

The earliest collection of an elusive alien? Evidence of early introduction of *Chenopodium ficifolium* (*Chenopodiaceae*) in New Zealand

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Abstract. Historical records and the current status of *Chenopodium ficifolium* (*Chenopodiaceae*) in New Zealand are considered. This species of Eurasian origin was and still is occasionally reported in New Zealand as a casual alien since its supposedly first record by Kirk in 1896, who found the species in 1892 in the port of Wellington on a ballast heap. At least seven reliable collections / records are known from locations ranging from the North Island (Auckland and Wellington) to the South Island (Christchurch), and one of the southern Titi Islands. However, the actual distribution of the species in New Zealand is probably underestimated because of its similarity to *C. album*. Probably *C. ficifolium* was initially introduced to New Zealand much earlier than 1892, as evidenced by the herbarium specimen collected by J. Everard Home in the 1840s. That specimen was recently found in the Turczaninow historical herbarium at the National Herbarium of Ukraine (KW); it is one of many other historical specimens at KW that were collected in New Zealand by Home, A. Cunningham and R. Cunningham in the first half of the 19th century. Most probably, Turczaninow received these New Zealand specimens from the Royal Botanic Gardens Kew in exchange for his Siberian or other collections. We expect that a thorough revision of New Zealand specimens in the Turczaninow herbarium at KW may bring important and interesting results not only on native plants (including type specimens), but also for non-native species introduced during the early stages of the European colonization, which will document their earliest stages of expansion in New Zealand.

Keywords: alien species, Eurasia, *Chenopodiaceae*, *Chenopodium ficifolium*, herbarium, history of botany, New Zealand

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Реферат. Розглядаються історичні відомості щодо трапляння *Chenopodium ficifolium* (*Chenopodiaceae*) та сучасний статус виду в Новій Зеландії. Цей вид євразійського походження наводився для Нової Зеландії як випадково занесений адвентивний вид, принаймні з часів першої вказівки Кирка 1896 року, який знайшов *C. ficifolium* у 1892 році в порту м. Веллінгтон на купах корабельного баласту. Відомо щонайменше сім надійних зборів або вказівок у різних географічних регіонах – від Північного острова (Окленд і Веллінгтон) до Південного (Крайстчерч) та одного з південних островів Тіті. Проте, фактичне поширення виду в Новій Зеландії, ймовірно, виявлене недостатньо через його подібність до *C. album*. Вірогідно що, *C. ficifolium* був уперше занесений до Нової Зеландії значно раніше, ніж у 1892 році, про що свідчить гербарний зразок, зібраний Дж. Еверардом Хоумом у 1840-х роках. Цей зразок нещодавно був знайдений в історичному гербарії Турчанинова (складова частина Національного гербарію України – KW); це лише один із багатьох ранніх зразків у KW, зібраних Хоумом, А. Каннінґемом і Р. Каннінґемом у Новій Зеландії в першій половині XIX століття. Швидше за все, Турчанинов отримав ці новозеландські зразки з Королівського ботанічного саду К'ю в обмін на свої сибірські чи інші колекції. Ми сподіваємося, що ретельний перегляд новозеландських зразків, наявних у гербарії Турчанинова в KW, виявить важливі та цікаві результати не лише щодо аборигенних рослин (включаючи типові зразки), але й щодо адвентивних (чужорідних) видів, занесених на ранніх етапах європейської колонізації; це дозволить прояснити найдавніші етапи їхньої експансії в Новій Зеландії.

Ключові слова: *Chenopodiaceae*, *Chenopodium ficifolium*, адвентивний вид, Азія, гербарій, історія ботаніки, Нова Зеландія

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Introduction

Chenopodium ficifolium Sm. (*Chenopodiaceae*, or *Amaranthaceae* sensu APG) is a species of the genus *Chenopodium* L. in the strict sense, meaning the group that resulted from the recent segregation of *Dysphania* R.Br. (see Mosyakin, Clemants, 2002, 2008; Clemants, Mosyakin, 2003; Fuentes et al., 2012b) and several other now recognized genera, such as *Blitum* L., *Chenopodiastrum* S.Fuentes, Uotila & Borsch, *Lipandra* Moq., *Oxybasis* Kar. & Kir., *Teloxys* Moq. (Fuentes et al., 2012a, b). This generic rearrangement is now widely accepted (see an overview in: Hernández-Ledesma et al., 2015, etc.). However, alternative views on generic delimitation in the group also exist. For example, Feodorova (2014, 2018) advocated a much wider circumscription of *Blitum*, including *Lipandra*, *Oxybasis*, and *Chenopodiastrum*. Zhu and Zhang (2016) and Zhu and Sanderson (2017) recognized additional segregate genera *Roubieva* Moq. and *Neobotrydium* Moldenke; however, it is not justified from both phylogenetic and morphological viewpoints (see comments in Sukhorukov et al., 2016a, 2019) because both *Roubieva* and *Neobotrydium* are phylogenetically deeply nested in *Dysphania*. The new genus *Carocarpidium* S.C.Sand. & G.L.Chu proposed by Zhu and Sanderson (2017) for *C. californicum* (S.Watson) S.C.Sand. & G.L.Chu (that species was originally described and is now properly accepted as *Blitum californicum* S.Watson, earlier it was also known as *Chenopodium californicum* (S.Watson) S.Watson) should also better remain in *Blitum*.

Within *Chenopodium* sensu stricto, *C. ficifolium* is an important species from taxonomic and evolutionary perspectives because it is a diploid ($2n = 18$) representing one of the primary evolutionary lineages, either the extended B-genome group of diploids (also containing *C. suecicum* Murr and some other less known species) or a close sister group to the core clade of B-genome diploids. Such diploids through hybridization and allopolyploidy gave rise to several other groups and taxa of derived tetraploids and hexaploids (Walsh et al., 2015; Mandák et al., 2018, and references therein). The names *C. serotinum* L. and *C. viride* L. were partly misapplied to *C. ficifolium* (see details in: Aellen, 1941; Uotila, 1979; Mosyakin, Iamónico, 2018).

Chenopodium ficifolium is widespread in temperate to subtropical regions of Eurasia, from Atlantic Europe in the west through southern Asia to the East Asian region (Aellen, 1929, 1960–1961; Uotila, 1997, 2001a, b; Paul, 2012; Mosyakin, 2016; Clemants, 2006; Sukhorukov

et al., 2016b, 2019; etc.). The species is also known as occasionally introduced in many other regions of the world, such as North America (Clemants, Mosyakin, 2003; Mosyakin, 2016, and references therein), Australia (Wilson, 1984; mentioned as not confirmed), and New Zealand (Kirk, 1896; Allan, 1940; Sykes, 1982; Webb et al., 1988, reported as casual). The highest morphological and probably also genetic diversity of *C. ficifolium* s. l. is concentrated in southern (Indian subcontinent) and southeastern Asia, where several infraspecific taxa are recognized, in particular, *C. ficifolium* subsp. *blomianum* (Aellen) Aellen (*C. blomianum* Aellen) and some varieties (see Aellen 1928, 1960–1961; Uotila, 1997, 2001a; Mosyakin, 2016; Mosyakin, Mandák, 2018, and references therein). Most probably several additional infraspecific entities or even segregate species will be recognized among Asian representatives of this group in the future.

In our opinion, *C. ficifolium* s. l. originated or at least diversified in southern and southeastern Asian regions, while in western Eurasia, including most of Europe, this species is an introduced archaeophyte (e.g., Preston et al., 2004). It is a more recent alien (kenophyte or neophyte; for terminology, see Richardson et al., 2011) in other parts of the world, as compared to Europe. In addition, at least some records of *C. ficifolium* worldwide are based on misidentifications, and thus the patterns of distribution and dispersal of that species in various parts of the world should be critically re-assessed based on reliable herbarium evidence.

***Chenopodium ficifolium* in New Zealand: available historical evidence**

Sykes (1982) listed *C. ficifolium* as first reported from New Zealand by Kirk (1896). In that article Kirk reported his observations on "the introduction of injurious weeds in earth-ballast" of ships visiting the port of Wellington. *Chenopodium ficifolium* was initially revealed "in great abundance" (Kirk, 1896: 506) on a ballast heap at a railroad near the port; the following information was also provided: "Amongst the plants of the first year [1892 – S.M. & P.dL.] were *Chenopodium ficifolium*, *Emex australis*, *Alternanthera sessilis*, *Galinsoga parviflora*, *Echium plantagineum*, *Cenia turbinata*, *Bowlesia tenera*, *Cichorium endivium*, none of which made their appearance the second year [1893 – S.M. & P.dL.] except the *Chenopodium*, which occurred in some quantity, and was represented by a few straggling specimens last year [1894 – S.M. & P.dL.], although not a scrap is to be seen at this date [in 1895 – S.M. & P.dL.]" (Kirk, 1896: 502).

Cheeseman (1906: 1085) mentioned Kirk's specimen or specimens in Appendix II "List of plants naturalized in New Zealand", but not in the main part of his *Manual of the New Zealand Flora*. Subsequent reports of it from New Zealand were by Sykes (1982: 327) who noted *C. ficifolium* from "Wellington, Christchurch, Ashburton etc.", whilst Webb et al. (1988: 523) treated it as a ζ record (i.e., a failed or casual naturalization), noting that the species "has been collected in Wellington (in 1894) and occasionally elsewhere since". Thus, it looks like the apparent first appearance of *C. ficifolium* in New Zealand in the 1890s was as an ephemeral, and that to date this species is still regarded in New Zealand as an uncommon casual rather than fully naturalised species (Webb et al., 1988).

The question remains though, was Kirk's 1894 observation of *Chenopodium ficifolium* truly the first occurrence of this species in New Zealand? Considering the importance of shipping to the then fledgling New Zealand colony, and the virtual absence of any interest in biosecurity or indeed local expertise versed in recognising new incursions during the 1800s, we think it highly likely that there were possible earlier introductions of that species (as well as some other unnoticed alien taxa) within ship ballast, agricultural goods, or packaging material. Central to this problem is deciding on a date of a "first" introduction or naturalization, an issue that has been treated in differing ways by New Zealand botanists and flora writers. Clearly it is difficult to truly know the exact date of when a species has arrived. Realistically, when such dates are given, they more often than not reflect the first undisputed herbarium evidence of an introduction event, thus a putative "first record", rather than the actual "oldest" specimen. By way of example, the accepted "first record" supporting the naturalization of *Banksia integrifolia* L.f. (*Proteaceae*) to New Zealand was given as 1991 by Webb et al. (1995) despite the existence of specimens predating that record by four years (E.K. Cameron 1987, AK herbarium; here and below herbarium acronyms are given following Thiers, 2008–onward). While "first records" have a specific meaning to the authors concerned, to the general public the distinction is less clear, potentially causing problems when dealing with the incursion of exotic biota that pose a threat to New Zealand's indigenous biota, ecosystems, landscapes, and economy (see an overview in: Allen, Lee, 2006).

Below we explore this problem through the documentation of a herbarium specimen of *Chenopodium ficifolium*, most probably collected from northern New Zealand by J. Everard Home in the 1840s.

The specimen of *Chenopodium ficifolium* from New Zealand in the Turczaninow herbarium at KW

During a search for additional type specimens of *Chenopodium* s. l. in the Turczaninow Historical Herbarium at the National Herbarium of Ukraine (KW, the herbarium of the M.G. Institute of Botany of the National Academy of Sciences of Ukraine), Sergei Mosyakin noticed in the general blue-paper folder labeled as "*Chenopodium album*" a specimen with the following label: "*Chenopodium album* L. | [one letter illegible, probably Greek γ or ε – S.M.] *viride* Moq. | Nova Zeelandia | Everard Home", KW barcode KW001003098, Fig. 1. The handwriting on the label corresponds to that on some other labels of Home's New Zealand specimens in the Turczaninow herbarium, e.g., the labels of original specimens of *Geranium homeanum* Turcz., KW001001014 and KW001001016 (see Mosyakin, de Lange, 2019). Most probably such labels are curatorial because their handwriting is different from that of J. Everard Home.

The original identification of the plant on the label of KW001003098 (*C. album* var. *viride*) needs some comments. This identification probably refers to the variety-rank name used by Moquin-Tandon in one of his publications. Moquin-Tandon (1840: 29) in his *Chenopodearum monographica enumeratio* used the name *C. album* L. γ [var.] *viridescens* St.-Amans [sensu Moq.] with a synonym "*Chenopodium viride plurimorum Auct. non Linn.*", thus indicating that the name *C. viride* L. s. str. (which he then accepted in the sense now partly corresponding to *C. opulifolium* Schrad. ex Koch & Ziz (1814); see Moquin-Tandon, 1840: 28) was misapplied by many authors ("*plurimorum auctorum*") to that variety. The reference to "St. Am." in Moquin-Tandon (1840: 29) refers to the book *Flore Agenaise* by J.F.B. de Saint-Amans (1821).

Saint-Amans (1821: 105) proposed the variety-rank epithet *viridescens* for *C. viride* L. s. str., as it is evident from his citation: " β . C. a. [*Chenopodium album* var.] *viridescens*. Grappes plus lâches... *C. viride*. Linn. Sp. 319, exclus. Vaill. Syn... J.B. Hist. 2. p. 972". Since in the protologue of var. *viridescens* the name *C. viride* was cited in synonymy, the name *C. album* var. *viridescens* St.-Amans is a superfluous name for the earlier combination *C. album* var. *viride* (L.) Pursh (Art. 52.1 of the ICN: Turland et al., 2018). In turn, Pursh (1813: 198) validated his variety β *viride* (variety-rank combination in modern terms) through a direct reference to Willdenow (1798: 1303), where Linnaean *C. viride* was accepted as a species.



Figure 1. The specimen of *Chenopodium ficifolium* Sm. from the Turczaninow Historical Herbarium (KW-TURCZ) at the National Herbarium of Ukraine (KW): "*Chenopodium album* L. | [one letter illegible, probably Greek γ or ϵ , meaning a variety] *viride* Moq. | Nova Zeelandia | Everard Home", KW barcode KW001003098

For var. *viridescens*, Moquin-Tandon (1849: 71) applied in his treatment in de Candolle's *Prodromus* the same nomenclature and the same taxonomic concept as he did earlier (1840) in his *Enumeratio...*, but in 1849 he also accepted *C. album* ε [var.] *viride* based on *C. viride* L. s. str. The treatment in *Prodromus* was probably the source of identification of the New Zealand plant in the Turczaninow herbarium.

Now the name *C. viride* L. has been proposed for rejection (Mosyakin, Iamónico, 2018) because of the uncertain identity of its type and also because that name was widely and inconsistently misapplied by many authors to several related or even quite unrelated taxa of *Chenopodium*, including species now accepted as *C. ficifolium*, *C. opulifolium*, *C. suecicum*, etc.

Reconstructing a possible history of Home's specimen of *Chenopodium ficifolium*

The British naval officer Sir James Everard Home (1798–1853) was also a plant collector who contributed to British herbaria with his specimens from China and Australasia (Beasley, 2000; Godley, 2010; JSTOR Global Plants, 2013–onward). Plant collections of or separate specimens collected by J. Everard Home are known to be deposited in the following herbaria: BM, K, LINN-SM, and FI (Jackson, 1901; Murray, 1904; Lanjouw, Stafleu, 1957; JSTOR Global Plants, 2013–onward). Until recently, no published information was available on the presence of Home's specimens in KW, but now we understand that many of his important specimens, mainly those from New Zealand, are incorporated in the vast Turczaninow historical herbarium (see Marchant, 1990; Mosyakin et al., 2019; Mosyakin, de Lange, 2019, and references therein).

Captain Home was given command of the frigate *HMS North Star* in 1841 and served on that ship until 1846. During this period, he in 1841–1842 participated in military operations (the First Anglo-Chinese War, also known as the Opium War) and did some scientific observations in China, visited and was stationed in Australia, and also visited New Zealand four times, in 1843, 1845, 1845–1846, and then briefly in 1852 (Godley, 2010; JSTOR Global Plants, 2013–onward). It is thought that most of his botanical collections from New Zealand were made during the second and third visits there, so probably the specimen of *C. ficifolium* (KW001001014) was collected in the mid-1840s.

Jackson (1901: 33) reported that Home's collections from Australia and New Zealand were received by the Kew Gardens in 1846–1851. He, however, noted in the

introductory part of his list that "there is no detailed records of the plants exchanged or presented to other herbaria, so that, though the collections here named were once here [at Kew] they may have since been transferred to other possessors" (Jackson, 1901: 2). That was probably what happened to some of the Kew collections of Everard Home, which were exchanged for some of Turczaninow's specimens. Jackson (1901: 65) listed "**Turczaninow, Nicolas Stepanowitch**, Baical, 1833–42" [the reported years cover most of the Siberian period (1828–1844) in the life of Turczaninow], thus indicating that the K herbarium received duplicates of Turczaninow's Siberian plants, which were used by the author for compiling his *Flora Baicalensi-Dahurica*; for bibliography and other details on that *Flora*, see Stafleu (1969), Lipschitz (1964), and Stafleu & Cowan (1986).

Murray (1904: 87 156) reported that the Department of Botany of the British Museum received in 1843 "90 plants from the east coast of China collected and presented by Sir Everard Home; the following year, 51 plants were presented" (Murray 1904: 87). In 1846 the Museum received "715 plants from Australia and the Pacific Islands, collected and presented by Sir Everard Home; in 1853, 400 plants, with numerous cryptogams, were presented; in 1854, 174" (Murray, 1904: 88). This information is also summarized on p. 156, where Murray (l.c.) reports 141 plant specimens from China presented in 1843–1844, and totally 1286 specimens from Australia and the Pacific presented in 1846 and 1853. It should be noted that in that case Murray (l.c.) reported the donations of Captain Sir J. Everard Home (2nd Baronet), not to be confused with his father Sir Everard Home (1756–1832; see Beasley, 1997, 2000), a British surgeon who was also mentioned (as "Sir Everard Home, Bart. [Baronet]") in the same volume as the presenter of a paleontological specimen, the "part of the vertebral column of *Ichthyosaurus*, from Lower Lias, Lyme Regis" (see Woodward 1904: 202, 298).

The visits of British ships to the Australasian region (Australia and/or New Zealand) and various southern and eastern regions of Asia (China, India, etc.) during the same navigation were definitely not exceptional. The ships often stopped in various East Indian and Chinese ports for supplies or trade items on the way to and from Australia and/or New Zealand. Early introductions of various weedy species brought to New Zealand in the 19th century with agricultural / horticultural goods and supplies or ship ballast are documented in many publications (see Allan, 1940; Williams, Cameron, 2006, and references therein).

Since *C. ficifolium* is one of the common species of *Chenopodium* in these parts of Asia (or the most common *Chenopodium* in some regions, judging from the experience of Sergei Mosyakin at various herbaria containing SE Asian specimens), there is little surprise that the seeds of that weedy species were probably brought to New Zealand quite early, in the first half of the 19th century, as contaminants of grain or other agricultural goods, or with ship ballast. Alternatively, the diaspores of *C. ficifolium* may have been brought from Europe, in particular, Britain, where that species was definitely present at that time (Preston et al., 2004). Judging from the characters of the KW specimen collected by Home, the plant belongs to *C. ficifolium* subsp. *ficifolium*, not to the Asian subsp. *blomianum*. However, subsp. *ficifolium* is also rather widespread in eastern Asia (see, e.g., comments in Dostálek, 1986) and the particular morphotype represented by the specimen KW001003098 is known from both Asia and Europe. Thus, the direct source of immigration in that case remains elusive.

One may argue that, since Home collected both in China and New Zealand, his specimen of *C. ficifolium* may have in fact originated in China but was mislabelled as a plant collected in New Zealand. Indeed, a chance of mislabelling always exists for any old herbarium, and such occasional cases are known in the Turczaninow herbarium as well, a few of them applicable to taxa supposedly described from New Zealand (see comments in Gardner, 2020). However, in our opinion, in the particular case of *C. ficifolium* this chance is almost negligible and definitely not higher than that with any other average specimen from the Turczaninow collection. The specimen of *C. ficifolium* and its label look naturally as if they belong to each other and, judging from impressions that were on the original blue-paper folder containing the specimen, neither the plant nor the label were misplaced since the times when Turczaninow placed them there. The realistic possibility of an event of early introduction of that species to New Zealand, either from its native range in Asia or from its secondary range in Europe, is discussed and evaluated above.

***Chenopodium ficifolium* in New Zealand: the present status**

In the interim *Chenopodium ficifolium* remains an uncommon plant in New Zealand. In that country it is known from at least seven collections lodged in the three main herbaria of New Zealand, AK, CHR, and WELT. On this evidence, the species is still a casual in that country's naturalized flora. However, despite the few collections available, it seems to be rather widespread (even if

scattered), with collections, including the Home specimen discussed above, ranging from the North Island (where it has been collected from Auckland and Wellington) to the South Island (Christchurch), with one collection from Poutama Island, one of the southern Titi Islands located south-west of Rakiura / Stewart Island. One recent iNaturalist observation (<https://www.inaturalist.org/observations/36525112>; also available from GBIF: <https://www.gbif.org/occurrence/2579254739>) made on 9 December 2019 in Christchurch shows three photographs of plants unmistakably identifiable as *C. ficifolium* s. str. The species is probably more widespread than this, as it has been widely confused with *C. album*, an extremely common and widely distributed naturalized species found throughout New Zealand, including the Chatham Islands (Webb et al., 1988; de Lange et al., 2011).

Judging from its present-day "ecological behavior" in Europe (see, for example, Preston et al., 2004; Thomas, Palmer, 2015, electronic supplement; Nobis et al., 2018, etc.), *C. ficifolium* has a rather low invasive potential and its chances to become a noxious invasive weed in New Zealand are rather low. However, other studies list *C. ficifolium* among "weeds that are increasingly spreading in Europe", especially weeds of grain legumes and root crops (Weber, Gut, 2005). The personal experience of the first author (Sergei Mosyakin) in Ukraine indicates that in that respect *C. ficifolium* is a rather unpredictable "oscillating" species, which sometimes can appear locally in great abundance (especially in crop fields or in gardens), but in just a few years can disappear totally or almost totally from that particular locality. Thus, New Zealand botanists, ecologists and farmers should keep a watchful eye on that seemingly innocent (not yet invasive) alien species.

Concluding remarks

The case described in the present note emphasizes the importance of old historical herbarium collections for tracing the dispersal and immigration patterns of alien species across the globe. A special revision of the 19-century herbarium specimens of *Chenopodium* (especially those identified as *C. album*, *C. viride*, etc.) from New Zealand is needed to confirm that *C. ficifolium* was indeed first brought to New Zealand and occurred there almost 50 years before it previously known "first official" record by Kirk (1896), or if additional collections were made between the mid-1840s and the 1890s.

We expect that a thorough revision of New Zealand specimens of early collectors and explorers, such as J. Everard Home, Allan and Richard Cunningham, which were recently revealed in the Turczaninow historical

herbarium at KW, may bring important and interesting results not only on native plants (including type specimens), but also for non-native species introduced during the early stages of the European colonization, which will document their earliest stages of expansion.

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