台灣產雀麥屬（禾本科）植物之數量分類學研究

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摘 要

本研究應用DELTA資料庫系統，以表徵分類之數量分類學方法檢驗台灣產雀麥屬(*Bromus* L.)植物之分類。根據歸群分析的結果，我們可以確認大扁雀麥(*Bromus catharticus* Vahl)、台灣雀麥(*Bromus formosanus* Honda)、玉山雀麥(*Bromus morrisonensis* Honda)及較晚發現之歸化種硬雀麥(*Bromus rigidus* Roth)。卑南雀麥(*Bromus remotiflorus* (Steud.) Ohwi var. *piananensis* Ohwi)則併入玉山雀麥。

關鍵詞：DELTA、數量分類學、歸群分析、雀麥屬、禾本科

收件日期：2001年10月8日 接受日期：2002年6月20日

緒 言

第一版的台灣植物誌中，雀麥屬列入大扁雀麥(*Bromus catharticus* Vahl)、台灣雀麥(*B. formosanus* Honda)、玉山雀麥(*B. morrisonensis* Honda)及卑南雀麥(*B. remotiflorus* (Steud.) Ohwi var. *piananensis* Ohwi)，其中大扁雀麥爲歸化種，台灣雀麥及卑南雀麥爲特有種及特有變種(許 1975; Hsu 1978)，玉山雀麥原先被認爲是特有種(許 1975; Hsu 1978)，後來於馬來西亞及菲律賓也有發現(Veldkamp 1991)。此外，另有較晚發現之歸化種硬雀麥(*B. rigidus* Roth)(Kuo 1979)。Ohwi (1941)發表卑南雀麥時，曾註明卑南雀麥與其原種*B. remotiflorus* (Steud.) Ohwi之差異在於稈上無毛，與玉山雀麥相似，但後者在外稃側脈基部有倒伏毛，而可區分爲不同種，但未提及卑南雀麥之外稃上脈之數目。Hsu(1978)僅以外稃之側脈有無倒伏毛來區別玉山雀麥及卑南雀麥，且描述二者之外稃皆具三條脈。荷蘭禾草分類專家Dr. J. F. Veldkamp未見到卑南雀麥的標本，但他根據Hsu(1978)之描述，對卑南雀麥被處理爲*B. remotiflorus*之變種，感到懷疑，因爲典型之*B. remotiflorus*之外稃具七條脈(Koyama 1987; Veldkamp 1991; 長田 1993)，因此他認爲卑南雀麥僅是玉山雀麥的一個變異型，於是將卑南雀麥處理爲玉山雀麥之同物異名(Veldkamp 1991)。筆者檢視國內各大標本館之標本，可以確認大扁雀麥、台灣雀麥、玉山雀麥及硬雀麥，但無法清楚識別出卑南雀麥，僅發現少數應可歸於玉山雀麥的標本，其外稃具七條脈，且其外稃之側脈上也具倒伏毛。究竟這些外稃上具七條脈之標本，是否即是卑南雀麥，因未見到模式而無法確定，因此筆者於第二版的台灣植物誌中，暫將卑南雀麥處理爲未確定種(Kuoh and Chen 2000)。

傳統的模式法分類學最爲人所詬病之處在於缺乏客觀性及穩定性，進入二十世紀以後，分類學者開始思考，如何將特徵量化，並應用數學及統計的運算，爲分類學提供一個較客觀的分析方法。1950年代以後，電子計算機的發展，使得這種構想得以實現，分類學開始從定性的、描述性的水平向定量的、精確的高水平前進，數量分類學(numerical taxonomy)於焉興起(徐 1996)。其中DELTA(DEscriptive Language for TAxonomy)系統是澳洲聯邦科學及工業研究部(Commonwealth Scientific and Industrial Research Organisation of Australia, CSIRO)昆蟲學組(Division of Entomology)的Michael J. Dallwitz開發建立的。這是一個功能強大的資料庫系統，已得到聯合國國際生物科學聯盟(International Union of Biological Sciences)之分類學資料庫工作群(Taxonomic Database Working Group)正式確定爲分類學資料的交流標準之一。除了基本的特徵資料的記錄、自動化產生檢索表及分類群描述外，DELTA可根據所建立的特徵基本資料，進行數量分類學的分析，包括表徵分類及支序分類(Askevold and O'Brien 1994; Dallwitz *et al*. 1999; Partridge *et al*. 1999; 陳及郭 2000)。

本研究之目的爲，筆者假定前述之少數應可歸於玉山雀麥，其外稃具七條脈，且其外稃之側脈上也具倒伏毛之標本即是卑南雀麥。應用DELTA系統，以台灣大學植物系標本館(TAI Herbarium)內台灣雀麥屬植物部分標本的特徵資料，進行表徵分類之數量分類學分析，視其結果是否支持這個假說。

材料與方法

筆者根據先前之研究結果(Chen and Kuo 2000)，選取台灣大學植物系標本館內18份台灣雀麥屬植物之標本，做爲分類操作單元(operation taxonomic unit, 簡寫做OTU)，各OTU編號及其標本採集編號資料如表1。根據前人研究(許 1975; Hsu 1978; Watson and Dallwitz 1994; Chen and Kuo 2000; Kuoh and Chen 2000)及筆者之觀察，選出可以用來區分及描述雀麥屬植物之特徵及各特徵之狀態(詳見附錄1.)，應用DELTA系統建立各OTU之特徵資料庫，詳細之操作請參閱Askevold and O'Brien (1994)、Dallwitz *et al*. (1999)、Partridge *et al*. (1999)、陳及郭 (2000)及Chen and Kuoh(2000)。

以建立之特徵資料庫爲基礎，DELTA程式可根據Gower(1971)的相似性係數(similarity coefficient)來計算各分類群兩兩之間的距離(距離 = 1－相似性係數)。然後執行NTSYS-pc2.02j軟體(Rohlf 1998)，應用非加權配對算數平均法(unweighted pair-group method using arithmetic average, UPGMA)進行歸群分析，建立各OTU之歸群圖。

結果與討論

本研究18個OTU各個特徵之狀態(states)列於表2，OTU兩兩之間的距離係數之矩陣列於表3，歸群結果之歸群圖列於圖1。由圖1看來，當距離約爲0.23時，全部18個OTU可分成4群，其中編號1至5歸爲第一群、編號6至9歸爲第二群、編號10至17歸爲第三群，以及編號18自成第四群。第一群即大扁雀麥，第二群爲台灣雀麥，第四群爲硬雀麥，此三群怠無疑問。然而編號15, 16, 17三個可能是卑南雀麥之OTU，不集合成群而分散於第三群中，顯示那些疑似卑南雀麥之標本並不獨立成群，而是與典型之玉山雀麥無法截然劃分。這樣的結果並不支持筆者先前所提出，該三個OTU即是卑南雀麥之假說，因此筆者認爲，卑南雀麥此一分類群並不成立，而可併入玉山雀麥，成爲玉山雀麥之一同物異

表1. 本研究所用之分類操作單位(OTU)之編號、種類及引證標本

Table 1. Codes, identification and vouchers of the 18 OTUs used in this study for *Bromus* of Taiwan

OTU編號	種　類	引證標本
1	大扁雀麥*B. catharticus*	Kuoh C. S. 80088
2	大扁雀麥*B. catharticus*	Tsai M. C. 17
3	大扁雀麥*B. catharticus*	Wang J. C. 2618
4	大扁雀麥*B. catharticus*	Hsu and Kuoh 7102
5	大扁雀麥*B. catharticus*	Wang *et al*. 3918
6	台灣雀麥*B. formosanus*	Fukuyama 4080
7	台灣雀麥*B. formosanus*	Hsu C. C. 12194
8	台灣雀麥*B. formosanus*	Shimada 2611
9	台灣雀麥*B. formosanus*	Hsu C. C. 5966
10	典型之玉山雀麥*B. morrisonensis*	Huang and Hsieh 8505
11	典型之玉山雀麥*B. morrisonensis*	Tsai M. C. 11
12	典型之玉山雀麥*B. morrisonensis*	Fukuyama *s.n*. Jul. 12. 1935
13	典型之玉山雀麥*B. morrisonensis*	Hsu C. C. 6331
14	典型之玉山雀麥*B. morrisonensis*	Kuoh 1283
15	應爲玉山雀麥，但其外稃具7條脈，疑似卑南雀麥*B. remotiflorus* var. *piananensis*	Hsu C. C. 12130A
16	應爲玉山雀麥，但其外稃具7條脈，疑似卑南雀麥*B. remotiflorus* var. *piananensis*	Hsu C. C. 6350
17	應爲玉山雀麥，但其外稃具7條脈，疑似卑南雀麥*B. remotiflorus* var. *piananensis*	Sasaki *s.n*. Jul. 15 1932
18	硬雀麥*B. rigidus*	Kuo C. M. 9611

名。這個結論與Veldkamp(1991)的結論一致。今將玉山雀麥之同物異名及特徵描述重新整理如下：

Bromus morrisonensis Honda, Bot. Mag. Tokyo **42**: 137. 1928; Honda, Monogr. Poac. Jap. 39. 1930; Hsu, Taiwania **16**: 237. 1971; Hsu, Taiwan Grass 299. *pl. 44*. 1975; Hsu, Fl. Taiwan **5**: 430. *pl. 1388*. 1978; Koyama, Grass. Jap. Neighb. Reg. 35. 1987; Veldkamp, Blumea **35**: 492. 1991; Kuoh and Chen, Fl. Taiwan, 2nd ed. **5**: 371. 2000.

Bromus remotiflorus (Steud.) Ohwi var. *piananensis* Ohwi, Acta Phytotax. Geobot. **10**: 106. 1941; Hsu, Taiwania **16**: 237. 1971; Taiwan Grass. 301. *pl. 45*. 1975; Fl. Taiwan **5**: 431. 1978.

表2. 本研究所用之18個OTU 各特徵之狀態（各OTU及各特徵以編號表示，其詳細內容請參閱表1及附錄I）

Table 2. The states of 48 characters of the 18 OTUs used in this study for *Bromus* of Taiwan (referring to Table 1. and Appendix I. for the codes of the OTUs and characters)

OTUs	Characters																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	55	2.5	21	5	1	2	2	1	2	3	1	15	4	1	27	5	1	1	2	4	1	2	12	7
2	42	2.5	22	7	3	2	1	1	1	3	1	16	4	1	27	5	1	1	2	4	1	2	12	7
3	87	3	32	5	2	2	3	1	2	3	1	31	5	1	28	6	1	1	2	4	1	2	13	7
4	62	5	30	9	3	2	2	1	2	3	1	24	7	1	28	6	1	1	2	4	1	2	14	7
5	34	2	25	5.5	2	2	2	1	2	3	1	13	9	1	24	5	1	1	2	4	1	2	13	7
6	30	1.5	18	3.5	3	2	3	2	1	0.5	1	10	8	2	24	6	2	2	1	2	1	1	9	3
7	31	1.5	24	4	3	2	3	1	2	0.5	1	11	7	2	20	6	2	1	1	2	2	1	11	3
8	40	1.5	15	3	3	2	3	1	1	0.5	1	10	7	2	23	6	2	2	1	1	1	1	11	3
9	36	1	18	3.5	3	2	3	2	2	0.5	1	8	8	2	23	6	2	1	1	2	1	1	10	3
10	90	1.5	23	3	3	1	3	1	2	2	1	15	5	3	18	2.5	2	1	3	4	1	2	5	1
11	65	2	19	4	3	1	2	1	1	2	1	18	10	2	25	4	2	1	3	2	3	2	4	1
12	41	2	18	4	2	2	1	1	2	2	2	14	5	1	15	2	2	1	3	4	3	2	5	1
13	60	2	20	4	3	2	3	1	1	2	1	13	8	2	17	3	2	1	3	2	3	2	4	1
14	45	2	22	5	2	2	3	1	1	2	1	10	7	3	24	3	2	1	3	4	1	2	6	1
15	82	2	18	4	3	1	1	1	2	2	1	11	5	2	11	3	2	1	3	2	3	2	5	1
16	60	2	15	3	2	2	3	1	1	2	1	13	6	2	20	2	2	1	3	4	3	2	6	1
17	50	2	18	3	3	2	3	1	1	2	1	17	6	2	15	3	2	1	3	2	3	2	5	1
18	61	3.5	18	5.5	1	1	2	1	1	3	1	20	8	1	45	4	2	1	1	2	3	2	20	1

OTUs	Characters																							
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	3	2	1	13	1	11	1	19	3	1	2	2	19	2	2		11	1	3	2	8	1	2	7
2	3	2	1	13	1	11	1	19	3	1	2	2	19	2	2		11	1	3	2	8	1	2	7
3	3	2	1	14	1	11	1	19	3	1	2	2	19	2	2		11	1	3	2	9	1	2	7
4	3	2	1	15	1	11	1	19	3	1	2	2	19	2	2		11	1	3	2	10	1	2	7
5	3	2	1	14	1	11	1	19	3	1	2	2	19	2	2		11	1	3	2	9	1	2	7
6	1	1	1	11	1	5	2	14	1	2	1	2	14	22	1	1	7	1	1	2	10	1	2	8
7	1	2	2	11	1	5	2	14	1	3	1	1	14	2	1	1	8	1	1	1	9	1	1	8
8	1	1	2	11	1	5	1	15	1	2	1	2	15	2	1	1	7	1	1	2	10	1	1	8
9	1	1	1	12	1	5	2	15	1	2	1	2	15	2	1	1	7	1	1	1	10	1	2	8
10	1	2	2	7	2	3	2	8	1	2	1	2	8	2	1	1	3	2		2	7	2	2	6
11	1	2	1	5	2	3	1	9	1	3	1	1	9	22	1	1	3	1	2	2	7	1	2	6
12	1	2	1	6	2	3	2	8	1	3	1	1	8	2	1	1	3	1	2	1	6	2	2	6
13	1	2	1	7	2	3	2	9	1	2	1	1	9	2	1	1	3	2		1	7	2	2	6
14	1	2	2	8	2	3	1	9	1	2	1	2	9	2	1	1	3	1	2	2	7	1	2	6
15	1	2	2	7	2	3	1	8	1	2	1	1	8	2	1	1	7	1	2	2	6	2	2	6
16	1	2	1	8	2	3	1	10	1	3	1	2	10	2	1	1	7	2		1	7	2	2	6
17	1	2	1	7	2	3	1	8	1	2	1	2	8	2	1	1	7	1	2	2	6	2	2	6
18	2	1	1	20	1	3	1	25	2	2	1	3	25	1	1	1	5	1	4	1	15	1	2	10

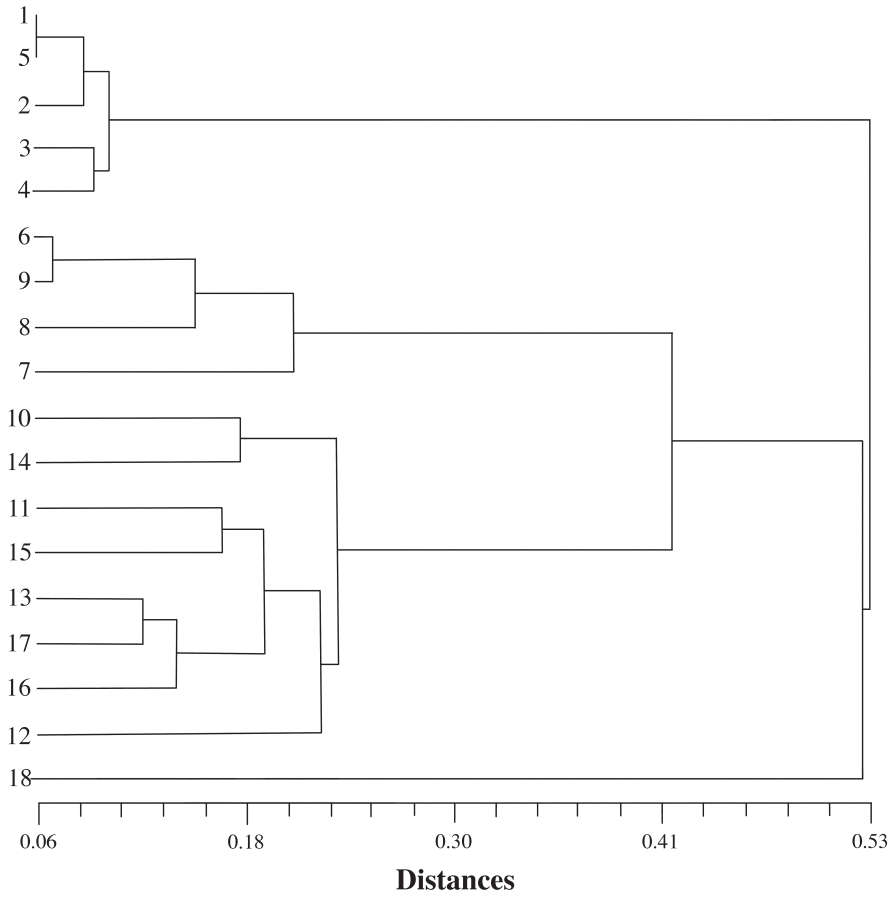

圖1. 台灣雀麥屬植物18個OTU經非加權配對算數平均法(unweighted pair-group method using arithmetic average, 簡寫做UPGMA)歸群後之歸群圖。

Fig. 1. The phenogram derived from the cluster analysis with 18 OTUs of the *Bromus* in Taiwan using UPGMA.

Perennials. Culms ascending, 28-100 cm tall, 2 mm wide. Leaf-blades chartaceous, linear, 12-28 cm long, 3-5 mm wide, sharp at apex, veins conspicuous, loosely puberulous to glabrous above, villous to glabrous beneath. Sheath villous to glabrous. Ligule membranous, rounded or acute at apex, 2 mm long. Inflorescence an open or contracted panicle, 9-18 cm long. Spikelets with 5-10 florets, elliptical or lanceolate or linear lanceolate, 11-25 mm long, 2-4 mm wide, slightly laterally compressed. Pedicels minutely hispid. Lower glumes membranous on margins, glabrous to minutely hispid, lanceolate to linear-lanceolate, sharp at apex, 4-6 mm long, 1-nerved. Upper glumes chartaceous, broadly lanceolate, sharp or acute to obtuse at apex, 5-8 mm long, 3-nerved, minutely strigose to glabrous. Florets 8-9 mm long, with

表3. 本研究所用之18個OTU兩兩之間的距離

Table 3. A matrix of the distances derived from the similarity coefficients among 18 OTUs used in this study for *Bromus* of Taiwan

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0																	
2	0.0777	0																
3	0.0997	0.1305	0															
4	0.0976	0.1143	0.0974	0														
5	0.0647	0.1059	0.0946	0.0960	0													
6	0.5237	0.4858	0.5371	0.5374	0.5064	0												
7	0.5332	0.5353	0.5391	0.5441	0.5155	0.2321	0											
8	0.5176	0.4797	0.5310	0.5313	0.5116	0.1222	0.2152	0										
9	0.5002	0.5048	0.5136	0.5139	0.4843	0.0748	0.1774	0.1840	0									
10	0.5268	0.5384	0.5279	0.5657	0.5496	0.4444	0.4368	0.4438	0.4301	0								
11	0.5103	0.5011	0.5691	0.5336	0.5105	0.4141	0.4040	0.4460	0.4431	0.2937	0							
12	0.5373	0.5419	0.5661	0.5994	0.5244	0.5225	0.4197	0.5671	0.4669	0.2767	0.2594	0						
13	0.5830	0.5537	0.6088	0.6140	0.5854	0.3744	0.3566	0.4483	0.3601	0.2104	0.1768	0.2017	0					
14	0.4532	0.4362	0.4583	0.5058	0.4318	0.3806	0.4205	0.3431	0.4095	0.1780	0.2319	0.2656	0.2389	0				
15	0.5475	0.5401	0.5785	0.5905	0.5711	0.4604	0.3993	0.4425	0.4465	0.1880	0.1681	0.2274	0.1923	0.2424	0			
16	0.5065	0.4989	0.5106	0.5664	0.5016	0.4328	0.4164	0.4247	0.4185	0.2425	0.2332	0.1892	0.1477	0.1974	0.2543	0		
17	0.4999	0.4658	0.5250	0.5371	0.5166	0.3447	0.4120	0.3650	0.3724	0.2163	0.1595	0.2347	0.1236	0.1718	0.1301	0.1360	0	
18	0.5154	0.5451	0.5777	0.5424	0.5380	0.5078	0.5620	0.5296	0.4847	0.6154	0.4413	0.5720	0.4984	0.5318	0.5327	0.5284	0.5005	0

rachilla. Lemmas chartaceous, lanceolate to elliptical, margins inrolled, rounded at apex or acute at apex, 8-9 mm long, with a awn longer than half to nearly as long as lemma, 3- or 7-nerved, slightly hairy on the base of nerves or glabrous. Paleas membranous, linear oblong, round or truncate at apex or acute at apex, 6-7 mm long, 2-nerved, ciliate to minutely ciliate on nerves. Callus glabrous. Anthers 2.5 mm long. Caryopsis linear-oblong, 6 mm long, hilum linear.

Distributed in Malaysia, the Philippines and Taiwan. Common in the alpine regions.

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附錄I. 所使用之特徵及各特徵所含之狀態

#1. culms <height>/
cm tall/
#2. culms <diameter>/
mm wide/
#3. leaf-blades <length>/
cm long/
#4. leaf-blades <width>/
mm wide/
#5. leaf-blades <indumentum above>/
1. puberulous above/
2. loosely puberulous above/
3. glabrous above/
#6. leaf-blades <indumentum beneath> /
1. villous beneath/
2. glabrous beneath/
#7. sheath <indumentum on surface>/
1. villous/
2. loosely villous/
3. glabrous/
#8. <adaxial> ligule <texture>/
1. membranous/
2. chartaceous/
#9. <adaxial> ligule <apex>/
1. rounded at apex/
2. acute at apex/
#10. <adaxial> ligule <length>/
mm long/
#11. inflorescence <type>/
1. an open panicle/
2. a contracted panicle/
#12. inflorescence <length>/
cm long/
#13. spikelets with <number of florets>/
florets/
#14. spikelets <shape>/
1. elliptical/
2. lanceolate/
3. linear lanceolate/
#15. spikelets <length, including the awn>/
mm long/
#16. spikelets <width>/
mm wide/
#17. spikelets <compressibility>/
1. strongly laterally compressed/
2. slightly laterally compressed/
#18. pedicels <vestiture>/
1. minutely hispid/
2. glabrous/
#19. lower glumes <texture>/
1. chartaceous/
2. subcoriaceous/
3. membranous on margins/
#20. lower glumes <vestiture on back>/
1. strigose/
2. glabrous/
3. loosely strigose/
4. minutely hispid/
#21. lower glumes <shape>/
1. lanceolate/
2. narrowly lanceolate/
3. linear-lanceolate/
#22. lower glumes <apex>/
1. acute at apex/
2. sharp at apex/
#23. lower glumes <length>/
mm long/
#24. lower glumes <number of nerves>/
-nerved/
#25. upper glumes <texture>/
1. chartaceous/
2. subcoriaceous/
3. coriaceous/

#26. upper glumes <shape>/
1. lanceolate/
2. broadly lanceolate/
#27. upper glumes <apex>/
1. sharp at apex/
2. acute to obtuse at apex/
#28. upper glumes <length>/
mm long/
#29. upper glumes <length 2>/
1. longer than 10 mm/
2. shorter than 10 mm/
#30. upper glumes <number of nerves>/
-nerved/
#31. upper glumes <vestiture on nerves>/
1. minutely strigose/
2. glabrous/
#32. florets <length>/
mm long/
#33. lemmas <texture>/
1. chartaceous/
2. subcoriaceous/
3. coriaceous/
#34. lemmas <shape>/
1. broadly lanceolate/
2. lanceolate/
3. elliptical/
#35. lemmas <margins>/
1. margins inrolled/
2. margins not inrolled/
#36. lemmas <apex>/
1. rounded at apex/
2. acute at apex/
3. shortly bilobed at apex/
#37. lemmas <length, including awn>/
mm long/
#38. lemmas <length>/
1. longer than 20 mm/
2. shorter than 20 mm/
#39. lemmas <awn presence>/
1. with awn/
2. awnless/
#40. lemmas <awn: ratio of length>/
1. with a short awn less than the 1/2 length of lemma/
2. with an awn longer than half to nearly as long as lemma/
3. with an awn longer than lemma/
#41. lemmas <number of nerves>/
-nerved/
#42. lemmas <presence of hairs>/
1. hairy/
2. glabrous/
#43. lemmas <vestiture>/
1. densely hirsute on marginal region of backside/
2. only slightly hairy on the base of nerves/
3. minutely hispid on nerves/
4. densely pubescent on back surface/
#44. paleas <apex>/
1. round or truncate at apex/
2. acute at apex/
#45. paleas <length>/
mm long/
#46. paleas <vestiture on nerves>/
1. ciliate on nerves/
2. minutely ciliate on nerves/
#47. caryopsis <shape>/
1. oblong/
2. linear-oblong/
#48. caryopsis <length>/
mm long/

A Numerical Taxonomic Study of the Genus *Bromus* L. (Poaceae) of Taiwan

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Abstract

We conducted a numerical taxonomic study on *Bromus* L. in Taiwan. According to the dendrogram derived from the cluster analysis with 48 characters, 18 OTUs were divided into four groups. They are identified as *Bromus catharticus* Vahl, *Bromus formosanus* Honda, *Bromus morrisonensis* Honda and *Bromus rigidus* Roth. Furthermore, we confirmed that *Bromus remotiflorus* (Steud.) Ohwi var. *piananensis* Ohwi is a synonym of *B. morrisonensis.*

Key words: DELTA, numerical taxonomy, cluster analysis, *Bromus*, Poaceae

Received: October 8, 2001 Accepted: June 20, 2002