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STATUS OF BASIC TAXONOMIC SKILLS IN BOTANICAL ARTICLES RELATED TO AZAD JAMMU AND KASHMIR, PAKISTAN: A REVIEW

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ABSTRACT

The problems of synonymy, incorrect species author citation/abbreviation and spelling errors are hampering botanical research around the globe. This article was aimed to quantify the intensity and errors encountered in this regard in published botanical articles pertaining to the Azad Jammu and Kashmir, Pakistan. To address this issue, 100 articles published in 1999-2015 were reviewed. A total of 5460 entries were processed carefully and 1350 species binomials (excluding repititions) were extracted that were linked with 1333 accepted binomials according to theplantlist.org. Out of these accepted species binomials, 1109 were communicated correctly, whereas the remaining 224 binomials were conveyed in the form of 241 synonyms. Average synonyms to accepted binomials ratio for the said timespan was calculated quite high as 13.99%. By taking these conveyed synonyms as our sub sample, we further detected 712 errors related to orthography, author citations and abbreviations. A strong positive and significant Pearson correlation was observed amongst the number of articles published, total numbers of species binomials communicated and the number of synonyms conveyed. These taxonomic errors and nomenclatural issues in botanical articles are causing ambiguity and confusions, thus reducing the reliability and reproducibility of botanical researches. Our results prove modest basic taxonomic skills of authors, dwindling taxonomic understanding and non-updating of regional floras on a periodic basis as primary reasons. We briefly discuss this global issue and its consequences and also document numerous suggestions to mitigate the impacts.

Keywords: Taxonomic Errors, Synonym, Author Citation, Online Taxonomic Databases, *Flora of Pakistan*, Azad Jammu and Kashmir.

INTRODUCTION

Plant taxonomy and systematics provide the most vital and baseline data in the field of plant sciences. Different botanical fields like ethnobotany, ethnopharmacology, phytomedicines, phytochemistry, forestry, rangeland, ecology, ecosystem services and conservation studies that deal with vascular plants would not be possible without plant taxonomy and systematics. Taxonomy is the branch of science that addresses the exploration, description, naming, and classification of all organisms. It is a complex and independent discipline which is always based on sound scientific hypothesis (Rouhan & Gaudeul, 2014). Within taxonomy, current International Code of Nomenclature for algae, fungi and plants provides a set of rules and recommendations to be followed globally to generate homogeneity and resultant reproducibility and reliability of botanical results.

The International Code of Nomenclature for algae, fungi, and plants (2011) provides a stable method for

naming plants. Thus the nomenclature of organisms provides a way of communication with others. It is an unambiguous reference system of materials that constitute biodiversity. The 3 important principles of the code states: 1. The application of names of taxonomic groups is determined by means of nomenclatural types 2. The nomenclature of a taxonomic group is based upon priority of publication 3. Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the rules, except in specified cases (Principle II-IV, Melbourne Code/McNeill *et al.,* 2011). The modest taxonomic skills, ignorance or careless attitude of taxonomists towards the nomenclatural issues has harmed the subject more than the non taxonomists. Basic botanical skills are frequently found lacking amongst the botanists, especially while dealing with plant taxonomy and botanical nomenclature problems. Different drawbacks related to familial naming, binomial status, use of synonyms, incorrect author citations and abbreviations are often encountered in botanical researches. There are many historical and geographical reasons thus one can find the application of two or more botanical names to the same taxon. We can distinguish a more appropriate name of taxa with the application of priority and typification principles. This can help in declaring the others as their synonyms (Rao, 2004; McNeill *et al.*, 2011; McNeill and Turland, 2011; Bennett and Balick, 2014).

Current researchers are providing new morphological, chemical and molecular evidences about the elements of biodiversity at much faster pace due to the advances in tools and techniques. Thus the study of evolutionary relationships amongst the plant groups is developing quickly. That's why we encountered a lot of revisions within plant taxonomy with every passing moment. According to an estimate, about 10000 changes or revisions of plant names are published every year. Out of these changes, ca. 40% occured when taxonomists repositioned species from one genus to another. The other ca. 40% of changes are due to splitting or merger of species on the basis of available evidences (Rivera *et al;* 2014). Thus there are two main reasons for name changes; the first one is if the name is contrary to the rules (illegitimate) and the second one is that additional research findings result in a changed definition and delimitation of the taxa. The merger or union of two or more taxa, splitting of a taxon into two or more, or a change in position and rank of a taxon on the basis of molecular findings is frequent in the 21st century due to advances in techniques, methodology and equipment, which further exacerbates the issue of synonymy in taxonomy (Rouhan & Gaudeul 2014). Likewise synonymy, incorrect author citation, abbreviations, spelling errors, current rank, position and placement of taxa are major issues which remain neglected in the majority of the botanical researches in Pakistan. Various suggestions and recommendations to combat the issue have already been conveyed or communicated by the several authors (viz. Brummitt & Powell, 1992; Cotton, 1996; Martin, 2004; Bennett & Balick, 2008; Heinrich *et al.*, 2009; Nesbitt *et al.*, 2010; McNeill *et al.*, 2011; Rivera *et al.*, 2014, Khan *et al.*,2015). These include the appropriate use of botanical nomenclature to achieve scientific rigor. This will result in more effective communication, as the ambiguity and error intensity decreases. Similarly researchers related to plant sciences need more rigorous training for better comparative utilization of reliable and coherent online taxonomic databases like JSTOR, EFLORAS, GRIN/NPGS, IPNI, THE PLANT LIST, WCSP, MMPND, ITIS, TROPICOS, GBIF, PFAF, Springer

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Reference, Plantsystematics.org, Global Names Index, etc.

This study was designed to quantify and correlate the taxonomic errors especially synonymy, incorrect author citation, and abbreviations and orthographic errors in the published botanical articles related to Azad Jammu & Kashmir, Pakistan and their possible impacts. We also aimed to document all the corrections in the detected taxonomic errors according to current taxonomic records. This article findings will be useful and will encourage authors and taxonomy students in their future research related to plant sciences, as the authors should always accurately know with which specimen they are working on and communicating with others. According to Venu (2002), well equipped taxonomists and taxonomy students are a dwindling tribe, so the understanding and utilization of basic taxonomy skills is the need of time before too much is lost.

MATERIALS AND METHODS

Review Design and Study Area: Azad Jammu and Kashmir (AJ&K) is located in the foothills of the Himalayas between 33º-36º north latitude and 73º-75º east longitudes. It is surrounded by the Gilgit Baltistan toward the north, the Punjab Province toward the south, Indian occupied state of Jammu and Kashmir to the east and Khyber Pakhtunkhwa province (formerly called NWFP) to the west (Figure 1). The total area of AJ&K is 13,297 square kilometers and its estimated population is about 4 million. The topography of the AJ&K is mainly hilly and mountainous and consists of world famous beautiful valleys stretching into plains. AJ&K is administratively divided into 3 divisions (Muzaffarabad, Mirpur and Poonch) which are further divided into 10 districts with Muzaffarabad as the capital of the state. The AJ&K valley is rich in plant resources, providing a large number of services to the local masses, that has been extensively surveyed floristically (Bano *et al.*, 2013; Bokhari *et al.*, 2013a,b).

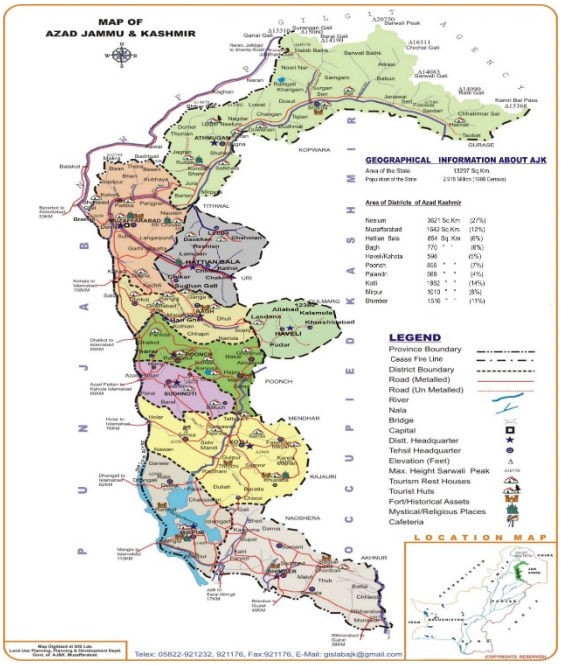

Figure 1. Geo-political map of Azad Jammu & Kashmir, Pakistan.

The different keywords like flora, ethnobotany, vegetation, biodiversity and Azad Jammu & Kashmir were entered in various combinations to search and download the relevant published botanical articles (samples) by using online search engines like Google Scholar, Web of Science, Scopus and PubMed. Each article was then thoroughly reviewed to determine the present status of any/all species binomial(s) mentioned in terms of "acceptability or synonymy" by using online taxonomic databases like JSTOR, EFLORAS, GRIN/NPGS, WCSP, MMPND, ITIS, TROPICOS, GBIF and especially TPL (2013) version 1.1 and IPNI etc (Brummitt & Powell 1992; McNeill *et al.*, 2011; Rivera, *et al.*, 2014, Khan *et al.*, 2015). All synonyms in reviewed articles were detected, tabulated and used as sub-samples to detect other taxonomic errors like spelling, rank of a taxon, author citation and abbreviation. Currently accepted names of these

synonyms and their position (followed by APG III, 2009) were searched and tabulated. If any author(s) of reviewed article(s) did not communicate any binomial, the number of synonyms was treated as zero. Localities or areas where reviewed articles' studies were conducted and author(s) who communicate synonymy were also tabulated. Furthermore each tabulated synonym and its currently accepted name was also searched within *Flora of Pakistan* at efloras.org and TROPICOS to find out whether a description of the said species/nomenclatural type exists or not. SPSS version 16.0 was employed to find out the Pearson correlation amongst the number of published articles, species binomials and synonyms communicated (excluding repetitions). These 3 variables were categorized on the basis of the time period or year of publication. All the citations of the reviewed articles were alphabetically arranged and author article codes were assigned and presented in tabular form. Furthermore, the number of species, synonyms, incorrect author citations, abbreviation and orthographic errors communicated in each article were also tabulated. The frequency (%) of synonyms for a specified time period (years) was calculated according to the following formula; SBC/TSBC*100 Where SBC is number of synonymous binomials communicated in a time period and TSBC is the total species binomials communicated in the same period.

RESULTS AND DISCUSSION

A total of 100 research articles related to plant sciences published from 1999-2015 were reviewed to find out the extent, intensity and consequences of taxonomic errors. These articles contained 5460 species binomial entries and 1350 plant species. These binomial numbers were calculated, after excluding repetition, as species names either accepted or synonyms frequently repeated in a majority of reviewed articles. According to TPL (2013), these 1350 binomials were found linked to 1333 accepted species names. This means that authors of reviewed articles communicated 1350 species, although the correct number was 1333, a taxonomic (synonymous) error. Out of 1333 accepted species names, 1109 binomials were reported correctly and the remaining 224 (accepted species names) were represented by 241 synonyms. In this article, we are presenting 224 accepted species names along with their 241 reported synonyms as Table 1. A complete list of all species extracted from reviewed articles is not presented here as it's outside the scope of this article. Our review results depicted that out of the total, 3 synonyms *Ziziphus mauritiana* Lam., *Ziziphus sativa* Gaertn., and *Ziziphus vulgaris* Lam. (Table 1) belong to the single accepted taxon *Ziziphus jujuba* Mill., but are reported by different authors (article number 06, 12, 29, 32, 34, 54, 57 & 61 of Table 5) as different species in the same article. Similarly, 2 synonyms each of the 15 accepted species names (11, 27, 31, 42, 63, 80, 99, 104, 134, 137, 145, 153, 154, 182 & 185 of Table 1) were encountered in different articles. Remaining 208 accepted species names were represented by 1 synonym each.

All of these 224 accepted binomials currently belong to 75 families of the vascular plants [Pteridophytes 4, Gymnosperms 2, Angiosperms (dicots) 59 and Angiosperms (monocots) 10]. Documentation of species distribution sites or localities (Table 1, Column 4) showed that four districts of AJ&K were extensively surveyed botanically as compared to others. The majority of communicated synonyms in reviewed articles were related to studies conducted in district Poonch (97), followed by Muzaffarabad (84), Kotli (83) and Bagh (68). Thus, it can be hypothesized that district Poonch is the most extensively surveyed area of AJ&K. We also

concluded that the leading synonyms (a synonym repeated in the majority of reviewed articles from different localities) means the wider distribution range of these species in Azad Jammu and Kashmir. This type of review methodology can also be very helpful in the determination of regional, as well as global geographic range of species for their conservational point of view.

The majority of authors of reviewed articles mentioned the utilization of *Flora of Pakistan* [presently 217 volumes (one per family) published from time to time] for their collected plant specimen identification. Each binomial of Table 1, either synonym or accepted, were also searched thoroughly within *Flora of Pakistan*. There were no records (description) for 47 species. The majority of these species belonged to Pteridophytes, some tribes of Compositae and Rosaceae because these are still unpublished. A serious question arises in this case, how the authors of the reviewed articles identified and cross-matched their plant specimens while they did not mentioned any other reliable literature or herbaria sources. Thus, plant material characteristics should be listed, searched and matched carefully with the available description of the species or nomenclatural types in the printed or electronic floras and herbaria of the regions. With every passing day, our taxonomic knowledge is updating and increasing. This should also be incorporated into existing databases like *Flora of Pakistan*. To check this, we also searched all binomials of Table 1 within *Flora of Pakistan*. Unfortunately, we detected many taxonomic errors in this reference source as well. A few examples are documented here, like incorrect author citations and binomial spellings (*Lentopodium alpinum* L. instead of *Leontopodium alpinum* Colm. ex Cass.), as well as accepted binomials treated as synonyms and vice versa [*Clinopodium repens* (Buch.-Ham. ex D.Don) Benth. as synonym of *Calamintha repens* (Buch.-Ham. ex D.Don) Benth.], incorrect synonym attachments [both *Bergenia himalaica* Boriss. and *Bergenia ligulata* Engl. described as synonyms of *Bergenia ciliata* (Haw.) Sternb. instead of *Bergenia pacumbis* (Buch.-Ham. ex D.Don) C.Y.Wu & J.T.Pan] and placement or position errors (*Trillium govanianum* Wall. ex D.Don is positioned in family Trilliaceae instead of Melanthiaceae). Thus, we concluded that *Flora of Pakistan* still has many binomials as accepted which are currently ruled as illegitimate/synonyms on the basis of taxonomic judgments and the principle of priority. Within *Flora of Pakistan*, a total of 197 treatments/volumes (one per family) were published from 1970-1995. Continuous periodic updating of this Pakistan Floral Database is needed because currently this literature source is serving as a reference point for hundreds of studies within Pakisatn annually. This will help the researchers in their future studies and play a vital role in the reduction of taxonomic errors.

As the taxonomic position of one species shifts from one genus to another on the basis of recent advances in molecular biology, thus earlier binomial becomes synonym. The comparative use of this synonym along with the species of previous genus in a study will convey the wrong signals. For example, the position of *Saussurea heteromalla* (D.Don) Hand.-Mazz. is now shifted to a new genus, *Himalaiella heteromalla* (D. Don) Raab-Straube, but if someone designs a comparative molecular study of *Saussurea heteromalla* (D.Don) Hand.-Mazz. and *Saussurea costus* (Falc.) Lipsch., then it will create ambiguity and convey wrong information. According to different ethnobotanical reports from Azad Jammu and Kashmir, *Saussurea costus* (Falc.) Lipsch. is a highly medicinal species. Due to its collection in bulk, it becomes endangered and restricted to few

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Table 1. Species localities of the reviewed articles, reported synonyms alongwith their acceptables and comparative findings within *Flora of Pakistan*.

S/No.	Family	Accepted name/reported synonym	Localities	Ref. (Table 5)	Fl. Pak.
Pteridophytes					
1	Aspleniaceae	*Asplenium dalhousiae* Hook. Syn. *Ceterach dalhousiae* (Hook.) C. Chr.	P	59	×
2		*Ceterach officinarum* Willd. Syn. *Asplenium ceterach* L.	M	41	×
3	Athyriaceae	*Deparia acrostichoides* (Sw.) M. Kato Syn. *Athyrium acrostichoides* (Sw.) Diels	B	97	×
4	Dryopteridaceae	*Dryopteris juxtaposita* Christ Syn. *Dryopteris odontoloma* (Bedd.) C. Chr.	AJ&K	35,36	×
5		*Polystichum discretum* (D. Don) J. Sm. Syn. *Polystichum nigropaleaceum* (Christ) Diels	H,N	30,80	×
6	Thelypteridaceae	*Christella dentata* (Forssk.) Brownsey & Jermy Syn. *Thelypteris dentata* (Forssk.) E.P. St. John	M	41	×
Gymnosperms					
7	Araucariaceae	*Araucaria columnaris* (G. Forst.) Hook. Syn. *Araucaria cookii* R.Br. ex Endl.	AJ&K	34	√
8	Cupressaceae	*Juniperus polycarpos* var. *seravschanica* (Kom.) Kitam. Syn. *Juniperus macropoda* Boiss.	N	65	√
9		*Platycladus orientalis* (L.) Franco Syn. *Thuja orientalis* L.	M,N	53	√
Angiosperms (Dicots)					
10	Acanthaceae	*Dicliptera chinensis* (L.) Juss. Syn. *Dicliptera roxburghiana* Nees	Bh,K,M,P	22,23,24,25,28,29, 50,57,61,71,73,78	√
11		*Justicia adhatoda* L. Syn. *Adhatoda zeylanica* Medik. Syn. *Adhatoda vasica* Nees	B,Bh,H,K, M,Mi,P	22,34,43,46,52,58, 61,63,64,67,71,78, 82,83,87,92,98	√
12		*Justicia quinqueangularis* K.D.Koenig ex Roxb. Syn. *Justicia peploides* (Nees) T.Anderson	P	61	√
13		*Strobilanthes urticifolia* Wall. ex Kuntze Syn. *Strobilanthes attenuata* Nees	H,P	61,87	√
14	Adoxaceae	*Viburnum cylindricum* Buch.-Ham. ex D. Don Syn. *Viburnum coriaceum* Blume	M	32	√
15		*Viburnum grandiflorum* Wall. ex DC. Syn. *Viburnum foetens* Decne.	P	57,61	√

16		*Viburnum odoratissimum* var. *awabuki* (K. Koch) Zabel ex Rümpler Syn. *Viburnum awabuki* K. Koch	M	32	×
17	Aizoaceae	*Zaleya pentandra* (L.) C.Jeffrey Syn. *Trianthema pentandra* L.	B	45	√
18	Amaranthaceae	*Achyranthes aspera* L. Syn. *Achyranthes aspera* var. *aspera* L.	M	41	√
19		*Dysphania ambrosioides* (L.) Mosyakin & Clemants Syn. *Chenopodium ambrosioides* L.	AJ&K,Bh, N	35,36,40,50	√
20		*Dysphania botrys* (L.) Mosyakin & Clemants Syn. *Chenopodium botrys* L.	AJ&K	35,36	√
21		*Suaeda vermiculata* Forssk. ex J.F.Gmel. Syn. *Suaeda fruticosa* Forssk. ex J.F.Gmel.	M	32	√
22	Anacardiaceae	*Cotinus coggygria* Scop. Syn. *Rhus cotinus* L.	H,K,M,P	22,23,25,29,34,41, 61,78,87	√
23		*Pistacia chinensis* subsp. *integerrima* (J. L. Stewart ex Brandis) Rech. f. Syn. *Pistacia integerrima* J. L. Stewart ex Brandis	P	01,57,59,61	√
24	Apiaceae	*Selinum wallichianum* (DC.) Raizada & H.O. Saxena Syn. *Selinum tenuifolium* Salisb.	P	61	√
25	Apocynaceae	*Carissa spinarum* L. Syn. *Carissa opaca* Stapf ex Haines	B,Bh,H,K, M,Mi	01,06,14,22,34,43, 46,50,52,66,69,71, 77,78, 83,86,87,98	√
26		*Cryptolepis dubia* (Burm.f.) M.R.Almeida Syn. *Cryptolepis buchananii* Roem. & Schult.	K	16	√
27		*Nerium oleander* L. Syn. *Nerium indicum* Mill. Syn. *Nerium odorum* Aiton	B,Bh,K,P	22,23,24,25,29,34, 50, 57,61,78,86	√
28		*Vinca major* L. Syn. *Vinca grandiflora* Salisb.	M	41	√
29		*Vincetoxicum hirundinaria* Medik. Syn. *Cynanchum vincetoxicum* (L.) Pers.	P	61	√
30	Balsaminaceae	*Impatiens sulcata* Wall. Syn. *Impatiens gigantea* Edgew.	H	31	√
31	Berberidaceae	*Sinopodophyllum hexandrum* (Royle) T.S.Ying Syn. *Podophyllum emodi* Wall. ex Hook.f. & Thomson Syn. *Podophyllum hexandrum* Royle	B,M,N,P	32,38,39,40,41,44, 59, 61,65,86	√
32	Boraginaceae	*Buglossoides arvensis* (Linn.) I.M. Johnston	P	61	√

		Syn. *Lithospermum arvense* L.			
33		*Buglossoides tenuiflora* (L.f.) I.M.Johnst. Syn. *Lithospermum tenuiflorum* L.f.	M	41	√
34		*Cordia dichotoma* G.Forst. Syn. *Cordia obliqua* Willd.	Bh	50,54	√
35		*Cordia sinensis* Lam. Syn. *Cordia gharaf* Ehrenb. ex Asch.	M	32	√
36		*Cynoglossum wallichii* var. *glochidiatum* (Wall. ex Benth.) Kazmi Syn. *Cynoglossum glochidiatum* Wall. ex Benth.	B,M,P	41,61,88	√
37		*Ehretia acuminata* R.Br. Syn. *Ehretia serrata* Roxb.	K	12	√
38		*Lindelofia macrostyla* (Bunge) Popov Syn. *Lindelofia anchusoides* (Lindl.) Lehm.	M	41	√
39		*Myosotis scorpioides* L. Syn. *Myosotis palustris* (L.) Nathh.	M	41	√
40	Brassicaceae	*Brassica rapa* L. Syn. *Brassica campestris* L.	Bh,H,K,N,P	06,08,50,55,57,69	√
41		*Eruca vesicaria* (L.) Cav. Syn. *Eruca sativa* Mill.	K	18	√
42		*Lepidium didymum* L. Syn. *Coronopus didymus* (L.) Sm. Syn. *Senebiera didyma* (L.) Pers.	K,Mi,P	61,66,76	√
43		*Raphanus raphanistrum* subsp. *sativus* (L.) Domin Syn. *Raphanus sativus* L.	K,P	06,57,69,92	√
44	Burseraceae	*Commiphora mukul* (Hook. ex Stocks) Engl. Syn. *Balsamodendrum mukul* Hook. ex Stocks	AJ&K	60	×
45	Buxaceae	*Sarcococca pruniformis* Lindl. Syn. *Sarcococca saligna* Müll.Arg.	B,H,K,M,P	23,25,29,41,44,61, 85, 86,87,89	√
46	Campanulaceae	*Campanula dimorphantha* Schweinf. Syn. *Campanula benthamii* Wall. ex Kitam.	P	61	√
47		*Codonopsis clematidea* (Schrenk) C.B.Clarke Syn. *Codonopsis obtusa* (Chipp) Nannf.	M	41	√
48	Cannabaceae	*Celtis australis* L. Syn. *Celtis eriocarpa* Decne.	H,K,M,N	12,20,22,40,43,47, 71, 78	√
49		*Celtis australis* subsp. *caucasica* (Willd.) C.C.Towns. Syn. *Celtis caucasica* Willd.	P	44	√

50	Caprifoliaceae	*Valeriana jatamansi* Jones Syn. *Valeriana wallichii* DC.	Ha	45	√
51	Caryophyllaceae	*Silene graminifolia* Otth Syn. *Silene tenuis* Willd.	M	41	√
52		*Vaccaria hispanica* (Mill.) Rauschert Syn. *Vaccaria pyramidata* Medik.	P	61	√
53	Celastraceae	*Gymnosporia royleana* Wall. ex M.A.Lawson Syn. *Maytenus royleana* (Wall. ex M.A. Lawson) Cufod.	H,K,M	06,14,22,43,52,71, 78, 82,83,87	√
54	Compositae	*Achillea santolinoides* subsp. *wilhelmsii* (K.Koch) Greuter Syn. *Achillea wilhelmsii* K.Koch	N	4	√
55		*Anaphalis margaritacea* (L.) Benth. & Hook.f. Syn. *Anaphalis timmua* (Buch.-Ham. ex D.Don) Hand.-Mazz.	H,K	25,87	√
56		*Askellia flexuosa* (Ledeb.) W.A.Weber Syn. *Crepis flexuosa* (Ledeb.) Benth. ex C.B.Clarke	M	41	×
57		*Baccharoides anthelmintica* (L.) Moench Syn. *Vernonia anthelmintica* (L.) Willd.	M	32	×
58		*Chaetoseris macrantha* (C.B.Clarke) C.Shih Syn. *Cicerbita macrantha* (Hook.f. & Thomson ex C.B.Clarke) Beauverd	P	61	×
59		*Chamaemelum nobile* (L.) All. Syn. *Anthemis nobilis* L.	M,P	41,61	√
60		*Chrysanthemum indicum* L. Syn. *Dendranthema indicum* (L.) Des Moul.	P	57	√
61		*Eclipta prostrata* (L.) L. Syn. *Eclipta alba* (L.) Hassk.	M,P	32,61	×
62		*Erigeron acer* var. *multicaulis* (Wall. ex DC.) C.B.Clarke Syn. *Erigeron multicaulis* Wall. ex DC.	P	61	×
63		*Erigeron bonariensis* L. Syn. *Conyza ambigua* DC. Syn. *Conyza bonariensis* (L.) Cronquist	K,M,P	23,25,41,44,61	×
64		*Erigeron canadensis* L. Syn. *Conyza canadensis* (L.) Cronquist	B,H,Ha,K, M,N	08,18,23,25,29,37, 55, 71,73,76,97	×
65		*Eurybia macrophylla* (L.) Cass. Syn. *Aster macrophyllus* L.	P	61	×
66		*Himalaiella heteromalla* (D. Don) Raab-Straube Syn. *Saussurea heteromalla* (D.Don)	K,P	58,61,98	×

		Hand.-Mazz.			
67		*Inula orientalis* Lam. Syn. *Inula grandiflora* Willd.	H,N	31,40	×
68		*Laphangium affine* (D.Don) Tzvelev Syn. *Gnaphalium affine* D.Don	B,P	61,88,91	√
69		*Laphangium luteoalbum* (L.) Tzvelev Syn. *Gnaphalium luteoalbum* L.	P	61	√
70		*Leontopodium nivale* subsp. *alpinum* (Cass.) Greuter Syn. *Leontopodium alpinum* Colm. ex Cass.	M	73	×
71		*Saussurea costus* (Falc.) Lipsch. Syn. *Saussurea lappa* (Decne.) Sch.Bip.	B,H,Ha,N	07,37,40,49,65,85, 100	×
72		*Symphyotrichum molle* (Rydb.) G.L.Nesom Syn. *Aster mollis* Rydb.	M	09	×
73		*Taraxacum campylodes* G.E.Haglund Syn. *Taraxacum officinale* (L.) Weber ex F.H.Wigg.	B,Bh,H,Ha,K,M,N, P	02,06,07,08,09,18, 22,23,25,29,37,40, 41,43,44,49,50,52, 58,61,62,64,65,69, 71,73,76,78,86,87, 88,91,97,98	×
74	Convolvulaceae	*Ipomoea aristolochiifolia* G. Don Syn. *Ipomoea cordata* L.B. Sm. & B.G. Schub.	K	23,25	×
75		*Ipomoea nil* (L.) Roth Syn. *Ipomoea hederacea* (L.) Jacq.	K	16,18	√
76	Crassulaceae	*Rosularia adenotricha* (Wall. ex Edgew.) C.-A. Jansson Syn. *Sedum adenotrichum* Wall. ex Edgew.	M,P	41,61	√
77	Cucurbitaceae	*Citrullus lanatus* (Thunb.) Matsum. and Nakai Syn. *Citrullus vulgaris* Schrad.	P	57,92	√
78		*Cucumis melo* L. Syn. *Cucumis melo* var. *agrestis* Naudin	Bh	62	√
79		*Luffa cylindrica* (L.) M. Roem. Syn. *Luffa aegyptiaca* Mill.	Bh,P	50,57	√
80		*Trichosanthes cucumerina* L. Syn. *Trichosanthes anguina* L. Syn. *Trichosanthes cucumerina* var. *anguina* (L.) Haines	Bh,K,P	16,50,57	√
81	Elaeagnaceae	*Elaeagnus angustifolia* L. Syn. *Elaeagnus orientalis* L.	M	41	√
82		*Elaeagnus rhamnoides* (L.) A.Nelson Syn. *Hippophae rhamnoides* L.	AJ&K	34	×

83	Euphorbiaceae	*Chrozophora plicata* (Vahl) A.Juss. ex Spreng. Syn. *Croton plicatus* Vahl	P	61	√
84		*Euphorbia cashmeriana* Royle Syn. *Euphorbia cognata* (Klotzsch) Boiss.	P	57,58,61	√
85	Fagaceae	*Quercus floribunda* Lindl. ex A.Camus Syn. *Quercus dilatata* Royle	B,H,K,M, N,P	20,22,23,24,25,26, 27,29,32,34,39,40, 41,44,47,57,61,78, 86,89,90	√
86		*Quercus oblongata* D.Don Syn. *Quercus leucotrichophora* A.Camus	B	91	×
87		*Quercus robur* L. Syn. *Quercus lanuginosa* Beck	B	89	√
88	Gentianaceae	*Gentiana argentea* (Royle ex D.Don) Royle ex D.Don Syn. *Gentianodes argentea* (Royle ex D.Don) Omer, Ali & Qaiser	N	40	√
89		*Gentiana kurroo* Royle Syn. *Gentianodes kurroo* (Royle) Omer, Ali & Qaiser	M,N	32,39,40	√
90	Geraniaceae	*Geranium mascatense Boiss.* Syn. *Geranium ocellatum* Jacquem. ex Cambess.	K	18	√
91	Juglandaceae	*Engelhardtia spicata* var. *integra* (Kurz) Man. ex Steenis Syn. *Engelhardtia colebrookiana* Lindl.	K	12	√
92	Lamiaceae	*Ajuga integrifolia* Buch.-Ham. Syn. *Ajuga bracteosa* Wall. ex Benth.	B,H,Ha,K, M,N,P	06,07,08,09,18,22, 23,25,29,32,35,36, 37,39,40,41,44,45, 46,55,61,68,71,78, 86,89,91	√
93		*Clinopodium hydaspidis* (Falc. ex Benth.) Kuntze Syn. *Micromeria hydaspidis* Falc. ex Benth.	P	61	√
94		*Clinopodium repens* (Buch.-Ham. ex D.Don) Benth. Syn. *Calamintha repens* (Buch.-Ham. ex D.Don) Benth.	P	61	×
95		*Clinopodium umbrosum* (M.Bieb.) Kuntze Syn. *Calamintha umbrosa* (M. Bieb.) Fisch. & C.A. Mey.	M,P	61,73	√
96		*Clinopodium vulgare* L. Syn. *Calamintha vulgaris* (L.) Druce	P	61	√
97		*Isodon coetsa* (Buch.-Ham. ex D.Don) Kudô Syn. *Plectranthus coetsa* Buch.-Ham. ex D.Don	P	61	√

98		*Isodon lophanthoides* var. *graciliflorus* (Benth.) H.Hara Syn. *Plectranthus striatus* Benth.	P	61	√
99		*Isodon rugosus* (Wall. ex Benth.) Codd Syn. *Plectranthus rugosus* Wall. ex Benth. Syn. *Rabdosia rugosa* (Wall. ex Benth.) H.Hara	H,K,M,N, P	07,08,22,23,25,26, 29,40,41,49,61,78	√
100		*Leucas cephalotes* (Roth) Spreng. Syn. *Leucas capitata* Desf.	K,P	22,61,78	√
101		*Mentha longifolia* (L.) L. Syn. *Mentha sylvestris* L.	Bh,P	50,57	√
102		*Mentha spicata* L. Syn. *Mentha viridis* (L.) L.	P	57	√
103		*Phlomoides bracteosa* (Royle ex Benth.) Kamelin & Makhm. Syn. *Phlomis bracteosa* Royle ex Benth.	M,N,P	40,41,61	√
104		*Phlomoides spectabilis* (Falc. ex Benth.) Kamelin & Makhm. Syn. *Phlomis cachemeriana* Benth. Syn. *Phlomis spectabilis* Falc. ex Benth.	M,P	41,61	√
105		*Phlomoides superba* (Royle ex Benth.) Kamelin and Makhm. Syn. *Eremostachys superba* Royle ex Benth.	K	18	√
106		*Pseudocaryopteris bicolor* (Roxb. ex Hardw.) P.D. Cantino Syn. *Caryopteris odorata* (D.Don) B.L.Rob.	K,P	14,57,59,61	√
107		*Roylea cinerea* (D.Don) Baill. Syn. *Roylea calycina* (Roxb.) Briq.	P	61	√
108		*Rydingia limbata* (Benth.) Scheen and Albert Syn. *Otostegia limbata* (Benth.) Boiss.	H,K,P	06,14,22,23,24,25, 26,29,34,35,36,55, 61,77,78,82,83,94	√
109		*Salvia mukerjeei* Bennet & Raizada Syn. *Salvia lanata* Roxb.	P	44,61	√
110		*Salvia nilotica* Juss. ex Jacq. Syn. *Salvia parviflora* Salisb.	M	41	×
111		*Scutellaria chamaedrifolia* Hedge & A.J.Paton Syn. *Scutellaria teucriifolia* Dunn	P	61	√
112		*Stachys melissifolia* Benth. Syn. *Stachys emodi* Hedge	B	88	
113	Lauraceae	*Machilus duthiei* King Syn. *Persea duthiei* (King) Kosterm.	B,P	57,61	√

114		*Neolitsea levinei* Merr. Syn. *Neolitsea chinensis* (Gamble) Chun	AJ&K	34	×
115		*Persea odoratissima* (Nees) Kosterm. Syn. *Machilus odoratissimus* Nees	B	90	√
116	Leguminosae	*Acacia nilotica* (L.) Delile Syn. *Acacia arabica* (Lam.) Willd.	H,K,M	47,71,73,82	√
117		*Astragalus rhizanthus* subsp. *candolleanus* (Benth.) Podlech Syn. *Astragalus candolleanus* Benth.	M,P	41,61	√
118		*Codariocalyx motorius* (Houtt.) H.Ohashi Syn. *Desmodium motorium* (Houtt.) Merr.	AJ&K	34	√
119		*Desmodium elegans* DC. Syn. *Desmodium tiliaefolium* G.Don	P	61	√
120		*Hylodesmum podocarpum* (DC.) H.Ohashi & R.R.Mill Syn. *Desmodium podocarpum* DC.	P	44,57,59,61	√
121		*Indigofera heterantha* Brandis Syn. *Indigofera gerardiana* Baker	Ha	37	√
122		*Lens culinaris* Medik. Syn. *Lens esculenta* Moench	Bh	45	√
123		*Medicago polymorpha* L. Syn. *Medicago denticulata* Willd.	K,M,P	23,25,29,41,57	√
124		*Melilotus officinalis* subsp. *alba* (Medik.) H.Ohashi & Tateishi Syn. *Melilotus alba* Ledeb.	K,M,P	02,44,76	√
125		*Senna alexandrina* Mill. Syn. *Cassia angustifolia* Vahl	AJ&K	34	√
126		*Senna obtusifolia* (L.) H.S.Irwin & Barneby Syn. *Cassia obtusifolia* L.	AJ&K	34	√
127		*Senna occidentalis* (L.) Link Syn. *Cassia occidentalis* L.	K,Mi	14,34,66	√
128		*Vigna aconitifolia* (Jacq.) Marechal Syn. *Phaseolus aconitifolius* Jacq.	Bh	45	√
129		*Vigna mungo* (L.) Hepper Syn. *Phaseolus mungo* L.	Bh	45,50	√
130	Linaceae	*Reinwardtia indica* Dumort. Syn. *Reinwardtia trigyna* Planch.	K	14	√
131	Lythraceae	*Trapa natans* var. *bispinosa* (Roxb.) Makino Syn. *Trapa bispinosa* Roxb.	Bh	62	√
132	Malvaceae	*Abelmoschus esculentus* (L.) Moench Syn. *Hibiscus esculentus* L.	B,M,P	45,57,97	√

133		*Alcea rosea* L. Syn. *Althaea rosea* (L.) Cav.	H	49	√
134		*Bombax ceiba* L. Syn. *Bombax malabaricum* DC. Syn. *Salmalia malabarica* (DC.) Schott & Endl	M,P	01,02,34,57	√
135	Meliaceae	*Azadirachta indica* A. Juss. Syn. *Melia azadirachta* L.	Bh,K,P	06,54,92	√
136		*Toona ciliata* M. Roem. Syn. *Cedrela toona* Roxb. ex Rottler	Bh,K,P	12,34,54,57,58,61	√
137	Menispermaceae	*Tinospora sinensis* (Lour.) Merr. Syn. *Tinospora cordifolia* (Willd.) Miers Syn. *Tinospora malabarica* (Lam.) Hook. f. & Thomson	K	16	√
138	Moraceae	*Ficus racemosa* L. Syn. *Ficus glomerata* Roxb.	P	57,61	√
139		*Ficus sarmentosa* Buch.-Ham. ex Sm. Syn. *Ficus foveolata* (Wall. ex Miq.) Miq.	AJ&K,M, P	34,35,36,41,61	√
140		*Morus macroura* Miq. Syn. *Morus laevigata* Wall. ex Brandis	AJ&K,Bh	03,34,54	√
141	Myrtaceae	*Corymbia citriodora* (Hook.) Hill and John. Syn. *Eucalyptus citriodora* Hook.	B,Bh,K,M i	06,34,50,67,97	√
142		*Eucalyptus camaldulensis* Dehnh. Syn. *Eucalyptus rostrata* Schltdl.	AJ&K	34	√
143		*Eucalyptus robusta* Sm. Syn. *Eucalyptus rostrata* Cav.	P	61	√
144		*Syzygium cumini* (L.) Skeels Syn. *Eugenia jambolana* Lam.	Bh,K	34,54,98,99	√
145	Oleaceae	*Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif. Syn. *Olea cuspidata* Wall. & G.Don Syn. *Olea ferruginea* Royle	B,Bh,H,K, M,N,P	01,06,07,08,12,20, 22,23,24,25,27,29, 32,34,35,36,43,48, 49,50,52,54,57,61, 71,78,82,83,84,87, 89,90,92,98,99	√
146	Papaveraceae	*Corydalis cornuta* Royle Syn. *Corydalis stewartii* Fedde	B,N	40,88	√
147	Phyllanthaceae	*Glochidion heyneanum* (Wight & Arn.) Wight Syn. *Glochidion velutinum* Wight	K	77	√
148		*Leptopus cordifolius* Decne. Syn. *Andrachne cordifolia* (Decne.) Müll.Arg.	B,M,P	41,57,58,61,86	√
149		*Phyllanthus emblica* L. Syn. *Emblica officinalis* Gaertn.	K	98,99	√

150	Plantaginaceae	*Plantago ovata* Forssk. Syn. *Plantago ispaghula* Roxb. ex Fleming	B	86	√
151		*Veronica polita* Fr. Syn. *Veronica didyma* Ten.	P	61	×
152		*Wulfeniopsis amherstiana* (Benth.) D.Y. Hong Syn. *Wulfenia amherstiana* Benth.	B,M,N,P	40,41,61,86	×
153	Polygonaceae	*Persicaria alpina* (All.) H.Gross Syn. *Aconogonon alpinum* (All.) Schur Syn. *Polygonum alpinum* All.	B,H,Ha,N, P	31,37,61,65,85,97	√
154		*Persicaria amplexicaulis* (D.Don) Ronse Decr. Syn. *Bistorta amplexicaulis* (D.Don) Greene Syn. *Polygonum amplexicaule* D.Don	B,H,Ha,M ,N,P	02,07,08,31,32,37, 39,40,41,49,59,61, 68,85,86,89,100	√
155		*Persicaria bistorta* (L.) Samp. Syn. *Polygonum bistorta* L.	B	97	×
156		*Persicaria nepalensis* (Meisn.) Miyabe Syn. *Polygonum nepalense* Meisn.	B,M,P	41,61,86,88,91	√
157		*Persicaria vivipara* (L.) Ronse Decr. Syn. *Polygonum viviparum* L.	AJ&K	35,36	×
158	Primulaceae	*Androsace sarmentosa* subsp. *primuloides* (Duby) Govaerts Syn. *Androsace primuloides* Duby	P	61	√
159		*Androsace tibetica* (Maxim.) R.Knuth Syn. *Androsace himalaica* (R.Knuth) Hand.-Mazz.	M	41	√
160	Ranunculaceae	*Anemone obtusiloba* D.Don Syn. *Anemone neelamiana* Qureshi & Chaudhri	M,N	32,39	√
161		*Caltha palustris* var. *alba* (Cambess.) Hook.f. & Thomson Syn. *Caltha alba* Cambess.	B,M,N,P	40,41,44,88,91	√
162		*Consolida ajacis* (L.) Schur Syn. *Delphinium ajacis* L.	N	40	√
163	Rhamnaceae	*Ziziphus jujuba* Mill. Syn. *Ziziphus mauritiana* Lam. Syn. *Ziziphus sativa* Gaertn. Syn. *Ziziphus vulgaris* Lam.	Bh,K,M,P	06,12,29,32,34,54, 57,61	√
164	Rosaceae	*Acomastylis elata* (Wall. ex G.Don) F.Bolle Syn. *Geum elatum* Wall. ex G.Don	B,P	61,88,91,97	×
165		*Cotoneaster bacillaris* Wall. ex Lindl. Syn. *Cotoneaster affinis* var. *bacillaris* (Wall. ex Lindl.) C.K.Schneid.	M	41	×

166		*Dasiphora fruticosa* (L.) Rydb. Syn. *Potentilla fruticosa* L.	B	97	×
167		*Malus domestica* Borkh. Syn. *Pyrus malus* L.	Bh,H,P	34,50,54,55,92	×
168		*Prunus domestica* L. Syn. *Prunus communis* Huds.	AJ&K	34	×
169		*Prunus dulcis* (Mill.) D.A.Webb Syn. *Prunus amygdalus* Batsch	M	41	×
170		*Rosa moschata* Herrm. Syn. *Rosa brunonii* Lindl.	K,M,P	01,06,16,34,41,44, 61	√
171		*Rosa pendulina* L. Syn. *Rosa alpina* L.	N	40	×
172		*Rubus vulgaris* Weihe & Nees Syn. *Rubus fruticosus* L. ex Dierb.	B,Bh,H,K, M,N,P	14,22,23,24,25,29, 32,35,36,39,41,44, 47,49,50,52,55,57, 61,73,78,85,86,94	×
173	Rubiaceae	*Himalrandia tetrasperma* (Wall. ex Roxb.) T.Yamaz. Syn. *Randia tetrasperma* (Wall. ex Roxb.) Benth. & Hook.f. ex Brandis	P	61	√
174		*Wendlandia heynei* (Schult.) San. & Mer. Syn. *Wendlandia exserta* (Roxb.) DC.	K	12	√
175	Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle Syn. *Citrus* × *acida* Pers.	Bh	54	√
176		*Citrus medica* L. Syn. *Citrus limetta* Risso	AJ&K	34	√
177		*Zanthoxylum armatum* DC. Syn. *Zanthoxylum alatum* Roxb.	B,Bh,H,K, M,P	23,24,25,29,43,49, 52,54,57,58,59,61, 71,92,94,97	√
178	Sabiaceae	*Meliosma simplicifolia* (Roxb.) Walp. Syn. *Meliosma pungens* Hook.f.	P	61	√
179	Salicaceae	*Populus* × *canadensis* Moench Syn. *Populus euramericana* Guinier	AJ&K	34	×
180		*Salix disperma* Roxb. ex D.Don. Syn. *Salix wallichiana* Andersson	H	47	√
181	Sapindaceae	*Cardiospermum microcarpum* Kunth Syn. *Cardiospermum halicacabum* var. *microcarpum* (Kunth) Blume	K,P	16,61	√
182	Saxifragaceae	*Bergenia pacumbis* (Buch.-Ham. ex D.Don) C.Y.Wu & J.T.Pan Syn. *Bergenia himalaica* Boriss. Syn. *Bergenia ligulata* Engl.	AJ&K,K, M	23,25,29,35,73	×
183	Simaroubaceae	*Brucea javanica* (L.) Merr. Syn. *Rhus javanica* L.	M	41	√

184	Solanaceae	*Capsicum annuum* L. Syn. *Capsicum frutescens* L.	M,P	33,57	√
185		*Datura metel* L. Syn. *Datura alba* Rumph. ex Nees Syn. *Datura fastuosa* L.	AJ&K,Bh	34,45	√
186		*Solanum americanum* Mill. Syn. *Solanum nigrum* L.	B,Bh,H,K, M, Mi,N,P	01,02,06,09,18,22, 23,25,29,32,33,35, 36,39,40,41,45,49, 52,64,65,66,68,73, 78,86,92,94,97	√
187		*Solanum villosum* Mill. Syn. *Solanum miniatum* Bernh. ex Willd.	Bh	50	√
188		*Solanum virginianum* L. Syn. *Solanum xanthocarpum* Schrad. & H. Wendl.	H,K	22,52,55,78,82	×
189	Urticaceae	*Boehmeria macrophylla* Hornem. Syn. *Boehmeria platyphylla* D.Don	M	41	√
190		*Debregeasia saeneb* (Forssk.) Hepper & J.R.I.Wood Syn. *Debregeasia salicifolia* (D.Don) Rendle	K,M,P	14,23,25,29,34,44, 58,57,61,71	√
191	Violaceae	*Viola pilosa* Blume Syn. *Viola serpens* Wall. ex Ging.	B,Bh,K,M	32,50,86,98	√
192	Vitaceae	*Cayratia trifolia* (L.) Domin Syn. *Vitis trifolia* L.	P	61	×
193		*Cissus trifoliata* (L.) L. Syn. *Cissus carnosa* Lam.	K	06	√
194		*Cissus vitiginea* L. Syn. *Vitis vitiginea* (L.) W.Theob.	Bh	50	×
195	Zygophyllaceae	*Tetraena simplex* (L.) Beier & Thulin Syn. *Zygophyllum simplex* L.	M	32	√
Angiosperms (Monocots)					
196	Araceae	*Arisaema propinquum* Schott Syn. *Arisaema wallichianum* Hook.f.	H	31	√
197		*Sauromatum venosum* (Dryand. ex Aiton) Kunth Syn. *Sauromatum guttatum* Schott	K,M	22,45,78	√
198	Arecaceae	*Chamaerops humilis* L. Syn. *Phoenix humilis* Royle	AJ&K	34	×
199	Asparagaceae	*Asparagus capitatus* subsp. *gracilis* Browicz Syn. *Asparagus gracilis* Royle ex Baker	AJ&K,K	18,22,35,52,71,78, 82,83	√
200		*Fessia purpurea* (Griff.) Speta Syn. *Scilla griffithii* Hochr.	AJ&K	35	√

201	Cyperaceae	*Cyperus cruentus* Rottb. Syn. *Cyperus globosus* Forssk.	K	23,25,29	×
202		*Cyperus serotinus* Rottb. Syn. *Juncellus serotinus* (Rottb.) C.B.Clarke	K	22,23,25	√
203		*Eriophorum comosum* (Wall.) Nees Syn. *Erioscirpus comosus* (Wall.) Palla	K	18,22,78	√
204		*Fimbristylis quinquangularis* (L.) Vahl. Syn. *Fimbristylis miliacea* (L.) Vahl	K	76	√
205		*Scirpoides holoschoenus* (L.) Soják Syn. *Scirpus holoschoenus* L.	M	41	√
206	Liliaceae	*Fritillaria cirrhosa* D.Don Syn. *Fritillaria roylei* Hook.	B,M,N	40,41,88,91	√
207		*Gagea lutea* (L.) Ker Gawl. Syn. *Gagea elegans* Wall. ex G.Don	M,P	41,61	√
208		*Tulipa clusiana* DC. Syn. *Tulipa stellata* Hook.	M,P	02,61	√
209	Melanthiaceae	*Trillium govanianum* Wall. ex D.Don Syn. *Trillidium govanianum* (Wall. ex D.Don) Kunth	M	41	√
210	Orchidaceae	*Herminium lanceum* (Thunb. ex Sw.) Vuijk Syn. *Spiranthes lancea* (Thunb. ex Sw.) Bakh.f. & Steenis	M	41	√
211	Poaceae	*Cenchrus ciliaris* L. Syn. *Pennisetum cenchroides* Rich.	Bh	62	√
212		*Elymus dentatus* (Hook.f.) Tzvelev Syn. *Agropyron dentatum* Hook.f.	M	41	√
213		*Glyceria notata* Chevall. Syn. *Glyceria plicata* (Fr.) Fr.	B	97	√
214		*Oplismenus burmanni* (Retz.) P.Beauv. Syn. *Oplismenus burmannii* f. *cristata* (J. Presl) Hier. ex Peter	P	61	√
215		*Pennisetum glaucum* (L.) R. Br. Syn. *Pennisetum typhoideum* Rich.	Bh	50	√
216		*Poa nemoralis* L. Syn. *Agrostis alba* L.	N	40	√
217		*Polypogon hissaricus* (Roshev.) Bor Syn. *Agrostis hissarica* Roshev.	B	97	√
218		*Polypogon viridis* (Gouan) Breistr. Syn. *Agrostis viridis* Gouan	B,K	52,76,82,83,97	√
219		*Setaria pumila* (Poir.) Roem. & Schult. Syn. *Setaria pallidifusca* (Schumach.) Stapf & C.E.Hubb.	Bh	50	√

220		*Sporobolus ioclados* (Trin.) Nees Syn. *Sporobolus arabicus* Boiss.	M	41	√
221		*Tenaxia cachemyriana* (Jaub. & Spach) N.P.Barker & H.P.Linder Syn. *Danthonia cachemyriana* Jaub. & Spach	B	97	√
222		*Tenaxia cumminsii* (Hook.f.) N.P.Barker & H.P.Linder Syn. *Danthonia schneideri* Pilg.	B	97	√
223	Smilacaceae	*Smilax elegans* Wall. ex Kunth Syn. *Smilax glaucophylla* Klotzsch	P	44	√
224	Xanthorrhoeaceae	*Aloe vera* (L.) Burm.f. Syn. *Aloe barbadensis* Mill.	M,Mi,P	45,67,92	√

Legends: AJ&K-Azad Jammu & Kashmir; B-Bagh; Bh-Bhimber; H-Hattian; Ha-Haveli; K-Kotli; M-Muzaffarabad; Mi-Mirpur; N-Neelam; P-Poonch; √-Species description exist; ×-Species description didn't exist within *Flora of Pakistan* (Fl. Pak.).

very small microhabitats (07, 37, 40, 49, 65, 85 & 100 of Table 5). Thus, taxonomically it should be conveyed/communicated correctly through publications which otherwise cause ambiguity and confusion related to its future conservational measures and ethnobotanical uses. To avoid the use of synonyms and incorrect author citations, abbreviation, rank and position of a taxon, a coherent, reliable and updated taxonomic database like TPL/IPNI can be employed (Rivera *et al.*, 2014, Khan *et al.*, 2015). A lack of such basic taxonomy skills and a careless attitude regarding the issue created more problems and confusion. Because taxonomic errors in botanical articles decrease the reliability and utility of research related to plant sciences, the issue should be addressed regularly to reduce the negative impact. Every botanist should identify the correct identity and current status of their specimens before communicating it through publication (Venu, 2002).

The maximum number of synonyms belonging to family Lamiaceae, (23) was communicated/conveyed followed by Compositae (21), Leguminosae (14) and Poaceae (12) in reviewed articles. *Olea cuspidata* Wall. & G.Don and *Olea ferruginea* Royle are the synonyms of *Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif. These two synonyms were encountered in the maximum number of reviewed articles (35), followed by *Taraxacum officinale* (L.) Weber ex F.H.Wigg. in 34, *Solanum nigrum* L. in 29, *Ajuga bracteosa* Wall. ex Benth. in 27, *Rubus fruticosus* L. ex Dierb. in 24, *Zanthoxylum alatum* Roxb. in 22 and *Quercus dilatata* Royle in 21 articles (Table 2).

All of the 100 reviewed articles were published in different national, as well as international journals during 1999-2015. These articles were categorized on the basis of time periods or years of publication into 8 groups. For example, two reviewed articles published from

Table 2. Leading families and synonyms communicated in the reviewed articles

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S/No.	Family	No. of Syn.	Leading Synonyms	No. of Articles
1	Lamiaceae	24	*Olea cuspidata* Wall. & G.Don *Olea ferruginea* Royle	35
2	Compositae	21	*Taraxacum officinale* (L.) Weber ex F.H.Wigg.	34
3	Leguminosae	14	*Solanum nigrum* L.	29
4	Poaceae	12	*Ajuga bracteosa* Wall. ex Benth.	27
5	Rosaceae	9	*Rubus fruticosus* L. ex Dierb.	24
6	Boraginaceae	8	*Zanthoxylum alatum* Roxb.	22
7	Polygonaceae	7	*Quercus dilatata* Royle	21
8	Solanaceae	6	*Otostegia limbata* (Benth.) Boiss.	18
9	Brassicaceae	5	*Carissa opaca* Stapf ex Haines	18
10	Cucurbitaceae	5	*Bistorta amplexicaulis* (D.Don) Greene *Polygonum amplexicaule* D.Don	17
11	Cyperaceae	5	*Adhatoda zeylanica* Medik. *Adhatoda vasica* Nees	17

1999-2001 were placed in the first group/category. Within this, a total of 88 species names were mentioned, out of which 16 were detected as synonyms. Thus the % synonyms error during this time period remained 18.18. Similarly, seven more categories developed for the years 2002-2015. In each category, 3 important variables, viz. number of articles reviewed, number of species names mentioned/communicated in the articles and number of synonyms communicated/detected, in these articles were counted. All 241 synonyms detected in reviewed articles were taken as a sub sample for further analysis like incorrect author citation, non-standardized abbreviations and orthographic errors. A total of 712 errors linked with 241 synonyms of 100 reviewed articles related to incorrect author citations (333), and non-standardized abbreviations and orthographic errors (379) were detected (Table 5). This of course was a huge number, representative of modest basic taxonomic skills. Also, one can imagine the error number if we go through all binomials (1350) of reviewed articles. Highest and consistent % synonym error value during 1999 to 2015 confirmed the modest taxonomic skills and careless attitude of authors towards the taxonomic issues in the area (Table 3). Pearson correlation of Table 3 variables like NAR, TSC and SCA depicted a strong positive ($r \geq +0.99$) and significant (p-values $\leq 2.06745^{E-06}$) relationship amongst all. This also suggested that the intensity of synonymy in botanical literature remained consistent during the years 1999 to the present irrespective of the fact that researchers communicated either few or hundards of binomials in their studies (Table 4).

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Table 3. Taxonomic errors grouping with respect to time period.

Time Period /Years	NAR	TSC	SCA	% Syn. Error	X	Y	Z=X+Y
1999-2001	2	88	16	18.18	5	6	11
2002-2003	3	171	22	12.86	9	9	18
2004-2005	3	117	13	11.11	5	4	9
2006-2007	8	244	36	14.75	15	19	34
2008-2009	5	302	42	13.91	15	26	41
2010-2011	14	584	81	13.87	25	16	41
2012-2013	41	2433	336	13.81	153	192	345
2014-2015	24	1521	204	13.41	106	107	213
Total/Ave.	**100**	**5460**	**750**	**13.99**	**333**	**379**	**712**

(**Legends)** NAR: No. of articles reviewed; TSC: Total spp. binomials communicated; SCA: Synonyms communicated in articles; X: Incorrect author citations; Y: Non-standardized abbreviations & orthographic errors.

Table 4. Pearson Correlation of NAR, TSC and SCA variables of Table 3.

Taxonomic Review of Botanical Literature		NAR	TSC	SCA
NAR	Pearson Correlation	1	0.990591474	0.991859965
	Sig. (2-tailed)		2.06745^{E-06}**	1.34018^{E-06}**
	N	8	8	8
TSC	Pearson Correlation	0.990591474	1	0.999680203
	Sig. (2-tailed)	2.06745^{E-06}**		8.17449^{E-11}**
	N	8	8	8
SCA	Pearson Correlation	0.991859965	0.999680203	1
	Sig. (2-tailed)	1.34018^{E-06}**	8.17449^{E-11}**	
	N	8	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

An incorrect author citation of a species simply means the tagging of a person with a species about which he or she did not work on. For example, both *Olea ferruginea* Wall. ex Aitch. and *Olea ferruginea* (Aiton) Steud. are homonyms belonging to two different types. The former one is an accepted binomial, whereas the latter one is declared a synonym of *Olea europaea* L. Thus, utmost care should be considered while writing authors of species. In addition to this, Brummitt and Powell (1992) communicated the standardized author abbreviations before the reviewed articles time span, but these were not considered. By using different online tools, we simply corrected the above mentioned errors and presented our results in tabular form (Table 1) in this article for future reference.

Different authors of the reviewed articles communicated different numbers of synonyms (one-to-many) in their studies. For example, authors of articles 30

and 38 worked on a single species, though they did not communicate accepted species binomials, whereas authors 41 and 61 communicated the maximum number of synonyms simply because they coveyed maximum number of species binomials (409 and 410 respectively) in their articles. These studies were related to species composition or phytodiversity of Machiara National Park, Muzaffarabad and district Poonch respectively (Table 5). Similarly, the confusing and most problematic impact of synonymy was not kept in mind, thus various authors viz. 23, 25, 29 & 61 (Table 5) recognized *Plectranthus rugosus* Wall. ex Benth. and *Rabdosia rugosa* (Wall. ex Benth.) H.Hara as two different species, even though both are synonyms of *Isodon rugosus* (Wall. ex Benth.) Codd. These four articles were related to conservation and ethnobotany thus conveying the faulty message and confusion especially amongst the non-taxonomists. Similarly authors of reviewed article 54 treated *Ziziphus mauritiana* Lam. and *Ziziphus sativa* Gaertn. as different species. Reporting a synonym instead of accepted binomials in articles creates less confusion as compared to when two or more synonyms of the same taxon are considered different species or when one accepted binomial and one of its synonyms treated as different species. Similar type of errors were also detected in reviewed articles 33 and 37 where authors treated *Capsicum annuum* L. and *Capsicum frutescens* L. and *Saussurea costus* (Falc.) Lipsch. and *Saussurea lappa* (Decne.) Sch. Bip. as two different species but actually the latter one in both cases is presently declared as a synonym of the first one. The use of various online tools to improve the basic skills in taxonomy and reducing the taxonomic errors to increase the reliability and reproducibility of botanical results are still a neglected field in Pakistan. When conservationists, ethnobotanists or ethnopharmacologists develop conservation strategies, record indigenous uses, discover the diversity and efficiency of plant active constituents respectively but if fail to provide a correct and current taxonomic identification of their plant material, all their efforts become wasted. All these taxonomic drawbacks need immediate attention otherwise, the issue will worsen day by day.

Table 5. Taxonomic and orthographic errors in the reviewed articles.

AAC	Reviewed articles	TSC	SCA	X	Y
1	Abbasi *et al.*, 2013a	20	6	1	3
2	Abbasi *et al.*, 2013b	45	6	5	4
3	Abbasi *et al.*, 2014	4	1	1	0
4	Adnan *et al.*, 2014	5	0	0	0
5	Ahmad *et al.*, 2008	1	0	0	0
6	Ahmad *et al.*, 2012a	112	13	3	6
7	Ahmad *et al.*, 2012b	39	6	2	1
8	Ahmad & Habib, 2014	59	7	0	2
9	Ahmed *et al.*, 2014a	30	4	3	1
10	Ahmed *et al.*, 2014b	1	0	0	0
11	Ahmed & Murtaza, 2015	24	0	0	0
12	Ajaib & Khan, 2014	39	7	1	4
13	Ajaib *et al.*, 2008	0	0	0	0
14	Ajaib *et al.*, 2010	38	8	1	3
15	Ajaib *et al.*, 2011	1	0	0	0

16	Ajaib *et al.*, 2012	36	6	2	3
17	Ajaib *et al.*, 2014a	1	0	0	0
18	Ajaib *et al.*, 2014b	93	10	3	2
19	Alamzeb *et al.*, 2013	1	0	0	0
20	Amjad, 2012a	10	3	3	0
21	Amjad, 2012b	97	0	0	0
22	Amjad, 2013	97	21	9	12
23	Amjad *et al.*, 2013a	110	21	9	12
24	Amjad *et al.*, 2013b	110	7	7	0
25	Amjad *et al.*, 2014a	110	22	11	13
26	Amjad *et al.*, 2014b	110	3	3	0
27	Amjad *et al.*, 2014c	5	2	1	2
28	Amjad *et al.*, 2014d	0	0	0	0
29	Amjad *et al.*, 2015	104	19	7	8
30	Awan *et al.*, 2013a	1	1	0	1
31	Awan *et al.*, 2013b	13	5	1	6
32	Awan *et al.*, 2013c	118	18	12	10
33	Awan & Murtaza, 2013	15	2	0	2
34	Bano *et al.*, 2013	168	30	6	16
35	Bokhari *et al.*, 2013a	66	13	3	2
36	Bokhari *et al.*, 2013b	46	10	10	3
37	Ch *et al.*, 2013	45	7	3	4
38	Chaudhari *et al.*, 2014	1	1	0	0
39	Dar, 2003	52	8	6	2
40	Dar & Malik, 2009	180	22	8	10
41	Dar *et al.*, 2012	409	48	10	41
42	Dar *et al.*, 2014	0	0	0	0
43	Dastagir *et al.*, 1999	35	7	2	1
44	Faiz *et al.*, 2014	146	15	15	1
45	Gorsi, 2002	76	11	0	6
46	Gorsi & Shahzad, 2002	43	3	3	1
47	Habib *et al.*, 2010	31	5	4	3
48	Habib *et al.*, 2011	2	1	1	0
49	Habib *et al.*, 2013	43	9	6	8
50	Hussain & Ch, 2009	120	20	7	16
51	Hussain *et al.*, 2014a	49	0	0	0
52	Hussain *et al.*, 2014b	49	11	4	11
53	Ishtiaq *et al.*, 2013a	12	1	0	0
54	Ishtiaq *et al.*, 2013b	58	10	6	9
55	Ishtiaq *et al.*, 2014	36	7	1	5
56	Javed *et al.*, 2012	3	0	0	0
57	Khan *et al.*, 2010	169	29	3	4
58	Khan *et al.*, 2012a	19	8	2	12
59	Khan *et al.*, 2012b	56	7	7	0
60	Khan *et al.*, 2014a	6	1	1	0

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61	Khan *et al.*, 2014b	410	76	49	54
62	Mahmood *et al.*, 2011a	32	4	1	0
63	Mahmood *et al.*, 2011b	24	1	0	0
64	Mahmood *et al.*, 2011c	38	3	1	0
65	Mahmood *et al.*, 2011d	40	6	1	0
66	Mahmood *et al.*, 2011e	29	4	1	2
67	Mahmood *et al.*, 2012a	35	3	1	0
68	Mahmood *et al.*, 2012b	61	3	0	0
69	Mahmood *et al.*, 2012c	25	3	1	4
70	Malik & Malik, 2004a	58	0	0	0
71	Malik & Malik, 2004b	58	13	5	4
72	Malik & Malik, 2012	0	0	0	0
73	Malik *et al.*, 2007a	77	9	4	4
74	Malik *et al.*, 2007b	0	0	0	0
75	Malik *et al.*, 2013a	0	0	0	0
76	Malik *et al.*, 2013b	63	6	5	1
77	Manzoor *et al.*, 2013	159	3	3	1
78	Muhammad *et al.*, 2012	96	20	9	18
79	Murtaza *et al.*, 2004	1	0	0	0
80	Murtaza *et al.*, 2006	4	1	0	1
81	Murtaza *et al.*, 2008	1	0	0	0
82	Nazir & Malik, 2006	38	8	3	3
83	Nazir *et al.*, 2012	40	7	7	0
84	Qasim *et al.*, 2010	24	1	0	0
85	Qureshi *et al.*, 2007	33	5	2	2
86	Saeeda & Zakir, 2012	70	15	15	4
87	Saghir *et al.*, 2001	53	9	3	5
88	Shaheen *et al.*, 2011a	69	9	2	3
89	Shaheen *et al.*, 2011b	72	7	7	0
90	Shaheen *et al.*, 2011c	15	3	3	1
91	Shaheen *et al.*, 2012	71	7	2	3
92	Shaheen *et al.*, 2014a	39	9	4	4
93	Shaheen *et al.*, 2014b	36	0	0	0
94	Shaukat *et al.*, 2012a	26	4	2	1
95	Shaukat *et al.*, 2012b	1	0	0	0
96	Shaukat *et al.*, 2013	1	0	0	0
97	Tanvir *et al.*, 2014	200	16	3	5
98	Ur-Rehman, 2006	66	8	3	8
99	Ur-Rehman, 2007	14	3	3	0
100	Waseem *et al.*, 2006	12	2	0	1
	Total	**5460**	**750**	**333**	**379**

Legends: AAC, Author article code; TSC, Total spp. communicated; SCA, Synonyms communicated in articles; X, Incorrect author citations; Y, Non-standardized abbreviations & orthographic errors).

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CONCLUSIONS AND RECOMMENDATIONS

The majority of authors of reviewed articles did not utilize the updated taxonomic information at the time of their publications. Thus, before communicating species identities with others, correct identification and current status of the taxon name should be first and foremost requirement. This is the most important step because as an author, every researcher should be assured about the identity of their collected plant specimens. Only then global communication with others through scientific articles will be fruitful which otherwise conveys wrong information particularly to those working on ecological assessments, conservation, ethnobotany, phytomedicines and ethnopharmacology. According to us, plant taxonomy is the mother of all related fields of plant sciences (ecological, genetical, molecular, cytological, palynological, karyology, etc.) because they all depend on its basic feed in the form of correct, globally accepted identity data. Thus application of the following recommendations will be fruitful. These include; development of independent advanced taxonomic institutes, training programs to enhance basic skills and consultation of skilled taxonomists while developing/preparing the manuscripts related to species naming, rank and position. Furthermore utilization of coherent reliable online taxonomic databases to minimize orthographic errors, construction of a single authoritative list of acceptable, compulsory taxonomic faculty in research institutes/universities, frequent taxonomists interactions, taxonomic research linkage through a single online database, plant genealogy and monographic studies. Finally we recommend changes in journal policies for taxonomic articles publication like submission of different related certificates with taxonomic manuscript at the time of their submission, periodic updating of regional floras, standardization of taxonomic tools and techniques, provision of funding for taxonomic research etc. Implemention of these suggestions can considerably decreases the impact of the taxonomic issues and errors. It will also make botanical researches especially related to conservation studies, phytogeography, ethnobotany, phytomedicines, ethnopharmacology, and biodiversity assessment more productive and reproducible.

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