next generation of Cathay silver fir which will be released in October, four months after fertilization, or 18 months from pollination. The cones will then remain on the branches for a number of years⁴.

devastated in a matter of hours—fire has no respect for reserve boundaries.

Also, not all *Cathaya* reserves are so inaccessible so as to prevent logging, which occurred at Huaping after the discovery of its virgin forests in 1954 before it received legal protection in 1961. The small populations at Baizang Shan, Tongzi county, Guizhou and at Baizhi Shan, Chongqing Municipality, which had ten trees with a maximum height of 5m and 52 trees with a maximum height of 8m respectively recorded in the 1989 census (Mao 1989), indicates that at least these further two populations were accessible and logged last century, possibly in the decades before, but more likely during the Cultural Revolution which occurred between 1966-1976. Richard Primack (1988) gives an insight into the chaos that occurred during those years, particularly in respect to the extensive damage done to the forests of the eastern coastal province of Fujian and the persecution of officers of the Forest Department that had managed that province's forests for sustained yield for hundreds, if not thousands of years. As Primack explains, once these officers had lost control of the forests by 1970, unsupervised cutting of trees, starting as a trickle, soon exploded into a six-year orgy of illegal logging that resulted in large tracts of the province being denuded of timber trees. Since he goes on to say that this wholesale destruction of forests occurred to a greater or lesser extent throughout China during this period, it is probable that the same fate befell the forests at Baizang and Baizhi mountains, and that possibly those logging the virgin forests at Huaping in the second half of the 1950s returned six years later to take advantage of the free-for-all. Due to the valuable high-grade timber of the tall and straight Cathay silver fir which is suitable for construction, shipbuilding, railway ties and furniture (Tang 1987), it is

inevitable that this would have been one of the timber trees to bear the brunt of this wanton destruction. Numerous books now available include photos which confirm the tree's large straight trunk (Fu 1992, photo p. 67; Grimshaw & Bayton 2009, photo p. 224; Shen 1994, photo p. 67; Tang, 1987, photo p. 89 etc.).

I have endeavoured to ascertain the current situation of *Cathaya* populations in the other nature reserves in China where it occurs, without success. If they mirror the situation at Huaping, then the future for this 'living fossil' would appear to be quite grim, especially when there are relatively few in ex-situ conservation when compared to *Metasequoia*.

In view of the situation as outlined above, I feel that it is time to review the conservation status of the remaining populations and upgrade *Cathaya* to one of the IUCN threatened classifications, probably *endangered*, as Lin, Hu & Wang (1996) reported that *Cathaya argyrophylla* was to be regarded as **one of the four most endangered conifer species endemic to China**. Furthermore, it is considered by the Chinese as **one of the eight most endangered plant species in China!** (Fu 1992 – in Chinese edition, in Wang & Zhu 1990).

In closing, I would like to advise any readers with an interest in *Cathaya* and the trees and forests of China, of the wonderful television documentary nature series *Forest China*, produced by Central China Television (CCTV) a few years back. If you missed the program when the English language version screened, the episodes entitled *Hermit of the Forest* which feature *Cathaya* (meaning "tree of China"), were filmed in Huaping National Nature Reserve and can be viewed on the internet at: http://english.cntv.cn/program/natureandscience/20100413/101965_1.shtml [Part 17]. [accessed 24 Dec., 2011]. http://english.cntv.cn/program/natureandscience/20100414/102263_1.shtml [Part 18]. [accessed 24 Dec., 2011].

In this program the Chinese give *Cathaya* the ultimate accolade, "the Lord of the Firs".

Endnotes

1. *Cathaya nanchuanensis* was not placed in synonymy by Cheng and Fu in 1978 as stated in my original article (Callaghan 2007a), based on an error in previously sighted literature.
2. Figure 5, Plate 2 in Chun & Kuang (1962) is incorrectly captioned as a female cone after pollination. This actually represents a female cone c. 14 months later, after fertilization!
3. The male cones are 4–6cm at pollen dispersal. The 2cm stated by some authors refers to their immature state of 1.25–2cm (see immature and mature cone photos, Callaghan 2009).
4. The leaves of *Cathaya* are retained for four years, in which year they progressively fall. Except on stressed trees, they do not fall after their first year as stated by some authors [18 months-old cones at seed dispersal in October are on leafy second year shoots!]

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Appendix Alternative Chinese names for people and places

PERSON'S NAME IN TEXT	ALTERNATIVE NAME(S)
CHENG Wan-chun	CHENG Huan-yong, ZHENG Wan-jun
CHUN Woon-young	CHEN Huan-yung, CHEN Huan-yong
KUANG Ko-zen	KUANG Ko-jen, KUANG Ke-ren
L. K. FU (FU Li-kuo)	FU Li-guo
SUGATCHEY	SUKACHEV (?)
YANG Hsien-chin	YANG Xian-jin, YANG Yén-chin, Y. C. YANG
ZHONG Ji-xin	TSOONG Chi-hsin
PLACE NAME IN TEXT	ALTERNATIVE NAME(S)
CHUNGKING	CHONGQING
JINFU SHAN (mountain)	JINFO SHAN
KIALING JIANG (river)	JIALING JIANG
KIANGSU	JIANGSU
KWANGSI	GUANGXI
HUAPING	FA PENG
LUNGSHENG	LONGSHENG
NANKING	NANJING
PEKING	PEIPING, BEIJING
PEI-PEI	BEIBEI
SZECHUAN	SICHUAN

Acknowledgements China/Australia/Singapore

I gratefully acknowledge Wang Yin-zheng for his kind permission to reproduce Y. C. Yang's herbarium specimen. Also to Xu Wei-bin for permission to reproduce photos of the tree and cones of *Cathaya* and the black and white photo of Zhong Ji-xin (superimposed on 1955 specimen). Zou Hong-fei is thanked for the black and white photo of Yang Hsien-chin (superimposed on 1938 specimen). Andy Ng in Sydney is thanked for his translating skills.

Assisting in my research of this article were the following botanical colleagues in Singapore, Australia, and China to whom I would like to extend my thanks for their time and patience in answering my numerous enquiries and requests. Also especially to my arboretum colleague S. K. Png for his help with this article above and beyond the call of duty!

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