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Diphasiastrum × *issleri* (Lycopodiaceae) in England and Wales

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Abstract
Diphasiastrum × *issleri* (Rouy) Holub has been much misunderstood and greatly confused in the British Isles, the consequence of both nomenclatural and practical identification issues. Following the clarification of its hybridogenous origin(s) and the parent taxa involved (which had been the source of dispute between European and American authors) the taxonomic treatment of this plant has seen various approaches adopted, some of which have regrettably led to mis-recording and a lack of clarity. In parallel to the taxonomic and nomenclatural issues are the very real difficulties posed by the differentiation of this taxon from its progenitors, a task made difficult by their morphological plasticity, the possibilities of introgression and the formation of triploid as well as diploid primary hybrids. Here we consider the appropriate treatment of this taxon: nomenclaturally as species *vs.* hybrid and from a conservation viewpoint. We elaborate and re-assess all of its English and Welsh records. As a consequence of this review a revised conservation status is required. We conclude that all Welsh and most English records of this taxon are erroneous, including those for the Northumbrian sites and that therefore it is currently Regionally Extinct (RE) in England and not CR (D) as given in the Red-List for England (as *D. complanatum*). It, however, remains NT (D) at a GB level because of the presence of the taxon in Scotland. Guidance for the discrimination of *D.* × *issleri* from atypical forms of *D. alpinum* is given.

Keywords: clubmoss; hybridisation; morphological plasticity; introgression

Introduction
In February last year FJR was visiting CM & HM and had expressed an interest in viewing plants at Williams Cleugh (v.c.67, South Northumberland) which had been previously accepted as *Diphasiastrum* × *issleri* (Rouy) Holub as he wished to try to resolve long standing doubts over their identity. That was not possible at that time, but during a spell of fine weather in June 2020 CM & HM resolved to visit the plant at its two other reported locations in v.c.67, at Dryburn Moor and Allendale Common, these together representing the only recorded extant English sites for this much misunderstood taxon, the then most globally threatened pteridophyte in the British flora (García Criado *et al*., 2017). Subsequently they have now visited all of the reported Northumbrian sites and photographed and collected material. On the basis of the collections made and other images taken, what commenced as a simple visit spiralled into this wider consideration of the history of recording of this plant, what we should be calling it and its status in England.

The late Clive Jermy did much to bring this plant to the attention of British botanists, most notably in his account of the taxon's history and taxonomic status in the British Isles (Jermy, 1989). This work and later guidance given in the Plant Crib 1998 (Rich & Jermy, 1998) stimulated searches for this plant, leading to its discovery in a range of new locations and its rediscovery in others (eg. Gurney & Amphlett, 2011). Even during the course of his investigation and publication Jermy was revising his concepts, as evidenced by comments he made on plants found shortly before in the Malverns (Jermy, 1989) and annotations to specimens at **BM**. In parallel to the taxonomic, nomenclatural and subsequent recording issues, many regrettably caused by Jermy's decision to treat *D.* × *issleri* as a subspecies of *D. complanatum*, are the very real difficulties posed by the differentiation of this taxon from its progenitors. A growing body of work by European pteridologists has helped elucidate the factors which have contributed to the difficulties experienced, including morphological plasticity and the possibilities of introgression (Aargard *et al*, 2009; Hanušová *et al*., 2014), or the formation of triploid as well as diploid hybrids (Bennert *et al*., 2011). These detailed morphometric studies have allowed further refinement of judgements on the characters which differentiate hybrids from atypical examples of the widespread *D. alpinum*. When considered alongside the difficulties experienced by Jermy working almost exclusively with old and scrappy herbarium specimens it is not surprising that re-determinations have been made. Here we aim to update the taxonomic treatment of this plant in the British Isles, review the historical records for England and Wales and produce a revised conservation assessment based on recent field investigations.

What is *Diphasiastrum* × *issleri*?

The genus *Diphasiastrum* is amongst the most distinctive of the segregates split from *Lycopodium* following molecular studies. Within Europe there are three unequivocal species: *D. alpinum* (L.) Holub, *D. complanatum* (L.) Holub and *D. tristachyum* (Pursh) Holub but where these are sympatric (and sometimes even in the absence of one or other taxon) rarer fertile intermediates occur. These have been accorded recognition both as species and as hybrids; indeed the plant under consideration here was initially described as a race of the then *Lycopodium alpinum* (Rouy, 1913). The genus (as *Lycopodium* section *Complanata*) was monographed by J. H. Wilce (1965) and the hybrid status of various taxa was discussed in detail. Wilce, on the basis of rather few specimens, considered *D.* × *issleri* to be the hybrid between *D. alpinum* and *D. tristachyum*, a view still maintained by Wagner & Beitel (1993) in the Flora of North America, where this rare hybrid is reported only from Maine. The hybrid between *D. alpinum* and *D. complanatum,* which later European authors considered Rouy's plant to actually represent, was not recorded for North America. Resolution of this confusion was achieved with the description of *D.* × *oellgaardii* Stoor et al. as the hybrid *D. alpinum* × *D. tristachyum* by Stoor *et al*., (1996) (although see Vogel & Rumsey, 1999 for some cautionary comments).

How should we treat the hybrid of *D. complanatum* and *D. alpinum*...when does a fertile hybrid become a species?

Most hybrids demonstrate sterility or greatly reduced fertility (Stace *et al*., 2015) and are thus reliant on vegetative propagation for dispersal, clearly functioning in a very different fashion biologically from "good" species. The hybrid *Diphasiastrum* taxa are however very unusual in showing from *c*.70% (Wilce, 1965) to >93% (Hanušová *et al*., 2014) good spore production (although germinability, gametophytic survival and reproductive competence have not been tested). If as a consequence of this degree of fertility these

hybrid entities can be shown to be behaving as biological species, there would seem to be few grounds for treating them in any other fashion. Practically the use of hybrid formula for markedly intermediate plants of known parentage is appealing, as it reflects their origin and relationship, if not the current biological reality. Perhaps key to the making of this decision, disregarding pragmatism for a moment, is clear evidence that these hybrid entities are (preferentially) interbreeding with one another and behaving as species do. The British occurrences of *D.* × *issleri* may be instructive in this regard. In the absence of the *D. complanatum* parent any occurrence is extremely unlikely to represent a novel origin (see below for fuller discussion), the plant(s) almost certainly having arisen through spore dispersal from another *D.* × *issleri* plant. At least at some of the plant's British localities, several to many discrete patches [ramets] are known (eg. Gurney & Amphlett, 2011). What is not clear is whether these represent separate genetically distinct individuals [genets] or are the consequence of fragmentation of extensive and ancient clonal patches. If the former could be demonstrated to be true we believe a very reasonable case could be made for elevating this taxon to specific rank. Aargard (2009) concluded from the then available molecular evidence that it was best to restrict specific status to the primary taxa, a view with which Hanušová et al., (2014) concurred, suggesting that most occurrences of intermediate plants represented polytopic origins. In the absence of clear evidence to the contrary we too choose to treat this taxon as a hybrid rather than species.

How has the taxon been recorded hitherto in the British Isles?

Within the British Isles the earliest recognition of plants distinct from *D. alpinum* that we would today regard as *Diphasiastrum* × *issleri* was by Druce (1882), the earlier attributions mentioned by Jermy (1989) all relating to Hampshire plants subsequently shown by Rumsey (2012) to be *D. tristachyum.* Material of H. P. Reader's Gloucestershire plant, which was the subject of Druce's communication, was lent by Druce to Boswell-Syme who had a drawing made of it by N.E. Brown for the Supplement to the 3rd edition of English Botany that he was editing (Boswell-Syme, 1886). The plate was labelled *Lycopodium alpinum* L. var. *decipiens* by Boswell "believing the plant to have nothing to do with *L. complanatum*" (in litt. to Druce, 3 June 1883). It is numbered 1834* (*L. alpinum* appeared as t.1834). The name *L. alpinum* var. *decipiens* was published without description and was only later validated by Druce (1892) and finally lectotypified by Jermy (1989) over a hundred years later. Scottish and Welsh material which appeared to differ from typical *D. alpinum* was also starting to be recorded as *L. alpinum* var. *decipiens,* or as *L. complanatum* var. *anceps* (eg. Babington, 1883).

A plant from Skye was collected by Prof. Marmaduke Alexander Lawson and H.E. Fox in 1868 and was exhibited at the Linnean Society on 22 November 1885 by J.G. Baker. While at the opposite end of *Diphasiastrum*'s British range the Gardeners' Chronicle (Anon. 1886) stated that "minds have been set at rest by the fine specimen of this species [*L. complanatum*] from the Somerset side of Exmoor", again exhibited by J.G. Baker at the Linnean Society on 17 December, 1885. The former at least is *D.* × *issleri* and almost certainly forms the lower plant featured on Brown's plate 1834* (Druce, 1892), the supporting specimen now at **BM** [BM001029152]. Jermy (1989) documents other specimens from Scotland, including ones collected by William Gardner on the Sidlaw Hills, and by Druce and E.S. Marshall in N. Scotland (e.g. Ben Avon, Banff, v.c.94, and Lochnagar, c. 3000 ft, v.c.92) that were subsequently labelled var*. decipiens*, as were many more at that period; he believed all to be etiolated forms of *D. alpinum*. Similarly the specimen collected near Advie, Grantown-on-Spey, J.S. Gamble, 1871 (**K**) recorded by

McCallum Webster (1978) as var. *decipiens*. All those specimens seen are sterile and are luxuriant or etiolated forms (through being in dense herbage) of *D. alpinum*, although Jermy felt the Lochnagar material (and site) warranted further investigation. There was, however, no consensus amongst the pre-eminent botanists of the time over the taxonomic treatment of these plants. Edward Marshall compared the Gloucestershire plant with material labelled *L. complanatum* in the Linnean herbarium and published an opinion (Marshall,1891) that Reader's plant "must go under *L. alpinum* L." and "*L. complanatum* ought to disappear from our list", whereas A. J. Willmot, in a pencilled note made in 1921 on one of Reader's Gloucestershire specimens [BM001082071], clearly recognised the plant for what it was, saying "These specimens are not *complanatum* but seem to be intermediate between it and *alpinum*". It is not surprising that a hybrid origin for these plants was not more generally considered given the absence of *D. complanatum* in the British Isles, even if its name had and would continue to be taken in vain by British botanists! Druce (1916) summarised the British occurrences of plants which he still regarded as *Lycopodium complanatum* but throughout the 20th century confusion still reigned and the presence of another taxon beyond *D. alpinum* met little support. Post-war British botanists initially preferred to sit on the fence, the Flora of the British Isles (Clapham *et al.*, 1952) being content to report that *Lycopodium complanatum* is "Several times reported as British but all the records are doubtful." However by 1962 (Clapham *et al.*, 1962) views had changed and our plant is treated for the first time as *L. issleri* (Rouy) Lawraleé and is referred to as "Native, Heaths and moors, very rare; extinct in ?Hants; Gloucester and Worcester; N. Devon; N. Wales; Scottish Highlands. Further investigation is needed to see if this plant is distinct from *L. alpinum*. Intermediates appear to occur, as do intermediates with *L. complanatum* L. on the Continent." Notwithstanding this, the species was not mapped in the 1962 Atlas of the British Flora (Perring & Walters, 1962).

The epithet by which we now call the hybrid of *D. alpinum* and *D. complanatum* was originally coined by Rouy (1913), as a "race" of *Lycopodium alpinum,* when describing material gathered by E. Issler in the Vosges mountains of Alsace in August 1908 (now in **BASBG**). In the 1950s a Belgian botanist, Andre Lawraleé, working on similar plants which appeared to be intermediate between *L. alpinum* and *L. complanatum* raised Rouy's "race" to the rank of species as *L. issleri* (Rouy) Lawraleé (Lawraleé 1957) and introduced the name to British botanists. Somewhat later, Anna Pacnya, studying material from Poland, concluded that it should be "considered a species of hybrid origin" under the name *Diphasium issleri* (Rouy) J. Holub (Pacyna 1972a, 1972b). The name *Diphasium* had been resurrected, as it would later prove erroneously, by Rothmaler (1944) for the whole of *Lycopodium* section *Complanata*; it briefly found currency in some European circles and was adopted in the first edition of Flora Europaea (Tutin *et al.*, 1964), before Holub (1975) created the new genus *Diphasiastrum* to accommodate these plants. He made the combination into the genus for the hybrid:

Diphasiastrum × *issleri* (Rouy) Holub (= *Diphasiastrum alpinum* (L.) Holub x *Diphasiastrum complanatum* (L.) Holub.) Preslia, 47:97-110 at p107 (Holub 1975) Basionym: *Lycopodium alpinum* L. race *issleri* Rouy (1913, p 489). No type was specified by Rouy, none being required for valid publication before that date, and none by Holub, none being required for the valid publication of a hybrid combination.

By the time of the 3rd edition of the British Flora (Clapham *et al.*, 1987) matters had moved on, presumably reflecting views expressed in the 1978 Fern Atlas (Jermy *et al.*, 1978) and the taxon is now referred to as *Diphasiastrum* × *issleri* although it is still

suggested that "the Scottish records seem to apply to atypical forms of *D. alpinum*". This may well have been the spur to Jermy's (1989) publication attempting to set the record straight. Unfortunately in this paper Jermy (1989) claimed that "because of apparent introgression between *D. alpinum* and *D. complanatum* and the likely hybrid origin of *D. issleri*, it and *D. alpinum* should be regarded as subspecies of *D. complanatum"*, a decision which was to be only partially adopted (*D. alpinum* was not sunk into *D. complanatum*) in all subsequent standard British floras (Stace, 1991; 1997; 2010; Sell & Murrell, 2018). As a consequence all too often *D.* × *issleri* has been abbreviated to *D. complanatum* causing further confusion.

How do we explain the presence of *Diphasiastrum* × *issleri* in the British Isles?

It is pertinent to consider the origins of the scattered British examples of *D.* ×*issleri.* It is highly probable that the parental taxa of *D.* × *issleri* may once have been sympatric and more abundant in the British Isles. Post-glacial conditions will have been conducive to *D. complanatum*, which is still widely distributed in areas of Arctic tundra and northern birch forest, but subsequent changes to climate and land-use could account for its loss from our islands. The high level of spore fertility (>90%, Hanušová *et al*., 2014) of the hybrid means that the taxon will have been able to persist and spread long after any pre-historical loss of the *D. complanatum* parent from the British flora. In this it would be extremely rare but not entirely unique; similar cases include *Stuckenia* ×*bottnica* (Hagstr.) Holub and *Equisetum* ×*moorei* Newman, although they both differ in their sterility and reliance on vegetative propagation, reflected in their respective restricted distributions. In contrast *D.* × *issleri* might be dispersed as spores from other British localities, or possibly from continental sources. Hanušová et al., 2014 suggest that primary hybrid occurrences in Central Europe are most plausibly the result of polytopic, i.e. local origins. This cannot be the case in the British Isles as the *D. complanatum* parent is absent. For all British occurrences, some known to be recent recruits, to be *de novo* formations we must invoke either persistent spore banks of *D. complanatum* from a period prior to recording, or repeated long-distance dispersal of *D. complanatum* spores, which upon germination are always hybridised by *D. alpinum*. While it is possible that *D. complanatum* gametophytes might be often outnumbered by those of the resident native *D. alpinum,* it defies belief that this would always be the case, unless perhaps if *D. complanatum* was an obligate outbreeder and dispersed spores arrived singly. There is no population genetic evidence to suggest the former. If this were the source of our *D.* × *issleri* plants we might also reasonably expect to be finding *D. complanatum*, if only short-lived. This has not been the case. A local, i.e. British (and effectively Scottish) source of *D.* × *issleri* spores seems most plausible as it would be strange that the spores of an uncommon hybrid have been dispersed from the continent while those of a more frequent parent apparently haven't.

Identification issues

The main difficulty which arises is the discrimination of *D.* × *issleri* from atypical forms of *D. alpinum* due to the morphological plasticity that both may show. Where shaded, on disturbed ground, or still juvenile, *D. alpinum* may adopt a colour and a broader, flatter stem shape, with more obvious, longer lateral leaves which mimic *D.* × *issleri* closely. The problem becomes more acute once individuals of *D.* × *issleri* which are backcrossed or introgressed to *D. alpinum* are considered. Likewise triploid hybrid individuals derived from two genomes of *D. alpinum* with one of *D. complanatum* produce plants which more closely resemble *D. alpinum* (Bennert *et al*., 2011). Morphologically these cases may not be definitely separable and reliance will need to be made on molecular evidence, although

this would not be trivial where introgressed and with a limited genomic complement from *D. complanatum*. Within Central Europe and Norden, where the three primary *Diphasiastrum* taxa (*D. alpinum*, *D. complanatum* & *D. tristachyum*) and their secondary intermediates of hybrid origin (*D.* × *issleri*, *D.* × *oellgaardii* & *D.* × *zeilleri* (Rouy) Holub are most frequent and regularly sympatric, there has been considerable debate over the occurrence and frequency of introgressive hybridisation. The patterns of hybridisation in *Diphasiastrum* have recently been addressed using two types of markers: low-copy nuclear genes and genome size as measured by flow cytometry (Hanušová et al., 2014). Sequences of three regions of nuclear genome (RPB2, LEAFY, LAMB4) confirmed the hybrid status of *D.* × *issleri*, *D.* × *oellgaardii* and *D.* × *zeilleri* and the directionality of hybrid formation (Aargaard, 2009; Aargaard et al., 2009). This study of a limited sample set also indicated that certain levels of recent hybridisation and backcrossing exist within European *Diphasiastrum* but left unknown its frequency and variation patterns in natural populations.

In contrast, Bennert *et al*., (2011) reported that discrete variation in genome size in several parts of Europe indicated only primary hybridisation with no hint of backcrossing (except for a few rare triploid hybrids which they report for the first time) or introgression. A more extensive survey by Hanušová *et al*., (2014) found that within Central European populations there exists a continuous pattern in both morphological variation and genome size (strongly correlated together) suggesting extensive levels of interspecific gene flow within this region, including several large hybrid swarm populations. The secondary character of habitats of Central European hybrid swarm populations suggests that man-made landscape changes might have enhanced unnatural contact of species, resulting in extensive hybridisation within this area. On the contrary, a distinct pattern of genome size variation among individuals from other parts of Europe (including the British Isles) indicates that pure populations prevail outside Central Europe. At least two of the three basic species (*D. alpinum* and *D. complanatum*) form taxonomically pure stands with negligible intra-population variation in genome size, but hybrids were predominantly found at localities where they co-occurred with basic species, resulting in populations with higher variance in genome size. Importantly, populations composed only of hybrids were extremely rare and contained few individuals. This pattern of distribution Hanušová *et al*., (2014) suggest indicates a polytopic and probably recent origin of the hybrid taxa. Each mixed population is likely a result of an independent hybridisation event. This is also supported by distinct habitat preferences of pure vs. complex populations. While pure populations of basic species prefer open subalpine habitats (*D.alpinum*) or moderately disturbed open forest patches and forest margins (*D. complanatum*), morphologically and cytologically intricate populations tend to occur in man-made secondary habitats such as timber storage places and deforested strips.

Although typical *D.* × *issleri* does not pose too many identification difficulties; problems arise when attempting to differentiate between material that may be introgressed with the *D. alpinum* parent and growth forms of *D. alpinum*. It is this material which accounts for the great majority of the putative English records of *D.* ×*issleri*. We cannot rule out the possibility that these English (and some equally equivocal Scottish) plants are the result of long distance spore dispersal from fertile introgressed plants in the Central European hot-spots for hybridisation, or are the results of local backcrossing given the arrival of × *issleri* spores into existing *alpinum* populations. For the more southerly occurrences at least this latter seems unlikely, the only representatives of the genus present being the oddities. Jermy, from comments on specimens at **BM** referred to in the catalogue below, obviously had the conviction that lowland occurrences were likely to,

even must, represent another taxon but there is nothing to suggest from its European range that *D. complanatum* or its hybrids would be any more likely, or be better suited to these lowland British sites than would *D. alpinum*. It seems to us extremely unlikely that these marginal occurrences would be exclusively favoured by the long distance dispersal of a rare introgressant and that much more parsimonious is the suggestion that in these marginal, often perturbed, climatically sub-optimal sites, the germination of long buried *D. alpinum* spores leads to atypical growth forms or juvenile plants often in shaded, more humid situations. It is on this basis that we have considered the available material. Detailed molecular work is required to establish if this is indeed the case.

A review of English and Welsh records

Here we consider the known records from England which are listed as *Diphasiastrum complanatum*, *D. complanatum* subsp. *issleri* or *D.* × *issleri* on the Botanical Society of Britain and Ireland Distribution Database (https://database.bsbi.org) (henceforth referred to as DDb), in major herbaria, those accessible online through Herbaria@home (https://bsbi.org/herbaria-at-home), or in published accounts.

v.c.4 (North Devon)

1) A specimen in **BM (**001185253), undated and unattributed from "Devonshire, Exmoor" was considered by Jermy in a note made on the specimen in 1977 as "verging towards *Diphasiastrum* ×*issleri*" and mentioned as such in Jermy (1989). This may be the plant referred to in the *Gardener's Chronicle* (Anon., 1886). It was redetermined as only a form of *D. alpinum* by A.C.Jermy in 1988, a view with which we concur.

2) W.R. Lawson, near Lynton, N. Devon [SS7149] (inferred), 12/1885 – ex herb. A. Bennett & G. Nicholson. Another specimen in **BM** (001185254) with similar history of change of mind was also considered by Jermy in 1977 as "verging towards *Diphasiastrum* ×*issleri*" (Jermy, 1989) but as with the plant above he redetermined it as a form of *D. alpinum* in 1988.

3) A sheet in **RAMM** collected by W.P. Hiern ex Herb.W.S. Hore is labelled *Lycopodium alpinum* var. *complanatum.* Martin and Fraser (1939) suggest the rather scrappy specimen was probably collected on the high moors near Yes Tor. It is *D. alpinum.*

v.c.5 South Somerset

A specimen from Dunkery Beacon, Exmoor, Somerset, A.W. Parsons, 16/9/1870, **BM** 001185255 which had been tentatively filed as *D.* × *issleri* is *D. alpinum*.

v.c.12 North Hampshire

Cited by Jermy (1989) as the earliest occurrence of *Diphasiastrum* × *issleri* in the British Isles, the specimens such as *Lycopodium complanatum*, John Lloyd, Lower Wagner's Wells, Bramshott, 1867, determined by A.C. Jermy as *Diphasiastrum* × *issleri* 1996 (**BM**!) been redetermined as *D. tristachyum* (Rumsey 2012).

v.c.33 East Gloucestershire.

Lycopodium complanatum is listed for this vice-county in Watson (1883) on the authority of Reader. It is presumably an error for v.c.34 below.

v.c.34 West Gloucestershire

1) Near Stroud, Gloucestershire, Revd Father Reader, **BM** 001082071 – with a note dated May 11/82 "Dear Mr Britten I enclose the best specimen I can procure of *Lycopodium complanatum* – gathered last July or August at Woodchester. In 1921 A. J. Willmott added the note "these specimens are not *complanatum* but seem to be intermediate between it and *alpinum*". This specimen was selected as the lectotype of *Lycopodium alpinum* var. *decipiens* by Jermy (1989).

2) There is a specimen in **HAMU** labelled B. King, Gloucestershire, 1881. Druce (1916) makes it clear that Bolton King sent examples of material he had received from Reader to Druce, and indeed a photograph of the material appears in Druce's article.

Specimens from Woodchester (eg. Fig. 1) collected in the summer of the following and subsequent years by Reader were distributed by the Botanical Record Club and are now to be found in **BRIST, CGE, GL, K, LIV, NMW, OXF** (Jermy, 1989). They are represented at **BM** by:

- Ferny ground, Woodchester, Glos., July 1882, H.P. Reader Ex. Herb. E.F. Linton - **BM** 001029157.
- Ferny banks, near Stroud, Glos., July 1882, ex Herb. H.P Reader **CGE**, Photo at **BM** 001029160; **BM** 001029137; **BM** 001029140; **BM** 001082074
- Bog? near Woodchester, Glos., Coll. Rev. Fr. Reader, Herb. R.P. Murray, **BM** 001082072
- Among bracken near Woodchester, Glos. April 1883, H. P. Reader, **BM** 001029139; **BM** 001029136
- Woodchester, Gloucestershire H.P. Reader, Aug. 1883, ex herb. G. Nicholson, **BM** 001029157
- nr. Woodchester, Glos. W., Oct. [18]84, H.P. Reader - comm. J.E. Griffith, ex. herb. E.F. Linton **BM** 001029158
- nr. Woodchester, Glos. Oct. 1884, E.M. Holmes **BM** 001082073.

In 2001 Kukkonen determined **BM** 001082071 & 001082074 as ×*issleri*, he considered the rather scrappy and shaded **BM** 001082072/3 as shade forms of *alpinum*. It seems extremely unlikely that if the specimens are accurately localised there would be a second *Diphasiastrum* present and we think it much more likely that these represent atypical ×*issleri.* This exemplifies the extreme difficulty that exists in discriminating these taxa. The copious material collected by Reader constitutes the most typical × *issleri* to be collected in England and indeed the only unequivocal specimens of this taxon from here (see below).

Henry Peter Reader was the incumbent at Woodchester when he found the plant. The location on many specimens is vague or not explicitly given. In later correspondence with G.C. Druce he described it as found "in one of the many valleys which intersect the Cotswolds about Stroud, where the ground is broken up into several ferny knolls, divided by streamlets" (Druce 1882). Outcrops with deposits of Fullers earth occur in this

otherwise limestone area and still support an unusual acidophile flora, although in spite of repeated searches the plant has not been refound (Riddelsdell et al., 1948), perhaps as a consequence of coniferisation and one might suspect not aided by over-collection.

Figure 1. Detail from one sheet of H. P. Reader's *Diphasiastrum x issleri* collected from Gloucestershire in 1883 and held at BM.

Druce considered that the illustration which appeared in the supplement to the 3rd Edition of Sowerby's English Botany (Boswell-Syme, 1886), as t. 1834*, was inferior to that presented as t.233 in his Journal of Botany paper (Druce, 1882). Boswell-Syme (in litt. to G.C. Druce 3/6/1883) correctly likened the New Forest [= Bramshott, v.c.12] plant to *L. chamaecyparissus* A. Braun ex Mutel. (= *tristachyum*) but refused to accept the Woodchester plant as *complanatum*, calling it instead *alpinum* var. *decipiens*, although he admitted that Lawson's July 1868 Skye plant (**BM** 001029152) might be *complanatum* but awaited further evidence. The name *Lycopodium alpinum* var. *decipiens* was not validly published, an omission later rectified by Druce (1892); a lectotype (**BM** 001060491) was selected by Jermy (1989).

v.c.36 Herefordshire

Several records exist on the DDb ascribed incorrectly to v.c.36 (and marked as such) from the site close to Herefordshire Beacon (SO764398) – see below.

v.c.37 Worcestershire

1) *Lycopodium alpinum* L., C. Babington, Hartlebury Common, Kidderminster, SO8270 (inferred), 7/1837. **CGE (**Photo at **BM**001060490**)!** Previously determined as *D.* × *issleri* by A.C. Jermy. C. Babington is the Rev. Churchill Babington, the brother of C.C. Babington (Druce 1882). According to Lees (1867), he was accompanied by a Miss Lea (later Mrs Waller) and she also collected a specimen, now apparently lost (Lees, 1867). See also

Amphlett & Rea 1909) where it is suggested that the gathering is not true *L. alpinum*. The material is rather scrappy and etiolated. It is not possible to definitely completely exclude the possibility that it is *D.* × *issleri* although we believe it more likely to be a shade form of *D. alpinum*.

2) Great Malvern, Worcestershire Beacon SO74S (inferred), Freeman Roper, 8/1893. **BM** 001029156. In a letter to A. Bennett, now mounted with the fragmentary specimen, Roper says "amongst moss at the top of the Worcester Beacon, Gt Malvern". See Amphlett & Rea 1909 where the plant is, by implication, the same taxon as Babington's gathering above. Freeman Clarke Samuel Roper (1819-1896) was an enthusiastic amateur botanist and microscopist (Desmond, 1994). His herbarium is at **BTN** but contains no duplicate of this gathering. In a note on the sheet Jermy says "impossible to determine exactly – *Diphasiastrum* × *issleri* is expected from here". The specimen is, we believe, *D. alpinum.*

3) Little Malvern, Herefordshire Beacon SO7640 (inferred), W.W. Boucher 20/9/1934. **BM** 001185256. Filed by Jermy as *D.* × *issleri* at **BM**; this is very similar to the Worcester Beacon specimen above and is, we believe, also *D. alpinum*.

4) *Diphasiastrum* plants were refound in the same area as Boucher's earlier find by John Day in 1981 as recorded on the DDb as: "Below the Herefordshire Beacon, above the British Camp Reservoir, SO76433981, 10/1981. Determined A.C. Jermy."

5) The same site was subsequently visited by Lynne Farrell in June 1982 with an NCC photographer - Photo at **BM**! and recorded on the BSBI database (incorrectly under v.c.36) as *Diphasiastrum complanatum* L. Farrell, Malvern Hills, 1982, SO765398.

6) The site was also visited by Jermy in the same year. His specimen is at **BM** (**BM**001185257) – Worcester: Little Malvern "on Broad Down on southern side of reservoir in *Cladonia ciliata* var. *tenuis* turf, with *Vaccinium vit-id*, *Calluna- Betula* Assoc. on well drained steep bank facing north." A.C. Jermy (*sn*) 1982. He notes on the specimen "This is not typical *D. comp*. subsp. *issleri* but neither is it good subsp. *alpinum*. I suspect introgression from populations of *issleri* in the W. of England – May 1989". The specimen was subsequently det. by I. Kukkonen as a "shade form" of *D. alpinum* in 2001, a view with which we concur.

7) The last known record of the clubmoss at this site was by Peter Garner - "South side of British Camp Reservoir, SO764398" on the 29/5/1996. Garner (in litt.) recalls that he monitored the site regularly until 1997 and the plant was still flourishing when last seen by him on 26/1/1997. He believes that Bracken encroachment and vegetation succession probably resulted in the subsequent loss of the plant. The site was visited by FJR in the company of Peter Garner in 2015 to advise on possible management to recover the plant.

v.c.49 Caernarvonshire

1) A single queried record is given in the DDb: J.E. Griffith, SH6458[inferred?], 8/1893 **NMW** Identified as *D. complanatum* by A.C. Jermy. This is not mentioned in Jermy (1989). It is surely another example of Jermy's revised views not always being captured on the specimen, or if so not communicated to update the database. Two more examples are at **BM** of etiolated *D. alpinum* from this area and originally determined as *L. complanatum.*

2) Another specimen presumed to be of the same gathering, labelled "*Lycopodium alpinum*, Cwm Idwal, 1893, J.E Griffith in Herbarium Grovesianum- **BM** 001185178 is the etiolated form of *D. alpinum*. Griffith (1895) says under *L. complanatum* "Messrs. H. and J. Groves (1891) have pointed out that this plant has been wrongly named and that it is only a form of *L. alpinum*. I found it growing in Cwm Idwal with the normal form." The authors have also seen atypical examples of *D. alpinum* above Llyn Idwal.

3) *L. complanatum.,* G.C. Druce, "Glydyr fawr, SH6458 [inferred], June 1878", [**BM** 001185201], distributed as such through the Botanical Record Club in 1883.

4) *L. complanatum.* H.R. Hewer, "Hillside to the south of Lake Ogwen, North Wales, 1,250ft, SH6458 [inferred], August 3rd, 1941," [**BM** 001185191].

v.c.54 North Lincolnshire

A single queried record is given in the DDb: Anon, SE81, 1856 apparently determined by A.C. Jermy from a specimen at BM. The supporting specimen "Crossby Warren, E. Coates, 1856 – Discovered by Rev. W. Fowler" **BM** 001185216 is *D. alpinum*, as already acknowledged by ACJ and confirmed by us. *D. alpinum* is given for the county in Druce (1932) on the basis of this record, presumably the same as referred to in Lees (1883) and Gibbons (1975) under *Lycopodium alpinum*, Rev William Fowler & E. Coates, Coneysby Pits, Crossby Warren, 1857. The date of 1875 given in Woodruffe-Peacock (1909) is presumably a typographical error.

*v.c.55 Leicestershire***.**

Lycopodium complanatum was listed for this vice-county in Watson (1883) on the authority of Churchill Babington. It is presumably an error for v.c.37 (see above), although v.c.55 is also given in Druce (1932). Not referred to in Horwood & Noel (1933), nor Primavesi & Evans (1988). We have seen no material.

v.c.62 North Yorkshire

There are two queried records for this vice-county on the DDb, neither of which is mentioned by Jermy (1989).

1) *Diphasiastrum complanatum* or *subsp. issleri* Anon, [SE98], ?Wykeham Forest, Hutton Moor?, 1843. This presumably relates to a specimen at **BM**, v.c.62, Hutton Bushil [Hutton Buscel] Moor, 1843, (**BM** 001185221) originally considered by Jermy as possible *D.* × *issleri* but later redet. by him as etiolated *alpinum*, a view with which we agree.

2) S. Thompson, [SE6360], 9/1846. Apparently det. A.C.Jermy and supported by a specimen at **BM**. This second record exemplifies some of the problems which can arise when dealing with legacy database records. The specimen in question "Strensall nr York, 9mo 1846" ex herb. Silvanus Thompson **BM**001185220 was originally labelled *Lycopodium inundatum* [=*Lycopodiella inundata* (L.) Holub], a plant known from the site. In 1977 A.C. Jermy added a determination slip saying "most likely ×issleri" and this presumably was captured for the database. Subsequently it was (correctly) re-determined by Jermy in June

1988 as *D. alpinum*. He and others have annotated the sheet to the effect that it is highly likely that there has been a mixing of specimens at some stage. So the database record is of a dubious specimen, only tentatively identified and then incorrectly so, corrected at source but this not captured!

v.c.63 South West Yorkshire

There is a single historical record on the DDb marked as queried: Anon., SE02, 8/1836. No supporting specimen location is listed although the record is given as identified by A.C. Jermy. It was not mentioned in Jermy (1989). This again relates to material held at **BM** which Jermy had tentatively identified as "? Diph. ×*issleri*" in 1977 but which by 1988 he had re-determined as *D. alpinum*. The specimen BM001185222 is from "Sowerby Moor, Yorks., Aug. 1836" – no stated collector. A second specimen with the same collection details [**BM**001185223], but not annotated by Jermy, is also *D. alpinum*.

v.c.64 Mid-West Yorkshire

Not listed by Druce (1916), Jermy (1989) or on the DDb but specimens originally collected as *L. alpinum* v. *decipiens* Syme exist at **BM**. The material labelled "Nidderdale, W. riding of York" [**BM**0011885233] was collected in June 1901 by W.C. Clarkson and sent to A. Bennett for identification. In his note Clarkson says of the habitat that it was on a steep, dry incline covered with stones of varying sizes…at about 1,000 ft altitude and growing with *L. clavatum* and *L. selago*. The specimen is slightly atypical *D. alpinum*.

v.c.67 South Northumberland – William's Cleugh

Diphasiastrum complanatum morphotype *decipens,* G.A. Swan, Slope above William's Cleugh at 520m, NY6399 (inferred), 1988. Det A.C. Jermy 1991. (Swan 1993) GAS notebook gives the date as 12/7/1988, NY639991 for *D. alpinum* from this site. Presumably in **HAMU**. The area has been visited on several occasions subsequently resulting in the following records:
- *Diphasiastrum complanatum,* C. Pogson, William's Cleugh, NY63959916, 16/6/2000.
- *Diphasiastrum complanatum,* J. Bowyer, William's Cleugh, NY63959916, 15/10/2011.
- *Diphasiastrum complanatum,* G. & A. Young, B. Harle, William's Cleugh, NY63959915, 1/9/2012.
- *Diphasiastrum complanatum,* B. Burlton, Mid Fell, NY6393699678*, 23/7/2019. No specimen taken but photographs reveal the plant to be clearly *D. alpinum*. Determined FJR. 6/2020. (* see comment below)
Good photographs of the William's Cleugh plants were also taken by Lenny Worthington on 25/7/2010 [https://www.flickr.com/photos/lennyworthington/ accessed 02/10/2020].

William's Cleugh was visited by CM & HM on 09/10/2020. They had the enormous advantage of being shown the site by Bill Burlton who has known the plant there since the early 1990s, when he had been shown it by distinguished local naturalist Angus Lunn, who in turn had had the locality described to him by Swan. At this point we should deal with the issue of the grid reference. Swan's reference on the BSBI database is simply NY69. A slightly more accurate grid, NY6499 has been deleted. Swan's notebook entry suggests that he visited the site on 12/7/1988 and gives the reference NY639991 for *D. alpinum*. The reference given by Bill Burlton as a result of his visit to the plant on 23/7/2019 is

NY6393699678. Bill confirmed to us that the reference is an error and should have been NY6393699078. Our reading for the plant on 09/10/20 was NY6393499076 well within the margin of error for our GPS. Specimens and photographs were taken (William's Cleugh 5). We were satisfied that the plant we were shown was *D. alpinum*.

It is worth noting, for completeness, that this plant was shown to a visiting group of BSBI botanists including Francis Rose, in June 1993 (see *BSBI News* 65:58). Bill was able to confirm that it was he, and not George Swan who was also on the trip, who demonstrated the plant, Swan visiting another location with a subset of the group. Further plants were found about 75 m away: at NY6395499158, where we collected material from and photographed three plants (William's Cleugh 1-3) taking a full herbarium specimen from number 2, and at NY6395199159 (William's Cleugh 4). There were many similar plants within a 10-20 m radius although no count was attempted. These plants are representative of the locations given for ?*issleri* by Boyer, Pogson and Young in 2011, 2000 and 2012 respectively. Interestingly there were plants of typical *D. alpinum* growing very close to the putative *D.* × *issleri*. The close juxtaposition of morphologically distinct plants might argue against the suggestion that the "issleri" form is environmentally induced, but variations in soils, shade, hydrology or other biotic factors at a micro-scale may be responsible. While the plants appear very different, the lateral and ventral leaf shapes are not those of typical *D.* ×*issleri*, although the ventral leaf is not consistently trullate and the strobili, where produced, appear shortly pedunculate. This may however be a consequence of shading; the sporophylls appear closer in shape to those of *D. alpinum* and on balance we feel it much more likely that these plants are atypical examples of that species rather than introgressants of *D.* × *issleri* (Fig. 2).

Figure 2. Shade form of *Diphasiastrum alpinum*, William's Cleugh, v.c. 67 photographed in October 2020 (C. Metherell).

v.c.67 South Northumberland – The Chimneys.

- *Diphasiastrum complanatum* subsp. i*ssleri,* G. Young, The Chimneys, Dryburn Moor, NY8120252928, 16/4/2012.
- *Diphasiastrum complanatum,* A.J. Richards, The Chimneys, NY8120153929, 28/9/2014.

- *Diphasiastrum complanatum,* A.J. Richards, The Chimneys, NY8120053930, 28/9/2014. The area was visited by CM and HM on 20/6/2020 when photographs were taken and specimens were collected from four locations close to B) and C) above: NY8120353928, NY8120253932, NY8120253931 and NY8120053920. All were determined by FJR (6/2020) as *D alpinum.*

v.c.67 South Northumberland – Allendale Moor

- *Diphasiastrum complanatum,* A. & G. Young, Allendale Moor, NY827446, 22/8/2011.
- *Diphasiastrum complanatum,* G. Young, Allendale Moor, NY8276044632, 5/10/2011*.
- *Diphasiastrum complanatum,* G. Young, Allendale Moor, NY8273244652, 15/10/2011.
- *Diphasiastrum complanatum,* G. Young, Allendale Moor, NY8277144630, 15-20/10/2011.
- *Diphasiastrum complanatum,* G. Young, Allendale Moor, NY8277144630, 28/4/2012.
- *Diphasiastrum complanatum* subsp. *issleri,* A.J. Richards, Allendale Moor, NY8275944623, 23//9/2012. See Dockerill (2012).
- *Diphasiastrum complanatum* subsp*. issleri,* Natural History Society of Northumbria, NY8274644655, 22/7/2015. Det. A.J. Richards.
- *Diphasiastrum complanatum* subsp*. issleri,* Natural History Society of Northumbria, Carriers Way, NY8277244631, 22/7/2015.
- *Diphasiastrum complanatum,* A.J. Richards, Carriers Way, NY827446, 23/7/2015.

Material from the second location above was sent to FJR in 2011 and was then considered possible as × *issleri* – a view he no longer holds with conviction. The area was visited by CM and HM on 20/6/2020 when photographs were taken and specimens were collected from close to three of the above locations: NY8274044643, NY8276044625 and NY8277244632. All were determined by FJR (6/2020) as *D. alpinum.*

v.c 67 South Northumberland – Ladycross Quarry

Diphastrium x issleri, Ladycross Bank Quarry, NY952550, alt. 340 m – growing with *L. clavatum* 28/1/1987 [G.A. Swann (*sic*)] – det. × *issleri* by A.C. Jermy. We consider this to be *D. alpinum*. Some doubt clearly attaches to the provenance of this specimen which is not mentioned in Swan (1993). The site was visited on 7/10/2020 by CM & HM. It is in the centre of a working quarry and the actual grid reference is for an area which appears entirely unsuitable. *L. clavatum* was however located some 200 m away from the GR and there are numerous records of *D. alpinum* from outside the quarry itself but within 350 m of the GR given. We presume the reference given on the sheet is a site centroid and not that for the plant itself.

v.c.69 Westmorland

L. complanatum, W. Borrer, Easdale, 1850. **K.** Mentioned in Druce 1916 (as var. *anceps*) on the basis of information supplied by H. Takeda. See also Wilson (1938). An etiolated form of *D. alpinum* – see Jermy (1989).

v.c.70 Cumberland

Mentioned in Druce (1916) as a vice-county for *L. complanatum* var. *decipiens.*

1) A. Templeman, NY20, 22/06/1922. Det. A.C. Jermy. **OXF.** This determination was

presumably subsequently reconsidered as Jermy (1989) states all records for this area relate to atypical shade forms of *D. alpinum*.

2) *Diphasiastrum x issleri,* J. & A. Harrington, Wrynose Pass, 1980. Determined C.N. Page. **CLE**. Halliday (1997) reported that A.C. Jermy considered this material to be *D. alpinum*.

In summary, aside from the material collected at Woodchester, Glos., v.c.34 between 1881 and 1884 there are no other unequivocal specimens/supported records of *D.* × *issleri* as an English plant.

Conservation assessment

In the England Red-List Stroh *et al*., (2014) assessed *Diphasiastrum* × *issleri* (as *D. complanatum*) as Critically Endangered (CR) under the D criterion, on the basis of the critically low population size at William's Cleugh, v.c.67, the only site believed extant when data was being gathered. Losses from elsewhere were largely historic and beyond the timescale stipulated for decline (criteria A-C) to be considered, although the loss of the Malvern site post-1997 was considered eligible but unlikely to result in a higher categorisation than that resulting from criterion D. Our re-assessment here of the taxonomic identity of both the Malvern and Northumbrian plants, and those recorded subsequently in other Northumbrian sites as atypical *D. alpinum* and not *D.* × *issleri* means that the latter must now be considered Regionally Extinct (RE) in England. The only unequivocal English material being that found near Woodchester, Glos., v.c.34 by Rev. H. P. Reader between 1881 and 1884. The taxon was not included in the Welsh Red-list (Dines, 2008) and indeed examination reveals that all past records ascribed to this, or associated synonyms have proven to be *D. alpinum*.

At a GB level the re-assessment of many of the English sites as *D. alpinum* reduces EOO/AOO and population numbers but also lowers the extent of decline. Provisionally we suggest retaining *D.* × *issleri* as Near Threatened (NT), as given by Cheffings & Farrell (2005), as we see little evidence for decline in the last 30 years+. The plant may however qualify as Vulnerable (VU) under the D criterion depending on how population size and the definition of discrete individuals is calculated.

Key diagnostic characteristics:

Etiolated forms of *D. alpinum* mimic *D.* × *issleri* very closely. We would strongly recommend consulting the excellent illustrated account given by Gurney & Amphlett (2011). As stressed there, the single most useful area on which to concentrate is the shape of the ventral leaves. In *D.* × *issleri* they are narrowly triangular, i.e. tapering from a broader base to the apex, flat backed and erecto-patent whereas in shade forms of *D. alpinum* they are rather trullate, with a narrower stalked base expanding somewhat and with a hunched back so that the blade lies parallel to the stem (Figs. 3 and 4). Lateral leaf shape differs too and is best seen on the previous year's growth where fully mature/expanded. In *D.* × *issleri* the lateral leaves are more longly decurrent with a margin parallel to the stem for much of its length, the free distal pointed tip portion shorter than the decurrent section. The expanded lateral leaves of shade forms of *D. alpinum,* while as broad, taper more rapidly to the stem and the free distal portion +/- equals to exceeds the lower portion. The typically paired, longer, pedunculate strobili of *D.* × *issleri* contrast with the usually solitary, shorter, sessile strobilus of *D. alpinum*. They also differ in sporophyll scale shape; those of *D. alpinum* are more evenly triangular and acute, whereas in *D.* × *issleri* they are more rounded with a more apiculate apex, there is

however considerable variation and comparisons are best made between sporophylls at a similar stage of development and position on the strobilus. Sadly most dubious plants are not fertile. Shade may also cause some etiolation of the fruiting shoots giving a more pedunculate appearance. Plant colouration is important but sometimes misleading: *D.* × *issleri* is typically a more yellow-green colour, whereas *D. alpinum* is glaucescent but age and exposure amongst other factors may influence this.

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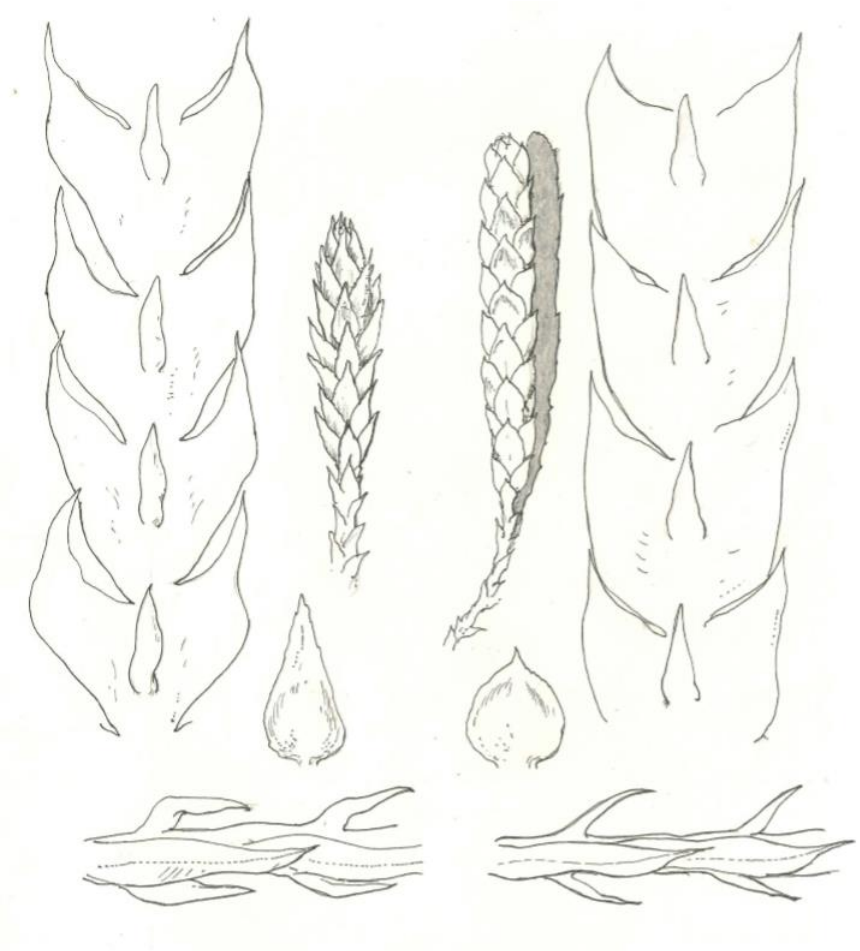

Figure 3. Comparison between atypical *Diphasiastrum alpinum* (left) and *D.* × *issleri* (right). View of shoot underside, strobilus, typical sporophyll from mid-strobilus and side view of shoot, lower surface uppermost, showing typical shape of underleaf and its insertion.

Figure 4. Details of the underside of a Scottish example of true *Diphasiastrum* x *issleri*.

References:

Aagaard, S.M.D. 2009. Reticulate Evolution in *Diphasiastrum* (Lycopodiaceae) [PhD Thesis]. Uppsala: Uppsala University.

Aagaard, S.M.D., Vogel, J.C. & Wikström, N. 2009. Resolving maternal relationships in the clubmoss genus *Diphasiastrum* (Lycopodiaceae). *Taxon* 58: 835–848.

Amphlett, J. & Rea, C. 1909. *The Botany of Worcestershire*. Birmingham: Cornish Brothers Ltd.

Anon. 1866. *Lycopodium complanatum. Gardener's Chronicle*, 18.

Babington, C.C. 1883. *Manual of British Botany, Additions and Corrections* 2. London.

Bennert, H.W., Horn, K., Kauth, M., Fuchs, J. & Jakobsen, I.S.B. 2011. Flow cytometry confirms reticulate evolution and reveals triploidy in Central European *Diphasiastrum* taxa (Lycopodiaceae, Lycophyta). *Annals of Botany* 108: 867– 876.

Boswell- Syme, J.T. & Brown, N.E. 1886. *English Botany*, 3rd. ed. Vol 12. London: G. Bell & Sons.

Cheffings, C.M., Farrell, L. (eds.), Dines, T.D., Jones, R.A., Leach, S.J., McKean, D.R., Pearman, D.A., Preston, C.D., Rumsey, F.J. & Taylor, I. 2005. The Vascular Plant Red Data List for Great Britain. Species Status 7: 1-116. Peterborough: Joint Nature Conservation Committee.

Clapham, A.R., Tutin, T.G. & Warburg, E.F. 1952. *Flora of the British Isles*, Cambridge: Cambridge University Press.

Clapham, A.R., Tutin, T.G. & Warburg, E.F. 1962. *Flora of the British Isles*, 2nd. ed. Cambridge: Cambridge University Press.

Clapham, A.R., Tutin, T.G. & Moore, D.M., 1987. *Flora of the British Isles*, 3rd. ed. Cambridge: Cambridge University Press.

Desmond, R. 1994. *Dictionary of British and Irish Botanists and Horticulturists including Plant Collectors, Flower Painters and Garden Designers.* London: Taylor & Francis and The Natural History Museum.

Dines, T.D. 2008. *A Vascular Plant Red Data List for Wales.* Salisbury: Plantlife International.

Dockerill, S. 2012. In Hexham, Northumberland 21-23rd September [Report of Field Meeting], *British Pteridological Society Bulletin*, 7(5): 403-4.
Druce, G.C. 1882. On *Lycopodium complanatum* L. as a British Plant, *Journal of Botany* 20: 321-323, tab233.
Druce, G.C. 1892. Plants of Glen Spean, Westerness. *Annals of Scottish Natural History*, 1892: 178-185.
Druce, G.C. 1916. Plant Notes etc. for 1915, *Report of the Botanical Society and Exchange Club of the British Isles*. 4: 219-233.
Druce, G.C. 1932. *The Comital Flora of the British Isles.* Arbroath: T. Buncle & Co.
García Criado, M., Väre, H., Nieto, A., Bento Elias, R., Dyer, R., Ivanenko, Y., Ivanova, D., Lansdown, R., Molina, J.A., Rouhan, G., Rumsey, F., Troia, A., Vrba, J. & Christenhusz, M.J.M. 2017. *European Red List of Lycopods and Ferns*. Brussels: IUCN.
Gibbons, E.J. 1975. *The Flora of Lincolnshire*. Lincoln: Lincoln Naturalists Trust.
Griffith, J.E. 1895. *Flora of Anglesey & Caernarvonshire*. Bangor: Nixon & Jarvis.
Groves, J. & Groves, H. 1891. Is *Lycopodium complanatum* a British Plant? *Journal of Botany* 29: 178-179.
Gurney, M & Amphlett, A. 2011. *Diphasiastrum* in Strath Nethy (v.c.96). *BSBI News* 117: 19-20.
Halliday, G. 1997. *A Flora of Cumbria.* Lancaster: Centre for North-West Regional Studies.
Hanušova. K., Ekrt, L., Vít, P., Kolář, F., Urfus, T. 2014. Continuous Morphological Variation Correlated with Genome Size Indicates Frequent Introgressive Hybridization among *Diphasiastrum* Species (Lycopodiaceae) in Central Europe. PLoS ONE 9(6): https://doi.org/10.1371/journal.pone.0099552
Holub, J. 1975. *Diphasiastrum* a New Genus in *Lycopodiacae. Preslia* 47: 97-110.
Horwood, A.R. & Noel, C.W.F. 1933. *The Flora of Leicestershire and Rutland* Oxford: OUP.
Jermy, A.C., Perring, F.H., Farrell, L. & Arnold, H. 1978. *Atlas of Ferns of the British Isles.* London: Botanical Society of the British Isles.
Jermy, A.C. 1989. The History of *Diphasiastrum issleri* (Lycopodiaceae) in Britain and a Review of its Taxonomic Status. *Fern Gazette* 13(5): 257-265.
Lawalree, A. 1957. Un Lycopode Ardennais Méconnu, *Lycopodium issleri*. *Bulletin de la Société de Botanique de Belgique* 90: 109-120.
Lees, E. 1867. *The Botany of Worcestershire.* Worcester: Worcestershire Naturalists' Club.
Lees, F.A. 1883. The North Lincoln *Lycopodium. Journal of Botany* 21: 84-85.
Marshall, E.S. 1891. Short notes: *Lycopodium complanatum* L. *Journal of Botany (London)* 29: 186.
Martin, W.K. & Fraser, G.T. 1939. *Flora of Devon.* Arbroath: T. Buncle.
Pacyna, A. 1972a. Biometrics and taxonomy of the Polish Species of the Genus *Diphasiastrum* Presl. *Fragmenta Floristica et Geobotanica* 18: 255-297.
Pacyna, A. 1972b. Distribution of the Genus *Diphasiastrum* in Poland. *Fragmenta Floristica et Geobotanica* 18: 309-341.
Perring, F.H & Walters, S.M. 1962. *Atlas of the British Flora* London: Botanical Society of the British Isles.
Primavesi, A.L & Evans, P.A. 1988. *Flora of Leicestershire* Leicester: Leicester Museums.
Rich, T.C.G. & Jermy, A.C. 1998. *Plant Crib.* London: Botanical Society of the British Isles.
Riddelsdell, H.J, Hedley, G.W. & Price, W.R. 1948. *Flora of Gloucestershire*, Cheltenham: Cotswold Naturalists Field Club.
Rothmaler, W. 1944. Pteridophyten-Studien I. *Feddes Repertorium Specierum Novarum Regni Vegetabilis* 54: 55–82.
Rouy, G. 1913. *Flore de France,* Vol 14. Paris: Les Fils d'Emile Deyrolle.

Rumsey, F. 2012. *Diphastrum tristachyum* (Pursh) Holub (Lycopodiacea: Lycopodiophyta) - An Overlooked Extinct British Native. *Fern Gazette* 19(2): 55-62.
Stace, C.A. 1991. *New Flora of the British Isles.* Cambridge: Cambridge University Press.
Stace, C.A. 1997. *New Flora of the British Isles*, 2nd. ed. Cambridge: Cambridge University Press.
Stace, C.A. 2010. *New Flora of the British Isles*, 3rd. ed. Cambridge: Cambridge University Press.
Stace, C.A., Preston, C.D. & Pearman, D.A. 2015. *Hybrid Flora of the British Isles.* Bristol: Botanical Society of Britain & Ireland.
Stace, C.A. 2019. *New Flora of the British Isles.* 4th. ed Middlewood Green, Suffolk: C.&.M. Floristics.
Stoor, A.M., Boudrie, M., Jérôme, C., Horn, K. & Bennert, H.W. 1996. *Diphasiastrum oellgaardii* (Lycopodiaceae, Pteridophyta), a new lycopod species from Central Europe and France. *Feddes Repert* 107: 149–157.
Stroh, P.A., Leach, S.J., August, T.A., Walker, K.J., Pearman, D.A., Rumsey, F.J., Harrower, C.A., Fay, M.F., Martin, J.P., Pankhurst, T., Preston, C.D. & Taylor, I. 2014. *A Vascular Plant Red List for England*. Bristol: Botanical Society of Britain and Ireland.
Swan, G.A. 1993. *Flora of Northumberland.* Newcastle upon Tyne: Natural History Society of Northumbria.
Tutin, T.G. *et al*., (eds.) 1964. *Flora Europea*, Volume 1: Lycopodiaceae to Platanaceae, Cambridge: Cambridge University Press.
Vogel, J.C. & Rumsey, F.J. 1999. On the status of *Diphasiastrum oellgaardii* (Lycopodiaceae, Pteridophyta). *Feddes Repert* 110: 439–445.
Wagner, W.H. & Beitel, J. 1983. Lycopodiaceae in Flora of North America: Volume 2: Pteridophytes and Gymnosperms: North of Mexico. Oxford: Oxford University Press
Watson, H.C. 1883. *Topographical Botany,* 2nd. ed., London: Bernard Quaritch.
Wilce, J.H. 1965. Section Complanata of the Genus *Lycopodium*, *Beih. Nova Hedwigia* 19: 1-233.
Wilson, A. 1938. *The Flora of Westmorland.* Conway: The Author.
Woodruffe-Peacock, E.A. 1909. *Check List of Lincolnshire Plants*, *Lincolnshire Naturalists' Union Transactions*,.1909: 1.

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