Bot. Rev. (2015) 81:306–316
DOI 10.1007/s12229-015-9159-1

Response to the Erroneous Critique of my *Cannabis* Monograph by R. C. Clarke and M.D. Merlin

Ernest Small[1,2]

[1] Science and Technology Branch, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada K1A 0C6
[2] Author for Correspondence; e-mail: ernie.small@agr.gc.ca

Published online: 24 November 2015

I have been involved in debates in scientific journals concerning the classification of *Cannabis sativa* for almost a half century. Its variation pattern is by no means more complex than posed by thousands of other plant species, which usually receive just a paragraph of mention in the literature. However, because it is the world's most controversial plant, *C. sativa* has attracted very widespread interest, not only by scientists but indeed by the public, who regrettably have been confused by its classification and nomenclature. Even in recent scientific publications there is frequent misunderstand about names applied to forms of *C. sativa*. The issues are not merely academic, since appropriate classification is the means by which certain biotypes are authorized for industrial and medical purposes, or subject to civil and criminal penalties. Accordingly, the evolutionary classification of *C. sativa* is very important, and I am very grateful to the editors of Botanical Review for having permitted me to publish a very extensive article on the subject (Small, 2015). Of course, as with most controversial issues, there is not unanimity of opinion on all aspects, as reflected by the criticism of Clarke and Merlin (2015). While I do not question their expertise, as detailed in the following, every one of their substantive criticisms of my contribution is mistaken. Much of the presentation of Clarke and Merlin quotes or rephrases material I presented in my paper, and of course I have no quarrel with this. My rejoinder is limited to their challenges regarding facts or interpretations in my presentation.

Classification and Nomenclatural Issues

Clarke and Merlin commented regarding the "species debate" concerning *Cannabis*: "is it really so important if we agree on one species, two or three? As Shakespeare might have interjected, the *Cannabis* taxonomic debate has become 'much ado about nothing'."

The *Cannabi*s taxonomic debate is certainly not much ado about nothing – it is primarily about using taxonomic names in a way that is unambiguous and is consistent with the norms of botanical classification. When some "apples" (from the species *Malus domestica*) are called "oranges" despite most people thinking that oranges come only from the species *Citrus sinensis*, misunderstanding is inevitable. As discussed in the following, this is the kind of communication problem that Clarke and Merlin have failed to acknowledge.

What matters is just exactly what is included in a given conception of a species (or indeed any other taxonomic group), and what isn't – otherwise there is unacceptable ambiguity about what the governing name designates. Figure 1, which shows the pre-Columbian geography of four cultivated (domesticated) forms of *Cannabis*, serves to demonstrate how ambiguity exists with respect to *Cannabis* names. I (and most of the botanical community) consider that all of these groupings belong to "*Cannabis sativa.*" By contrast, Clarke and Merlin and several other botanists use the name *C. sativa* to designate only Group 1, and assign Groups 2, 3, 4 and 6 to "*C. indica*." The ambiguities increase considerably when one also addresses the wild forms, as detailed in Small (2015), but since the commentary of Clarke and Merlin pertains mainly to domesticated forms there is no need to repeat this complicated information here. However, I note that in their comments Clarke and Merlin misinterpret my classification of *Cannabis* in asserting that I include wild counterparts in the respective groups in which I place the four basic domesticated forms.

Table 1 contrasts the scientific names employed by me and by Clarke & Merlin for the six groups. (As acknowledged by Clarke and Merlin, their classification is based on the work of several other botanists, whose contributions are discussed in my paper.) Notice that what is commonly referred to as "indica-type" marijuana in the marijuana trade and indeed in much of society is assigned to subsp. *afghanica* of *Cannabis indica* by Clarke and Merlin, but what is commonly referred to as "sativa-type" marijuana in the marijuana trade and indeed in much of society is assigned to subp. *indica* of

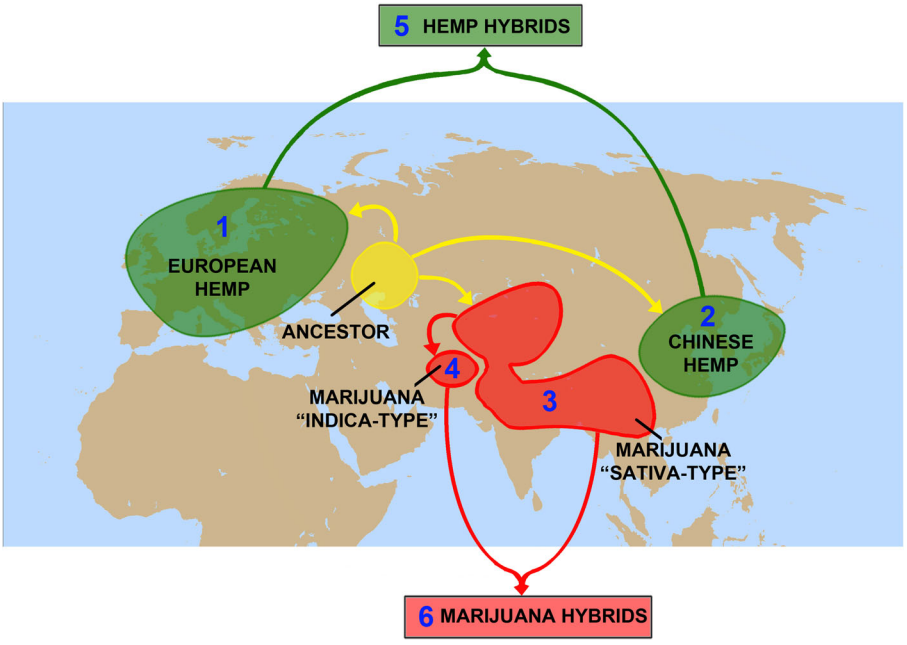

Fig. 1 Approximate postulated geographical locations of the four principal groups (1–4) of *Cannabis* domesticated more than a millennium ago, and subsequently transported to other parts of the world. Hybridization, mostly during the last century, has obscured differences between the two hemp groups, 1 and 2 (generating hybrid group 5) and between the two marijuana groups, 3 and 4 (generating hybrid group 6). For simplicity, "wild" forms are not shown, except for a presumed ancestor

Table 1 Nomenclature applied by Small and by Clarke & Merlin to the six domesticated groups of *Cannabis* shown in Fig. 1

Group	Small	Clarke & Merlin
1. European hemp	*Cannabis sativa* subsp. *sativa*	*Cannabis sativa* subsp. *sativa*
2. Chinese hemp	*Cannabis sativa* subsp. *sativa*	*Cannabis indica* subsp. *chinensis*
3. Marijuana "sativa-type"	*Cannabis sativa* subsp. *indica*	*Cannabis indica* subsp. *indica*
4. Marijuana "indica-type"	*Cannabis sativa* subsp. *indica*	*Cannabis indica* subsp. *afghanica*
5. Hemp hybrids	*Cannabis sativa* subsp. *sativa*	*Cannabis sativa* × *C. indica*[a]
6. Marijuana hybrids	*Cannabis sativa* subsp. *indica*	*Cannabis indica* subsp. *indica* × subsp. *afghanica*[a]

[a] These are the appropriate scientific names, although not given by Clarke and Merlin

Cannabis indica by Clarke and Merlin. The word "indica" seems to be associating with the wrong combination (why shouldn't "indica type" marijuana be assigned to *Cannabis indica* subsp. *indica*, rather than *Cannabis indica* subsp. *afghanica*?). Even more confusing, "sativa type" marijuana is assigned to *Cannabis indica*, not *Cannabis sativa* as one might intuitively expect. The reasons for these seeming contradictions rest in the technical nature of plant nomenclature, coupled with the inadvisable but established societal usages of "indica-type" and "sativa-type" to designate classes of marijuana (as discussed in my monograph), for which Clarke and Merlin are blameless. Nevertheless, because of the seeming contradictions pointed out here, the scientific names that they are advocating are contributing to the immense confusion associated with *Cannabis* scientific nomenclature.

The consequences of misunderstanding what a scientific or vernacular name includes and doesn't include can be serious. For example, "star anise" is a widely used spice from *Ilicium verum*, but some people think the name also refers to another species (*I. anisatum*) which is extremely toxic and has, with disastrous results, been substituted in spice preparations (Small, 1996). The consequences of misunderstanding what is and isn't included under the names *C. sativa* and *C. indica* can also be serious. A very recent paper (which I will not cite for fear of provoking another protesting letter-to-the editor) in one of the most respected of scientific journals misassigned many of the research materials to *C. sativa* and *C. indica* because the authors did not understand the relevant taxonomic complexities discussed in the previous paragraph, making their results incomprehensible unless the misinterpretations are evident to the reader.

Clarke and Merlin, and I, do agree that domesticated cannabis can be recognized as comprising: a European group (1) and a Chinese group (2) as well as their widespread hybrids (5), all of which are usually low in the intoxicant cannabinoid THC (tetrahydrocannabinol) but high in the non-intoxicant cannabinoid CBD (cannabidiol), and which have historically been dedicated mostly to the production of a stem fiber, but to an increasing degree for seed oil; and two Asian groups, so-called "sativa-type" (3) and so-called "indica-type" (4), as well as their widespread hybrids (6), all of which contain substantial levels of THC.

Groups 1, 2 and 5, which are non-intoxicating, are commonly known as "hemp" while Groups 3, 4 and 6 have traditionally been termed "marijuana." Clarke and

Merlin, and I, disagree on (a) a postulated evolutionary model for the relationships of the cultivated groups and wild-growing populations; (b) taxonomic circumscription: appropriate amalgamations of the cultivated groups and wild-growing populations; (c) taxonomic ranking: the assignment of populations or groups of populations to species, subspecies or varieties (varietas); and (d) appropriate common names for the groups. Table 2 in Small (2015) compared my classification and nomenclature for *Cannabis* with that of several other recent botanists, including Clarke and Merlin. Although the bulk of my 100-plus page paper dealt with these problems, and attempted to simplify the complexities of classification of species such as *C. sativa* which comprise both domesticated and free-living populations, the criticism of Clarke and Merlin scarcely mentions any of these topics. Their "rebuttal" challenges just a few selected issues.

As shown in Table 1, Clarke and Merlin place European-origin hemp cultivars (Group 1) and Chinese-origin hemp cultivars (Group 2) in different species (respectively *C. sativa* and *C. indica*). Plants of these "species" are so similar in so many respects (like ducks that walk, swim and quack identically) that their assignment to different species, in my opinion, defies credulity. More seriously, the recognition of these domesticated groups of plants as different species is symptomatic of a flawed understanding of the norms of botanical classification, particularly as it relates to the species category. As discussed at length in my monograph, plants that are different because they have been altered by humans are appropriately treated under the plant cultivar code (Brickell et al., 2009), not the botanical code utilizing exclusively Latin nomenclature (McNeill et al., 2012). Also as I discussed, recognition of such cultivar groups (often termed "cultigens") as species distorts understanding of their true evolutionary nature and has both theoretical and practical negative consequences.

As shown in Fig. 1, I interpret the cultivated forms as having originated from a common wild ancestor, which so far as can be determined is extinct. Clarke and Merlin hypothesize the existence of several independent wild ancestors, a view which I criticized in my paper as speculation without foundation. Although Clarke and Merlin (2013, page 64, for example) refer to these hypothetical groups as "taxa" (taxonomic groups), they are so nebulous as to be unacceptable by the standards of botanical classification as reflected in the botanical code governing naming of all plants (McNeill et al., 2012). The existence of hypothetical taxa, like Martians, unicorns, the Loch Ness Monster and the Sasquatch, cannot be disproven but, until there is reliable evidence of their presence, they should not be taken seriously.

Genetic Isolation and Protection from Pollen Contamination

The ability to interbreed and the actual degree to which interbreeding occurs among populations are critical considerations in recognizing taxa, because gene exchange among them tends to eliminate the differences that are employed to define them. Indeed, as pointed out in my monograph, this is an essential consideration arguing for the existence of only one species of *C. sativa*. My view is that the enormous rain of pollen produced by *C. sativa*, in conjunction with wide geographical distribution by humans and the complete lack of interbreeding barriers, has been responsible for such extensive widespread genetic interchange (hybridization, introgression) that on a global

basis, separating *Cannabis* into distinctive species is unwarranted – a view with which Clarke and Merlin obviously disagree, since they recognize two species.

In their critique of my paper as well as in their book (2013), Clarke and Merlin strongly argue that some cultivated strains and land races remain genetically pure, indicating the limited occurrence of introgression of genes into (but not necessarily out of) cultivated strains. They appear to be offended by my view that over time genes flow into, as well as out of cultivation. As discussed in my paper, stabilizing selection is required to maintain the purity of desired strains, and no doubt geographical isolation, such as occurs among land races grown in isolated mountain villages, has protected some strains from genetic contamination. In arguing that there is a continuum of variation connecting all cannabis plants, I certainly do not deny that domesticated strains and land races have unique genomes which can often be maintained for long periods depending on circumstances. This is no different from the variation pattern that occurs in numerous other crop-weed complexes (Andersson & de Vicente, 2010). Clarke and Merlin argued that because marijuana cultivators today mainly grow female plants, the degree of pollen availability is limited but, as documented in my paper, there is abundant pollen from hemp cultivation and weedy cannabis, and prevention of genetic contamination requires quite extraordinary physical separation (5 km is recommended for commercial purposes, but even this does not guarantee protection).

Clarke and Merlin wrote: "'land race germplasm in the Vavilov Research Institute … has been extensively hybridized (Small and Marcus 2003, Hillig 2004) due to inadequate maintenance.' The VIR Cannabis seed collection was established in the 1970s and the hybridization 'due to inadequate maintenance' occurred over the years as each accession was reproduced without adequate pollen isolation, and their genomic purity was compromised by intercrossing. The VIR's error in seed bank multiplications should not be interpreted as evidence for evolutionarily significant introgression amongst naturally distributed ruderal populations, landraces, or intentionally bred and selected cultivars."

On the contrary, the inability of the Vavilov Institute to maintain the purity of its cannabis collections is indisputable evidence that, without substantial geographical isolation, cultivated forms will be genetically infiltrated by foreign pollen.

Number Designations for Cultivated Groups

Clarke and Merlin complained that I "assigned numbers to the hybrid hemp (NLH/BLH or Group 5) and hybrid drug (NLD/BLD or Group 6) gene pools also previously described by Clarke and Merlin (2013). Assigning numbers to plant groups strips them of their descriptive names, weakens our perception of them as gene pools, and divorces them from their evolutionary past. We fail to see how this constitutes any improvement in our understanding of *Cannabis* evolution and its taxonomic ramifications."

Gentlemen, the numbers have no nomenclatural significance! They are there merely for location, like room numbers. And how is this worse than your practice of assigning codes like "NLH" and BLH?" [The abbreviations respectively translate to "narrow-leaf hemp" and "broad-leaf hemp" – botanically inaccurate since what is really meant is "narrow-leaflet hemp" and "broad-leaflet hemp"].

The Cultivated Plant Code Does Not Recognize Marijuana Strains as Cultivars

Clarke and Merlin show insufficient respect for the code that governs the rules of cultivar recognition (Brickell et al., 2009), which is foundational for much of the world's agricultural and horticultural activities. They criticize the cultivated plant code for forbidding recognition of most marijuana "strains" as cultivars (current descriptive requirements are rarely satisfied), a fact which I pointed out in my article, while noting that marijuana strains are conceptually identical to cultivars. It needs to be understood that both botanical nomenclature codes pertaining to the classification of plants do not have legal status comparable to codified governmental laws and regulations. Rather, they have pragmatic and moral status. They are the result of international collaboration by classification experts representing the interests of all fields of botanical sciences, and are revised every few years as needs and knowledge evolve. The botanical codes are by and large adhered to by scientists, commercial interests and editors because they provide stability and reliability to names that otherwise would result in confusion. Marijuana strain names, at present numbering over 1000, are currently so spectacularly unreliable (Sawler et al., 2015) that it would not be useful to automatically convert strain names to cultivar names. Most strains were created by clandestine breeders, operating more or less criminally, and their nature and status is, not surprisingly, very uncertain. Today, it is much easier to conduct legitimate activities on marijuana, and those producing and marketing marijuana biotypes should be encouraged to follow the rules of cultivar recognition as is done for hemp cultivars, in order to adequately characterize medical and recreational strains and bring order to the current chaotic situation. In the meantime, those purchasing or using a marijuana strain need to follow the warning *caveat emptor*.

Misunderstanding of what "Drug" and "Psychoactive" Mean

As discussed later, Clarke and Merlin expressed extreme dissatisfaction with my use of the terms "narcotic" and "intoxicant" to describe high-THC forms of *C. sativa* used for marijuana, and as substitutes they recommended that "A simple solution would be to use the terms "drug *Cannabis*" and "psychoactive *Cannabis*" which are accurately descriptive." They are completely mistaken, as pointed out in the next two paragraphs. In my paper (page 236) I discuss the applicability of numerous terms that have been applied to the psychic effects of marijuana, stressing that finding an appropriate descriptor is very problematical.

CBD is the predominant cannabinoid of hemp cultivars (Groups 1, 2 and 5 in Fig. 1 and Table 1). This is well-known to have at least as much potential for use in drugs as THC (the principal or at least a major component of Groups 3, 4 and 6), and indeed is currently under exploration for treatment of many more medical conditions than is THC (Zuardi, 2008; Fernández-Ruiz et al., 2013; Devinsky et al., 2014). Accordingly, it is impossible to distinguish the high-THC "narcotic" forms on the basis of whether they furnish drugs, since the "non-narcotic" forms also furnish drugs.

It is also important to clarify the meaning of "psychoactive," a term which is very extensively employed for cannabis in a misleading way, and indeed Clarke and Merlin

have fallen into this trap. Etymologically, "psychoactive" should mean "psychologically active," i.e. significantly affecting mental status, which could include any of mood, emotion, perception and cognition. However, in the context of discussing cannabis, a misguided tradition has developed of employing "psychoactive" to refer exclusively to the euphoria (the "high" or intoxicated state) produced by marijuana, while ignoring other significant induced mental states, most particularly sedation, but also such other effects as anxiety modulation (reduction or increase). Burstein (2015) pointed out that "the structure of CBD was not completely elucidated until 1963. Subsequent studies resulted in the pronouncement that THC was the 'active' principle of cannabis and research then focused primarily on it to the virtual exclusion of CBD." As a result, most of the pharmacological and experimental cannabis literature misuses the term psychoactive. Most egregiously, the cannabinoid CBD is almost universally referred to as "non-psychoactive," which indisputably is incorrect. Although CBD will not induce marijuana intoxication, depending on dosage and context it will modify psychological status. For example, CBD has sleep-inducing or sedative properties at high dosages (Carlini & Cunha, 1981; Pickens, 1981), although at lower doses it has alerting properties (Nicholson et al., 2004; Russo & Guy, 2006).

Clarke and Merlin use the word "drug" as part of the names of several of their taxa: "putative drug ancestor," "narrow-leaf drug ancestor," "narrow-leaf drug" and "broad leaf drug." Since, as pointed out above, legitimate drugs are equally obtainable from every biotype of *C. sativa*, including forms used as hemp as well as forms used for marijuana, their use of the word drug in their nomenclature is inappropriate, regrettable and simply wrong.

The word "marijuana" may be the most appropriate way of distinguishing high-THC cannabis from low-THC forms, but even this word has its problems. The seemingly oxymoronic phrase "highless marijuana" refers to biotypes rich in CBD but low in THC that are used to produce herbal preparations for medical purposes (Lubell, 2012). Very low-THC material (almost always rich in CBD) has been contemptuously referred to as "ditchweed," and it is highly ironic that such preparations (in principle not that different from conventional hemp) are now being marketed as a kind of "marijuana" for smoking. It may be noted, however, that "vaping" (vaporization) based on extracts is widely believed to represent a much safer mode of consumption than smoking, and this allows precise dosing of the content of cannabinoids, and indeed other medical components of possible value.

The Etymology of "Cannabis"

Clarke and Merlin wrote: "Concerning the linguistic origins of the word 'cannabis' Small casually states (page 219) that, 'During the age of sailing ships, *Cannabis* was considered to provide the very best canvas, and indeed this word, as well as the genus name *Cannabis*, are derived from an Arabic word for hemp.' According to the *Oxford Dictionary Online* the name 'cannabis' is from Greek k*annabis*, via Latin *cannabis*; and the Online Etymology Dictionary tells us that 'cannabis' was originally a Scythian or Thracian word. There is no mention of derivation via Arabic."

Clarke and Merlin should have examined the facts more thoroughly before criticizing my "casual statement." A much more scholarly and accurate view, demonstrating

the connection of the word "cannabis" to Arabic (as well as other languages), is in Quattrocchi (2000), the most authoritative guide to the etymology of plant names: "From the Latin *cannabus*, *i* (Dioscorides), *cannabis*, *is*; Greek *kannabis*, *kannabios*, *kannabeos* "hemp" (Sophocles); Arabian *ganeh*, Sanskrit *gangika* and *bhanga*; Akkadian *hannabu*, *hanbu* "blooming, thriving" [*i* = nominative declension, *is* = genitive declension]. Benet (1975) stated "the term *cannabis*… is derived from Semitic languages… both its name and forms of its use were borrowed by the Scythians from the peoples of the Near East… Both in the original Hebrew text of the Old Testament and in the Aramaic translation, the word *kaneh* or *keneh* is used either alone or linked to the adjective *bosm* in Hebrew and *busma* in Aramaic, meaning aromatic. It is *cana* in Sanskrit, *qunnabu* in Assyrian, *kenab* in Persian, *kannab* in Arabic and *kanbun* in Chaldean."

Selection for Short Marijuana Plants

Clarke and Merlin wrote: "When describing phenotypic changes in stalk architecture resulting from domestication for drug use, Small (page 217) refers to Asia (likely the Himalayan foothills) where: '…one method of preparing hashish involved using hands or leather to collect (by adherence) sticky resin from the inflorescences at the top of the plants (alternatively and more conventionally today, hashish is prepared by filtering techniques …). Accordingly, strains suitable for hashish collection based on stickiness should not be too tall. As Bouquet (1950) recorded: 'The cultivators, dressed in leather, moved about through the plantations. The resin sticks to their clothes, which are scraped from time to time with a blunt curved knife. This method of collection shows clearly that in those regions the plant does not grow to any great height.'"

Clarke and Merlin commented regarding this: "Although Afghan BLD ["broad-leaf drug"] or Group 4 plants may be shorter than NLD ["narrow-leaf drug] or Group 3 plants, BLD populations often average 2 to 3 m tall, and therefore they were likely not selected for stature shorter than a human."

However, the adherence method of collection is rarely practiced in recent times because it is so inefficient, so observation of the height of present-day Group 4 plants is not definitive. Certainly there is selection of marijuana cultivars for limited height, as pointed out by Clarke and Merlin (2013, page 40): "Growers of *Cannabis* for sieved hashish production traditionally select plants of short stature." Moreover, the literature and the internet often present illustrations of short Group 4 plants in cultivated fields in Afghanistan and other areas of Asia, and Group 4 is widely described as shorter then Group 3.

Glandular Trichome Functions

In referring to my discussion of the glandular trichomes, Clarke and Merlin stated that they "are confused by his conclusions concerning resin gland function." I presume their challenge is based on their statement "there is no evidence that resins flow onto the surface of the bracts and leaflets." As pointed out in my paper, the foliage of *C. sativa* can become so sticky that there has been speculation that the function of the resin is a

kind of coating sunscreen, a hypothesis that I reject, but at least it points out that the plant surfaces can becomes resinous.

As discussed in the next two paragraphs, Clarke and Merlin failed to distinguish the large stalked glandular hairs ("capitate glands") which predominate in the inflorescence from the much smaller but quite numerous small more or less stalkless glands which predominate on the foliage. As noted in the following discussion, this distinction is critical to interpreting (and rejecting) Clarke and Merlin's proposal regarding the allelopathic significance of cannabis resin.

The inflorescence, in contrast to the foliage, is dominated by much larger, capitate stalked glandular hairs. Clarke and Merlin speculated about the natural function of the so-called "abscission layer" – really a narrowly constricted and hence potentially relatively weak zone at the summit of the stalks, just underneath the secretory gland heads. I have observed that, in the living state, the gland heads always burst immediately when touched, but do not readily fall off from the living plant, so just why stalked glandular trichomes develop a constricted area just beneath the gland heads is unclear. In no way is the "abscission area' of cannabis stalked trichomes comparable to the abscission zone at the base of the foliage of deciduous trees, or at the base of fruits that abscise at maturity. I am intrigued, but not at all convinced by Clarke and Merlin's interpretation that the "abscission layer" is adaptive in allowing gland heads to fall to the ground and release allelopathic constituents to repel competing vegetation. As pointed out in Small and Naraine (2015), about 30% of flowering plants possess glandular trichomes producing secondary chemicals, usually at the tip of the structures, often in distinctive head-like containers, and there is an overwhelming majority view that these are primarily an adaptation protecting the plant against herbivorous animals, not against competing plants. In any case, living plants simply do not drop the resin heads. Indeed, is there any plant species for which a convincing case can be made that it drops its glandular hairs to act as chemical warfare micro-bombs to contaminate the soil in order to repel competing plants? There is also a timing problem with Clarke and Merlin's hypothesis: *C. sativa* does not produce its inflorescences until late summer and early autumn, so it does not have a supply of stalked glands to drop until then. It hardly makes sense to schedule allelopathic activity so late in the season, when competing plants have completed most of their seasonal growth. As Clarke and Merlin appreciate, when the plants are dead and dry the "abscission layer" actually does dramatically weaken the attachment of the gland heads, facilitating production of gland-head-rich drug preparations, and indeed humans may have accentuated separation of the gland heads by selection of biotypes (as I pointed out in my paper). However, selection by humans does not reflect natural adaptations in nature.

The foliage surface has many small glands, which unlike the much larger capitate glands of the inflorescence, do not burst when touched (their function also seems to be to discourage herbivores from eating the plant, but not to additionally act as flypaper like the glands discussed above). Also unlike the larger inflorescence stalked glands, the glandular heads of which fall off with light agitation in dried material, the foliage glands of the leaves are extremely difficult to separate, and remain rigidly attached to desiccated, dead leaves. This, I believe, holds the key to the allelopathic nature of *C. sativa*, not the hypothesis of Clarke and Merlin that the plant drops glandular heads from the capitate glands to discourage competing plants. Allelopathy is very well known in the plant kingdom, but the toxic chemicals mainly leach into the soil from the roots or other

vegetative parts of the plant. Older, senescent foliage of *C. sativa* characteristically abscises and falls to the ground, and while the content of resin in the foliage is much lower than in the inflorescence glands, the fallen leaves doubtless contribute to allelopathic protection. In any event, allelopathy of *C. sativa* is not particularly effective, since nearby weeds and grasses are usually superior competitors (unless *C. sativa* has grown large enough to shade out lower plants). Moreover, allelopathy is most effective in repelling seedlings, not established plants. *Cannabis sativa* is an annual, and does not become large enough in the spring to produce a sufficient volume of resin to have any substantial effect on surrounding competing seedlings. (Whether overwintering litter from the plant can affect the next year's growth is another issue.)

Semantic Correctness

Much of the criticism of Clarke and Merlin seem less associated with science and more concerned with a sort of political correctness about labels that they perceive stigmatize marijuana. In particular, they unfairly and selectively cite dictionary definitions and condemn at length my use of the word "narcotic," despite my extensive discussion and qualification of how I was employing the term in a very limited psychopharmacological technical sense (page 236). I clearly divorced the pejorative and legal associations of the term from the physiological meanings. "Narcotics," most prominently the opiates and opioids, are widely understood to be both a curse and a blessing on humankind, and although the opiates are more toxic than cannabis (as pointed out by Clark and Merlin), this is not an excuse to ignore the harmful aspects of the latter (a "soft drug" can be very hard on some individuals). Every scientist acquires respect for their study material, and those who have dedicated their career to a particular subject sometimes tend to over-champion it while ignoring associated negatives. Indeed, I have extolled the virtues of narcotic plants (Small, 2004), none of which has been adequately or objectively examined for its beneficial potential. However, complaining about adjectives like "narcotic" and "intoxicant" to describe marijuana reveals an excessively defensive mindset. While I do not wish to dwell on the merits of the current debates concerning the wisdom of medical and recreational usage of marijuana, I consider it unwise to ignore the current scientific consensus that there are *both* harmful and beneficial potentials.

In conclusion, I would like to acknowledge the monumental contributions of both Clarke and Merlin to knowledge of *Cannabis sativa*. I trust that our debate will further a better understanding of its scientific nature and societal value.

Literature Cited

Andersson, M. S. & M. C. de Vicente. 2010. Gene flow between crops and their wild relatives. Johns Hopkins University Press, Baltimore.

Benet, S. 1975. Early diffusion and folk uses of hemp. Pp 39–49. *In:* V. Rubin (ed). Cannabis and culture. Mouton, The Hague.

Bouquet, R. J. 1950. *Cannabis*. Bulletin on Narcotics 2(4): 14–30.

Brickell, C. D., C. Alexander, J. C. David, W. L. A. Hetterscheid, A. C. Leslie, V. Malecot, X. Jin & J. J. Cubey. 2009. International code of nomenclature for cultivated plants. International Society for Horticultural Science, Leuven. http://www.actahort.org/chronica/pdf/sh_10.pdf (accessed Oct 16, 2015).

Burstein, S. 2015. Cannabidiol (CBD) and its analogs: a review of their effects on inflammation. Bioorganic & Medicinal Chemistry 23: 1377–1385.

Carlini, E. A. & J. M. Cunha. 1981. Hypnotic and antiepileptic effects of cannabidiol. Journal of Clinical Pharmacology 21: 417–427.

Clarke, R. C. & M. D. Merlin. 2013. *Cannabis*: Evolution and ethnobotany. University of California Press, Los Angeles.

——— **&** ———**.** 2015. Rebuttal to: Small, Ernest. 2015. Evolution and classification of *Cannabis sativa* (marijuana, hemp) in relation to human utilization. Botanical Review 81(3): 189–294. **Botanical Review: xx–xx**.

Devinsky, O., M. R. Cilio, H. Cross, J. Fernandez-Ruiz, J. French, C. Hill, R. Katz, V. Di Marzo, D. Jutras-Aswad, W. G. Notcutt, J. Martinez-Orgado, P. J. Robson, B. G. Rohrback, E. Thiele, B. Whalley & D. Friedman. 2014. Cannabidiol: pharmacology and potential therapeutic role in epilepsy and other neuropsychiatric disorders. Epilepsia 55: 791–802.

Fernández-Ruiz, J., O. Sagredo, M. R. Pazos, C. García, R. Pertwee, R. Mechoulam & J. Martínez-Orgado. 2013. Cannabidiol for neurodegenerative disorders: important new clinical applications for this phytocannabinoid? British Journal of Clinical Pharmacology 75: 323–333.

Hillig, K. W. 2004. A multivariate analysis of allozyme variation in 93 *Cannabis* accessions from the VIR germplasm collection. Journal of Industrial Hemp 9(2): 5–22.

Lubell, M. 2012. What a drag, Israeli firm grows "highless" marijuana. Reuters July 3, 2012. http://www.reuters.com/article/2012/07/03/us-israelmarijuana-idUSBRE8620FU20120703 (accessed Oct 16, 2015).

McNeill, J., F. R. Barrie, W. R. Buck, V. Demoulin, W. Greuter, D. L. Hawksworth, P. S. Herendeen, S. Knapp, K. Marhold, J. Prado, W. F. Prud'homme van Reine, G. F. Smith, J. H. Wiersema & N. J. Turland. (eds.). 2012. International code of nomenclature for algae, fungi, and plants (Melbourne Code). Koelz Scientific Books, Koenigstein, Germany (Regnum Vegetabile 154.) http://www.iapt-taxon.org/nomen/main.php?page=title. (Accessed Oct. 16, 2015.)

Nicholson, A. N., C. Turner, B. M. Stone & P. J. Robson. 2004. Effect of Δ^9-tetrahydrocannabinol and cannabidiol on nocturnal sleep and early-morning behavior in young adults. Journal of Clinical Psychopharmacology 24: 305–313.

Pickens, J. T. 1981. Sedative activity of cannabis in relation to its Δ^1-trans-tetrahydrocannabinol and cannabidiol content. British Journal of Pharmacology 72: 649–656.

Quattrocchi, U. 2000. CRC World Dictionary of Plant names, common names, scientific names, eponyms, synonyms, and etymology, Vol. 4 vols. CRC Press, Boca Raton.

Russo, E. B. & G. W. Guy. 2006. A tale of two cannabinoids: the therapeutic rationale for combining tetrahydrocannabinol and cannabidiol. Medical Hypotheses 66: 234–246.

Sawler, J., J. M. Stout, K. M. Gardner, D. Hudson, J. Vidmar, L. Butler, J. E. Page & S. Myles. 2015. The genetic structure of marijuana and hemp. PLoS ONE 10(8), e0133292. doi:10.1371/journal.pone.0133292.

Small, E. 1996. Confusion of common names for toxic and edible "star anise" (*Illicium*) species. Economic Botany 50: 337–339.

——— 2004. Narcotic plants as sources of medicinals, nutraceuticals, and functional foods. Pp. 11–67. *In*: F.-F. Hou, H.-S. Lin, M.-H. Chou & T.W. Chang (eds). Proceedings of the international symposium on the development of medicinal plants, 24–25 Aug. 2004, Hualien District Agricultural Research and Extension Station, Hualien. Hualien, Taiwan. http://www.hdares.gov.tw/htmlarea_file/web_articles/hdais/1370/9308_11-68.pdf. (Accessed Oct. 16, 2015.)

——— 2015. Evolution and classification of *Cannabis sativa* (marijuana, hemp) in relation to human utilization. Botanical Review 81: 189–294.

——— **& D. Marcus.** 2003. Tetrahydrocannabinol levels in hemp (*Cannabis sativa*) germplasm resources. Economic Botany 57: 545–558.

——— **& S. G. U. Naraine.** 2015. Size matters: evolution of large drug-secreting resin glands in elite pharmaceutical strains of *Cannabis sativa* (marijuana). Genetic Resources and Crop Evolution 62: in press. doi: 10.1007/s10722-015-0254-2.

Zuardi, A. W. 2008. Cannabidiol: from an inactive cannabinoid to a drug with wide spectrum of action. Revista Brasileira de Psiquiatria 30: 271–280.