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Bunzo Hayata and His Contributions to the Flora of Taiwan

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ABSTRACT: Bunzo Hayata was the founding father of the study of the flora of Taiwan. From 1900 to 1921 Taiwan's flora was the focus of his attention. During that time he named about 1600 new taxa of vascular plants from Taiwan. Three topics are presented in this paper: a biography of Bunzo Hayata; Hayata's contributions to the flora of Taiwan; and the current status of Hayata's new taxa. The second item includes five subitems: i) floristic studies of Taiwan before Hayata, ii) the first 10 years of Hayata's study of the flora of Taiwan, iii) *Taiwania*, iv) the second 10 years, and v) Hayata's works after the flora of Taiwan. The third item is the first step of the evaluation of Hayata's contribution to the flora of Taiwan. New taxa in *Icones Plantarum Formosanarum* vol. 10 and the gymnosperms described by Hayata from Taiwan are exampled in this paper.

KEY WORDS: biography, Cupressaceae, flora of Taiwan, gymnosperms, Hayata Bunzo, *Icones Plantarum Formosanarum*, *Taiwania*, Taxodiaceae.

INTRODUCTION

Bunzo Hayata (早田文藏) [1874-1934] (Fig. 1) was a Japanese botanist who described numerous new taxa in nearly every family of vascular plants of Taiwan. The most well known of the plants he described is perhaps *Taiwania cryptomerioides* Hayata (Hayata, 1906). New species and new infraspecific names published for Taiwanese plants by Hayata number roughly 1600. This figure was extracted from the 2710 entries attributed to Hayata as the author in the *International Plant Name Index* (IPNI, www.ipni.org, in January 2008). The total number includes not only new taxa described from Taiwan but also new combinations, new names (avowed substitutes) and new taxa, though not as many, from Japan, China and Indochina.

Hayata not only provided the foundation for our present knowledge of the flora of Taiwan, but also proposed a unique principle for plant classification, the "Dynamic system", which denied the existence of the evolution and phylogeny of plants. He did not accept Darwin's concept of evolution, the survival of the fittest, but instead believed in the eternal life of species based on the diversity of plants in the tropics that he observed during his work in Taiwan and Indochina. He was not only a taxonomist, but also an early Japanese researcher on pollination biology (Hayata and Ono, 1904, 1912), plant distribution and vegetation (Hayata, 1905, 1912, 1934b), and succession (Hayata, 1928b, 1928c, 1929) in Japan and Taiwan.

Many biographies and memoirs of Hayata have been published in Japanese (Yamada, 1934, Hatta, 1960, Satake, 1960, Kimura, 1987a, etc.), but only a few brief ones exist in English (Masamune, 1934; Merrill, 1934a, cf. Stafleu and Cowan, 1979) and French (Gagnepain, 1944). Wu (1997) wrote a biography of Hayata in Chinese as a botanist who worked in Taiwan during the period of Japanese occupation based biographies and memoirs written in Japanese. Although there are many articles on the works of Hayata in Japanese, many of them concerned his later works especially on his concepts on classification, phylogeny and evolution. I convinced that Bunzo Hayata and his botanical works need to be known more widely, not only for their historic interest, but also for their relevance to further floristic and taxonomic studies in Taiwan, China, and southeast Asia.

I encountered Hayata for the first time when I discovered a new species of *Desmodium*, *D. hayatae* H. Ohashi, among unnamed collections by Hayata from Indochina in 1921 preserved in the herbarium of the University of Tokyo (TI) (Ohashi, 1971). During studies on the flora of Taiwan, especially on the Leguminosae (Huang and Ohashi, 1977, 1993; Ohashi et al., 1984, 1985, 1988, 1991), I became greatly interested in the works of Hayata. Since then, it occurred to me that the taxa described by Hayata from Taiwan are in need of both taxonomic and nomenclatural evaluation to determine how many are still recognized and the number that have been placed in synonymy.

This paper is based on my talk under the same title, which was presented at The International Symposium on the centenary of the discovery of *Taiwania cryptomerioides* organized by The Experimental Forest, National Taiwan University, held on 8-10 December 2007 at Chitou, Taiwan (Ohashi, 2007). A huge tree of *T. cryptomerioides* Hayata, planted by Hayata in 1905-1910 when he visited there, still grows near the office of the Experimental Forest at Chitou (Figs. 2 & 3). The Experimental Forest had been affiliated with the Imperial University of Tokyo at that time.

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1. **Biography of Bunzo Hayata (1874-1934)**

Bunzo Hayata, the second son of Shinkichi Hayata (早田新吉) and his wife, Hatsu Hayata (早田ハツ), was born on December 2, 1874 in Kamo-machi, Niigata Prefecture (Yamada, 1934). He had two brothers, Sashirô and Ryôsuke (Hatta, 1960). His family was very devoutly Buddhist embracing Hokke Sect, a kind of Tendai Sect of Buddhism. His father Shinkichi, a dealer of molds, died when Bunzo was only 6 years old. From then on, he was brought up by his mother and grandparents. He entered Nagaoka Gakkô, a private middle school, in 1887 after graduating from Kamo elementary school.

In his later life, Hayata (1933b) mentioned that he was deeply concerned with birth and death from his childhood and he was motivated to study botany to seek answers to his basic questions on life. It is suspected that he was greatly affected by the death of his father and his family's strong religious beliefs. At the age of 16, he had already determined in his own mind to study botany (Hayata, 1933b). Unfortunately he had to leave school after two years because of the death of his grandparents in 1889 and 1890. After leaving school, he was obliged to apprentice to a clothing shop Tatemi gofuku-ten in Nagaoka (Heibonsha Publ. Co., 1979), but he continued to study botany on his own. After joining the Botanical Society of Tokyo in 1892, when he was 18, he often sent questions on plants to the Botanical Society (Yamada, 1934). He expressed interest not only in vascular plants but also in bryophytes. His interest in mosses collected in Kamo-machi in his boyhood in 1893 and 1894 was reported by Hayata in 1928 and 1929 (Hayata, 1928a, 1929f).

In 1895, when he was 21 years old, Hayata left his native town, Kamo-machi, and entered Ikubunkan Middle School in Tokyo. In the following year, his mother, Hatsu, died. After graduating from middle school in March 1897, he entered Daiichi High School in July 1897, at the age of 23 (Fig. 4). In July, before the new academic term began (the new term started in September), he visited Taiwan at the invitation of his countryman and friend, Kôjiro Kawakami (川上浩二郎) who was an engineer and had worked in Taiwan on the construction of the port at Keelung. It was Hayata's first of many visits to Taiwan, but he left no record that he collected plants during that trip. While he was in high school, however, he eagerly studied botany and made plant collections on weekends and during school vacations (Hatta, 1960). The first and second papers by Hayata (1903a, 1903b) were floristic notes and a list of the vascular plants of the Oze-numa and Ozegahara moor district in Aizu where he botanized in 1898, during his high school years.

Hayata entered the botany program in the College of Science, Imperial University of Tokyo in September 1900. He made his first botanical trip to Taiwan from July to September in the same year, just before beginning his course of study at the University. He graduated in July 1903 at the age of 29. His paper, *Euphorbiaceae of Japan*, was presented to meet one of the requirements for graduation (Yamada, 1934). Hayata then entered the graduate program of the Department of Botany at the Imperial University of Tokyo in September 1903. His supervisor Professor Dr. Jinzo Matsumura (松村任三) [1856-1928] (Fig. 5) assigned him the thesis topic, Flora of Taiwan (Hayata, 1931a). On 17 September 1904 Hayata was appointed Assistant in the Botanical Garden, The College of Science, Imperial University of Tokyo (Ogura, 1940).

In May 1905, when he was 31 years old, he was temporarily employed by the government of Taiwan to determine specimens collected by government botanists. That work was the impetus for his later investigation of the flora of Taiwan.

Hayata submitted four papers to meet the requirement for the degree of Doctor of Science and left the graduate school in September 1907 (Yamada, 1934). His papers were: *Compositae Formosanae* (Hayata, 1904a), *Revisio Euphorbiacearum et Buxacearum Japonicarum* (Hayata, 1904b), *Enumeratio Plantarum in insula Formosa* (Matsumura and Hayata, 1906), and *On Taiwania, a new genus of Coniferae from the island of Formosa* (Hayata, 1906) (Yamada, 1934). Hayata was awarded his degree on 6 November 1907 from the Imperial University of Tokyo (Ogura, 1940). Later that year, in December, he married Kuni Amaya (雨谷クニ), the second daughter of Yozaemon Amaya, in Fujisawa-shi, Kanagawa Prefecture 1907 (Hatta, 1960) (Fig. 6).

On 13 August 1908, when he was 34 years old, he was promoted from Assistant in the Botanical Garden to Lecturer in the Department of Botany (Ogura, 1940).

In 1910 Hayata visited Kew and several European herbaria to study Taiwanese plants. Immediately after returning from Europe in 1911, he published a book of about 470 pages, *Materials for a Flora of Formosa* (Hayata, 1911a). His first volume of *Icones Plantarum Formosanarum nec non et Contributiones ad Floram Formosanam* (hereafter abbreviated *Icones*) published by the Bureau of Productive Industry, Government of Formosa, also appeared in 1911. The first volume of the *Icones* comprised 265 pages and 40 plates (Hayata, 1911b).

There remains a photograph of Hayata with his wife and son probably photographed at the festival day for his son, Bunichi, aged five (actually four in the present count) in 1912 in Tokyo (Fig. 7).

When Adolf Engler stopped in Japan on the way to United State in July 1913, Hayata guided him from Shimonoseki to Nagasaki and Miyajima (Hayata,

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1913). A picture of Engler with the staff of the Department of Botany, Imperial University of Tokyo, is kept in the Botanical Garden of the University of Tokyo (Fig. 9).

With funding from the Government of Formosa, Hayata undertook a botanical expedition to Tonkin from May to August 1917, probably in an attempt to solve taxonomic problems dealing with Taiwanese plants. He was promoted to Associate Professor of the University of Tokyo in 1919 when he was 45 years old. There remains a picture of Bunzo Hayata standing by the stature of Urbain Faurie (1847-1915) in the Taipei Botanical Garden in Taipei taken probably in 1918 or 1919 (Fig. 8).

In 1920 Hayata was awarded the Prince Katsura Commemoration Prize from the Imperial Academy of Japan for his contribution to the flora of Formosa. Hayata reported this honor in the introduction of volume 10, the last volume of the *Icones*. He donated all the award to the Tokyo Botanical Soeiety (present The Botanical Society of Japan) and the Formosan Natural History Society. It is ironic that the honor coincided with the unexpected end of the *Icones*. The final volume of the *Icones*, containing 355 pages, but without plates, was published in 1921. From May 1921 to March 1922 (Hayata, 1923) Hayata botanized in Indochina for a second time.

On 17 May 1922, when he was 48 years old, he was appointed Professor of Systematic Botany in the University of Tokyo, becoming the third Professor of Systematic Botany in the University and succeeding his supervisor, Professor Matsumura (Ogura, 1940). Unfortunately, Hayata had been sick since about 1922 (Hayata, 1923). He was also appointed the Director of the Botanical Garden on 26 April 1924 (50 years old) following Professor Manabu Miyoshi (三好學) [1861-1939], who retired on 2 April 1924.

On 1 September 1923 Tokyo was hit by a strong earthquake, the Kanto jishin. The department of botany and the botanical garden were damaged by the earthquake, but the buildings did not catch fire. According to Ogura (1940), some of the buildings and the botanical garden were occupied by survivors of the earthquake (ca. 25,000 people on 1 Sept., 35,000 on 2 Sept., and 400 on 14 Sept.). In October 1923, 22 barracks were constructed by the government along the main road of cherry trees in the garden as first-aid stations for the victims. The Department of Botany was able resume classes and experiments in November. People living in the garden numbered 840 on 3 October, 2,438 on 30 October 1923 (maximum), and 562 on 31 December 1924. They left on 12 January 1925 and the garden was cleared by 15 May 1925 (Ogura, 1940). Miyoshi and Hayata were directors of the garden during that period. He continued in that position until 1930 when he was 56 years old.

After the promotion to Professor of the Department of Botany and assumption of the Director of the Botanical Garden, Hayata had to leave from studies on the Flora of Taiwan. Looking through his bibliography, Hayata had not published original articles between 1920 and 1924 in spite of his high activity of publication in botany through his life (cf. Yamada, 1934; Merrill and Walker, 1938).

Hayata had been worked for construction of a new system of plant classification. He sought to combine new anatomical characters together with external morphological characters for ferns and seed plants, and he proposed an importance of the stele (Hayata, 1918c, 1929c). His theory regarding the stele, however, has not been generally accepted by the botanical community. Fujii (1918) critically reviewed Hayata's concept of the stele. However, he had continued and concentrated his research on the diversity of the stele in ferns (Hayata, 1927-28, 1929b, 1929d, 1929e, 1931b) and seed plants (Hayata, 1929c, 1930a; Hayata and Satake, 1929). Hayata talked at the end of his presentation in the third Pan-Pacific Science Congress held in Tokyo in 1926 that "I must apologize that I have gone so much too far afield as to enter upon the discussion of the origin of species and their natural system. However, much I may be criticized I shall not mind it, for the motive which led me to devote my life to the study of botany was the desire to understand what life is." (Hayata, 1928c).

Hayata's condition became critical due to heart disease in September 1929 (Yamada, 1934). Fortunately, he made a partial recovery after about six months.

He continued work on a textbook on plant taxonomy based on his lectures in the botany course in the department of botany, taxonomic papers based on his "stelar system" and "dynamic system," various essays based on his thoughts on life, and on the principles in taxonomy, and so on. He kept these works on his sick bed at home except when he lectured twice a week in the department of botany in the botanical garden (Honda, 1935). To make it more convenient to give lectures, Hayata moved to a small house close to the botanical garden after he recovered from his heart disease (Kimura 1960a). Yoshisuke Satake (1960), then assistant of Prof. Hayata, often helped him by bringing materials and references to his home for study from the department of botany.

There remains a picture of Hayata photographed with staff of the Department of Botany and students of graduation of the Botany Course in front of the Botany Institute in the Botanical Garden in March 1931 (Fig. 10). This may be his last figure at official occasions.

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Hayata published *Rashi-shokubutsu* (Gymnosperms), as the first volume of his *Shokubutsu Bunruigaku* (Plant Taxonomy), written in Japanese in 1933, to which he devoted most of his remaining energy. Representative essays during his final years were: *Principal aims of systematic botany* (Hayata, 1933b), *What is eternal life*? (Hayata 1933d), and *What is taxonomy?* (Hayata, 1934a). Hayata died from chronic heart disease on 13 January 1934 at the age of 59 years and 43 days. His funeral was held on 16 January at Honmyoji temple in Shinjuku and his ashes were placed in the Aoyama Bochi cemetery (Yamada, 1979).

The second volume in his *Shokubutsu Bunruigaku*, *Hishi-shokubutsu* (=Angiosperms) was published after his death in 1935 and was based on an unpublished manuscript edited by Masaji Honda (本田正次) [1897-1984], who was an assistant when Hayata passed away and who was then promoted to Associate Professor in April 1934.

Ten years later, in April 1944, Professor Hayata's wife, Kuni Hayata, followed him in death (Hatta, 1960). They had one son and three daughters. Their son, Bunichi, the eldest child, who taught mathematics at a middle school in Tokyo and studied nuclear physics in the University of Tokyo, died in February 1945 at the age of 36. The eldest daughter, Yukiko, married Shigeo Akiyama, a student of Bunzo Hayata and later professor of plant taxonomy at Hokkaido and Kanazawa Universities, and who was a specialist of *Carex* of eastern Asia. She asked Hatta who was a friend of Bunzo Hayata from their high school age and wrote his excellent short biography that is the only record of young Hayata and his family (Hatta, 1960), died on 7 June 2004 at the age of 92. The second daughter, Kiyoko, died at the age of three. The third daughter, Kisako, left Tokyo during bombing in the second World War to Sapporo where her elder sister lived. She married Mutsuo Terui in 1949 in Sapporo when he was an Assistant of the Hokkaido University, later a professor of plant pathology at Hirosaki University in Aomori Prefecture and founder of Herbarium Hirosaki University, Fungi (HHUF). She died in 1975 at the age of 55 in Hirosaki.

Yukio Yamada (1934), a student of Hayata at the Imperial University of Tokyo between 1923 and 1924 and later professor of systematic botany in Hokkaido University, wrote a memorial biography of Hayata in Japanese. It includes Hayata's bibliography listing 148 articles plus four books, of which the 10 volumes of the *Icones* are treated as a single article, although a few should be added to the list, e. g. Hayata 1908b, 1908f, etc. Genkei Masamune (1934a, 1934b), also a student of Hayata at the university and later professor of systematic botany in Taihoku Imperial University, published Hayata's curriculum vitae and bibliography in English. Merrill and Walker (1938) listed 100 of Hayata's articles with a short introduction to the content of each, but the list omits his papers concerning most of his theoretical articles including the dynamic system of plant classification, taxonomy and evolution.

Yamada (1934) considered representative works of Hayata to address 1) the flora and vegetation of Mt. Fuji, 2) the flora of Taiwan, 3) the *Stelar System* in ferns, and 4) the *Dynamic System* of plant classification. Yamamoto (1936) and Satake (1960) divided Hayata's 32 years of academic activities into two periods. In the first period between 1903 and 1920 or 1922, Hayata concentrated on the flora of Taiwan, botanized more than 10 times in Taiwan, and published the *Icones* (1911-1921). In the second period, between (1918-)1920 or 1922 and 1934, he sought the basic principles of plant taxonomy. He worked on the structure and system of the stele as the basic character for fern classification, and proposed the *Dynamic System* for plant classification.

Bunzo Hayata's personality was mentioned by many persons. Hayata was enthusiastic for plant taxonomy and a person of sincerity, strong beliefs and enthusiasm (Yamada, 1934). Heikichi Hatta (1960) who had been a classmate with Hayata in high school between 1897 to 1900, mentioned that Hayata behaved as a Spartan, always hated futility and did not show pride himself. He worked to overcome all difficulties to achieve his goals, so he may have been sometimes misunderstood. However, he had deep feelings for the sufferings of others and was characteristically friendly. Merrill (1934, page 389), who met Hayata several times in Tokyo when he traveled between United States and Manila, said that "throughout our long association I was impressed with his breadth of view, with his scholarship, with his intense interest in his chosen profession, and with his most attractive personality. Throughout his career as a publishing botanist one is impressed with the fact that he was constantly extending his botanical horizons, building year by year the greater structure on the sound basis of his earlier comprehensive taxonomic experience." Satake (1960) who had been a student and then an assistant of Hayata from 1926 to 1934 noted that Hayata neither drank nor smoked and enjoyed no amusements or recreation (Satake, 1960). Yojiro Kimura (1960a), who had just entered the botany course at the University of Tokyo, mentioned that Hayata signed the cover of his *Shokubutsu Bunruigaku*, *Rashi-shokubutsu* as "Theory of participation as the base of taxonomy" when Kimura visited Hayata at his home on 13 July 1933, a half year before his death. He eagerly told Kimura of his "Dynamic theory" in spite of his poor health.

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Hayata had a fine command of English, French, Germany and Latin. He introduced and reviewed Merrill: "An interpretation of Rumphius's Herbarium Amboinense" and Martius: "Flora Brasiliensis" to Japanese botanists (Hayata, 1918, 1924). We suspect that he liked to write sentences in Japanese, English, Germany and French, and, in fact, he published many botanical articles, books and various essays in general and biological journals and in newspapers. He was a stylist and his sentences were clear and smooth. We have been strongly impressed through his works that Hayata was truly devoted throughout his life to plant taxonomy.

Pupils of Hayata were Yoshimatsu Yamamoto (山本由松) [1893-1947] (Fig. 11) who had worked in Taihoku Imperial University, later National Taiwan University, in Taiwan, the successor of Hayata for the flora of Taiwan, published five volumes of supplements for Hayata's *Icones Plantarum Formosanarum*. Genkei Masamune (正宗巖敬) [1899-1993] who was also a professor of Taihoku Imperial University, later Kanazawa University, worked on Taiwan flora especially Orchidaceae, Yukio Yamada (山田幸男) [1900-1975] (Hokkaido University), Arika Kimura (木村有香) [1900-1996] (Tohoku University, specialist of Salicaceae), Hisao Migo (御江久夫) [1900-1985] (Shanghai Science Institute, later Yamaguchi University, worked for flora of China), Yoshisuke Satake (佐竹義輔) [1902-2000] who was the director of Botany Division in The National Science Museum, and had assisted Hayata for his Stelar System when he was a research assistant of the University of Tokyo. He was a specialist of *Bohemeria* and Juncaceae, and a main compiler of a popular flora of Japan, *Wild Flowers of Japan* in five volumes, and Shigeo Akiyama (秋山茂雄) [1906-1984] (Hokkaido University, later Kanazawa University, specialist of *Carex* of East Asia).

2. **Hayata's contributions to the flora of Taiwan**

Hayata worked on the flora of Taiwan for 20 years, from 1903 to 1922. His work on the flora of Taiwan can be divided into two periods: the first 10 years, from his initiation in 1903 to publication of fascicle 2 of the *Icones* in 1912, and the second 10 years, from publication of volume 3 of the *Icones* in 1913 through the last volume in 1921 to 1922 when he returned from his last expedition to Indochina and was promoted to professor of systematic botany in the University of Tokyo.

At the beginning of the second period, Hayata realized the richness of the flora of Taiwan through his studies in the European herbaria in 1910 and through his two, extensive botanical expeditions in Taiwan 1912. He revised his previous project on the flora of Taiwan and restarted publication of the *Icones* from volume 3 in 1913 by inclusion of a new series of articles entitled *Contributions to the flora of Formosa*. The *Icones* was discontinued after publication of volume 10 in 1921, although Hayata had intended it to continue to volume 15 (Hayata, 1921a).

This chapter describes Hayata's contributions to the flora of Taiwan in four parts: i) floristic studies in Taiwan before Hayata, ii) the first 10 years of Hayata's flora of Taiwan, iii) Taiwania, iv) the second 10 years, and v) Hayata's works after the flora of Taiwan.

i) **Floristic studies in Taiwan before Hayata**

Much floristic research had been performed in Taiwan before Hayata began his study of the flora. Although Robert Fortune [1812-1880] was the first botanist to collect plants along the seacoast at Tamsui, Taiwan, on 20 April 1854, during his third plant hunting tour to China, his gatherings of Taiwanese plants were extremely limited, consisting of several specimens, because he collected only when his ship stopped in port. Charles Wilford collected plants in Taiwan for the first time in June 1858. Robert Swinhoe [1836-1877] listed 246 species of plants from Taiwan in 1863 or 1864. Before 1895, Augustine Henry [1857-1930] was the last botanist to study the Taiwanese flora. He produced *A list of plants from Formosa* in which were enumerated 1428 species from Taiwan (Henry, 1896). The botanical history of Taiwan was reviewed by Hayata (1911b), Kanehira (1936) and Wu (1999). The works of Forbes and Hemsley (1886-1905) and Henry (1896) were important basic works for Japanese botanists who studied Taiwan's flora.

The first collections by a Japanese botanist, between July and September, 1874, were gathered by Manjirô Kurita (栗田萬次郎) [1833?-1900] in southern Taiwan, and recorded by Kurita (1888-89) 101 species of vascular plants, though many of which were referred to their genera, with short description on their habitat, use, vanacular names and others in Japanese. Kurita is recorded by Ito (1936).

In 1895, after the Sino-Japanese War of 1894-95, Japan began to govern Taiwan politically. With the establishment of the Government of Formosa, Japan initiated various expeditions, investigations and explorations to study the natural products of Taiwan. Yasusada Tashiro (田代安定) [1856-1928], who was the first to begin research on the natural products and tropical plants in the Ryukyus and Taiwan, sent a number of herbarium specimens collected in various parts of Taiwan to Professor Matsumura at Tokyo University between 1895 and 1898 (Matsumura and Hayata, 1906). Tashiro worked for the Government of Formosa from 1895 to 1910 and published a flora of

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Penghu as early as 1895, which was second flora of Taiwan prepared by a Japanese botanist. He is recorded in Hatusima (1975).

Seiroku Honda (本多靜六) [1866-1952], Associate Professor of Forestry, Imperial University of Tokyo, visited Taiwan to observe the forests in 1896. One of his collections, *Chamaecyparis formosensis* Matsum., collected on Mt. Morrison in October, was designated by Farjon (2005) as the lectotype of the name of the species (Fig. 12). Honda (1899) published his findings in a paper on the altitudinal distribution of forests in Taiwan.

The Imperial University of Tokyo sent the First Taiwan Expedition Team to Taiwan in 1896. Tomitaro Makino (牧野富太郎) [1862-1957] (assistant in the Botany Department), Chûtarô Owatari (大渡忠太郎) (botany student), and Tomijiro Uchiyama (内山富次郎) [1846-1915] (gardener and plant collector in the Botanical Garden) made up the team. The team collected plants for about one month and returned to Tokyo in December (Ogura, 1940). Plant collections were again made by Owatari in 1897 and 1898, and by Kiichi Miyake (三宅驥一) [1876-1964] in 1899-1900. These botanical projects must have been promoted through the support of Professor Matsumura.

Matsumura was one of the earliest botanists in Japan to work on the flora of Taiwan, in which he was deeply interested. His name became famous in Taiwan as the author of *Chamaecyparis formosensis* Matsum. (Matsumura, 1901) (Fig. 12). His study of the family Leguminosae in Taiwan is a representative example that reflects his interest in the Taiwanese Flora. He treated the family in Ito and Matsumura's *Tentamen Florae Lutchuensis* published in 1899 (Matsumura, 1899). The Leguminosae included not only the plants of the Ryukyus, but also those in Taiwan, based on earlier collections in the University of Tokyo. Ito treated only the plants of the Ryukyus. Actually, Matsumura mainly listed the Leguminosae collected in Taiwan rather than those from the Ryukyus. He described such new species from Taiwan as *Crotalaria formosana* Matsum., *Uraria hamosa* var. *formosana* Matsum., *Mucuna ferruginea* Matsum., and *Galactia formosana* Matsum. (Matsumura, 1899). Matsumura also published *Enumeratio Plantarum in insula Formosa*… based on collections in the herbarium of The Imperial University of Tokyo (Matsumura and Hayata, 1906).

Takiya Kawakami (川上瀧弥) [1871-1915] was the most important botanist to be associated with Hayata's exploration and collecting in Taiwan. He graduated from Sapporo Agricultural College in 1900 and was a plant pathologist and botanist (e.g., Kawakami, 1895, 1896; Kawakami and Miyabe, 1903, etc.). Kawakami organized botanical explorations of Taiwan under the auspices of the Bureau of Productive Industries. The chief officer of the Bureau of Productive Industries was Inazo Nitobe, who graduated from Sapporo Agricultural College and was a classmate of Kingo Miyabe, Professor of plant taxonomy in Sapporo Agricultural College, later the Faculty of Agriculture, Hokkaido University). The Government of Formosa employed Kawakami in October 1903 and he began to collect plants in 1905. Staff members working with Kawakami were Genji Nakahara (中原源治), Ushinosuke Mori (森丑之助) [1877-1926], Sadaichi Nagasawa (長澤定一), Yaichi Shimada (島田彌市) [1884-1971], and Shun'ichi Sasaki (佐々木舜一) [1888-1960] (Kawakami, 1910). Kawakami was temporarily employed by the Department of Botany, The University of Tokyo, in 1904-1906 and 1911-1915, as was Nakahara in 1906-1907 (Ogura, 1940), probably to collect herbarium specimens. Other collectors listed by Kawakami (1910) were Tokutarô Itô (伊藤篤太郎) [1866-1941], Shunsuke Kusano (草野俊助) [1874-1962], Nariaki Konishi (小西成章), and others. Collections made by these people are mostly kept in the Herbarium, Taiwan Forestry Research Institute, Taipei (TAIF). Kawakami's publication, *A list of plants of Formosa*, published in 1910, recorded 2368 species, of which 2,199 were native to Taiwan and 170 were introduced.

Collections by S. Yano (probably same person with Seikichiro Yano 矢野勢吉郎 from Kochi prefecture) in 1896-1897 and N. Konishi are kept in part in the herbarium at Hokkaido University (SAPT) (Ohashi et al., 2006). Urban J. Faurie collected plants in Taiwan in 1903 and 1927-1929. Teijiro Soma (相馬禎二郎) [1879-1917], who was a teacher of Japanese in Taiwan from 1910 to 1917, also actively collected plants for the Imperial University of Tokyo (TI) (Hayata, 1917b). Additional earlier collectors are recorded in Matsumura and Hayata (1906) and Kanehira (1936).

ii) **Hayata's first 10 years, 1903-1912**

Hayata began to study the flora of Taiwan in 1900 when he made his first botanical trip to Taiwan. The flora of Taiwan became his theme in graduate school in the University of Tokyo, which he entered in 1903. According to Nakai, when Kimura visited him in 1934, Hayata's research topic was assigned by Matsumura; Hayata had wished to study mosses (Kimura, 1987b). Why did Matsumura assign that topic to Hayata? Matsumura said that a specialist of cryptogams could not find a job (Nakai in Kimura, 1987b). There appear to have been two good reasons to initiate a research project on the flora of Taiwan; Matsumura had deeply interested in the Taiwanese flora and the herbarium (TI) had many Taiwanese specimens.

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Hayata had already botanized in Taiwan in 1900 and studied his collections eagerly, even in his undergraduate days. He collected plants in Taipei in July 1900 and published a list of his collections, his first paper on the flora of Taiwan, as soon as he began to study the flora of Taiwan (Hayata, 1903a). He soon published three additional papers on Taiwanese plants (Hayata, 1903d-f). When Hayata began his thesis research, Matsumura allowed him to study all the plants he had collected in Taiwan (Hayata, 1923). Furthermore, he had a great fortune to be employed by the Government of Formosa to identify specimens collected by government botanists from 1905 until 1924. He may have been recommended for the position by Matsumura, although no record remains.

Hayata (1911d) reported on the early stages of the study of the plants of Taiwan in the introduction to the first volume of the *Icones*. "No great progress was made in the botanical study of the island [=Taiwan], until in 1904 the Government of Formosa decided to carry out a botanical survey of the whole island. Mr. T. Kawakami with several assistants was then engaged to collect plants, and I [=Hayata] devoted myself to the investigation of the materials sent by the collectors to the Herbarium at Tokyo. It was in these circumstances that, in 1906, I wrote *Enumeratio Plantarum Formosanarum* in conjunction with Prof. J. Matsumura. At that time, … the botanical survey did not extend to regions having an elevation of more than 3,000 ft. … During 1905-1907, several excursions to the mountainous districts were carried out by the Government. In 1908, as a result of the study of the mountain-collections, I published *Flora Montana Formosae*. … Since that publication, I have had many more collections from the island. These collections are, in greater part, from the mountainous regions, and contain a considerable number of novelties."

In fact, Hayata published many papers on alpine plants of Taiwan including many noteworthy conifers endemic to Taiwan (Hayata, 1907, 1908a-1908f, 1909).

In 1910, from January 5 to October 13 (Ogura, 1940) Hayata studied Taiwanese plants in several European herbaria: Kew, Paris, Berlin, and St. Petersburg. He brought many Taiwanese specimens from Japan to Kew and compared them with the specimens in Kew, especially those from China (Hayata, 1911a). Hayata stated as follows: "I first went to Kew taking all my materials with me. ····· I found that many of the species of my collections are represented in the Chinese herbaria at Kew, and also among the specimens from other regions. At the same time, I found also that the greater part of my materials are not yet represented at Kew, and that, in great probability, they are species not yet described. After finishing my work at Kew, I went to the Herbarium at Paris, in order to see the type specimens of Chinese plants mainly described by Franchet. During my work on the continent, I was successful in placing some species which I had not been able to determine at Kew. Still, many of the plants in my collections which remain as yet undetermined, are not represented in any of the herbaria on the continent. It is, therefore, highly probable that they are species not yet described." While working in Kew, he attended the 3rd International Botanical Congress at Brussels on 16-22 May 1910 (Ogura, 1940) and presented a paper on a botanical survey of Formosa (Hayata, 1911a). Through these studies, especially in Kew, he was convinced he had many new species in his collections from Taiwan. Hayata (1911a) published a large supplement to his previous two works, *Materials for a Flora of Formosa*, immediately after returning from his visits to the European herbaria. The book carries a long subtitle: *Supplementary notes to the Enumeration Plantarum Formosanarum and Flora Montana Formosae, based on a study of the collection of the botanical survey of the Government of Formosa, principally made at the Herbarium of the Royal Botanic Gardens, Kew*. The *Supplementary notes* enumerate "735 species belonging to 343 genera and 109 families." Hayata (1911a) reported the number of species in Taiwan in the *Materials for a Flora of Formosa*. In *Enumeratio Plantarum Formosanarum* by Matsumura and Hayata (1906), "1999 species belonging to 701 genera and 153 families" were recorded. In *Flora Montana Formosana* by Hayata (1908c) and in the *Materials* in 1911, "2660 species belonging to 836 genera and 156 families" were reported for Taiwan. Accordingly, 661 species, 136 genera and 3 families had been added by Hayata's work between 1906 and 1911. On 15 September 1911 Hayata published the first volume of the *Icones* with the full title in English, *Icones of the Plants of Formosa, and Materials for a Flora of the Island, based on a Study of the Collections of the Botanical Survey of the Government of Formosa*, which was issued by the Bureau of Productive Industry, Government of Formosa.

iii) ***Taiwania***

Shortly after beginning his study of the flora of Taiwan, Hayata (1906) published as new *Taiwania* and *T. cryptomerioides* with a fine illustration. The specimen cited in the original description, *Nariaki Konishi* in February 1904 at "Ushokô [烏松坑], Shorinzan [杉林山], Rinkiho [林杞埔], ad pedem montis Morrison ad 2000 m (TI), has been treated as "type" (Li and Keng, 1994) or "holotype" (Farjon, 2005). Ohashi and Ohashi (2008) noticed that the

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specimen is a mixture of two elements and therefore selected a lectotype of *T. cryptomerioides* Hayata from among the syntypes (Fig. 15).

Hayata considered *Taiwania* to be closely related to *Cunninghamia* in reproductive characters, and to *Cryptomeria* in habit and in the shape of the leaves. The specific epithet was derived from the similarity to *Cryptomeria japonica*. *Taiwania cryptomerioides* was considered to be representative species endemic to Taiwan before its discovery by Handel-Mazzetti in 1916 in the Salween-Irrawaddy divide in NW Yunnan (Sorger, 1925) (Fig. 13). Plants of *Taiwania* in Yunnan are considered to be different from those in Taiwan, as indicated in the names for them, *T. flousiana* Gaussen (Gaussen, 1939) or *T. yunnanensis* Koidzumi (Koidzumi, 1942). It is still controversial, however, whether *Taiwania* consists of one or two species or one species with two variety. The morphological, genetic, and phylogenetic aspects of the Taiwanese and continental races were discussed in a symposium in Taiwan (The Experimental Forest, National Taiwan University, 2007). Nowadays *Taiwania* is known from Taiwan, China (SE. Guizhou, SW. Hubei, SE. Sichuan, SE. Xizang [Tibet], and W. Yunnan), N. Myanmar and N. Vietnam.

In describing *Taiwania*, Hayata began his paper as follows: "The very interesting conifer described in this paper was kindly sent to me by Mr. N. Konishi, Government Expert of Formosa." Hayata had already studied the conifers of Taiwan before the discovery. In 1905 he published a comprehensive survey of the distribution of the conifers of Taiwan and compared them with other conifers of Asia. He had already recognized 12 genera and 17 species of conifers in Taiwan. It is likely that he immediately recognized the material sent to him from Konishi to be a new species. Examining the flowers and cones, however, he must have also realized that it also represented a new genus. To be certain, he sought the opinion of one of the world's authorities on conifers at the time, M. T. Masters of the Linnean Society, London. Hayata sent a fragment of the specimen to him along with a note, which still remains at Kew (Fig. 14).

Hayata (1905) considered the conifers to be plants of ancient origin and gradually disappearing from the world. He therefore believed *Taiwania* to be a relict survivor from ancient times. Accordingly, he considered the discovery of a new genus of conifers to be a great contribution to botany. Kanehira (1934) noted in a memoir that Hayata had told him, probably when he accompanied Hayata to Mt. Alisan in 1913, that the publication of *Taiwania* was the greatest contribution he had made during his study of the plants of Taiwan, and that such a discovery would never come again in his work on the flora. Hayata was proud of the discovery of *Taiwania*.

Hayata maintained an interest in *Taiwania* throughout his life. He published two additional papers on *Taiwania* (Hayata, 1907, 1932) and illustrations of *Taiwania* three times: first in the original publication in 1906 (Fig. 16), the second with the addition of features of leaf anatomical in 1907 (Fig. 17), and the third with the addition of male inflorescence and flowers instead of leaf anatomy in 1933 (Fig. 18). Finally, after about 30 years had passed since his first publication on *Taiwania*, he split it out from the Taxodiaceae and placed it in a distinct, new family, the Taiwaniaceae (Hayata, 1932). Others failed to follow him, but continued to recognize *Taiwania* as belonging to Taxodiaceae (Kanehira, 1936; Koidzumi, 1942; Li, 1975; Li and Keng, 1994), or, recently, Cupressaceae (Farjon, 2005).

Taiwania cryptomerioides was called "Taiwan sugi (タイワンスギ or 臺灣杉)" in Japanese before the 1940s, or "Taiwan san (臺灣杉)" in Chinese. Hayata (1933a) renamed *Taiwania* "Taiwanya-sugi (臺灣爺杉)" in Japanese in his textbook of plant taxonomy. He reasoned thus; "as the Japanese name of *Sequoia* is "Sekaiya-sugi 世界爺杉," I wish to give *Taiwania* as "Taiwanya-sugi 臺灣爺杉," because of analogy of pronunciation between *Sequoia* and *Taiwania*" (Hayata, 1933a, in Japanese translated by Ohashi here). Although Hayata did not talk excessively about his desires, he perhaps hoped that *Taiwania* would become as world famous and long-lived as *Sequoia*.

iv) **Hayata's second 10 years, 1912-1921**

In 1912, Hayata conducted two botanical expeditions in Taiwan, which enabled him to better understand the richness of Taiwan's flora. He noted that his estimation of the number of species in Taiwan had been too small in the *Icones*. He therefore decided to revise the *Icones* starting at volume 3. Volume 3 (not fascicle 3 as continued from fasc. 2) and subsequent volumes of the *Icones* differ from the earlier edition in that they contain additional new species and varieties. The work, under the title *Contributions to the flora of Formosa*, was expanded to include plants from outside of Taiwan, including those from geographically related regions such as the Ryukyus and Bonin islands, Japan, and from Hainan, China.

Hayata prepared a large number of manuscripts for each volume of the *Icones* every year from 1911 to 1921. The entire series of *Icones* was published as follows: Fasc. 1, 265 pp., 40 plates (1911); fasc. 2, 156 pp., 40 plates (1912); vol. 3, 122 pp., 35 plates (1913); vol. 4, 264 pp., 25 plates (1914); vol. 5, 358 pp., 17

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plates (1915); vol. 6, 168 pp., 20 plates (1916); [*General Index to the Flora of Formosa. Supplement to Icones Plantarum Formosanarum VI.* 155 pp. (1917a)]; vol. 7, 107 pp., 14 plates (1918); vol. 8, 164 pp., 15 plates (1919); vol. 9, 155 pp., 7 plates (1920), and vol. 10, 355 pp., without plates (1921).

At the same time he was preparing manuscripts, he also identified numerous specimens from Taiwan and published many new taxa within an extremely short period. I suspect that he still held the conviction, based on his studies at Kew in 1910, that many new species were awaiting discovery in Taiwan. He must have considered as specific distinctions, rather than variations of a known species, even slight differences he found in specimens from Taiwan.

Icones vol. 10 was published in 1921, but it was an unexpected last volume of the *Icones*. Hayata stated that "the original plan of the work was that it should be completed in 15 volumes," but the project "come to an abrupt end" (page 11 in *Icones* vol. 10). He ended the series of *Icones* with a *General index to the series, from the first volume to the tenth, and also to the studies published by the author, while he was preparing this work on Icones*. Hayata recorded 3658 species and 79 varieties belonging to 1197 genera and 170 families of vascular plants in Taiwan at that time (Hayata, 1921a). Hayata's research on the flora of Taiwan was nearly finished in 1921 when he was 47 years old.

Hayata maintained an interest in the flora of Taiwan after he completed his own studies by donating 2,000 yen (the equivalent of nearly 10,000,000 yen in 2006) to the University for further research on Taiwanese plants in 1924 (Ogura, 1940). Hayata's work on the Flora of Formosa was succeeded by Yamamoto (1893-1947), who was his first student in the Department of Botany and who graduated in March 1923. Yamamoto published on flora of Taiwan since 1924 (Yamamoto, 1924), and was appointed Associate Professor of Taihoku Imperial University in 1928. He published a supplemental series to Hayata's *Icones* in 1925-1928 and 1932.

v) **Hayata's research after the Flora of Taiwan**

Since he believed his work on the flora of Taiwan would finish soon, in 1919, Hayata considered expanding his research to the Asian continent. He was thankful to his supervisor and to the senior members of the staff on the project, and to previous collectors of herbarium specimens in Taiwan (Hayata, 1923). To return their kindness, he sought a new area and a new focus for younger Japanese plant taxonomists in the way that he had been assigned to study Taiwan's flora for his research (Hayata, 1923). To meet his objectives, Hayata proposed expeditions to Indochina. He obtained financial support for his plans from the Government of Formosa in 1921. He already had experience in Indochina in 1917 and published several papers after that expedition (Hayata, 1918a, 1919). His second expedition to Indochina was from May 1921 to March 1922 (Hayata, 1923; Tuyama, 1960).

Hayata was deeply impressed by the richness of species in Indochina, which resulted in his unique ideas on evolution and plant classification. Also, Hayata extended his thoughts to plant taxonomy during the final stages of his work on the *Icones*. In volume 10 of the *Icones*, the last volume of the series, Hayata (1921b-c) published two papers from *Contributions to the flora of Formosa VII*: the first one, *An interpretation of Goethe's Blatt in his Metamorphose der Pflanzen, as an explanation of the principle of natural classification*" and the second one, *The natural classification of plants according to the Dynamic System* (pp. 97-234). The two papers present his basic concept on plant classification and his ideas on a new classification system for the angiosperms. According to Hayata (1920), the second paper was prepared between April and mid August in 1920.

At this time Hayata had fundamental doubts on the natural classification of plants based on evolution and phylogeny. He thought "the principle of natural classification should be founded on the participation theory, the dynamic system, and the manifold views of the mutability of species" (on page 95 in *Icones* vol. 10). He published many papers on his Dynamic System based on the theory of participation as a principle of plant classification (Hayata, 1920, 1921c, 1928c, 1931a, 1931c, 1931d, 1931e, 1931f, 1935). Hayata's Dynamic System was introduced by Krause (1923, fide Hayata 1931d) and Dy Ruetz (1930, fide Hayata, 1931d), but has rarely been accepted by the botanical community. Hayata concluded his talk at the third Pan-Pacific congress in Tokyo as follows: "I have viewed the origin of species, the morphological relationship among different orders and the natural system in the light of the Succession Theory, and have come to the conclusion that the ancestors of any given species were numerous, that phylogeny is an illusion and that the system should be dynamic, changing with the view of the systematizer and subject to alteration according to the criteria for comparison" (on page 1868 in Hayata, 1928b).

Hayata's concepts on plant classification, evolution, and life were discussed by Tamura (1953) and Kimura (1960b, 1987a) from a historical point of view.

3. **Present recognition of new taxa described by Hayata**

How many species and infraspecific taxa did Hayata describe? Most of Hayata's new taxa were published in *Materials for a Flora of Formosa* (1911a) and in the

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Icones (1911b-1921). About 1600 names are attributed to 'Hayata' in IPNI. Hayata described new species and infraspecific taxa mostly from Taiwan, but he also recognized and described new taxa from China, Indochina, and Japan. The number of species and infraspecific taxa described by Hayata from Taiwan has not been determined. Furthermore, how many correct taxa are among them? They have been examined through successive works on the flora of Taiwan by Hayata himself and by many students working on the flora of Taiwan since Hayata, but have not been totally resolved. Even though the exact number of new taxa is unknown, we can estimate the total based on currently accepted Hayata names and synonyms in recent works on the flora of Taiwan.

In the checklist of the vascular plants, 237 families, 1419 genera and 3897 species are attributed to Taiwan (Boufford et al., 2003; Huang et al., 1993-2003). Among them, 356 species in 109 families described by Hayata are adopted as distinct; 193 names proposed by Hayata in 63 families are cited as the basionym of recognized species. Hayata discovered 549 species recognized in the present Flora of Taiwan or about 14% of all the species of vascular plants in Taiwan.

To clarify the present status of new taxa described by Hayata for this paper, I examined those in the "Icones" vol. 10 (1921) as an example among his publications and those of gymnosperms as an example among plant groups, although those taxa are far fewer than the total described by Hayata. Those treatments are merely examples, and further examinations are needed.

i) *Icones* volume 10 (1921)

To determine the present status of Hayata's new taxa, some of those described by Hayata in the last volume of *Icones* were evaluated. Although only 14 families of vascular plants were treated in the volume, Hayata (1921) published 54 new species and 1 new variety in this volume, including three species of *Trichosanthes* (Cucurbitaceae), of which two are from Hainan, China, and one is from Okinawa, Japan (Tab. 1).

Among the remaining taxa, as indicated in table, 11 species are accepted and 1 species is regarded as a variety of another species in the *Checklist of the Flora of Taiwan, second Edition* (Boufford et al., 2003). The accepted taxa are *Trichosanthes homophylla* Hayata (of seven species and one variety in Cucurbitaceae); *Angelica morii* Hayata, *A. tarokoensis* Hayata, *Conioselinum morrisonense* Hayata and *Peucedanum formosanum* Hayata) of six species described in the Umbelliferae; *Zingiber kawagoii* Hayata in Zingiberaceae; *Dioscorea matsudae* Hayata and *Dioscorea japonica* Thunb. var. *pseudojaponica* (Hayata) Yamam. of six species of Dioscoreaceae; *Eriocaulon nantoense* Hayata of five species described

Table 1. New taxa published by Hayata in Icones Plantarum Formosanarum vol. 10 (1921).

1 *Viola acutilabella* Hayata Icon. 10: 1 (1921)
2 *Viola matsudae* Hayata Icon. 10: 1 (1921)
3 *Chisocheton erythrocarpa* Hayata & Kanehira, Icon. 10: 2 (1921).
4 *Entada koshunensis* Hayata & Kanehira, Icon. 10: 3, fig. 1 (1921).
5 *Gynostemma pedata* Benth. var. trifoliata Hayata, Icon. 10: 5, fig. 3 (1921).
6 *Trichosanthes formosana* Hayata, Icon. 10: 7 (1921).
7 ***Trichosanthes homophylla* Hayata**, Icon. 10: 8, fig. 4-5 (1921).
8 *Trichosanthes koshunensis* Hayata, Icon. 10: 10 (1921).
9 *Trichosanthes matsudae* Hayata, Icon. 10: 10 (1921).
10 *Trichosanthes mushaensis* Hayata, Icon. 10: 11, fig. 6 (1921).
11 Trichosanthes schizostroma Hayata, Icon. 10: 13 (1921).
12 Zehneria kelungensis Hayata, Icon. 10: 13, fig. 7 (1921).
13 *Sium formosanum* Hayata, Icon. 10: 16, fig. 9 (1921).
14 *Pimpinella astilbifolia* Hayata, Icon. 10: 20, fig. 10 (1921).
15 ***Conioselinum morrisonense* Hayata**, Icon. 10: 20, fig. 12 (1921).
16 ***Peucedanum formosanum* Hayata**, Icon. 10: 22, fig. 13 (1921).
17 ***Angelica morii* Hayata**, Icon. 10: 24, fig. 15 (1921).
18 ***Angelica tarokoensis* Hayata**, Icon. 10: 27, fig. 15 (1921).
19 Loranthus matsudae Hayata, Icon. 10: 30, fig. 9 (1921).
20 Lithocarpus shinsuiensis Hayata & Kanehira, Icon. 10: 30, fig. 17 (1921).
21 **Zingiber kawagoii** Hayata, Icon. 10: 35 (1921).
22 Dioscorea kelungensis Hayata, Icon. 10: 36, fig. 19 (1921).
23 **Dioscorea matsudae Hayata**, Icon. 10: 39, fig. 20 (1921).
24 Dioscorea pseudojaponica Hayata, Icon. 10: 42, fig. 21 (1921).
=Dioscorea japonica Thunb. **var. pseudojaponica (Hayata) Yamam.**
25 *Dioscorea raishaensis* Hayata, Icon. 10: 44, fig. 23 (1921).
26 *Dioscorea tarokoensis* Hayata, Icon. 10: 44, fig. 25 (1921).
27 *Dioscorea tashiroi* Hayata, Icon. 10: 44, fig. 26 (1921).
28 *Eriocaulon formosanum* Hayata, Icon. 10: 49, fig. 27 (1921).
29 ***Eriocaulon nantoense* Hayata**, Icon. 10: 51, fig. 28 (1921).
30 *Eriocaulon pachypetalum* Hayata, Icon. 10: 52, fig. 29 (1921).
31 *Eriocaulon petrosepalum* Hayata, Icon. 10: 55, fig. 30 (1921).
32 *Eriocaulon suishaense* Hayata, Icon. 10: 55, fig. 31 (1921).
33 *Carex remotispicula* Hayata, Icon. 10: 57, fig. 32 (1921).
34 *Carex pachinensis* Hayata, Icon. 10: 58, fig. 33 (1921).
35 *Carex shichiseitensis* Hayata, Icon. 10: 58, fig. 34 (1921).
36 *Carex taiheiensis* Hayata, Icon. 10: 59 (1921).
37 *Carex uraiensis* Hayata, Icon. 10: 60, fig. 35 (1921).
38 *Carex daibuensis* Hayata, Icon. 10: 61 (1921).
39 *Carex dolichostachya* Hayata, Icon. 10: 61, fig. 38 (1921).
40 *Carex gracilispica* Hayata, Icon. 10: 62, fig. 39 (1921).
41 *Carex kelungensis* Hayata, Icon. 10: 63, fig. 40 (1921).
42 *Carex rankanensis* Hayata, Icon. 10: 64, fig. 41 (1921).
43 *Carex gokwanensis* Hayata, Icon. 10: 65, fig. 42 (1921).
44 ***Carex longistipes* Hayata**, Icon. 10: 66 (1921).
45 ***Carex hoozanensis* Hayata**, Icon. 10: 67, fig. 44 (1921).
46 *Carex remotiflora* Hayata, Icon. 10: 68, fig. 45 (1921).
47 *Carex sharyotensis* Hayata, Icon. 10: 69, fig. 46 (1921).
48 ***Carex taihokuensis* Hayata**, Icon. 10: 70 (1921).
49 *Diplocarex matsudae* Hayata, Icon. 10: 70, fig. 47 (1921).
50 *Lycopodium remoganense* Hayata, Icon. 10: 72 (1921).
= *Lycopodium squarrosum* Hayata, Gen Ind. 117, non Forst
51 *Hymenophyllum retusilobum* Hayata, Icon. 10: 72 (1921).
52 *Cyclophorum matsudae* Hayata, Icon. 10: 73, fig. 48 (1921).

Total 51 new species and one new variety described by Hayata from Taiwan in which 10 species in bold face are recognized in Fl. Taiwan ed. 2 (Boufford et al. 2003) as correct as he described and one species as a variety of other species.

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in Eriocaulaceae; *Carex hoozanensis* Hayata, *C. longistipes* Hayata and *C. taihokuensis* Hayata of 17 species described in Cyperaceae. Therefore, 21% of Hayata's new species described in *Icones* vol. 10 are accepted in the *Flora of Taiwan, second edition* (Huang et al., 1993-2003). On the other hand, Hayata produced 41 synonymous taxa in the "Icones" vol. 10, perhaps because he was working under too short a schedule for publication to complete the work.

A concluding remark for Hayata's *Icones*: Despite his great contribution to our understanding of the flora of Taiwan, Hayata produced a great many names that are now placed in synonymy, and some ambiguous names for Taiwanese plants. Many such names were published in the *Icones.* Later taxonomists, however, have sometimes overlooked Hayata's diagnostic characters for his taxa. The new taxa proposed by Hayata should be carefully reexamined to determine their correct status. The taxa treated in his taxonomic works have still not been entirely clarified.

ii) **Gymnosperms**

Hayata described 20 new taxa (17 species, two varieties and one form) of gymnosperms from Taiwan which were classified in five families and 11 genera. While eight families of gymnosperms including 17 genera, 21 species and 7 varieties are recognized in Taiwan in the present *Flora of Taiwan, second edition* (Boufford et al., 2003). Hayata's taxa of gymnosperms are enumerated with comparison of recent recognition in the *Flora of Taiwan, second edition* volume 1 (Huang et al., 1994), and *Flora of China* volume 4 (Wu and Raven, 1999). A review of status is as follows:

CEPHALOTAXACEAE

1. ***Cephalotaxus wilsoniana*** Hayata, Icon. Pl. Formosan. **4**: 22 (1914) (Fig. 19): Fl. Taiwan ed. 2, **1**: 555 (1994) & **6**: 37 (2003) =***Cephalotaxus sinensis*** (Rehder & Wilson) H. L. Li var. ***wilsoniana*** (Hayata) L.K. Fu & Nan Li: Fl. China **4**: 86 (1999).

CUPRESSACEAE

2. ***Chamaecyparis obtusa*** (Siebold & Zucc.) Endlicher f. ***formosana*** Hayata in Gard. Chron. ser. 3, **43**: 194 (1908) (Fig. 20) =***Chamaecyparis obtusa*** Siebold & Zucc. var. ***formosana*** (Hayata) Hayata: Fl. Taiwan ed. 2, **1**: 588 (1994), as "(Hayatya) Rehder," & **6**: 38 (2003); Fl. China **4**: 69 (1999).
3. ***Juniperus formosana*** Hayata in J. Coll. Sci. Tokyo **25**(Art. 19): 209 (1908) (Fig. 21): Fl. Taiwan ed. 2, **1**: 593 (1994) & **6**: 38 (2003); Fl. China **4**: 70 (1999).
4. ***Juniperus formosana*** Hayata var. ***concolor*** Hayata, Icon. Pl. Formosan. **7**: 39 (1918) (Fig. 22) =***Juniperus formosana*** Hayata.
5. ***Juniperus morrisonicola*** Hayata in Gard. Chron. ser. 3, **43**: 194 (1908) (Fig. 23); et in J. Linn. Soc., Bot. **38**: 298 (1908); et in J. Coll. Sci. Imp. Univ. Tokyo **25** (Art. 19) 211 (1908) =***Juniperus squamata*** Buch.-Ham. *ex* D. Don: Fl. Taiwan ed. 2, **1**: 593 (1994); Fl. China **4**: 73 (1999).

PINACEAE

6. ***Abies mariesii*** Masters var. ***kawakamii*** Hayata in J. Coll. Sci. Imp. Univ. Tokyo **25** (Art. 19) 223 (1908) (Fig. 24) =***Abies kawakamii*** (Hayata) T. Itô: Fl. Taiwan ed. 2, **1**: 567 (1994) & **6**: 37 (2003), as "Tak.Itô"; Fl. China **4**: 51 (1999).
7. ***Keteleeria formosana*** Hayata in Gard. Chron. ser. 3, **43**: 194 (1908) (Fig. 26-1, 2, 3) =***Keteleeria davidiana*** (Franch.) Beissner var. ***formosana*** **(**Hayata) Hayata in Gard. Chron. ser. 3, **43**: 194 (1908); et in J. Coll. Sci. Tokyo **25** (Art. 19): 221 (1908): Fl. Taiwan ed. 2, **1**: 569 (1994) & **6**: 37 (2003); Fl. China **4**: 44 (1999).
8. ***Picea morrisonicola*** Hayata in J. Coll. Sci. Tokyo **25**(Art. 19): 220 (1908) (Fig. 27-1, 2): Fl. Taiwan ed. 2, **1**: 571 (1994) & **6**: 37 (2003); Fl. China **4**: 29 (1999).
9. ***Pinus brevispica*** Hayata, Icon. Pl. Formosan. **3**: 191 (1913) (Fig. 25) =***Pinus taiwanensis*** Hayata.
10. ***Pinus mastersiana*** Hayata in Gard. Chron. ser. 3, **43**: 194 (1908) (Fig. 28) =***Pinus armandii*** Franch. var. ***mastersiana*** (Hayata) Hayata; et in J. Coll. Sci. Tokyo **25** (Art. 19): 217 (1908): Fl. Taiwan ed. 2, **1**: 573 (1994) & **6**: 37 (2003); Fl. China **4**: 23 (1999).
11. ***Pinus morrisonicola*** Hayata in Gard. Chron. ser. 3, **43**: 194 (1908) (Fig. 29): Fl. Taiwan ed. 2, **1**: 573 (1994) & **6**: 37 (2003); Fl. China **4**: 24 (1999).
    =***Pinus formosana*** Hayata in J. Linn. Soc., Bot. **38**: 297 (1908) & in J. Coll. Sci. Tokyo **25**(Art. 19): 217 (1908). Hayata proposed this as a new name for *P. morrisonicola* Hayata, because the latter was a erroneously copied name from his manuscript (Hayata, 1908c). It is a superfluous name for *P. morrisonicola* Hayata based on the same type of this species.
12. ***Pinus taiwanensis*** Hayata in J. Coll. Sci. Tokyo **30** (Art. I): 307 (1911) (Fig. 30): Fl. Taiwan ed. 2, **1**: 577 (1994), & **6**: 37 (2003); Fl. China **4**: 17 (1999).
13. ***Pinus uyematsui*** Hayata, Icon. Pl. Formosan. **3**: 192 (1913) (Fig. 31) =***Pinus morrisonicola*** Hayata.
14. ***Pseudotsuga wilsoniana*** Hayata, Icon. Pl. Formosan. **5**: 204 (1915) (Fig. 32): Fl. Taiwan ed. 2, **1**: 577 (1994) =***Pseudotsuga sinensis*** Dode var. ***wilsoniana*** (Hayata) L.K. Fu & Nan Li: Fl. China **4**: 38 (1999).
15. ***Tsuga formosana*** Hayata in Gard. Chron. ser. 3, **43**: 194 (1908) (Fig. 33) = ***Tsuga chinensis*** (Franch.).

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Pritz. ex Diels var. ***formosana*** (Hayata) H. L. Li & H. Keng: Fl. Taiwan ed. 2, **1**: 580 (1994) & **6**: 37 (2003); Fl. China **4**: 41 (1999)

PODOCARPACEAE

16. ***Podocarpus nakaii*** Hayata, Icon. Pl. Formosan. **6**: 66 (1916) (Fig. 34): Fl. Taiwan ed. 2, **1**: 565 (1994) & **6**: 37 (2003); Fl. China **4**: 82 (1999).
17. ***Podocarpus nankoensis*** Hayata, Icon. Pl. Formosan. **6** (Suppl.: Gen. Ind. Fl. Formos.): 74 (1917); et Icon. Pl. Formos. **7**: 39 (1918) (Fig. 35) =***Nageia nagi*** (Thunb.) Kuntze: Fl. Taiwan ed. 2, **1**: 559 (1994); Fl. China **4**: 80 (1999).

TAXODIACEAE (CUPRESSACEAE)

18. ***Cunninghamia kawakamii*** Hayata, Icon. Pl. Formosan. **5**: 207 (1915) (Fig. 36) =***Cunninghamia konishii*** Hayata.
19. ***Cunninghamia konishii*** Hayata in Gard. Chron. **43**: 194 (1908); et in J. Linn. Soc., Bot. **35**: 299 (1908) (Fig. 37): Fl. Taiwan ed. 2, **1**: 582 (1994) & **6**: 37 (2003) =***Cunninghamia lanceolata*** (Lambert) Hook. var. ***konishii*** (Hayata) Fujita: Fl. China **4**: 55 (1999).
20. ***Taiwania cryptomerioides*** Hayata in J. Linn. Soc., Bot. **37**: 330 (1906) (Fig. 15): Fl. Taiwan ed. 2, **1**: 584 (1994) & **6**: 37 (2003); Fl. China **4**: 56 (1999).

Of the 20 taxa enumerated above, 14 are accepted as distinct taxa regardless of rank in the *Flora of Taiwan, second edition*, and *Flora of China*.

Nine species are treated as distinct species in the *Flora of Taiwan, second edition*, while the same nine taxa are treated as six species and three varieties in the *Flora of China*. A change in rank is recognized for *Cephalotaxus wilsoniana* vs. *C. sinensis* var. *wilsoniana*, *Pseudotsuga wilsoniana* vs. *Pseudotsuga sinensis* var. *wilsoniana*, and *Cunninghamia konishii* vs. *C. lanceolata* var. *konishii*.

Tsuga formosana Hayata is regarded as a variety of *Tsuga chinensis* (Franch.) Pritz. ex Diels in the two floras. One of Hayata's three varieties: *Abies mariesii* var. *kawakamii* Hayata is treated as *Abies kawakamii* (Hayata) T. Itô in both floras. *Chamaecyparis obtusa* f. *formosana* Hayata is treated also in both Floras as *Chamaecyparis obtusa* var. *formosana* (Hayata) Hayata.

There remain two problems on the Hayata's gymnosperms of Taiwan in recent works. *Pinus uyematsui* Hayata (Fig. 31) is treated as a synonym *Pinus morrisonicola* Hayata in the *Flora of Taiwan, second edition* (Li and Keng 1994; Boufford et al., 2003) and in the *Flora of China* (Fu et al., 1999). However, Businsky (2004) recognized it as distinct from the latter in cones and seeds. Another one is on *Podocarpus nankoensis* Hayata (Fig. 35). It had been recognized by Li and Keng (1954) and Li (1963, 1975) as distinct, and also by Mill (1999) under *Nageia* as *N. nankoensis* (Hayata) R. R. Mill. *Nageia nagi* has been treated in a broad concept in the *Flora of Taiwan, second edition* (Li and Keng 1994) and in the *Flora of China* (Fu et al., 1999) including *P. nankoensis* as a synonym.

In summary, Hayata found 14 (or 16) new taxa among 20 (or 22) gymonosperms recognized as valid in Taiwan at present. It corresponds to about 70% of the total taxa. The taxonomic work of Hayata on the gymnosperms of Taiwan is recognized as a distinguished contribution towards elucidating the Flora of Taiwan.

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(Articles with a title only in Japanese are translated into English by Ohashi)

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臺灣植物誌的奠基之父－早田文藏

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摘要：早田文藏為臺灣植物誌研究的奠基之父。他從 1900 年至 1921 年之間，全力專注於臺灣植物的研究，且命名臺灣之維管束植物 1600 種新分類群。本文陳述三個主題：早田文藏的傳記，對臺灣植物誌的貢獻，以及早田氏所發表的新分類群的現今地位。第二個主題包括下列五個分項：一、前早田時期的植物相研究；二、早田氏最初十年的臺灣植物研究；三、臺灣杉研究；四、早田氏的第二個十年；五、臺灣植物誌出版後的早田工作。第三個主題乃針對早田氏對臺灣植物貢獻的初步評估。本文中所採的例子為臺灣植物圖譜第十卷的新分類群及早田氏所描述的臺灣裸子植物。

關鍵詞：傳記，柏科，臺灣植物誌，裸子植物，早田文藏，臺灣植物圖譜，臺灣杉，杉科。

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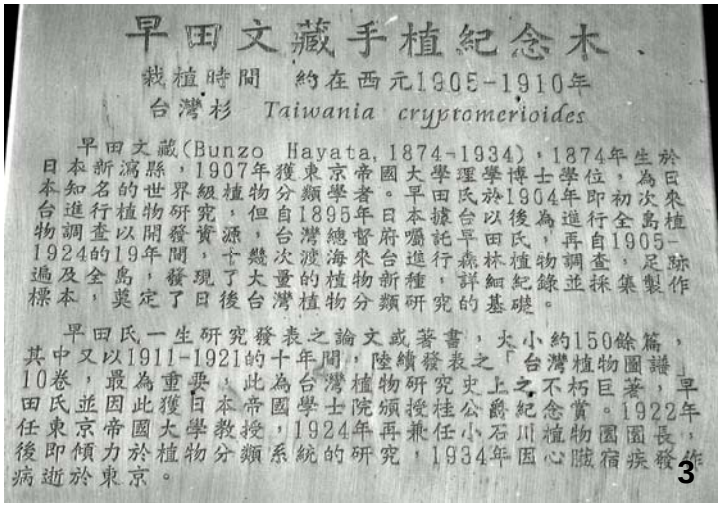




Fig. 1. Bunzo Hayata, 53 years old, in front of the Herbarium, Department of Forestry, Government Research Institute, Taipei, on 18 December 1927. Photo by S. Sasaki (copy from Trans. Nat. Hist. Soc. Formosa 24. 1934).
Fig. 2. A tree of *Taiwania cryptomerioides* Hayata planted by Hayata in 1905-1910 near the office of the Chitou Experimental Forest, National Taiwan University, photo on 10 Dec. 2007.
Fig. 3. The plate at the base of the tree in Fig. 2 with the title "The tree planted by Bunzo Hayata". Photo on 10 Dec. 2007.
Fig. 4. Bunzo Hayata, probably in commemoration of entrance to the Daiichi High School in 1897, at age 23.

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Fig. 5. Professor Jinzo Matsumura, the supervisor of Hayata in The University of Tokyo, whose name was written by Hayata. Date unknown, from Hayata's private album.
Fig. 6. Hayata and his wife Kuni probably at the wedding in December 1907. The copyright is holded by Mr. Hiroshi Terui.
Fig. 7. Hayata with his wife and son probably photographed at the festival day for his son, Bunichi, aged five (actually four) in 1912 in Tokyo. The copyright is holded by Mr. Hiroshi Terui.
Fig. 8. Hayata by the stature of Urban Faurie in Taipei Botanical Garden, probably in 1918 or 1919.

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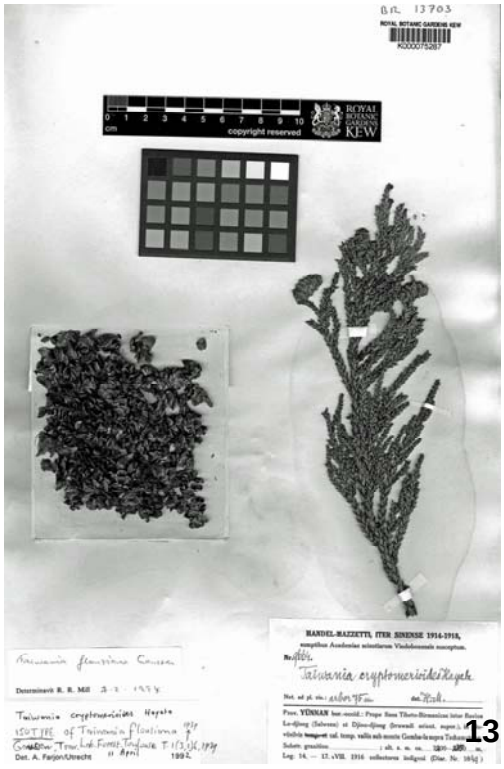
Fig. 9. Bunzo Hayata, 39 years old (second from right in back row), 16 or 25 July 1913 in commemoration picture of visit of Adolf Engler (center in front row) at Botanic Garden, Koishikawa. From left in front row: Manabu Miyoshi, Jinzo Matsumura, Engler, Seiichiro Ikeno and Kenjiro Fujii; from left in back row: Keita Shibata, probably Hikoemon Kimura, Tomitaro Makino, Hayata and Hirotarô Hattori. The copyright is hold by Botanical Garden, Tokyo University.

Fig. 10. Hayata in March 1931, when he was 57 years old in Commemoration picture of graduation of the Botany Course, Faculty of Science, The University of Tokyo. This may be his last figure at official occasions. Persons related to Taxonomy from the left in front row: Masaji Honda (assistant of Taxonomy), Shizuo Hattori (assistant of Physiology), Yuzuru Ogura (Associate Professor of Morphology and Anatomy), Hayata (Professor of Taxonomy), Keita Shibata (Professor of Physiology and Biochemistry), Takenoshin Nakai (Professor of Taxonomy) and students of future taxonomists in back row: Hirosi Ito (Pteridophyte, third from the left), and Yosio Kobayasi (Mycology, fifth from the left).

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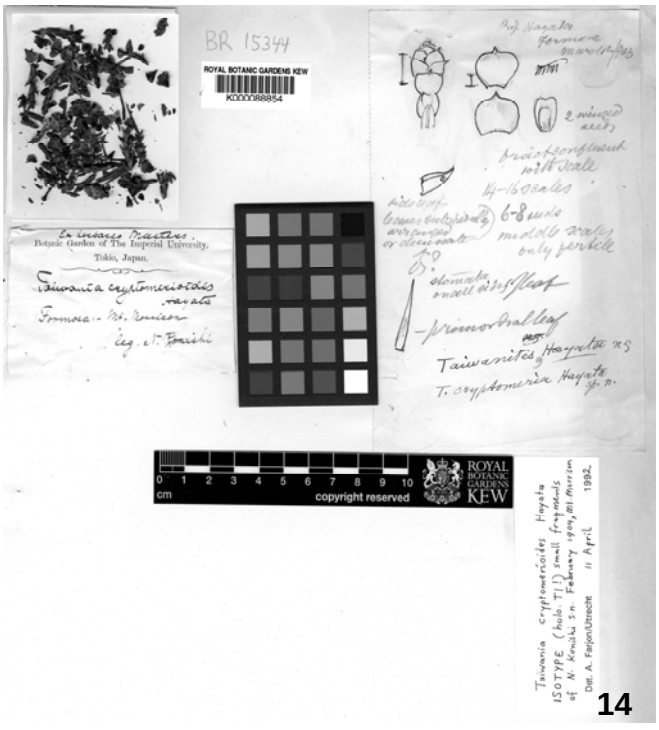


Fig. 11. Hayata with Yoshimatsu Yamamoto of Taihoku Imperial University, and Naoyoshi Mochizuki, chief gardener, probably at Nikko Branch Botanical Garden of the Tokyo Imperial University, Nikko, Tochigi Prefecture, in 1929 or 1930.

Fig. 12. Lectotype of *Chamaecyparis formosensis* Matsum. Lectotypified by Farjon (2005). The scientific name is written by Matsumura directly on the sheet above the label. The specimens were collected by Seiroku Honda 147 in Oct. 1896, but the label may be not written by himself.

Fig. 13. Isotype of *Taiwania flousiana* Gaussen from Yunnan: Handel-Mazzetti 9664 (K). Photo by L. Rico Arce. The copyright is holded by Kew.

Fig. 14. Syntype (probable isolectotype) of *Taiwania cryptomerioides* Hayata at Kew, with a memo by Hayata.

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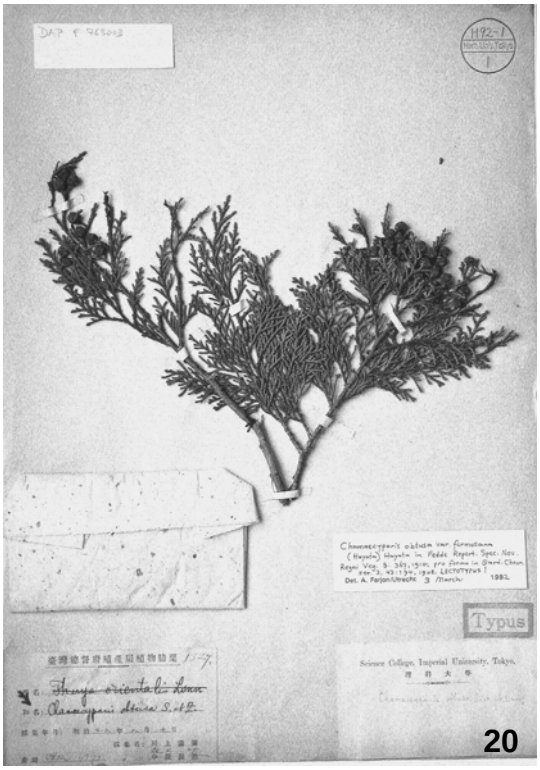
Fig. 15. Lectotype of *Taiwania cryptomerioides* Hayata (left side) with probable isolectotype (right side above) in TI. Lectotypified by Ohashi and K. Ohashi (2008). A syntype (one young branch, center) and two branches of *Cryptomeria japonica* (L. f.) D. Don (right side below) are mounted together.

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Fig. 16. ***Taiwania cryptomerioides*** **drawn by Hayata in the original publication (1906).**
Fig. 17. Revised illustration of ***Taiwania cryptomerioides*** **by Hayata (1907) in addition of leaf anatomical features.**
Fig. 18. Last illustration of ***Taiwania cryptomerioides*** **by Hayata (1933) with male vegetative organs instead of leaf anatomical features on the previous illustration in 1907.**
Fig. 19. A part of the holotype of ***Cephalotaxus wilsoniana*** **Hayata collected by K. Uyematsu (no. 18) in Mt. Arisan.**

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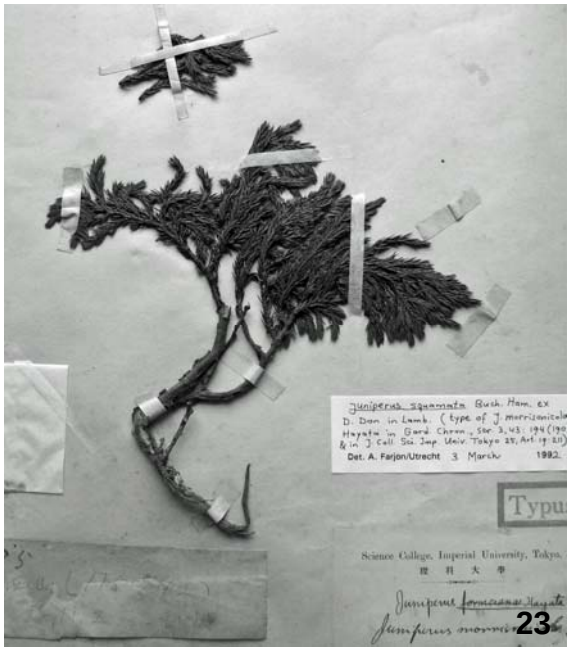
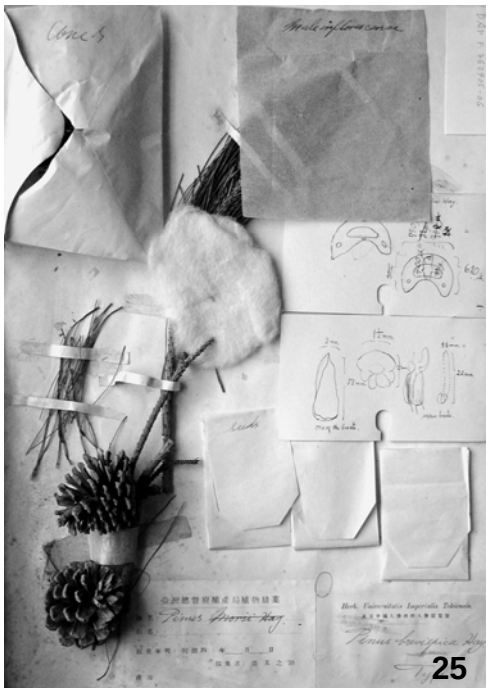


Fig. 20. Lectotype of *Chamaecyparis obtusa* (Siebold & Zucc.) Endlicher f. *formosana* Hayata.
Fig. 21. Holotype of *Juniperus formosana* Hayata.
Fig. 22. Holotype of *Juniperus formosana* Hayata var. *concolor* Hayata.
Fig. 23. Holotype of *Juniperus morrisonicola* Hayata.

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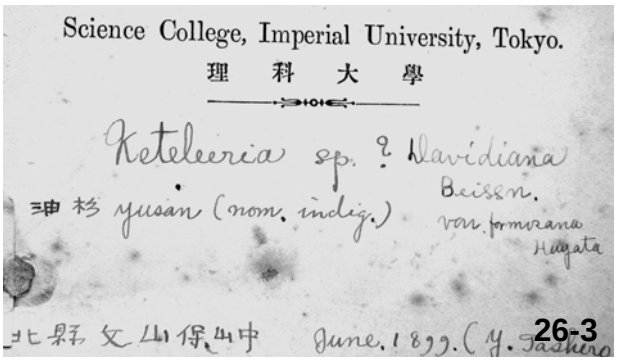


Fig. 24. Lectotype of *Abies mariesii* Masters var. *kawakamii* Hayata collected by T. Kawakami and U. Mori no. 2369 on 20 Oct. 1906 (TI).
Fig. 25. Holotype of *Pinus brevispica* Hayata.
Fig. 26. 1) Holotype of *Keteleeria formosana* Hayata collected by Y. Tashiro in June 1899 (TI); 2) seed specimens in the package; 3) The label of the holotype that is written by Hayata.

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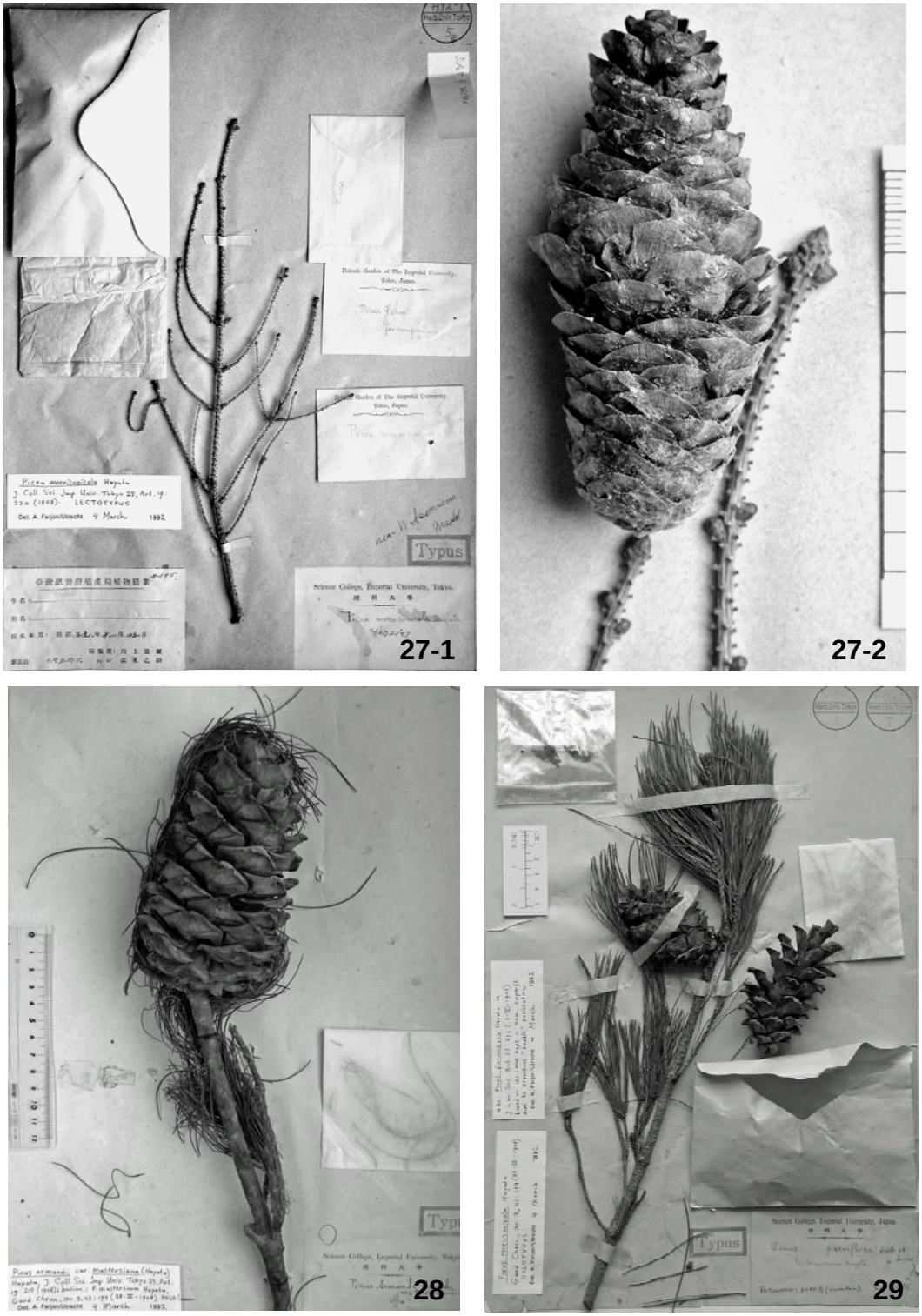


Fig. 27. 1) Lectotype of *Picea morrisonicola* Hayata collected by T. Kawakami and U. Mori no. 2108 on 25 Nov. 1906. 2) A fruit from the packet on the type.
Fig. 28. Holotype of *Pinus mastersiana* Hayata.
Fig. 29. Holotype of *Pinus morrisonicola* Hayata. The label was originally written by Jinzo Matsumura and the plant was determined as "*Pinus parviflora* Sieb, et Zucc.". The name, *P. morrisonicola* Hayata, was added by Hayata on the same label.

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Fig. 30. Lectotype of *Pinus taiwanensis* Hayata.
Fig. 31. Holotype of *Pinus uyematsui* Hayata.
Fig. 32. Holotype of *Pseudotsuga wilsoniana* Hayata.
Fig. 33. Holotype of *Tsuga formosana* Hayata.

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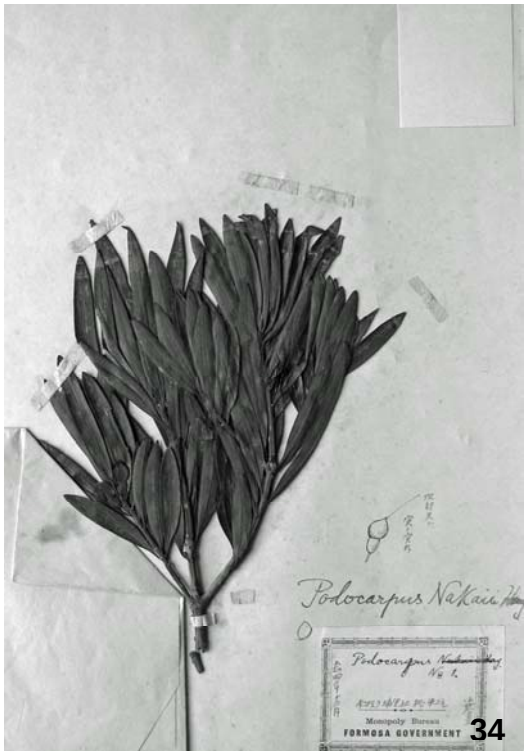








Fig. 34. Holotype of *Podocarpus nakaii* Hayata. The collector's name, Sôzô Nakai (中井宗三), is written in Chinese characters on the right of the name of habitat, Nantô, Holisha, Toshôkô in Chinese characters. These must be written by Nakai himself.
Fig. 35. Holotype of *Podocarpus nankoensis* Hayata.
Fig. 36. Holotype of *Cunninghamia kawakamii* Hayata.
Fig. 37. Holotype of *Cunninghamia konishii* Hayata.

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