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Confusion between Multiple and Aggregate Fruits

RICHARD W. SPJUT

USDA, Agricultural Research Service
Systematic Botany, Mycology, and Nematology Laboratory, Bldg. 265
Beltsville, Maryland 20705

JOHN W. THIERET

Biological Sciences
Northern Kentucky University
Highland Heights, Kentucky 41076

I. Abstract

The definitions of aggregate and multiple fruits, and the classification of these fruits, are reviewed chronologically, beginning in 1751 with Linnaeus' *Philosophia botanica.* In 1788, Joseph Gaertner defined a multiple fruit as one derived from many ovaries in a single flower, and a compound fruit as one derived from many ovaries of many flowers; in 1813, Augustin de Candolle referred to Gaertner's compound fruits as aggregate fruits. Gaertner's 1788 definition of multiple and de Candolle's 1813 definition

of aggregate (compound) fruits have been employed in non-English botanical textbooks for nearly two centuries, but equivalent English books currently give opposite meanings for these terms. We have traced the modern English definitions of aggregate and multiple fruits to John Lindley's 1832 *Introduction to botany*. The long history of confusion over the meanings of multiple and aggregate (compound) fruits is only one example of a need to stabilize descriptive fruit terminology; in such cases where an established meaning is not clear we suggest that priority be applied—i.e., application of these terms follow Gaertner. Since classification of fruits is in chaos, we urge authors to reference their use of fruit terminology to an authoritative source.

Résumé

Les définitions des fruits agrégés (composés) et multiples, et la classification de ces fruits, sont revues chronologiquement, depuis 1751 avec la *Philosophia botanica* de Linné. En 1788, Joseph Gaertner définit un fruit multiple comme un fruit dérivant de plusieurs ovaries d'une seule fleur, et un fruit composé comme un fruit dérivant de plusieurs ovaires de plusieurs fleurs; en 1813, Augustin de Candolle fait référence aux fruits composés de Gaertner sous le nom de fruits agrégés. Les définitions des fruits multiples de Gaertner (1788) et des fruits composés de de Candolle (1813) ont été employées dans les manuels de botanique non-anglais pendant presque deux siècles, mais les équivalents anglais donnent actuellement à ces termes de sens inversés. Nous avons recherché la trace des définitions anglaises modernes des fruits composés et multiples jusqu' à l'*Introduction to botany* de John Lindley (1832). La longue histoire de la confusion des sens des fruits multiples et composés n'est qu' un exemple de la nécessité de stabiliser la terminologie descriptive des fruits; dans de tels cas où l'usage n'est pas clair nous suggérons d'appliquer un principe de priorité—i.e., d'utilise ces termes au sens de Gaertner. La classification des fruits étant très chaotique, nous demandons que les auteurs fasse référence à un systeme quand ils appliquent une terminologie aux fruits.

II. Introduction

Fruit classifications have largely appeared in botanical textbooks in a format where authors traditionally do not reference their statements. Occasionally, authors have published their fruit classifications in journals in the same manner (e.g., Dickson, 1871). We regard Bischoff (1833), de Candolle (1813), Desvaux (1813), Dumortier (1835), Gaertner (1788), Lindley (1832), Linnaeus (1751), and Mirbel (1813, 1815) as primary sources to establishing a classification of fruits. Unfortunately, these publications are not readily available, and because they are rarely cited by later authors, it is very difficult to trace the later author's definition of a

fruit term, even in cases where the primary author has been cited (e.g., L. C. Richard *in* de Candolle, 1813).

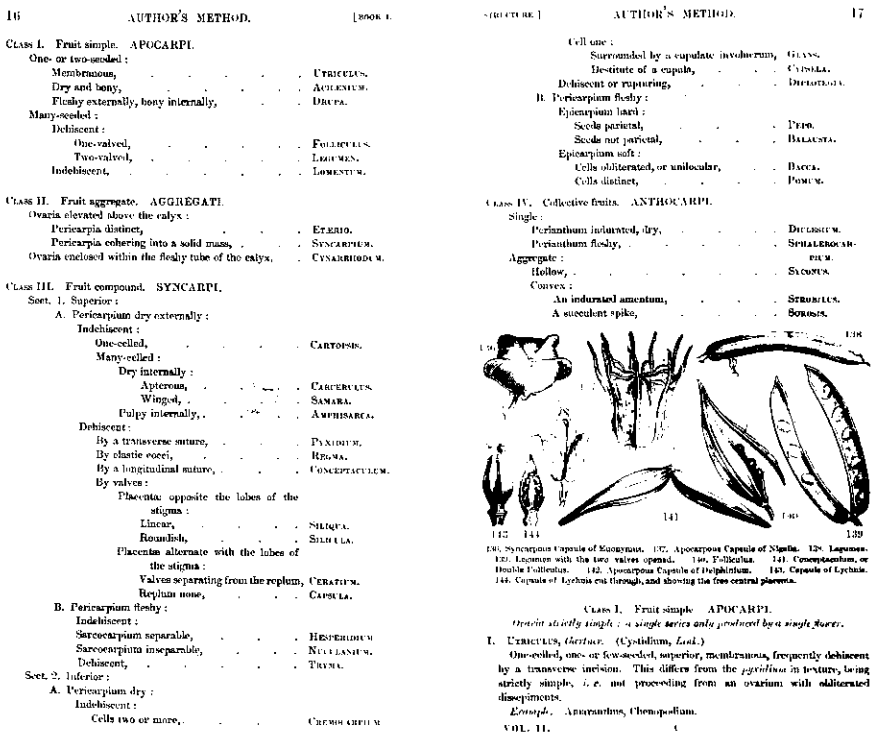
Fruit classifications usually take into consideration the morphology of the gynoecium—the entire female reproductive system of a flower, consisting of one or more pistils. A pistil includes the ovary, style, and stigma. In a primitive flower, such as the magnolia or buttercup (*Ranunculus*), there are many pistils, but in the more evolutionarily advanced flowers these have fused into one pistil; the simple pistil or pistillate part of a compound pistil is also regarded as a carpel. Many early carpologists thought in terms of pistils, not carpels. Lindley (1832), however, was the first to employ "simple pistils" (solitary or aggregate carpels) and "compound pistils" (united carpels) in a fruit classification (Fig. 1).

Aggregate and multiple fruits are usually thought of as fruits with many matured pistils in which those derived from a single multi-pistillate flower are aggregate (e.g., buttercup, *Rubus, Alisma*), and those derived from the coalescence of many pistils in an inflorescence are multiple [e.g., mulberry (*Morus*), pineapple (*Ananas*), *Cornus kousa* Hance]. Definitions of aggregate and multiple fruits, as usually given in English textbooks (e.g., Radford, 1986), date back to Lindley (1832) (Table I). Prior to Lindley (1832), definitions of these terms were reversed—a multiple fruit was considered to have been derived from a single flower, and an aggregate fruit from several to many flowers. It must be noted, however, that many German, French, Russian, and Spanish botanists have continued to follow pre-Lindley concepts (Caruel, 1886; d'Orbigny, 1849; Font Quer, 1953; Germain de Saint-Pierre, 1869; Goby, 1921; Guibourt, 1848; Janchen, 1949; Sachs, 1875; Schultz-Schultzenstein, 1864).

What has been surprising to us is that so little has been said about Lindley's definitions for aggregate and multiple. We have also wondered if there is any justification for Lindley's reversal. Our paper, therefore, examines the historical data behind definitions for aggregate and multiple, and clarifies how these and related terms have been applied in fruit classifications. Furthermore, the concept of what constitutes a fruit itself is linked to the usage of these terms (Egler, 1943), and this we regard as another problem. For the purpose of this paper, we present Lindley's (1832) definition: "the fruit is the ovarium or pistillum arrived at maturity; but, although this is the sense in which the term is strictly applied, yet in practice it is extended to whatever is combined with the ovarium when ripe."

III. The First Textbook of Botany, Linnaeus' *Philosophia botanica* (1751)

Linnaeus (1753) is recognized as the starting point for a priority system in botanical nomenclature, but there are no comparable applicable rules



16 AUTHOR'S METHOD. [BOOK I.

CLASS I. Fruit simple. APOCARPI.
One- or two-seeded :
Membranous, ... UTRICULUS.
Dry and bony, ... ACULEUM.
Fleshy externally, bony internally, . . DRUPA.
Many-seeded :
Dehiscent :
One-valved, ... FOLLICULUS.
Two-valved, ... LEGUMEN.
Indehiscent, ... LOMENTUM.

CLASS II. Fruit aggregate. AGGREGATI.
Ovaria elevated above the calyx :
Pericarpia distinct, ... ETAERIO.
Pericarpia cohering into a solid mass, . . SYNCARPIUM.
Ovaria enclosed within the fleshy tube of the calyx, . CYNARRHODIUM.

CLASS III. Fruit compound. SYNCARPI.
Sect. 1. Superior :
A. Pericarpium dry externally :
Indehiscent :
One-celled, ... CARTOPSIS.
Many-celled :
Dry internally :
Apterous, ... CARCERULUS.
Winged, ... SAMARA.
Pulpy internally, ... AMPHISARCA.
Dehiscent :
By a transverse suture, ... PYXIDIUM.
By elastic cocci, ... REGMA.
By a longitudinal suture, ... CONCEPTACULUM.
By valves :
Placentæ opposite the lobes of the stigma :
Linear, ... SILIQUA.
Roundish, ... SILICULA.
Placentæ alternate with the lobes of the stigma :
Valves separating from the replum, CERATIUM.
Replum none, ... CAPSULA.
B. Pericarpium fleshy :
Indehiscent :
Sarcocarpium separable, . . . HESPERIDIUM.
Sarcocarpium inseparable, . . . NUCULANIUM.
Dehiscent, ... TRYMA.
Sect. 2. Inferior :
A. Pericarpium dry :
Indehiscent :
Cells two or more, . . . CREMOCARPIUM.

STRUCTURE.] AUTHOR'S METHOD. 17

Cell one :
Surrounded by a cupulate involucrum, GLANS.
Destitute of a cupula, . . . CUPULA.
Dehiscent or rupturing, . . . DICTAMNUS.
B. Pericarpium fleshy :
Epicarpium hard :
Seeds parietal, ... PEPO.
Seeds not parietal, . . . BALAUSTA.
Epicarpium soft :
Cells obliterated, or unilocular, . BACCA.
Cells distinct, ... POMUM.

CLASS IV. Collective fruits. ANTHOCARPI.
Single :
Perianthium indurated, dry, . . . DICLESIUM.
Perianthium fleshy, ... SPHALEROCARPIUM.
Aggregate :
Hollow, ... SYCONUS.
Convex :
An indurated amentum, . . . STROBILUS.
A succulent spike, ... SOROSIS.

136. Syncarpous Capsule of Euonymus. 137. Apocarpous Capsule of Nigella. 138. Legumen. 139. Legumen with the two valves opened. 140. Folliculus. 141. Conceptaculum, or Double Folliculus. 142. Apocarpous Capsule of Delphinium. 143. Capsule of Lychnis. 144. Capsule of Lychnis cut through, and showing the free central placenta.

CLASS I. Fruit simple. APOCARPI.
Ovarium strictly simple ; a single series only produced by a single flower.

I. UTRICULUS, *Gærtner.* (Cystidium, *Link.*)
One-celled, one- or few-seeded, superior, membranaceous, frequently dehiscent by a transverse incision. This differs from the *pyxidium* in texture, being strictly simple, *i. e.* not proceeding from an ovarium with obliterated dissepiments.
Examples. Amaranthus, Chenopodium.

Fig. 1. John Lindley's classification of fruits (Lindley, 1848). Note Syncarpium under Class II (Aggregati) and Syncarpi as Class III fruits; note Class II as Aggregati fruits and aggregate as a key term under Class IV (Anthocarpi). Lindley (1831, 1861) indicated that all fruits were simple or multiple; the term "multiple" does not even appear in this classification, first published in 1832.

for adopting botanical terms and their definitions (Rickett, 1944). However, as a matter of practicality, we begin with Linnaeus' *Philosophia botanica* (1751). "It is the first textbook of descriptive systematic botany and botanical Latin" (Stearn, 1966). Linnaeus, in addition to establishing the binomial system, also is recognized for his precision in defining botanical terms (Stafleu, 1971; Stearn, 1966); Green (1914) suggested that *Philosophia botanica* is perhaps Linnaeus' greatest work.

Linnaeus (1751) recognized eight different kinds of fruits (capsula, siliqua, legumen, conceptaculum or folliculus, drupa, pomum, bacca, and strobilus), but he did not explicitly classify fruits as simple, aggregate, and multiple. The morphology of both flowers and fruits was described under the general heading "fructificatio" (Rickett, 1944). Flowers and/or fruits were regarded as simple, compound, or aggregate, and their distinction

was based on what are now considered inflorescence types. Simple flowers were solitary flowers; compound flowers were many sessile flowers surrounded by an involucre [e.g., dandelion (*Taraxacum*)]; and aggregates were umbellate or involucrate inflorescence types in which the flowers were not sessile but pedicellate [e.g., carrot (*Daucus*).] Aggregate was also used as a general classification term for seven infloresence types (umbellatus, cymosus, compositus, aggregatus, amentaceus, glumosus, and spadiceus).

Linnaeus, in his *Philosophia botanica,* defined only two terms under "simplex"—a simple flower "intra Perianthium aut Corollam unicam Thalamum constituit," and a compound fruit ("fructus compositus")—"nequit florem compositum constituere" (Fig. 2). This parallel of Linnaeus (1751) was to emphasize that a compound flower may not bear any relationship to a compound fruit. Rose (1775), whose text is a close translation of Linnaeus' (Rickett, 1944), added, "for a compound fruit may be, and often is, where the flower is simple"; Barton (1836), in citing Linnaeus' work, referred to the Asteraceae as an example of a compound flower and the raspberry as an example of a compound fruit.

IV. Gaertner's *De fructibus et seminibus plantarum* (1788)

Gaertner (1788) applied Linnaeus' fructification types to fruits with some clarification and modifications. He contrasted simple fruits with multiple fruits ("non perinde facile est, fructum simplicem a multiplici distinguere: quare in his ad numerum styloum & ad dehiscentiam fructus maturi probe erit attendendum"), and indicated multiple fruits occur in a single flower ("plures, seu multiplices numero fructus, ex duobus aut pluribus ovariis singuli floris enascuntur"). He further recognized "partibilis" and "lobati" on the basis of gynoecia that split or dehisce into several or more parts as they mature into fruit, and these were subclassified by the number of parts [e.g., Bipartiiles (Seminibus corticatis—*Blairia, Lippia, Diodia, Phyllis*; Capsulis—*Cinchona, Knoxia, Parilium*; Baccis—*Grumilea, Psychotria*; Drupis—*Messerschmidia*; Siliquis—*Coronopus, Iberis, Biscutella*; Leguminibus—*Astragalus*); Tripartibiles (*Richardia, Chamitis, Trioccae variae*), Quadripartibles (*Cephalanthus, Verbena, Ovieda, Clerodendrum*); Quinquepartibiles (*Tribulus, Bartramia, Ayenia*); and Multipartibiles (*Hura, Aristolochia,* and in some respect, *Hypericum, Hedysarum, Coronilla,* etc.)].

Composite or compound fruits were single fruiting structures that formed by the fusion of ovaries from several to many flowers ["quod ex duobus aut pluribus ovariis diversorum florum, in fructum singulum coalitis, formati sint" with examples: "Caprifolii, Mitchellae, Morindae, Ananae, Pandani and Sitodi" (=*Artocarpus*)].

The fruiting infloresence or "communis" was classified as "separati" if

Table I

Authors and their terms for two classes of multiovarian fruits

Author(s)	Derived from one flower	Derived from many flowers
Linnaeus, 1751	compositus	compositus
Gaertner, 1788	multiplices	compositi
L.-C. Richard, 1808	multiple (includes multi-carpellate pistils)	not recognized
de Candolle, 1813	multiples	agrégés
Desvaux, 1813	composés, in part	composés, in part
Mirbel, 1815	étairionnaries (free, or free carpels that fuse in fruit)	angiocarpiens (includes fruits derived from one pistil, with floral remnants attached)
A. Richard, 1819	multiple, composés	composés, aggrégés
———, 1825	multiples	agrégés, ou composés
———, 1846	polycarpés, agrégés ou multiples	synanthocarpés ou composés
Lindley, 1831	simple	multiple
———, 1832	aggregate	collective (anthocarpi)
Bischoff, 1833	not recognized	not recognized
Dumortier, 1835	multiple	not recognized
Gray, 1836	aggregate	collective
———, 1842	aggregate	multiple
———, 1880	accessory or aggregate	multiple or collective
Schleiden, 1842 (1849 translation)	multiple	fructifications
Guibourt, 1848	séparés ou carpochorizes	agrégés ou carpoplesés
Balfour, 1855	aggregate	multiple or anthocarpous
Lestiboudois, 1855	polycarpes	polythalamiques
A. de Candolle, 1857	not recognized	agrégés
Henslow, 1858	not defined	aggregate
Schultz-Schultzenstein, 1864	Polycarpien, Vielfrüchte	Carpodien, Fruchtstielstücke
Germain de Saint-Pierre, 1869	polycarpellés	agrégés (infructescences)
Henfrey & Masters, 1870	multiple or polycarpous	confluent or polythalamic
Sachs, 1875 (translation)	multiple	pseudocarp
——— & Goebel, 1887 (translation)	aggregate	pseudocarp

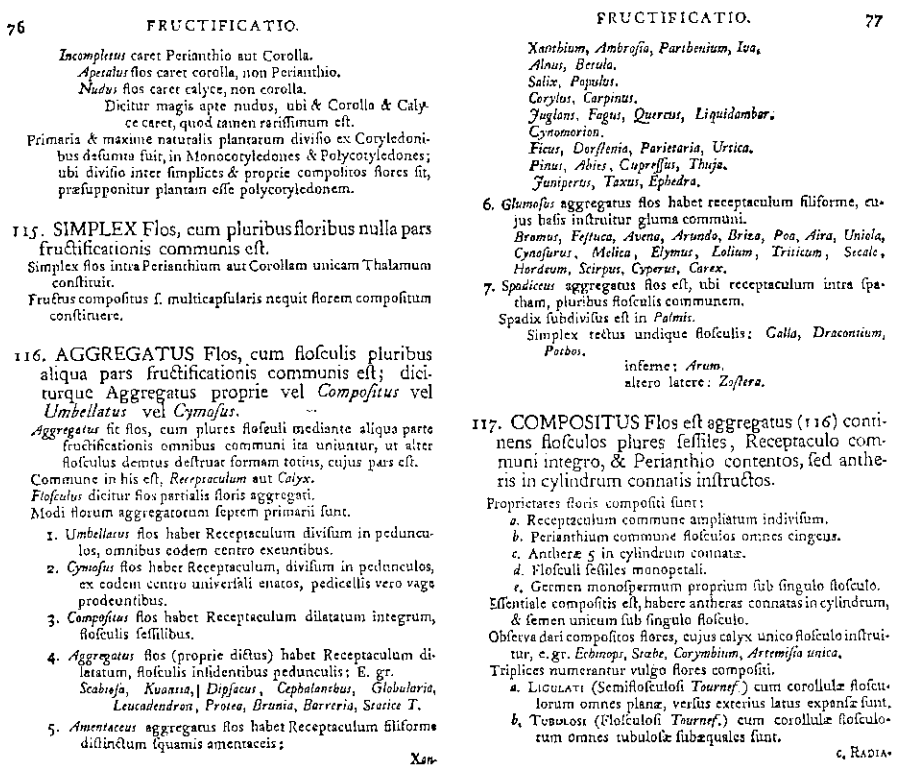
Table I
Continued

Author(s)	Derived from one flower	Derived from many flowers
Duchartre, 1877	not recognized	not recognized
Brousse, 1880	agrégés	composés (synanthocarpés)
Wood, 1880	not recognized	confluent (aggregate)
Dugés, 1882	multíplices	sinantocarpados
Caruel, 1886	multiples	syncarpes
Beck, 1891	apocarpium (dehiscens & indehiscens, under simple fruits)	polyanthocarpi
Vines, 1895	apocarpous, pseudocarp for carpels that fuse in fruit	pseudocarp or spurious
Goby, 1921	"multi," in combination with specific fruits, e.g., multiakene	composés (includes fleshy fruits derived from one flower)
Gérard, 1928	multiples	anthocarpés
Johnson, 1931	aggregate	multiple
Janchen, 1949	Mehrblattfrucht, Pleiokarpium (oder Synkarpium)	Gemeinschaftsfrucht (oder Fruchtverband), Zönokarpium
Font Quer, 1953	múltiples	complejos
Ullrich & Aruold, 1953	Sammelfrüchte (one or more flowers)	Zusammengesetzte (one or more flowers, with accessory parts)
Radford, 1986	aggregate	multiple
Spjut & Thieret, this study	multiple	compound

the ovaries were pedicellate or "consociati" if spicate; the latter were "aggregati" in compact spikes ["Opetiola" (=*Mariscus*), "Sparganio, Cephalantho, Plantano, Protea, Brunia, Banksis & Compositis variis"] or "segregati" if receptacles were at least partially distinct ("Pini, Carpini, Cupressi, Thujae, Scolymi & Dipsacearum, Liquidambaris Gundeliae, Opercullariae, Elephantopo, Sphaerantho, Oederia, Filagine").

V. L.-C. Richard's *Démonstrations botaniques, ou analyse du fruit* (1808)

Louis-Claude Richard (1808), in his *Analyse du fruit,* regarded "simple" and "multiple" fruits as products of a single flower, but he did not mention aggregate. As with Gaertner (1788), L.-C. Richard (1808) elaborated on



76 FRUCTIFICATIO.

Incompletus caret Perianthio aut Corolla.
Apetalus flos caret corolla, non Perianthio.
Nudus flos caret calyce, non corolla.
Dicitur magis apte nudus, ubi & Corolla & Calyce caret, quod tamen rariſſimum eſt.
Primaria & maxime naturalis plantarum diviſio ex Cotyledonibus deſumta fuit, in Monocotyledones & Polycotyledones; ubi diviſio inter ſimplices & proprie compoſitos flores fit, præſupponitur plantam eſſe polycotyledonem.

115. SIMPLEX Flos, cum pluribus floribus nulla pars fructificationis communis eſt.
Simplex flos intra Perianthium aut Corollam unicam Thalamum conſtituit.
Fructus compoſitus ſ. multicapſularis nequit florem compoſitum conſtituere.

116. AGGREGATUS Flos, cum floſculis pluribus aliqua pars fructificationis communis eſt; dicturque Aggregatus proprie vel *Compoſitus* vel *Umbellatus* vel *Cymoſus*.
Aggregatus fit flos, cum plures floſculi mediante aliqua parte fructificationis omnibus communi ita uniuntur, ut alter floſculus demtus deſtruat formam totius, cujus pars eſt.
Commune in his eſt, *Receptaculum* aut *Calyx*.
Floſculus dicitur flos partialis floris aggregati.
Modi florum aggregatorum ſeprem primarii ſunt.
1. *Umbellatus* flos habet Receptaculum diviſum in pedunculos, omnibus eodem centro exeuntibus.
2. *Cymoſus* flos habet Receptaculum, diviſum in pedunculos, ex eodem centro univerſali enatos, pedicellis vero vage prodeuntibus.
3. *Compoſitus* flos habet Receptaculum dilatatum integrum, floſculis ſeſſilibus.
4. *Aggregatus* flos (proprie dictus) habet Receptaculum dilatatum, floſculis inſidentibus pedunculis; E. gr.
Scabioſa, *Kuautia*, | *Dipſacus*, *Cephalanthus*, *Globularia*, *Leucadendron*, *Protea*, *Brunia*, *Barreria*, *Statice T.*
5. *Amentaceus* aggregatus flos habet Receptaculum filiforme diſtinctum ſquamis amentaceis;

Xan-

FRUCTIFICATIO. 77

Xanthium, *Ambroſia*, *Partheníum*, *Iva*,
Alnus, *Betula*.
Salix, *Populus*.
Corylus, *Carpinus*.
Juglans, *Fagus*, *Quercus*, *Liquidambar*.
Cynomorion.
Ficus, *Dorſtenia*, *Parietaria*, *Urtica*.
Pinus, *Abies*, *Cupreſſus*, *Thuja*.
Juniperus, *Taxus*, *Ephedra*.
6. *Glumoſus* aggregatus flos habet receptaculum filiforme, cujus baſis inſtruitur gluma communi.
Bromus, *Feſtuca*, *Avena*, *Arundo*, *Briza*, *Poa*, *Aira*, *Uniola*, *Cynoſurus*, *Melica*, *Elymus*, *Lolium*, *Triticum*, *Secale*, *Hordeum*, *Scirpus*, *Cyperus*, *Carex*.
7. *Spadiceus* aggregatus flos eſt, ubi receptaculum intra ſpatham, pluribus floſculis communem.
Spadix ſubdiviſus eſt in *Palmis*.
Simplex tectus undique floſculis: *Calla*, *Draconticum*, *Pothos*.
inferne: *Arum*.
altero latere: *Zoſtera*.

117. COMPOSITUS Flos eſt aggregatus (116) continens floſculos plures ſeſſiles, Receptaculo communi integro, & Perianthio contentos, ſed antheris in cylindrum connatis inſtructos.
Proprietates floris compoſiti ſunt:
a. Receptaculum commune ampliatum indiviſum.
b. Perianthium commune floſculos omnes cingens.
c. Antheræ 5 in cylindrum connatæ.
d. Floſculi ſeſſiles monopetali.
e. Germen monoſpermum proprium ſub ſingulo floſculo.
Eſſentiale compoſitis eſt, habere antheras connatas in cylindrum, & ſemen unicum ſub ſingulo floſculo.
Obſerva dari compoſitos flores, cujus calyx unico floſculo inſtruitur, e. gr. *Echinops*, *Strabe*, *Corymbium*, *Artemiſia unica*.
Triplices numerantur vulgo flores compoſiti.
a. LIGULATI (Semifloſculoſi *Tournef.*) cum corollulæ floſculorum omnes planæ, verſus exterius latus expanſæ ſunt.
b. TUBULOSI (Floſculoſi *Tournef.*) cum corollulæ floſculorum omnes tubuloſæ ſubæquales ſunt.
c. RADIA-

Fig. 2. Linnaeus' (1751, 1780, 1790) classification of simple, aggregate, and compound flowers in *Philosophia botanica*. Note that under "Simplex" (item #115), Linnaeus contrasts simple flowers against compound (composite) fruits. Gaertner (1788) recognized simple, multiple, and compound (composite) fruits; de Candolle (1813) substituted the term aggregate for compound. Photocopy taken from the 1790 edition for best quality reproduction; the page shown matches that found in the 1751 edition, including the page number. Linnaeus (1751) went through four editions, and was translated into many languages.

the difficulties in distinguishing between simple and multiple fruits, and he referred to dehiscent fruits as "partibilites." However, L.-C. Richard's (1808) multiple fruits include both simple and compound pistils, and also fruits derived from many flowers. This work (L.-C. Richard, 1808) is preceded by his dictionary [1798 and later editions (Stafleu & Cowan, 1976–1983)], which appears to be a source cited by later authors for certain types of fruit.

VI. Classifications of de Candolle, Mirbel, Desvaux, and A. Richard

In 1813, three fruit classifications were independently published: de Candolle (1813), Mirbel (1813, 1815), and Desvaux (1813), although

Desvaux made reference to de Candolle's and Mirbel's classifications. It is at this time that numerous fruit terms evolved (Saint-Hilaire, 1841). However, it was de Candolle (1813) who clearly established aggregate fruits, and he treated aggregates as one of three classes of fruits as follows:

1. Simple—those which are derived from a single ovary, for example, the cherry ("ou qui proviennent d'un seul ovaire, par exemple, la Cerise"). The examples given, all deriving from a single flower, include both simple and compound pistils.
2. Multiple—those which formed from several ovaries belonging to a single flower, as in the blackberry ("ou qui sont formés de plusieurs ovaires appartenant à la même fleur, comme le fruit de la Ronce").
3. Aggregate—those composed of several ovaries belonging originally to several flowers, as in the mulberry ("ou composés de plusieurs ovaires appartenant originairement à plusieurs fleurs, comme la Mûre").

It may have been de Candolle's intent to substitute aggregate for compound of Gaertner (1788) to show that various kinds of inflorescences form fruits; also "compound" might be interpreted in the Linnaean sense to mean only fruits of the Asteraceae. Unfortunately, "compound" in the sense of Desvaux (1813) included multiple fruits of Gaertner (1788) and de Candolle (1813). Mirbel (1813) employed other concepts to classify fruits, but he later (Mirbel, 1815) added the terms simple and compound to some of his examples; evidently he was correlating certain fruit types with Desvaux's (1813) classification.

Dunal (1817) proposed that "carpellum" be substituted for multiple, and that the individual fruit part be regarded as a carpel, but carpel has since been adopted as a general term for a "division of the gynoecium before and after pollination" (Stearn, 1966).

A. Richard (1819, 1825, 1846) integrated the terminology and classifications of his father (L.-C. Richard, 1808), Desvaux (1813), Mirbel (1813), and others. But in his first edition of *Nouveaux éléments de botanique* (1819) he was inconsistent in classifying fruits, and furthermore confused the definitions of compound and multiple fruits. For example, he (A. Richard, 1819) initially indicated that fruits could be divided in three ways [sensu de Candolle, 1813, except "compound" (Gaertner, 1788) was substituted for aggregate (de Candolle, 1813)], but then in the last paragraph of the introduction, he proposed to simplify the nomenclature of fruits by dividing them into dry, fleshy, and aggregate or multiple. Instead, he presented four classes of fruits: dry, fleshy, compound, and aggregate. Moreover, compound fruits became defined in two ways: (1) in the introduction they were defined as those that resulted from the union of several pistils derived from different flowers, and (2) in the classification they were considered a product of fused pistils in the same flower, the

same definition applied to multiple in the introduction. Multiple was not included in the classification, and aggregate, although not defined in the introduction, was defined in the classification sensu de Candolle (1813). He (A. Richard, 1825) later rectified his errors, recognizing three primary classes of fruits sensu de Candolle (1813); aggregate and compound were terms used interchangeably to classify fruits derived from the fusion of pistils from many flowers (sensu de Candolle, 1813).

VII. John Lindley

John Lindley, a prolific author of botanical textbooks, glossaries, and systematic treatments, had more than a passing interest in fruit classification. He (Lindley, 1819) translated L.-C. Richard's (1808) *Démonstrations botaniques, ou analyse du fruit* (111 pp.) into English. Lindley's (1832, 1848) classification and glossary of fruits is one of the most comprehensive; the text of the 1848 edition is nearly identical to that of 1832, and an edited version also appears in Gray's (1836) first textbook of botany.

Lindley (1831, item 444; 1861, item 591), in outlining his botanical principles, stated that "all fruits are either *simple* or *multiple,*" and defined "simple" as those that "proceed from a single flower" and "multiple" as fruits "formed out of several flowers." This binary division of fruits, and definition of "simple" is in contrast to the four classes of fruits and the meaning attached to "simple" fruits by Lindley (1832) in his *Introduction to botany* and its later editions (Fig. 1).

In *Introduction to botany,* Lindley (1832) recognized four classes of fruits (Fig. 1): Apocarpi [simple, fruits developing from a flower considered (by him) to be monocarpellary]; Aggregati (aggregate, developing from several to many distinct ovaries of one flower); Syncarpi (compound, formed from a single pistil composed of more than one carpel); and Anthocarpi (collective, fruits including other floral parts outside the mature ovary). Syncarpium was also considered by Lindley as a type of aggregate fruit (sensu L.-C. Richard, e.g., *Annona, Magnolia*). Additionally, in Lindley's fruit key under "collective fruit," "aggregate" and "single" are used to differentiate fruits derived from an inflorescence (mulberry) as opposed to those surrounded by remnants from only one flower (e.g., the calyx of *Mirabilis* fruits).

Lindley's (1832, 1848) rationale for establishing another meaning to the terms simple and compound fruits is based on his theoretical (or strict) definition of a fruit. "In using the terms simple and compound, I have employed them precisely in the sense that has been attributed to them in my remarks upon the ovarium; being of opinion that, in an arrangement like the following and those which have preceded it, in which theoretical

rather than practical purposes are to be served, the principles on which it depends should be conformable to the strictest theoretical rules of structure." Lindley (1832) had defined a simple pistil as one consisting of a single carpel, and a compound pistil as one composed of more than one carpel. The idea that a carpel was an evolutionary product of a leaf was just beginning to be established, and the evolutionary fusion of simple carpels to form a compound pistil was considered an important theoretical foundation. Thus, Lindley carried this concept over to the fruit with the awareness that a compound fruit had other meanings. He had also recognized that fruit nomenclature was in chaos: "So much discordance, indeed, exists in the application of terms expressive of the modifications of fruit, that it is quite indispensable to give the definitions of some of the most eminent writers upon the subject in their own words, in order that the meaning attached by those authors to carpological terms, when employed by themselves, may be clearly understood."

Lindley (1832), in extending the floral concept of simple and compound pistils to the fruit, followed with his explanation of aggregate fruits. "In simple fruits are stationed those forms in which the ovaria are multiplied so as to resemble a compound fruit in every respect except their cohesion, they remaining simple. But, as the passage which is thus formed from simple to compound fruit is deviated from materially when the ovaria are placed in more than a single series, I have found it advisable to constitute a particular class of such under the name of aggregate fruit. Care must be taken not to confound these with the fourth class containing collective fruits, as has been done by more carpologists than one. While the true aggregate fruit is produced by the ovaria of a single flower, a collective fruit, if aggregate, is produced by the ovaria of many flowers; a most important difference." Lindley's attempt to correlate gynoecium terminology with fruits is in contrast to Linnaeus (1751) who emphasized that simple and compound parts of flowers and fruits were not necessarily related, by his antithesis of defining a simple flower and a compound fruit (Fig. 2).

Lindley (1832, 1848) also expressed concern for priority. In referring to what he considered to be the three major fruit classifications (Desvaux, 1813; Mirbel, 1813, 1815; A. Richard, 1825; referred to by Lindley without reference to date of publication), he commented that "each of the three writers has felt himself justified in contriving a nomenclature at variance with that of his predecessors, for reasons which it is difficult to comprehend. I have attempted to adjust the synonyms of carpological writers, and have also ventured to propose a new arrangement, in which those names which seem to be most legitimate are retained in every case, their definitions only being altered." Although Lindley had a strong argument for adopting his concept of compound fruit, his justification for

reversing the meanings of aggregate and multiple is not clear to us. On the one hand, it is hard to imagine that he could have switched the historical meanings of these terms without providing solid reasoning; at the same time it is also difficult to believe that Lindley may have made a mental error in this particular situation.

VIII. Post Lindley

Bischoff (1833), in footnotes to his classifications of fruit dehiscence (or indehiscence, lobed fruits or cocca) and fruit disposition, indicated that the distinction between Gaertner's (1788) multiple and compound fruits was not clear. Gaertner's (1788) examples of multiple fruits included indehiscent fruits derived from a gynoecium with many free carpels (e.g., Ranunculaceae) and dehiscent fruits derived from a gynoecium whose carpels were united in the flowering stage but break apart into their carpellary parts after fertilization (schizocarpic fruits, e.g., Geraniaceae). To Bischoff (1833), Gaertner's terminology (multiple and compound) seemed to reflect the disposition of fruiting carpels that might be better described than named; Bischoff (1833) had defined the fruit as a product of the ovary, and not of the gynoecium or inflorescence. Moreover, he lumped fruits derived from one flower with those derived from many flowers under an aggregate ("gehaüft") type of disposition, citing such examples as *Ranunculus, Sedum, Rubus, Annona,* and *Morus.* He also made reference to L.-C. Richard (1798, 1808), de Candolle (1819), Desvaux (1813), Mirbel (1813, 1815) but not Lindley (1832), without citing dates of publications. Although Bischoff's (1833) *Handbuch der botanischen Terminologie und Systemkunde* appeared after Lindley's *Introduction to botany* (1832), much of the content in the first of his three-volume work on botanical terminology was likely to have been in development before Lindley's (1832) textbook was published.

Dumortier (1835), whose comprehensive work included a detailed review of the fruit classifications of Mirbel (1813, 1815), Desvaux (1813), de Candolle (1813, 1819), and A. Richard (1819, 1825) (Dumortier referred to the authors without citing dates of publications), did not recognize fruits derived from inflorescences; he based his classification on the gynoecium (not the carpel), and multiple fruits were included as one of three classes. A simple fruit was an entire one derived from a single pistil; partibles, in a more restrictive sense than Gaertner (1788), were fruiting parts that formed from the breaking apart of a single pistil (=schizocarpic fruits of many modern authors); and, finally, multiple fruits were defined in the same sense as Gaertner (1788) and de Candolle (1813)—being derived from multi-pistillate flowers. Since Dumortier (1835) did not mention Lindley (1831, 1832), he evidently was not aware of Lindley's classification.

Lestiboudois (1855), in drawing comparisons among the classifications of Lindley (1832, 1848), A. Richard (1819, 1825), and de Candolle (1813, 1819) (Lestiboudois cited authors without reference to dates of publications) indicated that Lindley's use of multiple and aggregate was exactly the opposite of de Candolle. But Lestiboudois (1855) also felt that the terminology in either case inaccurately described fruits derived from an inflorescence, and furthermore, he criticized A. Richard (1825) for not taking into consideration the carpellate parts in his classification. Thus he justified his "polythalamiques" as a better name for those fruits derived from an inflorescence. Polythalamic and monothalamic fruits (fruits derived from only one receptacle) were the primary classes of Lestiboudois' (1855) fruit classification.

Lindley's (1832) switch in defining aggregate and multiple had not escaped the attention of Alphonse de Candolle (1857), the son of Augustin de Candolle. In a footnote in his *Introduction a l'étude de la botanique,* A. de Candolle (1857) objected to Lindley's application of aggregate, and pointed out that he and many other authors had used this term in another sense for at least 20 years prior to Lindley. While retaining the usage of aggregate, A. de Candolle (1857) conceded to Lindley's method of classifying fruits on the basis of free or united carpels. The three divisions of A. de Candolle (1857) were: (1) simple—fruits derived from only one carpel, (2) compound—fruits derived from one flower with fused carpels, and (3) aggregate—fruits derived from fusion of many flowers. In this classification, fruits derived from multi-pistillate flowers were regarded as simple, without any special name.

Duchartre (1877) also recognized the confusion between Lindley's and de Candolle's definition of multiple, but since fruit according to Duchartre (1877) was more of a product of the ovary than inflorescence, the problem of whether to use multiple or aggregate was of lesser concern. His classification (Duchartre, 1877) adopted Lindley's (1832) Apocarpi (Class I) and Syncarpi (Class III).

Gray (1880), in a footnote to his definition of "multiple or collective fruits," stated that "collective is the preferable name. The term *multiple* was applied by de Candolle to what are here (following Lindley) called *aggregate* fruits; and the *aggregate* fruits of de Candolle are here called *multiple* or *collective.* Moreover, the distinction between accessory or anthocarpous and collective or multiple fruits was not recognized by Lindley, who combined the two in his original '*Introduction to Botany.*' In this work four classes are given" (see Fig. 1). "Later, in his '*Elements of Botany',* Lindley reduced the classes to two: 1. *Simple fruits,* those proceeding from a single flower; 2. *Multiple fruits,* those formed out of several flowers." This interpretation by Gray (1880) is not entirely correct. Lindley (1831) had stated that fruits were either simple or multiple before he published his original *Introduction to botany* (Lindley, 1832). In com-

paring Lindley's 1831 and 1861 editions of *Elements of botany,* and his 1832 and 1848 editions of *Introduction to botany,* respectively, the format and wording, with the exception of very minor editing, were never changed under the subject matter of fruit (the phrase "and are called *anthocarpous*" was appended to the definition of multiple in the 1861 edition, item 593).

Sablon (1884) implied that aggregate of Lindley (1832) corresponded to multiple of L.-C. Richard; Sablon (1884) probably meant A. Richard (1825), whose classification is similar to that of de Candolle (1813).

Sampaio (1937) noted that many authors had abandoned Lindley's designations of syncarp (fused carpels of a single flower) and apocarpous (free carpels in one flower); Sampaio (1943) later commented on the considerable confusion over the terms multiple, aggregate, compound, apocarp, and syncarp, with reference to Gray ("1881"; i.e., 1880). However, Sampaio (1937, 1943) did not include de Candolle's classification among the many that he summarized. The terms aggregate and multiple have appeared less frequently in the late nineteenth century classifications of fruits, probably because it was unclear as to how they should be defined; the confusion is evident in English translation of German works that reversed the original authors' meaning (cf. Sachs, 1875; Sachs & Goebel, 1887). Other terms that were applied, such as to fruits formed from inflorescences, include "collective" (Gray, 1880; Lindley, 1832), "polyanthocarpes" (Beck, 1891; de Candolle, 1857) or "polyathalamiques" (Lestiboudois, 1855), "synanthocarpés" (Dugés, 1882; A. Richard, 1846), "spurious" or "pseudocarp" (Vines, 1895), and "compound" (Brousse, 1880). Multiple and aggregate fruits (sensu de Candolle, 1813) were sometimes combined together under the category of "spurious fruits" (e.g., Vines, 1895).

Since de Candolle (1813, 1819), many authors have employed the terms aggregate and/or multiple in classifying fruits, but their definitions are usually without references. Most English and American authors define multiple and/or aggregate fruits according to Lindley while many non-English authors have followed de Candolle (1813) (Table I). Henfrey and Masters (1870) and Wood (1880) are examples of English authors who referred to aggregate or multiple sensu de Candolle (1813) while other authors have either lumped them together (Oronoz et al., 1964; Vines, 1895) or have developed hybrid classifications. For example, in Niethammer and Tietz (1961), compound fruit is synonymous with that of Gaertner (1788), whereas "Sammelfrüchte" is equivalent to the fleshy etaerio under Lindley's "Aggregati" (Fig. 1, e.g., *Fragaria, Rubus*). Stearn (1966) indicated that many of the English definitions given for botanical terms in general can be traced to Lindley, and that Jackson's (1900) *Glossary of botanic terms* were derived from Gray (1842), Henslow [1848–1856 (1858)], and Lindley (1839).

Contrary to Gray (1880), we feel that Lindley recognized the distinction between anthocarpous and collective fruits (sensu Gray, 1880), but we strongly suspect that he inadvertently substituted aggregate for multiple in Class II (Fig. 1). Under Class IV (Fig. 1, Anthocarpi), Lindley separated the accessory fruits (sensu Gray, 1880) from the multiple fruits (sensu Gray, 1880) in his key under "single" and "aggregate" (Fig. 1). The use of "aggregate," and other terms, in more than one sense, and providing alternative terms for the same concept (simple or apocarpi, compound or syncarpi, anthocarpous or collective), may have been confusing to Lindley himself, as it has been to others. It is interesting that Lindley (1831, 1861) defined "multiple" in his *Elements of botany* but the term does not even appear in his *Introduction to botany* (Lindley, 1832, 1848), except in his collation of other fruit classifications. Moreover, in his translation of L.C. Richard (1808), Lindley (1819) erroneously substituted "compound" for "multiple." Since A. Richard (1819) had earlier confused compound with multiple, it is also possible that A. Richard (1819) was a source of confusion for Lindley (1832). But Lindley's (1832) summary of A. Richard's classification is similar to the 1825 or later editions, and Lindley (1832) should have referred to de Candolle (1813, 1819).

Green (1914), in discussing Lindley's misconceptions of applying a physiological basis to his classification of the Vegetable Kingdom, makes a general statement that Lindley was not always consistent in applying the taxonomic characters he selected, "or in some instances (characters were) founded wholly on error." We regard the differences between Lindley's 1831 and 1832 fruit classifications as an example of Lindley changing the framework of the system; such changes by Lindley were not unusual (Green, 1914; Sachs, 1890). Our criticisms of Lindley's fruit classification are not meant to discredit his work. Lindley's classification and definitions are logical and well thought out, which was not uncharacteristic of Lindley in his other botanical endeavors (Green, 1914; Stearn, 1966).

Lindley's definition of a fruit on a theoretical basis (a matured ovary), but application of it on another basis (anthocarpi in Fig. 1), is a good example of Green's (1914) reference to Lindley as "presenting to us something of a puzzle; he laid down decidedly and with emphasis, what he considered the true principles of classification," but "on the other hand, he did not finally base his classification in any great detail upon those principles," or as stated by Sachs (1890) "he did not literally and habitually follow the rules he himself laid down." In this particular case, Lindley was not alone—many authors have continued to apply a double standard to the definition of a fruit in their fruit classifications (Schleiden, 1849); one notable exception was Dumortier (1835), who criticized others for giving names to fruits derived from inflorescences.

IX. Recommendations

Stearn (1966, 1983) brings together Lindley's definitions with the recommendations by the Systematic Association Committee for Descriptive Terminology (1960) and those by Rickett (1954) for leaf and stem terminology. Rickett (1944) also reviewed definitions for inflorescence terms, but fruit terminology has evidently not been reviewed by anyone since Bischoff (1833), Dumortier (1835), and Lindley (1832).

It has been suggested that in choosing among terms to attach to a definition, the term with the longer established meaning be given consideration rather than basing a decision strictly on priority (Aeschimann & Bocquet, 1980; A. de Candolle, 1880; Rickett, 1944); however, when the meaning is unclear, then priority should take precedence (A. de Candolle, 1880). By now, the meaning of multiple and aggregate fruits should be unclear, but it should also be noted that definitions for other fruit types have further confused the issue. Syncarp, for example, was originally defined by L.-C. Richard (1798) as a fruit that formed from the fusion of many distinct pistils of one flower (e.g., *Annona, Magnolia*); currently it may refer to fruit derived from (1) fusion of carpels from more than one flower (Correll & Johnston, 1970; vanRoosmalen, 1985), especially when fleshy (Usher, 1966), or (2) fused carpels of a compound pistil (Oronoz et al., 1964). Obviously, there is a need to standardize fruit terminology, and until this is done, we urge authors to reference fruit types, preferably to a primary source. We, therefore, recommend following the usage of multiple by Gaertner (1788).

Lindley (1832), feeling that definitions of simple and compound fruits should correlate with simple and compound pistils of a flower, abandoned his principle of priority when he redefined these fruit terms. While it is logical to equate homologous floral and fruit parts (e.g., a simple pistil produces a simple fruit), most fruits as defined (berry, capsule, drupe) do not form a natural classification. As for those that are intended to characterize a natural taxonomic group, such as the legume (Fabaceae)—typically regarded as a fruit of one carpel that commonly splits along two sutures—there are many exceptions to the typical form (indehiscent and fleshy, *Hymenaea*; or indehiscent and winged, *Pterolobium*), and attempting to construct a definition that covers all the morphological variation would be fruitless. We reject Lindley's (1832) arguments for correlating the definitions of these fruit terms, and we further propose to keep fruit morphology independent of floral morphology in accordance with Linnaeus (1751). It follows then that "compound" of Gaertner (1788) has priority over that of Lindley (1832) and aggregate of de Candolle (1813).

It is evident that we consider fruit as a product of either the gynoecium

[simple or multiple fruits (Gaertner, 1788)], or gynoecia when an entire inflorescence forms a single fructification [compound fruits (Gaertner, 1788)]. Fruit has been narrowly defined as a matured ovary, but the more appropriate term for this definition is pericarpium (Barton, 1836; de Candolle, 1819; Link, 1824; Linnaeus, 1751; Willdenow, 1811). The individual units of a multiple, schizocarpic, or compound fruit might be regarded as fruitlets, a term that has been employed without definition (e.g., Johnson, 1931; Roth, 1977). We are working out the systematics of fruit nomenclature for the development of a comprehensive key and glossary to commonly recognized fruit types; multiple (Gaertner) and compound (Gaertner) are two examples.

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