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CLADISTIC PARSIMONY ANALYSIS OF INTERNAL TRANSCRIBED SPACER REGION (nrDNA) SEQUENCES OF *BOUTELOUA* AND RELATIVES (GRAMINEAE: CHLORIDOIDEAE)

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ABSTRACT

The primary goal of the study was to estimate the phylogeny of *Bouteloua* and relatives (Gramineae: Chloridoideae) employing cladistic parsimony analysis of nuclear ribosomal internal transcribed spacer region (ITS1 + 5.8S + ITS2) DNA sequences. Included were *Aegopogon* (2 of 4 species), *Bouteloua* (34 of 42), *Buchloë* (1 of 1), *Buchlomimus* (1 of 1), *Cathetecum* (2 of 4), *Cyclostachya* (1 of 1), *Griffithsochloa* (1 of 1), *Hilaria* (1 of 7), *Opizia* (2 of 2), *Pentarrhaphis* (2 of 3), *Pleuraphis* (2 of 3), *Pringleochloa* (1 of 1), *Soderstromia* (1 of 1), and five outgroup genera/species for a total of 18 genera, 56 species, and ten varieties. In all, the ITS region of 72 plants was sequenced and analyzed utilizing PAUP. *Aegopogon*, the *Hilaria*-*Pleuraphis* clade, and *Tragus* (an outgroup representative) formed a tetratomy with a clade containing the remaining ingroup taxa. Neither *Bouteloua* nor its two subgenera, *Bouteloua* and *Chondrosium*, were found to be monophyletic. *Bouteloua chondrosioides* was sister to *Opizia*. *Bouteloua rigidisetata* formed a clade with *Buchlomimus* and *Pringleochloa*. *Bouteloua eludens* formed a clade with *Buchloë*, *Cathetecum*, *Griffithsochloa*, *Pentarrhaphis*, and *Soderstromia*. *Bouteloua annua* and *B. aristoides* (subg. *Bouteloua*) formed a clade with *B. eriopoda*, *B. eriostachya*, *B. hirsuta*, and *B. pectinata* (subg. *Chondrosium*). *Bouteloua juncea*, which has been included in the *B. curtipendula* complex, was not a member of that clade. No new circumscriptions were proposed, although recognition of *Bouteloua* in the broad sense, with *Chondrosium* reduced to synonymy, was advocated. The findings suggested homoplasy in morphological, anatomical, and breeding system traits.

Key words: *Bouteloua*, Chloridoideae, cladistics, dioecy, DNA sequences, Gramineae, internal transcribed spacer (ITS), monoecy, nuclear ribosomal DNA, phylogeny, 5.8S.

INTRODUCTION

In 1805 Lagasca described the genus *Bouteloua* (nom. cons., originally *Botelua*) and four species: *B. barbata*, *B. hirsuta*, *B. racemosa* (= *B. curtipendula*), and *B. simplex* (Gramineae: Chloridoideae). In the most recent taxonomic treatment of the genus, Gould (1980) recognized 39 species in two subgenera, *Bouteloua* and *Chondrosium* (Desv.) Gould. Since then, three additional species have been recognized (Reeder and Reeder 1981; Beetle 1986; Columbus 1996b) for totals of 25 species in subg. *Bouteloua* and 17 species in subg. *Chondrosium*. Over the years some taxonomists, led of late by Clayton (1982) and Clayton and Renvoize (1986), have chosen to treat *Chondrosium* Desv. as a distinct genus, a decision that Gould (1963) himself contemplated. Reeder and Reeder (1963b) and Estes and Tyrl (1982) argued to maintain *Chondrosium* as a subgenus or section.

The principal differences between the subgenera are shown diagrammatically in Fig. 1 (see Gould [1980] and Clayton and Renvoize [1986] for additional characters). Species in subg. *Bouteloua* usually have 7–80 deciduous branches per inflorescence, each 0.8–2 cm long and bearing 1–10(–20) appressed spikelets,

whereas *Chondrosium* species generally possess fewer branches (1–6) that are persistent (spikelets disarticulating at the base of the fertile [proximal] floret), longer (2–5 cm), and bear more (20–100), spreading (pectinate) spikelets (Gould 1980; Clayton and Renvoize 1986). Not all species, however, conform fully to this general characterization. For example, *Bouteloua chondrosioides* (“like *Chondrosium*”) has been placed by most authors in subg. *Bouteloua* in spite of its relatively few inflorescence branches (usually 3–8) and “clearly” (Reeder and Reeder 1963b) or “moderately” (Gould 1980) pectinate spikelets. In subg. *Chondrosium*, *B. eriopoda* and *B. eriostachya* are exceptional in having relatively few (8–18) appressed or ascending spikelets. Other species in possession of atypical characteristics were noted by Gould (1980) and Clayton and Renvoize (1986). These authors, however, were not dissuaded by these exceptions, concluding, “the species of *Bouteloua* comprise two well-defined subgenera” and “divergence within each of the groups has resulted in a slight overlap of characteristics in a few taxa” (Gould 1980), and “though closely related, and with some overlap of individual characters, the two [groups] seem distinct enough” (Clayton and Renvoize 1986).

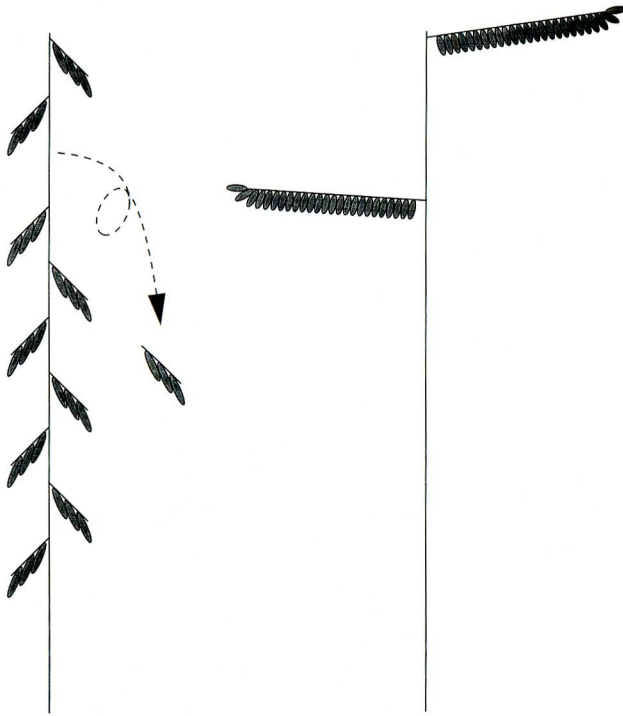


Fig. 1. Diagrams of representative inflorescences of *Bouteloua* subg. *Bouteloua* (left) and subg. *Chondrosium* (right). Shaded ellipses represent spikelets.

Clayton and Renvoize (1986) placed *Bouteloua* s.s. and *Chondrosium* in subtribe Boutelouinae of tribe Cynodonteae. Shown in Fig. 2 are the other genera comprising Boutelouinae, their relationships as suggested by these authors, and numbers of species. The species now treated in the monotypic genera *Buchlomimus* Reeder, C. Reeder, & Rzed., *Cyclostachya* Reeder & C. Reeder, and *Neobouteloua* Gould were transferred out of *Bouteloua* in the 1960s. *Buchlomimus* and *Cyclostachya* were described upon discovery that their constituent species are dioecious and sexually dimorphic (Reeder and Reeder 1963a; Reeder et al. 1965). Reeder and Reeder (1966) also reported "dioecy (or gynodioecy)" in some *Bouteloua chondrosioides*, but refrained from erecting a new genus because correlated characters were lacking. Five other taxa having unisexual flowers distributed in separate inflorescences are *Buchloë* Engelm. (nom. cons.), *Cathestecum brevifolium* (Pierce 1979), *Opizia* J. Presl, *Pringleochloa* Scribn., and *Soderstromia* C. V. Morton. Monoecy (obligate in *Opizia bracteata*, predominate in *Pringleochloa*) and dioecy are known to be expressed in these taxa. Markedly dimorphic are the carpellate (pistillate) and staminate inflorescences of *Buchloë*, *Opizia*, and *Pringleochloa*. Interestingly, the staminate inflorescences of these three genera and *Buchlomimus* and *Cyclostachya* closely resemble one another and inflorescences of species in *Bouteloua* subg. *Chondrosium* (Fig. 1, right), prompting Clayton and Renvoize (1986) to suggest the staminate inflo-

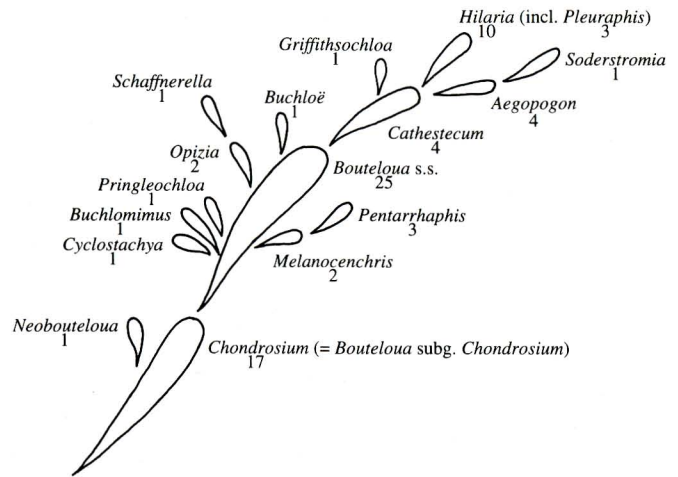


Fig. 2. Relationships among the genera of Boutelouinae as diagrammed by Clayton and Renvoize (1986) and numbers of species. In Clayton and Renvoize's complete diagram of Cynodonteae, *Chondrosium* is situated near the base of *Chloris*. (Redrawn from a portion of Clayton and Renvoize's [1986] Fig. 16.)

rescences "seem to have been undisturbed by the evolutionary pressures which have shaped the female [= carpellate] plants."

In *Aegopogon* Humb. & Bonpl. ex Willd., *Cathestecum* J. Presl, *Griffithsochloa* G. J. Pierce, *Hilaria* Kunth, and *Pleuraphis* Torr. (often treated as a subgenus of *Hilaria*, e.g., Hitchcock 1951; Sohns 1956; Clayton and Renvoize 1986), each inflorescence branch bears three spikelets, the terminal or central spikelet containing a hermaphroditic or carpellate floret (with or without staminate, neuter, and/or rarely hermaphroditic florets above) while the two lateral spikelets (one often not developed in *A. bryophilus* Döll) usually contain staminate florets (sometimes neuter, rarely hermaphroditic). *Aegopogon* and *Pleuraphis*, with hermaphroditic central spikelets, are andromonoecious, and *Hilaria*, possessing a carpellate central spikelet, is monoecious. As described by Pierce (1978, 1979), sexuality in *Cathestecum* and *Griffithsochloa* is quite labile; both andromonoecy and monoecy are known in *Griffithsochloa* and two species of *Cathestecum*, while *C. brevifolium* may be monoecious or dioecious and *C. varium* may be andromonoecious, monoecious, or trimonoecious (staminate, carpellate, and hermaphroditic flowers all present; Cruden and Lloyd 1995). Other than sexuality, the lateral spikelets of *Aegopogon*, *Cathestecum*, and *Griffithsochloa* primarily differ from the central in being smaller and possessing fewer florets (in *Cathestecum* the first glumes also differ), whereas the spikelets of *Hilaria* and *Pleuraphis* are quite dimorphic. Clayton and Renvoize (1986) grouped these genera plus the monoecious/dioecious *Soderstromia* together in their diagram of relationships (Fig. 2) because all possess three spikelets per inflorescence branch (in *Soder-*

stromia each lateral spikelet is represented by a sterile bract).

Except for the facultatively dioecious or gynodioecious *Bouteloua chondrosioides*, the remaining species of *Bouteloua*, *Melanocenchris* Nees, *Neobouteloua*, *Pentarrhaphis* Kunth, and *Schaffnerella* Nash lack unisexual spikelets. A staminate floret, however, may accompany the hermaphroditic floret in spikelets of some species, mainly species in the *Bouteloua repens* complex (Gould 1969), *Melanocenchris*, and *Pentarrhaphis*.

Clayton and Renvoize's (1986) diagram of generic relationships in subtribe Boutelouinae (Fig. 2) was based in part on "strong trends towards deciduous abbreviated racemes [= inflorescence branches] and dicyly [= monoecy and dioecy]." Situated at the base of the diagram are *Chondrosium* and *Neobouteloua*, which have relatively long, persistent branches bearing relatively numerous, hermaphroditic spikelets (Reeder and Reeder [1963b, 1969], however, reported deciduous branches in *Bouteloua* [*Chondrosium*] *karwinski*). The remaining taxa have deciduous branches, except for *Schaffnerella*, that are usually shorter and typically bear fewer, sometimes unisexual, spikelets.

Apart from *Melanocenchris*, distributed from Chad to India and Sri Lanka, and a single collection of *Aegopogon* from an isolated mountain top in Papua New Guinea (Veldkamp 1985), the genera in subtribe Boutelouinae have a natural distribution in the New World. Ten of the 16 genera and 58 of the 75 species are restricted to North America and the West Indies. With 14 genera (five endemic) and 64 species (27 endemic), Mexico is the center of diversity. Only *Aegopogon* (two species, one endemic), *Bouteloua* (nine species representing both subgenera, one endemic), *Neobouteloua* (one endemic species), and *Pentarrhaphis* (two species) are represented in South America. The most widespread species is *Bouteloua curtipendula*, extending from southern Canada to Argentina and Uruguay.

Bouteloua and relatives occur in areas, including deserts, characterized by relatively high temperatures and low precipitation. They are grassland associates or grow in openings in other vegetation types such as scrub and woodland. *Bouteloua curtipendula*, *B. gracilis*, *B. hirsuta*, and *Buchloë* are common prairie elements on the North American Great Plains; *Bouteloua gracilis* and *Buchloë* dominate the western, shortgrass region (Sims 1988). These and many of the other taxa are associated with and sometimes dominate semidesert grasslands, which extend in North America from the southwestern U.S.A. to southern Mexico (Rzedowski 1975; Brown 1982).

In his taxonomic revision "The grama grasses: *Bouteloua* and related genera," Griffiths (1912) wrote, "it is doubtful whether there is another group of native pasture grasses which is of as much economic impor-

tance as this, when both quality and quantity are considered." Stubbendieck et al. (1992) included nine species of *Bouteloua* and relatives among their 75 most important North American native range grasses.

OBJECTIVES

In their classification of the world's grass genera, Clayton and Renvoize (1986) explained that "the diagrams are intended to give a visual impression of phenetic relationships, progressing from simple to complex structures; they obviously have phylogenetic implications, but no attempt has been made to treat these rigorously." Nonetheless, Fig. 2 represents the only explicit hypothesis of relationship that has been published for *Bouteloua* and relatives. In addition, insights into possible intrageneric relationships have been largely confined to remarks concerning a few species. The principal goal of this study, therefore, was to improve upon our limited understanding of the evolutionary relationships among *Bouteloua* and relatives. Some specific objectives were to ascertain the monophyly of the genera, intrageneric taxa, and informal groups (i.e., *Bouteloua curtipendula* complex [Gould and Kapadia 1964], *B. repens* complex [Gould 1969]) and to determine the phylogenetic distribution of the various sexual phenotypes (andromonoecy, monoecy, dioecy, etc.). The method chosen for this investigation was cladistic parsimony analysis of internal transcribed spacer (ITS) region sequences of nuclear ribosomal DNA (Baldwin et al. 1995).

MATERIALS AND METHODS

Taxa and Collections

The taxa and collections used in this study are listed in Table 1. Included were 72 collections representing 18 genera (five outgroup), 56 species (five outgroup), and ten varieties. All genera in subtribe Boutelouinae were sampled except *Melanocenchris*, *Neobouteloua*, and *Schaffnerella*. Living material of these three genera was not obtained and attempts to amplify the ITS region from herbarium specimens were unsuccessful. Most species of *Bouteloua* were sampled; those not sampled included six species that are undisputed members, based on morphology and leaf blade anatomy (Columbus 1996a), of the *Bouteloua curtipendula* complex of 12 species (Gould and Kapadia 1964), *B. quiriegoensis* Beetle (scarcely distinct from *B. hirsuta*), and the South American endemic *B. megapota mica* (Spreng.) Kuntze.

Gould (1980) and Clayton and Renvoize (1986, their Fig. 16) suggested that *Bouteloua* s.l. is closely related to *Chloris*; *C. virgata*, therefore, was chosen as an outgroup species. Other outgroup species, likewise members of subfamily Chloridoideae, included: *Cy-*

Table 1. Taxa, collections/vouchers, and origin of collections utilized in cladistic parsimony analysis of ITS region sequences. Asterisks denote those taxa not included in *Boutelouinae* by Clayton and Renvoize (1986) and employed herein as the outgroup. In bold are members of *Bouteloua* subg. *Chondrosium*. Collection/voucher numbers are those of Columbus unless indicated otherwise. Vouchers are deposited in RSA unless indicated otherwise.

Taxon	Collection/Voucher	
	Number	Origin
<i>Aegopogon</i>		
<i>cenchroides</i> Humb. & Bonpl. ex Willd.	2383	Mexico: Mexico
<i>tenellus</i> (DC.) Trin.	2296	Mexico: Sonora
<i>Bouteloua</i>		
<i>alamosana</i> Vasey	2301	Mexico: Sonora
<i>americana</i> (L.) Scribn.	Worthington 22775	Grenada: St. George
<i>annua</i> Swallen	2434	Mexico: Baja California Sur
<i>aristidoides</i> (Kunth) Griseb.		
var. <i>aristidoides</i>	2444	U.S.A.: Arizona
var. <i>arizonica</i> M. E. Jones	2273	U.S.A.: Arizona
<i>barbata</i> Lag.		
var. <i>barbata</i>	2229	U.S.A.: Arizona
var. <i>rothrockii</i> (Vasey) Gould	2454	U.S.A.: Arizona
<i>breviseta</i> Vasey	2908	U.S.A.: Texas
<i>chasei</i> Swallen	2861	Mexico: Nuevo León
<i>chihuahuana</i> (M. C. Johnst.) J. T. Columbus	2824	Mexico: Chihuahua
<i>chondrosioides</i> (Kunth) Benth. ex S. Watson	2422	Mexico: Oaxaca
<i>curtipendula</i> (Michx.) Torr.		
var. <i>caespitosa</i> Gould & Kapadia	2449	U.S.A.: Arizona
	2500	U.S.A.: Arizona
var. <i>tenuis</i> Gould & Kapadia	2499	U.S.A.: Arizona
<i>elata</i> Reeder & C. Reeder	2358	Mexico: Jalisco
<i>eludens</i> Griffiths	2272	U.S.A.: Arizona
	2452	U.S.A.: Arizona
<i>eriopoda</i> (Torr.) Torr.	2461	U.S.A.: Arizona
	Herrera & Siqueiros 1340 (CIIDIR, HUAA)	Mexico: Chihuahua
<i>eristachya</i> (Swallen) Reeder	2843	Mexico: Coahuila
<i>gracilis</i> (Kunth) Lag. ex Griffiths	2460	U.S.A.: Arizona
	Herrera & Siqueiros 1349 (CIIDIR, HUAA)	Mexico: Durango
<i>hirsuta</i> Lag.		
var. <i>glandulosa</i> (Cerv.) Gould	2448	U.S.A.: Arizona
var. <i>hirsuta</i>	2453	U.S.A.: Arizona
<i>johnstonii</i> Swallen	2851	Mexico: Coahuila
<i>junceae</i> (Desv. ex P. Beauv.) Hitchc.	Axelrod 8856 (UPRRP)	Puerto Rico: Guánica
	Axelrod 8862 (UPRRP)	Puerto Rico: Guánica
<i>karwinskii</i> (E. Fourn.) Griffiths	2208	Mexico: Zacatecas
<i>kayi</i> Warnock	2281	U.S.A.: Texas
<i>media</i> (E. Fourn.) Gould & Kapadia	2420	Mexico: Oaxaca
<i>parryi</i> (E. Fourn.) Griffiths var. <i>parryi</i>	2299	Mexico: Sonora
<i>pectinata</i> Feath.	2899	U.S.A.: Texas
<i>radicosa</i> (E. Fourn.) Griffiths	2462	U.S.A.: Arizona
<i>ramosa</i> Scribn. ex Vasey	2287	Mexico: Coahuila
<i>repens</i> (Kunth) Scribn. & Merr.	2450	U.S.A.: Arizona
<i>rigidiseta</i> (Steud.) Hitchc.	2231	U.S.A.: Texas
<i>scorpioides</i> Lag.	2344	Mexico: Mexico
<i>simplex</i> Lag.	2335	Mexico: Hidalgo
<i>triaena</i> (Trin.) Scribn.	2357	Mexico: Jalisco
<i>trifida</i> Thurb. ex S. Watson	2465	U.S.A.: Arizona
	2902	U.S.A.: Texas
<i>uniflora</i> Vasey		
var. <i>coahuilensis</i> Gould & Kapadia	2319	Mexico: Zacatecas
var. <i>uniflora</i>	2901	U.S.A.: Texas
<i>warnockii</i> Gould & Kapadia	2907	U.S.A.: Texas
<i>williamsii</i> Swallen	2353	Mexico: Jalisco
<i>curtipendula</i> var. <i>caespitosa</i> X <i>B. uniflora</i> var. <i>coahuilensis</i> ?	2191	Mexico: Coahuila
<i>Buchloë dactyloides</i> (Nutt.) Engelm.	2198	Mexico: Nuevo León
<i>Buchlomimus nervatus</i> (Swallen) Reeder, C. Reeder, & Rzed.	2336	Mexico: Mexico

Table 1. Continued.

Taxon	Collection/Voucher	
	Number	Origin
<i>Cathestecum</i>		
<i>brevifolium</i> Swallen	2520	U.S.A.: Arizona
<i>varium</i> Swallen	2413	Mexico: Puebla
* <i>Chloris virgata</i> Sw.	2455	U.S.A.: Arizona
<i>Cyclostachya stolonifera</i> (Scribn.) Reeder & C. Reeder	2206	Mexico: Zacatecas
	2601	Mexico: San Luis Potosí
	3044	Mexico: Zacatecas
* <i>Cynodon dactylon</i> (L.) Pers.	2691	U.S.A.: California
<i>Griffithsochloa multifida</i> (Griffiths) G. J. Pierce	2417	Mexico: Oaxaca
<i>Hilaria ciliata</i> (Scribn.) Nash	2371	Mexico: Jalisco
* <i>Leptochloa dubia</i> (Kunth) Nees	2456	U.S.A.: Arizona
* <i>Microchloa kunthii</i> Desv.	2345	Mexico: Mexico
<i>Opizia</i>		
<i>bracteata</i> McVaugh	2373	Mexico: Michoacán
<i>stolonifera</i> J. Presl	2375	Mexico: Michoacán
	2423	Mexico: Oaxaca
<i>Pentarrhaphis</i>		
<i>polymorpha</i> (E. Fourn.) Griffiths	3043	Mexico: Aguascalientes
<i>scabra</i> Kunth	2424	Mexico: Chiapas
<i>Pleuraphis</i>		
<i>mutica</i> Buckley	2463	U.S.A.: Arizona
<i>rigida</i> Thurb.	2443	U.S.A.: Arizona
<i>Pringleochloa stolonifera</i> (E. Fourn.) Scribn.	2412	Mexico: Puebla
	2642	Mexico: Puebla
<i>Soderstromia mexicana</i> (Scribn.) C. V. Morton	2398	Mexico: Oaxaca
* <i>Tragus racemosus</i> (L.) All.	2228	U.S.A.: Arizona

nodon dactylon and *Microchloa kunthii*, placed by Clayton and Renvoize (1986) along with *Chloris virgata* in tribe Cynodonteae, subtribe Chloridineae; *Tragus racemosus*, Cynodonteae, subtribe Zoysiinae; and *Leptochloa dubia*, tribe Eragrostideae.

Most plants were grown in a controlled environment chamber, screenhouse, and/or greenhouse at Rancho Santa Ana Botanic Garden (RSABG) from seed (caryopses) or transplants. Frank Axelrod kindly sent live material of *Bouteloua juncea* from Puerto Rico. *Bouteloua americana* was grown from caryopses removed from a specimen recently accessioned at RSA. For some plants, at least 1 g of healthy living leaves and young shoots was removed while in the field, wrapped in aluminum foil, and immediately plunged into a dewar of liquid nitrogen; these samples were transported to RSABG and transferred to a -80 C freezer. Tissues removed from plants growing at RSABG were immediately placed in a -80 C freezer or used directly for DNA extraction. Samples of *Bouteloua chasei* and two collections of *Cyclostachya stolonifera* (Columbus 2206 and 2601) were obtained from herbarium specimens. Determinations of all collections were made by the first author and, other than the *B. juncea* material, vouchers were deposited at RSA (Table 1).

DNA Extraction

About 1 g from each sample was ground to a powder in liquid nitrogen with a mortar and pestle. From

the pulverized tissues total genomic DNA was extracted using a 2X CTAB buffer protocol (Doyle and Doyle 1987) with the following modifications: after addition of isopropanol the sample was kept at -20 C overnight to enhance precipitation, centrifuged, and the resultant pellet was washed for 10 min with 5 ml of 76% ethanol containing 10 mM ammonium acetate. Pellets were dried in a vacuum oven and resuspended in 0.2–1.0 ml of 10 mM Tris-HCl and 1 mM EDTA at pH 8.0. For samples taken from herbarium specimens, DNA extraction followed a 2X CTAB microprep protocol (Cullings 1992). All samples were diluted with sterile deionized water to a final concentration of 10 ng/μl.

Amplification and Sequencing

The ITS region (ITS1 + 5.8S + ITS2) was amplified using the polymerase chain reaction (PCR). Equal proportions of primers ITS4 and ITS5 (White et al. 1990) and 4–40 ng of total genomic DNA were included in each 100 μl reaction; for most taxa 20 ng of DNA resulted in the best amplification. A PTC-100™ (MJ Research) or Robocycler™ 96 (Stratagene) was used to carry out PCR: an initial denaturing step of 1 min at 97 C was followed by 40 cycles of 1 min at 97 C, 1 min at 48 C, and 2 min at 72 C, and concluded with a final extension step of 7 min at 72 C. The double-stranded PCR product was electrophoresed

on a 1.5% agarose gel to verify amplification. Purification of the PCR product was accomplished via filtration through Millipore Ultrafree-MC[™] filters or a polyethylene glycol precipitation protocol (Morgan and Soltis 1993), followed by resuspension in sterile deionized water. The template DNA was then cycle-sequenced using the PRISM[™] DyeDeoxy[™] Terminator Kit (Perkin Elmer) following the manufacturer's recommendations. The primers used for sequencing were ITS2, ITS3, ITS4i, and ITS5i (White et al. 1990; Porter 1997). Sequencing products were read by an Applied Biosystems 373A automated DNA sequencer using a Sequagel-6 polyacrylamide gel (National Diagnostics).

The four sequences obtained per sample were assembled, edited, and a consensus sequence constructed using Sequencher[™] version 3.0 (Gene Codes Corporation). The bounds of ITS1, 5.8S, and ITS2 were determined by comparison with sequences in Hsiao et al. (1994) and Buckler and Holtsford (1996; sequences in GenBank). The latter authors included four more bases on the 3' end of ITS2, a decision we followed.

Cladistic Analysis

The consensus sequences were aligned visually and analyzed utilizing Phylogenetic Analysis Using Parsimony (PAUP) version 3.1.1 (Swofford 1993). The entire ITS region, including 5.8S, was analyzed. Characters (nucleotide sites) were treated as unordered, weighted equally, and optimized via accelerated transformation. Gaps were treated as missing data. For a particular taxon, a site having multiple nucleotides was interpreted as a polymorphism. The heuristic option was used to search for all most parsimonious (minimum-length) trees. Starting trees were obtained via random stepwise addition, with one tree held at each step. Tree bisection-reconnection was employed as the branch-swapping algorithm. The steepest descent option was not in effect. Zero-length branches were collapsed. One hundred replicates were performed.

Also computed using PAUP were the character status, pairwise distance matrix, strict consensus tree, consistency index (CI), rescaled consistency index (RC), and retention index (RI). The trees were drawn by PAUP.

To assess support for clades, a bootstrap analysis of 100 replicates was performed employing the same settings as above except that a closest addition sequence was used. In addition, decay indices (Bremer 1988; Donoghue et al. 1992) were calculated following the method of Baum et al. (1994) using a PAUP block appended to the file to automate the procedure (Leigh Johnson pers. comm.).

RESULTS

The aligned sequences are provided in Appendix 1. Alignment necessitated insertion of gaps, resulting in a length of 705 base pairs (bp), 94 (*Pleuraphis mutica*) to 121 (*Soderstromia*) bp longer than the unaligned sequences. In some regions alignment was not straightforward; in these cases, an alignment was arrived at that minimized variation. Of the 705 characters, 387 (55%) vary and 324 (46%) are potentially phylogenetically informative. Most variable is ITS2 (182 of 266 characters vary, or 68%), followed by ITS1 (179/274, 65%) and 5.8S (26/165, 16%). The percentage of variable characters that are potentially informative is nearly the same, ca. 84%, in each of ITS1, 5.8S, and ITS2. The pairwise distance matrix is shown in Appendix 2. Mean distances (proportions of divergent nucleotide sites to total sites, excluding gaps and polymorphic sites) range from 0 between several conspecific samples to 28% (162 sites) between *Bouteloua simplex* and *Hilaria ciliata*.

The heuristic search located 4747 most parsimonious trees of 1817 steps (nucleotide substitutions). The trees have a CI of 0.43, RC of 0.31, and RI of 0.73. The strict consensus of these trees is shown in Fig. 3, including bootstrap percentages and decay indices. Figure 4 is one of the most parsimonious trees drawn as a phylogram with branch lengths (numbers of nucleotide substitutions) indicated. As seen in the strict consensus tree (Fig. 3), a tetratomy is formed among *Tragus racemosus* (an outgroup representative), the *Aegopogon* clade, the *Hilaria-Pleuraphis* clade, and a poorly resolved but well-supported clade comprising the majority of the ingroup taxa. With the aim of improving the resolution of this last clade, a second analysis was carried out after removing *Aegopogon*, *Hilaria*, *Pleuraphis*, and the five designated outgroup species. This search found 376 most parsimonious trees of 1293 steps, each tree with a CI of 0.50, RC of 0.39, and RI of 0.77. Figure 5 is the strict consensus tree and Fig. 6 is one of the most parsimonious trees, upon which are mapped the insertions/deletions (indels) identified and enumerated in Appendix 1. Only unambiguous indels shared by two or more taxa are identified; these can be regarded as another measure of support for clades. Rooting of these trees was accomplished by designating *Bouteloua kayi* and *B. trifida* as the outgroup; common to these species and *Aegopogon*, *Hilaria*, *Pleuraphis*, and the five outgroup species in the more inclusive analysis are a single base (indel 11) and a string of six bases (indel 25) lacking in the remaining taxa (Appendix 1; Fig. 6).

DISCUSSION

Aegopogon

Circumscription of *Aegopogon* has never been disputed and monophyly of the genus is strongly sup-

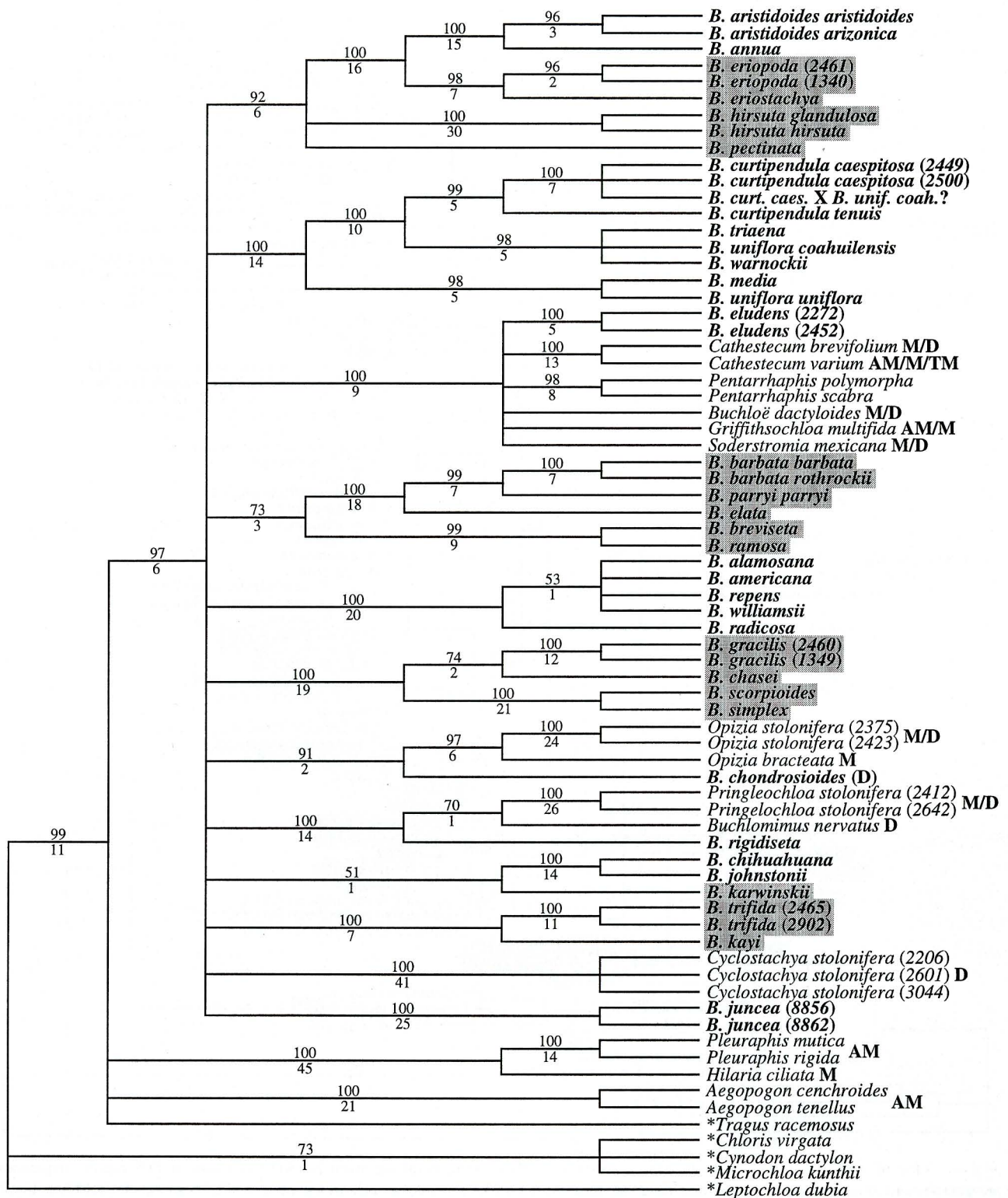


Fig. 3. Strict consensus of 4747 most parsimonious trees resulting from a PAUP analysis of ITS region sequences of representatives of *Bouteloua* and related and outgroup genera. Asterisks precede species designated as the outgroup. In bold are members of *Bouteloua*. Shaded are members of *Bouteloua* subg. *Chondrosium*. Numbers above and below branches are bootstrap percentages and decay indices, respectively. AM = andromonoecious, D = dioecious, M = monoecious, TM = trimonoecious. Tree length = 1817, CI = 0.43, RC = 0.31, RI = 0.73.

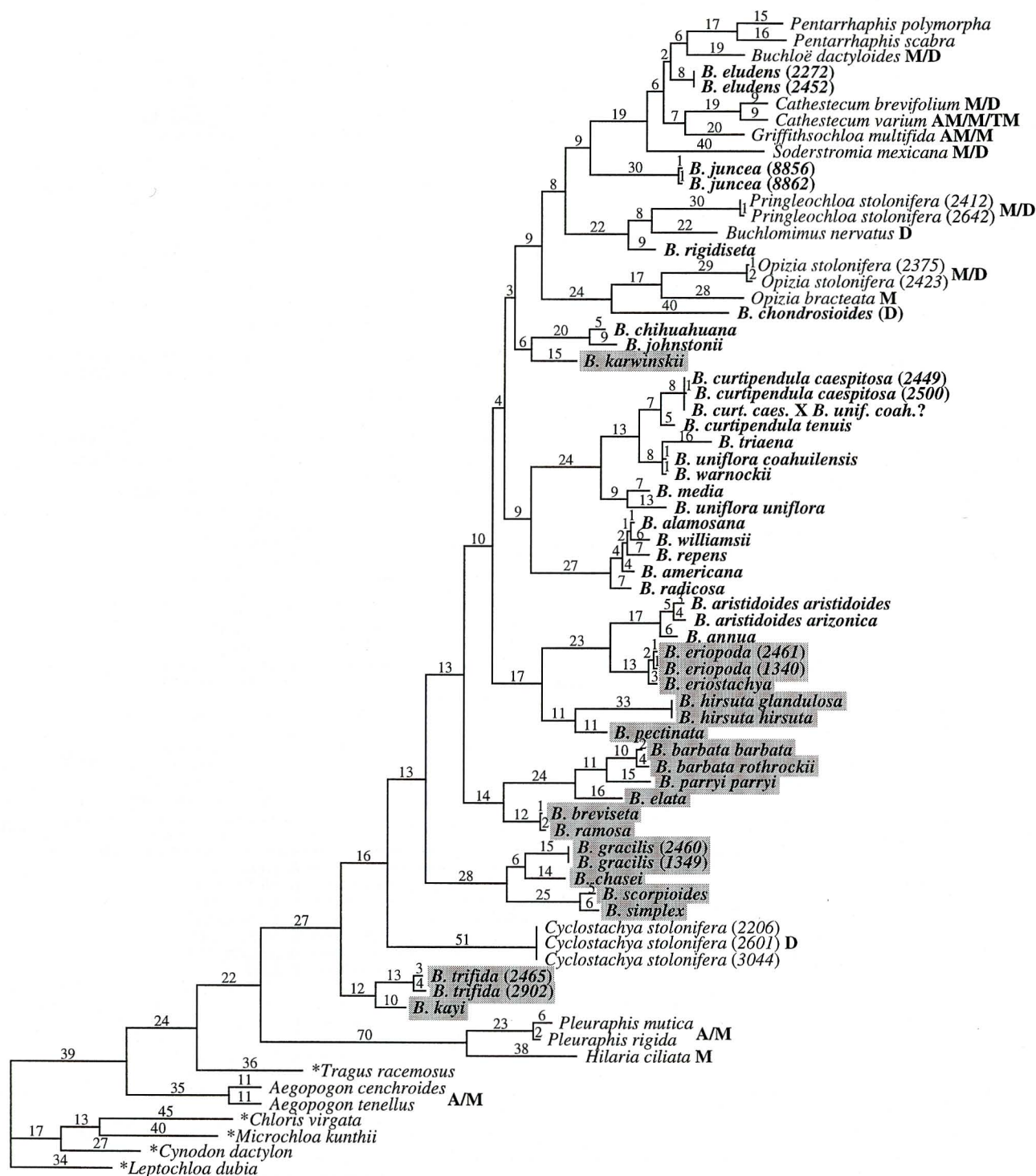


Fig. 4. One of 4747 most parsimonious trees, drawn as a phylogram, resulting from a PAUP analysis of ITS region sequences of representatives of *Bouteloua* and related and outgroup genera. Asterisks precede species designated as the outgroup. In bold are members of *Bouteloua*. Shaded are members of *Bouteloua* subgenus *Chondrosium*. Numbers above branches are branch lengths. AM = andromonoecious, D = dioecious, M = monoecious, TM = trimonoecious. Tree length = 1817, CI = 0.43, RC = 0.31, RI = 0.73.

ported in this study (Fig. 3). *Aegopogon* is one of six genera, grouped together by Clayton and Renvoize (1986), having spikelets arranged in triads. In the ITS region phylogeny, *Aegopogon* does not form a monophyletic group with any of these genera (*Cathestecum*, *Griffithsochloa*, *Hilaria*, *Pleuraphis*,

Soderstromia). Columbus (1996a) found that *Aegopogon* is unlike these and the other genera in subtribe Boutelouinae in microscopic features of the abaxial epidermis of the lemma and in leaf blade transverse structure. In the strict consensus tree (Fig. 3), *Aegopogon*, along with the *Hilaria*-*Pleuraphis*

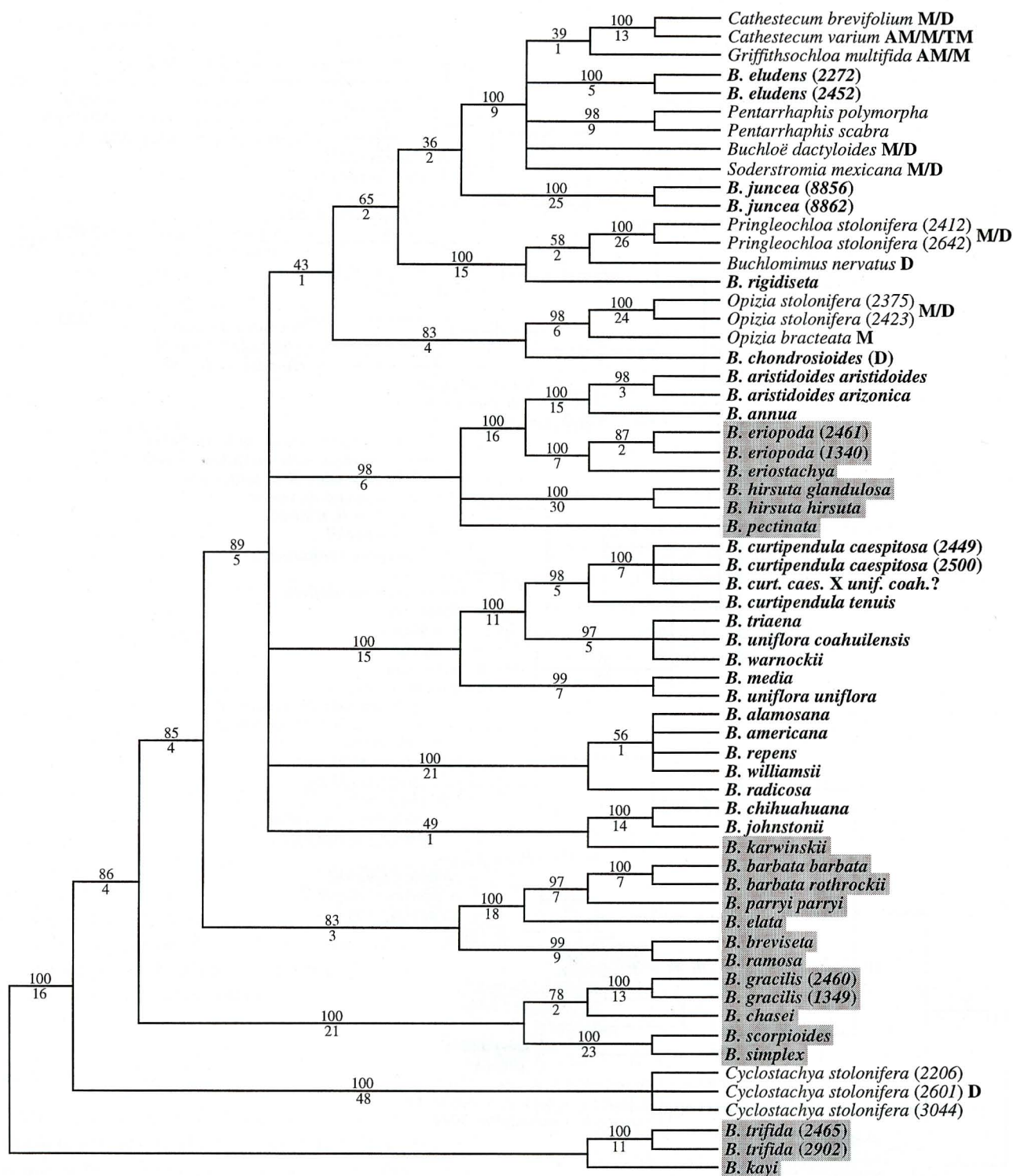


Fig. 5. Strict consensus of 376 most parsimonious trees resulting from a PAUP analysis of ITS region sequences of representatives of *Bouteloua* and related genera, but excluding *Aegopogon*, *Hilaria*, *Pleuraphis*, and five species designated as the outgroup in the more inclusive analysis. In bold are members of *Bouteloua*. Shaded are members of *Bouteloua* subg. *Chondrosium*. Numbers above and below branches are bootstrap percentages and decay indices, respectively. AM = andromonoecious, D = dioecious, M = monoecious, TM = trimonoecious. Tree length = 1293, CI = 0.50, RC = 0.39, RI = 0.77.

clade, *Tragus racemosus* (an outgroup representative), and the clade comprising the remainder of the ingroup taxa, form a tetratemy. Noteworthy, following Bentham's (1881) lead, until the mid 1900s *Ae-*

gopogon, *Hilaria*, and *Pleuraphis* were routinely placed, along with *Tragus* and *Soderstromia*, in tribe Zoysieae, separate from the other genera included in this study.

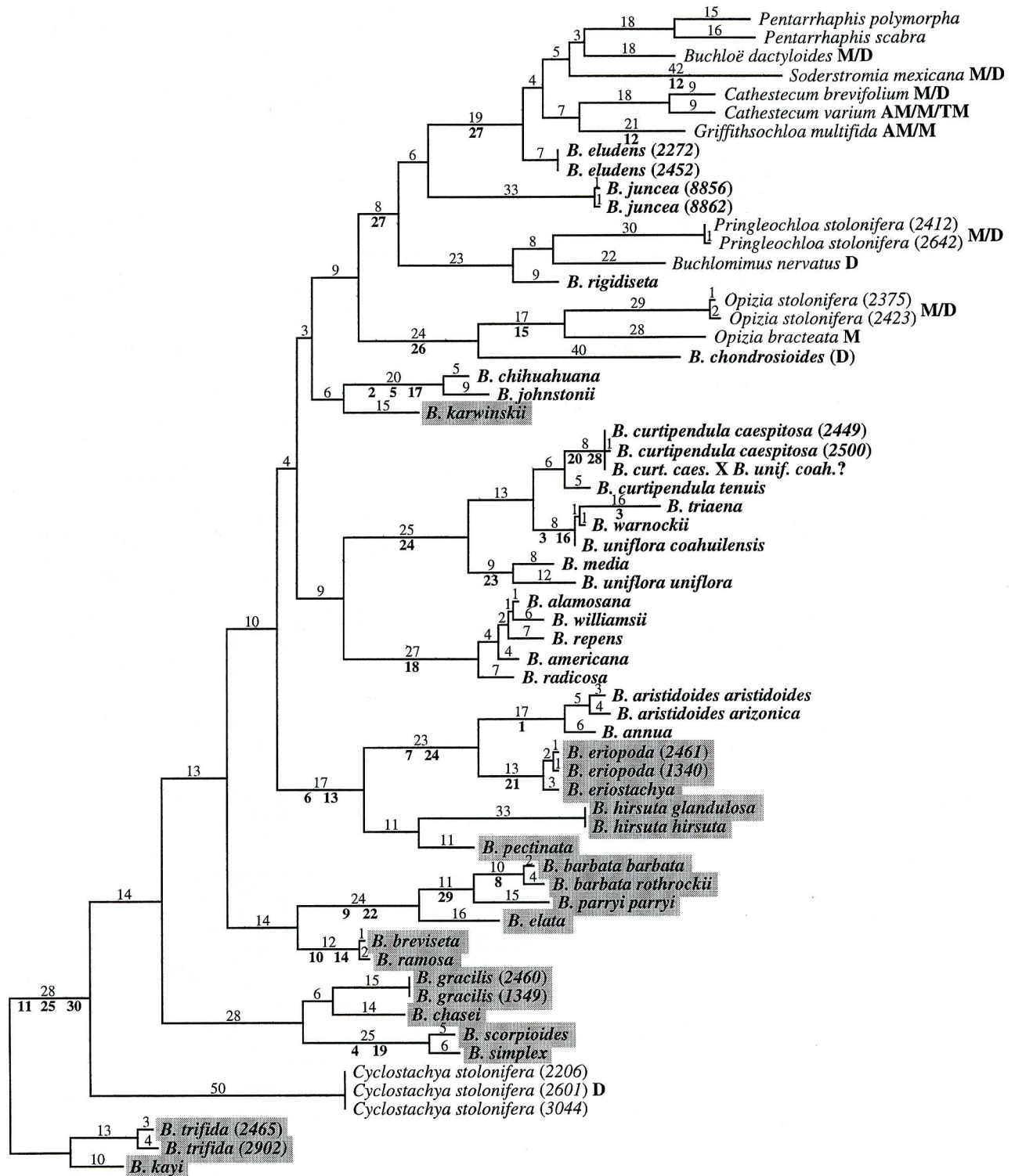


Fig. 6. One of 376 most parsimonious trees, drawn as a phylogram, resulting from a PAUP analysis of ITS region sequences of representatives of *Bouteloua* and related genera, but excluding *Aegopogon*, *Hilaria*, *Pleuraphis*, and five species designated as the outgroup in the more inclusive analysis. In bold are members of *Bouteloua*. Shaded are members of *Bouteloua* subgenus *Chondrosium*. Numbers above branches are branch lengths. Numbers in bold below some branches represent indels, identified and enumerated in Appendix 1, shared by two or more taxa and mapped onto the tree. AM = andromonoecious, D = dioecious, M = monoecious, TM = trimonoecious. Tree length = 1293, CI = 0.50, RC = 0.39, RI = 0.77.

Hilaria-Pleuraphis Clade

Not surprisingly, *Hilaria* and *Pleuraphis* form a strongly supported clade (Fig. 3). A close relationship between these taxa, often treated as congeneric, has never been questioned. Clayton and Renvoize (1986) remarked that *Hilaria* (including *Pleuraphis*) is “rather isolated but its ‘spikelet triads strongly suggest a link with the *Cathetecum* group of genera.” Such a link is not evident from the ITS region phylogeny (Fig. 3), save possibly with *Aegopogon*. Among the most divergent sequences are those of *Hilaria-Pleuraphis* (Appendix 2) and the branch leading to these genera is by far the longest in the entire phylogeny (Fig. 4), mirroring the numerous morphological synapomorphies that set them apart from the other members of subtribe Boutelouinae. *Hilaria* and *Pleuraphis* also differ in basic chromosome number from the other genera in the subtribe (Avdulov 1931; Nielsen 1939; Brown 1950; Gould 1958, 1960, 1965, 1966, 1968, 1980 and refs. therein; Tateoka 1962; Pratt 1965 and refs. therein; Reeder et al. 1965; Anderson 1965; Reeder 1966, 1967, 1968, 1971, 1977, 1984, unpubl. data; Roy 1970; Pohl and Davidse 1971; Davidse and Pohl 1972; Holmgren and Holmgren 1977; Pierce 1979 and refs. therein; Reeder and Reeder 1981, 1988, 1990; Löve and Löve 1981; Windham and Schaack 1983). These reports suggest a basic number of nine for *Hilaria* and *Pleuraphis* and ten for the other genera except *Melanocenchris* (one report of $2n = 24$, Swami 1963) and *Neobouteloua* and *Schaffnerella* (no reports).

A significant amount of sequence divergence has also occurred between the sole representative of *Hilaria* in this study and the two *Pleuraphis* species (Fig. 4; Appendix 2), paralleling morphological and anatomical divergence (Columbus 1996a: lemma micro-morphology, leaf blade anatomy). In contrast, the *Pleuraphis* sequences differ relatively little from one another.

Bouteloua

Monophyly of *Bouteloua*, either s.s. or s.l., is unsupported by the findings of this study (Fig. 3–6). *Bouteloua* subg. *Chondrosium* is also not monophyletic. What follows is discussion of those clades comprised entirely of *Bouteloua* species. *Bouteloua chondrosioides*, *B. eludens*, and *B. rigidiseta* will be discussed later in conjunction with the genera they form clades with.

Bouteloua kayi-B. trifida clade.—As indicated in the results section, *Bouteloua kayi* and *B. trifida* are the only species in the genus that share indels with *Aegopogon*, *Hilaria*, *Pleuraphis*, and the five outgroup species in the more inclusive analysis. The two species

constitute a strongly supported clade (Fig. 5, 6). The two plants of *B. trifida* used in this study, collected in Arizona and Texas, were substantially less divergent in sequence than either one was from *B. kayi* (Fig. 6; Appendix 2), a narrow endemic known only from Brewster Co., Texas, lending no support to Correll and Johnston’s (1970) assertion that *B. kayi* is “probably only a form” of *B. trifida*. These species are atypical in subg. *Chondrosium* because they possess relatively few spikelets per branch (6–24[–32], Gould 1980), the spikelets are appressed or ascending rather than spreading, and the base of the sterile (distal) floret lacks a tuft of hairs.

Bouteloua gracilis-B. simplex clade.—*Bouteloua chasei*, *B. gracilis*, *B. scorpioides*, and *B. simplex*, all members of subg. *Chondrosium*, form a strongly supported clade (Fig. 5). *Bouteloua simplex*, an annual distributed in both North and South America, is sister to the perennial *B. scorpioides*, endemic to central Mexico. A close relationship between these two species is also suggested by morphology and leaf blade anatomy (Columbus 1996a). *Bouteloua scorpioides* and *B. simplex* are unique in *Bouteloua* in consistently developing only one branch per inflorescence.

A single polymorphic site (529) in ITS2 is the only difference between the sequences of the two *Bouteloua gracilis* plants sampled, from Arizona and Durango (Appendix 2; Fig. 6). The species is distributed from southern Canada to central Mexico. Its sister species is *B. chasei*, restricted to gypsum soils in northeastern Mexico. Support for the *B. chasei*-*B. gracilis* clade is not as strong as that for the *B. scorpioides*-*B. simplex* clade (Fig. 5, 6). The infolded, cylindrical leaf blades of *B. chasei* and *B. scorpioides* differ little and share a unique combination of anatomical features (Columbus 1996a).

Chondrosium procumbens (Durand) Desv. (= *Bouteloua simplex*) is the type species of *Chondrosium*.

Bouteloua barbata-B. breviseta clade.—*Bouteloua barbata*, *B. elata*, *B. parryi*, *B. breviseta*, and *B. ramosa* are members of subg. *Chondrosium* and constitute a well-supported and well-resolved clade (Fig. 5). The first three species form a clade sister to a clade formed by the last two species, each clade also strongly supported (Fig. 5, 6).

Bouteloua barbata and *B. parryi* in turn comprise a strongly supported clade that is sister to *B. elata* (Fig. 5, 6). Close relationships among these species have been suggested previously. Watson (1883), in describing var. *vestita* (= *B. parryi* var. *parryi*) of *B. polystachya* (Benth.) Torr. (= *B. barbata* var. *barbata*), treated *B. barbata* and *B. parryi* as conspecific. Gould (1949) compared *B. parryi* var. *gentryi* (Gould) Gould (not included in our study) to *B. barbata*. Reeder and Reeder (1963b) recognized the morphological similar-

ities between *B. elata* and *B. parryi* var. *parryi*, although the former is a large perennial and the latter a smaller annual. A close relationship among the three species is also suggested by lemma micromorphology and leaf blade anatomy (Columbus 1996a); lemma micromorphology supports a closer relationship between *B. parryi* and *B. elata* while leaf anatomy supports a closer relationship between *B. parryi* and *B. barbata*. Contrary to Gould (1980), Griffiths (1912) treated the perennial *B. barbata* var. *rothrockii* as specifically distinct from the annual var. *barbata*. While the perennial *B. elata* is restricted to southern Mexico, the annuals *B. barbata* var. *barbata* and *B. parryi* var. *parryi* are more widespread, distributed in the southwestern U.S.A. and Mexico, the former also disjunct in Argentina. The two perennial varieties of *B. barbata*, var. *rothrockii* and var. *sonorae* (Griffiths) Gould (not included in this study), have narrower distributions in southwestern U.S.A.-northern Mexico and western Mexico, respectively.

The sequences of *Bouteloua breviseta* and *B. ramosa* differ by only three nucleotide substitutions (Fig. 6; Appendix 2). Gould (1980) treated these species as conspecific, but Reeder and Reeder (1981) effectively argued, based on morphology, ploidy level, geography, and habitat, that the two are distinct. *Bouteloua breviseta* is restricted to gypsum soils in southeastern New Mexico and adjacent Texas and Mexico, whereas *B. ramosa* occurs farther south on calcareous substrates in the Chihuahuan Desert of western Texas and northern Mexico.

Bouteloua aristidoides-*B. eriopoda*-*B. hirsuta* clade.—*Bouteloua annua* and *B. aristidoides* (members of subg. *Bouteloua*) form a well-supported clade with *B. eriopoda*, *B. eriostachya*, *B. hirsuta*, and *B. pectinata* (members of subg. *Chondrosium*) (Fig. 5, 6). The first four species make up a strongly supported and well-resolved clade that in turn forms a tritomy with *B. hirsuta* and *B. pectinata* in the strict consensus tree (Fig. 5). In 78% of the most parsimonious trees, including the tree in Fig. 6, *B. hirsuta* and *B. pectinata* form a clade that is sister to the *B. aristidoides*-*B. eriopoda* clade.

Bouteloua annua, *B. aristidoides*, *B. eriopoda*, and *B. eriostachya* (originally described as a variety of *B. eriopoda*) are similar in spikelet orientation and form, including lodicules and the abaxial epidermis of the fertile lemma, and in transectional structure of the leaf blade (Columbus 1993, 1996a, 1999). The two most widely distributed species, *B. aristidoides* (southwestern U.S.A., Mexico, South America) and *B. eriopoda* (southwestern U.S.A., northern Mexico), differ considerably in general appearance. *Bouteloua eriopoda* usually has 2–6 branches per inflorescence, each 2–5 cm long and persistent (characteristics of subg. *Chondro-*

sium), while *B. aristidoides* typically has more numerous (7–20), shorter (1–3 cm), deciduous branches (characteristics of subg. *Bouteloua*). In addition, branches of *B. eriopoda* usually bear 8–18 spikelets (exceptionally few for subg. *Chondrosium*) and are usually distichous and ascending or spreading (see Griffiths 1912, Plate 74B), whereas branches of *B. aristidoides* usually have fewer spikelets (2–10) and, in var. *aristidoides*, are frequently pendulous along one side of an ascending or arching main axis (rachis), rendering the inflorescence secund (see Griffiths 1912, Plate 77A). The differences between the inflorescences, along with the fact that *B. eriopoda* is a stoloniferous perennial with pubescent internodes while *B. aristidoides* is a nonstoloniferous annual with glabrous internodes, have long masked their close relationship and led to the two species being placed in separate subgenera. In the ITS region phylogeny (Fig. 5, 6), the annuals *B. annua* (endemic to Baja California Sur) and *B. aristidoides* form a clade that is sister to a clade comprised of perennials *B. eriostachya* (endemic to Coahuila) and *B. eriopoda*; each clade is strongly supported. See Columbus (1999) for a more detailed discussion of these four species.

The nomenclatural combinations *Bouteloua hirsuta* var. *pectinata* (Feath.) Cory and *B. hirsuta* subsp. *pectinata* (Feath.) Wipff & S. D. Jones attest to the morphological similarity between *B. hirsuta* and *B. pectinata*. Each of these taxa has been advocated as a close relative of *B. gracilis* (Roy 1968; Correll and Johnston 1970; Roy and Gould 1971). Although the second (distal) glume of *B. hirsuta*, *B. pectinata*, and often *B. gracilis* (as well as *B. elata* and *B. parryi*) bears long, bulbous-based hairs, the spikelet of *B. gracilis*, especially the fertile lemma, differs considerably from those of the other species (see Griffiths 1912, Fig. 34, 35). Lemma micromorphology and leaf blade anatomy also suggest a relationship more distant than believed by the above authors (Columbus 1996a). A conspicuous feature of *B. hirsuta* and *B. pectinata*, often employed in keys to distinguish these taxa from *B. gracilis*, is that the inflorescence branch axis is prolonged beyond the terminal spikelet node. The branch axis is also prolonged in the four species comprising the *B. aristidoides*-*B. eriopoda* clade. In fact, *B. eriopoda*, *B. eriostachya*, *B. hirsuta*, *B. pectinata*, and *B. quiriegoensis* (not included in this study, but unequivocally closely related to *B. hirsuta* based on morphology and leaf blade anatomy [Columbus 1996a]) are the only members of subg. *Chondrosium* that exhibit this feature.

No author has hypothesized that *Bouteloua hirsuta* or *B. pectinata* is closely related to any of the species in the *B. aristidoides*-*B. eriopoda* clade as is suggested in the ITS region phylogeny. This is for good reason. Other than the prolonged axis of the inflorescence

branch, obvious morphological similarities are lacking (see figures and plates in Griffiths 1912). The two groups also differ markedly in leaf blade transectional structure (Columbus 1996a).

With regard to the two varieties of *Bouteloua hirsuta*, the plants used in this study came from the same population. Their sequences were found to be identical except for a polymorphism at a single site (469) in ITS2 of var. *hirsuta* (Appendix 1). The varieties, recognized by Gould (1980), are distinguished simply by the presence (var. *glandulosa*) or absence (var. *hirsuta*) of pubescence on culm internodes. Expressing doubt and citing a mixed collection, Griffiths (1912) nonetheless recognized *B. hirticulmis* Scribn. (= *B. hirsuta* var. *glandulosa*) as a distinct species. We assert that if these taxa are to be recognized at all, it should be at the rank of form.

Bouteloua karwinskii.—Although this species, a member of subg. *Chondrosium*, is sister to the *Bouteloua chihuahuana*-*B. johnstonii* (subg. *Bouteloua*) clade in the strict consensus tree (Fig. 5), the relationship is weakly supported by a bootstrap percentage of 49 and decay index of 1.0. Lacking are obvious morphological and anatomical (leaf blade x. s., Columbus 1996a) similarities between *B. karwinskii* and *B. chihuahuana*-*B. johnstonii* that would suggest a close relationship. Swallen (1943), Reeder and Reeder (1963b, 1969), and Gould (1980) considered *B. karwinskii* to be closely related to *B. chasei*, a member of the *B. gracilis*-*B. simplex* clade discussed above. *Bouteloua karwinskii* and *B. chasei*, both endemic to northern Mexico, have similar distributional ranges. Reeder and Reeder (1963b, 1969) pointed out differences between the species, however, including deciduous inflorescence branches and the absence of a tuft of hairs at the base of the second floret in *B. karwinskii*, features that Gould (1980) and Clayton and Renvoize (1986) associated with subg. *Bouteloua*. Columbus (1996a) found that *B. karwinskii* is most similar to *B. gracilis*, *B. scorpioides*, and *B. simplex* based on lemma micromorphology and to *B. gracilis* and *B. rigidisetia* (subg. *Bouteloua*) based on leaf blade anatomy.

Bouteloua chihuahuana-*B. johnstonii* clade.—A sister relationship between these species in subg. *Bouteloua* is strongly supported (Fig. 5, 6). These little-collected species are known only from Chihuahua and Coahuila, respectively. *Bouteloua chihuahuana* grows on calcareous substrates while *B. johnstonii* is an obligate gypsumophile. The close relationship is also suggested by morphology and leaf blade anatomy (Columbus 1996a).

Bouteloua americana-*B. repens* clade.—This strongly supported clade is a group of species recognized by Griffiths (1912) and Gould (1969) plus *Bouteloua ala-*

mosana, which Gould (1980) eventually discovered also belongs to this group. The species are members of subg. *Bouteloua*. Although there is considerable sequence divergence among the species (Fig. 6; Appendix 2), the relationships are unresolved (Fig. 5). In 79% of the most parsimonious trees, including the tree in Fig. 6, this clade is sister to the *B. curtipendula* clade (discussed below). Columbus (1996a) found the groups to be very similar in microscopic features of the abaxial surface of the fertile lemma.

Bouteloua curtipendula clade.—Gould and Kapadia (1964) recognized 12 species and five varieties in the *Bouteloua curtipendula* complex (subg. *Bouteloua*). Included in our study were six species, four varieties, and a possible interspecific hybrid inferred from morphology. All but *B. juncea* (discussed below) comprise a strongly supported and well-resolved clade (Fig. 5, 6). Incongruent with morphology, the two varieties of *B. uniflora* are quite divergent in sequence (Appendix 2) and the species is polyphyletic (Fig. 5). The sequence of *B. uniflora* var. *coahuilensis* scarcely differs from that of *B. warnockii* (Fig. 6; Appendix 1, 2), although the latter species is morphologically more similar to *B. curtipendula*. Sequences from the two *B. curtipendula* var. *caespitosa* plants from Arizona and the putative hybrid from Coahuila are nearly identical, differing at only three nucleotide sites (249, 438, 693, the last two polymorphic; Appendix 1). As an interesting aside, Griffiths (1912) positioned *B. triaena* in the monotypic genus *Triaena* Kunth (under the misapplied name *T. juncea* [Desv. ex P. Beauv.] Griffiths [= *B. juncea*]).

Bouteloua racemosa Lag. (= *B. curtipendula*) is the type species of *Bouteloua*.

Bouteloua juncea.—This species in subg. *Bouteloua*, endemic to the West Indies, was suspected by Columbus (1996a), based on morphology (including lemma micromorphology) and leaf blade anatomy, to be misplaced in the *B. curtipendula* complex (Gould and Kapadia 1964; discussed above). The sequence divergences (Appendix 2) and phylogeny (Fig. 5) lend support to this hypothesis.

Cyclostachya

Clayton and Renvoize (1986; Fig. 2) suggested that the monotypic and dioecious *Cyclostachya*, endemic to central Mexico, is closely related to the dioecious *Buchlomimus* and monoecious/dioecious *Pringleochloa*. The ITS region phylogeny (Fig. 5), however, supports Reeder et al. (1965) who contended, based on morphology of bicellular microhairs on the abaxial surface of the leaf, that *Cyclostachya* does not appear to be closely related to either of these genera. In the phylogeny, *Cyclostachya* is situated among members

of *Bouteloua* subg. *Chondrosium* (all having hermaphroditic flowers), but note its numerous autapomorphies (Fig. 6). Although the staminate and carpellate inflorescences of *Cyclostachya* consist of a single *Chondrosium*-like branch, the branches are deciduous, unlike most species of *Chondrosium*. Also noteworthy is the lack of sequence divergence among the three plants originating from widely separated sites throughout the range of the species (Fig. 6; Appendix 2).

Bouteloua chondrosioides-*Opizia* Clade

The monophyly of *Opizia* is strongly supported by the ITS region phylogeny (Fig. 5, 6), validating McVaugh's (1983) decision to position his new species, *O. bracteata*, in *Opizia*. The monoecious and nonstoloniferous *O. bracteata* is known only from southwestern Michoacán while its monoecious/dioecious and stoloniferous sister species, *O. stolonifera*, is much more widespread (southern Mexico, Honduras, West Indies). Both species have markedly dimorphic staminate and carpellate inflorescences (Columbus 1994). Sister to *Opizia* is the nonstoloniferous *Bouteloua chondrosioides* (subg. *Bouteloua*), a relationship well supported by a bootstrap percentage of 83, decay index of 4, and a three-base insertion in ITS2 of all three species (Fig. 5, 6; Appendix 1). A close relationship between *B. chondrosioides* (Arizona, Texas, Mexico, Central America) and *Opizia* has never been hypothesized. Interestingly, *B. chondrosioides* is the only species of *Bouteloua* known to be dioecious (or gynodioecious), although the condition is facultative and without associated dimorphism (Reeder and Reeder 1966). Note also the long branches in this clade.

Bouteloua rigidiseta-*Buchlomimus*-*Pringleochloa* Clade

Based on morphology, including copossession of linear bicellular microhairs on the abaxial surface of the leaf, Reeder et al. (1965) suggested that the dioecious *Buchlomimus* and monoecious/dioecious *Pringleochloa* are closely related, a hypothesis supported by the ITS region phylogeny (Fig. 5). These two stoloniferous monotypic genera have small distributional ranges in central Mexico, the former known only from the states of Hidalgo and Mexico and the latter from Puebla. The other member of this strongly supported clade is the caespitose, perfect-flowered *Bouteloua rigidiseta*, a member of subg. *Bouteloua* and distributed in Oklahoma, Texas, Coahuila, and Tamaulipas. A close relation of *B. rigidiseta* to *Buchlomimus* and *Pringleochloa* has not previously been suggested.

Bouteloua eludens-*Buchloë*-*Cathestecum*-*Griffithsochloa*-*Pentarrhaphis*-*Soderstromia* Clade

This strongly supported clade, though backing monophyly of both *Cathestecum* and *Pentarrhaphis*, is poorly resolved (Fig. 5). In 1978 Pierce segregated the monotypic and andromonoecious/monoecious *Griffithsochloa* from the andromonoecious/monoecious/tri-monoecious/dioecious *Cathestecum*. These genera plus the monotypic and monoecious/dioecious *Soderstromia*, along with *Aegopogon*, *Hilaria*, and *Pleuraphis* (discussed above), constitute a group of genera that Clayton and Renvoize (1986) considered to be related (Fig. 2). These authors also situated *Pentarrhaphis* (perfect-flowered, although the second floret may be staminate) next to the Old World genus *Melanocenchris* (not included in our study) and apart from the above genera (Fig. 2), although earlier Clayton and Richardson (1973) wrote that *Aegopogon*, *Cathestecum*, and *Soderstromia* "are clearly related to *Melanocenchris* Nees and *Pentarrhaphis* H. B. K., and they to *Bouteloua* Lag."

Bouteloua eludens, a member of subg. *Bouteloua* having hermaphroditic flowers, has never been postulated to be closely related to any of the other members of this clade. Gould (1980) and Reeder and Reeder (1990) considered *B. eludens* to be closely related to *B. chondrosioides* (discussed further below).

Of the members of this clade, the monotypic, monoecious/dioecious, and markedly dimorphic *Buchloë* has been compared only to *Soderstromia* because each possesses unisexual flowers (Reeder and Reeder 1963a; Reeder et al. 1965). Inflorescence morphology, however, does not indicate a close relationship. In fact, the staminate and carpellate inflorescences of *Buchloë*, which are *Chondrosium*-like and burrlike, respectively, not only differ markedly from each other but from the inflorescences of all the other taxa in this clade.

CONCLUSIONS

Although monophyly of *Bouteloua* s.l. or s.s. and *Chondrosium* is not supported by cladistic parsimony analysis of ITS region sequences, no new circumscriptions are proposed herein. This study represents one line of evidence in a larger systematic investigation, and additional phylogenetic estimates, particularly from the nonrecombining chloroplast genome, are needed before taxonomic changes, if any, are proposed. Columbus (1999), however, presents morphological and anatomical evidence corroborating the close relationship between *Bouteloua aristoides* and *B. (Chondrosium) eriopoda* (Fig. 5). He recommends that for now *Bouteloua* be treated in the broad sense, with *Chondrosium* reduced to synonymy and no subgeneric divisions, a position we also advocate.

If the ITS region phylogeny provides an accurate

estimate of the organismal phylogeny, then some intriguing cases of parallel or convergent morphological, anatomical, and breeding system evolution have taken place, although retention of plesiomorphic traits is a less parsimonious alternative. For instance, inflorescence branches of *Aegopogon*, *Cathestecum*, *Griffithsochloa*, *Hilaria*, *Pleuraphis*, and *Soderstromia* each bear a triad of spikelets, the central spikelet differing in some manner from the laterals, but *Aegopogon*, *Hilaria*, and *Pleuraphis* appear distantly related to the other genera (Fig. 3). Also, inflorescence branches of *Bouteloua hirsuta*, *B. karwinskii*, *B. pectinata*, species in the *B. barbata*-*B. breviseta* and *B. gracilis*-*B. simplex* clades, *Buchlomimus*, *Cyclostachya*, and the staminate branches of *Buchloë*, *Opizia*, and *Pringleochloa* all bear numerous spreading spikelets (Fig. 1, right), but these taxa are scattered throughout the phylogeny (Fig. 5).

While a close relationship among *Bouteloua chihuahuana*, *B. chondrosioides*, *B. eludens*, and *B. johnstonii* has been advanced by Swallen (1943), Gould (1980), Reeder and Reeder (1990), and Columbus (1996b), the ITS region phylogeny supports a close relationship only between *B. chihuahuana* and *B. johnstonii* (Fig. 5). *Bouteloua eludens* commonly grows sympatrically with *B. chondrosioides* and their inflorescences are so similar that the two species can be difficult to distinguish in the field. In addition, the leaf blades of these two species and *B. chihuahuana* are virtually identical in transectional structure to one another and to the blades of *B. hirsuta*, *B. pectinata*, *B. quiriogoensis*, and *Pentarrhaphis scabra* (Columbus 1996a). Also similar are the blades of *B. johnstonii*, *Griffithsochloa*, *Opizia*, the two other species of *Pentarrhaphis*, and *Soderstromia*. Examination of the ITS region phylogeny (Fig. 5) reveals that these taxa are distributed in four separate clades, suggesting homoplasy at the anatomical level.

Taxa possessing unisexual spikelets are distributed throughout the ITS region phylogeny. The andromonoecious *Aegopogon* and *Pleuraphis*, monoecious *Hilaria*, and dioecious *Cyclostachya* are more distantly related to the other taxa, which are distributed in three separate well-supported clades (Fig. 3, 5). However, the relationship among these three clades is unclear as evidenced by the weak bootstrap and decay index support for the branches linking the clades in the strict consensus tree (Fig. 5). Interestingly, hermaphroditism, monoecy, and dioecy are expressed in each of these clades. These data suggest, therefore, that spikelet unisexuality and its various manifestations are homoplastic, and that *Bouteloua* and relatives appear to be predisposed to this condition.

Some of these genera deemed divergent on the basis of cryptic data are remarkably convergent morphologically. For instance, *Aegopogon* resembles the distantly

related *Cathestecum* and *Griffithsochloa*, all having spikelets arranged in triads and exhibiting andromonoecy. More striking, however, is the likeness between the distantly related *Buchlomimus* and *Cyclostachya*, each stoloniferous and dioecious and "might almost be included in the same genus" (Clayton and Renvoize 1986).

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Appendix 1. Aligned ITS region sequences of representatives of *Bouteloua* and related and outgroup genera. Nucleotide sites are numbered 5' to 3'. Polymorphic sites are coded as follows: K = G/T, M = A/C, R = A/G, S = C/G, W = A/T, Y = C/T. Dashes represent gaps. ITS1, 5.8S, and ITS2 correspond to positions 1–274, 275–439 (ends marked by asterisks), and 440–705, respectively. Plus signs denote indels shown in Fig. 6. Unaligned sequence lengths are given at the end.

	10	20	30	40	50	60
1 <i>Aegopogon cenchroides</i>	TCGTGACCCGTGACCA	AAAAAGACCGTGAACATGTCATCCATGCCGCCGTTT	GATGGGGCTT			
2 <i>A. tenellus</i>	TCGTGACCCGTGACCA	AAAAAGACCGTGAACATGTCATCCATGCCGCCGTTT	GATGGGGCTT			
3 <i>Bouteloua alamosana</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
4 <i>B. americana</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
5 <i>B. annua</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
6 <i>B. aristidoides aristidoides</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
7 <i>B. aristidoides arizonica</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
8 <i>B. barbata barbata</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
9 <i>B. barbata rothrockii</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
10 <i>B. brevifolia</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
11 <i>B. chisei</i>	TCGTGACCCGTGACCA	AAACAAACAGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
12 <i>B. chihuahuana</i>	TCGTGACCCGTGACCA	AAAAAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
13 <i>B. chondrosioides</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
14 <i>B. curtipendula caespitosa</i> (2449)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
15 <i>B. curtipendula caespitosa</i> (2500)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
16 <i>B. curtipendula tenuis</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
17 <i>B. elata</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
18 <i>B. eludens</i> (2272)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
19 <i>B. eludens</i> (2452)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
20 <i>B. eriopoda</i> (2461)	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
21 <i>B. eriopoda</i> (1340)	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
22 <i>B. eriostachya</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
23 <i>B. gracilis</i> (2460)	TCGTGACCCGTGACCA	AAACAAACAGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
24 <i>B. gracilis</i> (1349)	TCGTGACCCGTGACCA	AAACAAACAGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
25 <i>B. hirsuta glandulosa</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
26 <i>B. hirsuta hirsuta</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
27 <i>B. johnstonii</i>	TCGTGACCCGTGACCA	AAAAAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
28 <i>B. juncea</i> (8856)	TCGTGACCCGTGACCA	AAACAAACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
29 <i>B. juncea</i> (8862)	TCGTGACCCGTGACCA	AAACAAACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
30 <i>B. karwinskii</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
31 <i>B. kayi</i>	TCGTGACCCGTGACCA	AAACAAACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
32 <i>B. media</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
33 <i>B. parryi parryi</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
34 <i>B. pectinata</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
35 <i>B. radicata</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
36 <i>B. ramosa</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
37 <i>B. repens</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
38 <i>B. rigidiseta</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
39 <i>B. scorpioides</i>	TCGTGACCCGTGACCA	AAACAAACAGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
40 <i>B. simplex</i>	TCGTGACCCGTGACCA	AAACAAACAGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
41 <i>B. triaena</i>	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
42 <i>B. trifida</i> (2465)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
43 <i>B. trifida</i> (2902)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
44 <i>B. uniflora coahuilensis</i>	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
45 <i>B. uniflora uniflora</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
46 <i>B. warnockii</i>	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
47 <i>B. williamsii</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
48 <i>B. curt. caes. X B. unif. coah.?</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
49 <i>Buchloë dactyloides</i>	TCGTGACCCGTGACCA	AAAAAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
50 <i>Buchloë minus nervatus</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
51 <i>Cathastecum brevifolium</i>	TCGTGACCCGTGACCA	AAATAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
52 <i>C. varium</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
53 <i>Chloris virgata</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
54 <i>Cyclostachya stolonifera</i> (2206)	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
55 <i>C. stolonifera</i> (2601)	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
56 <i>C. stolonifera</i> (3044)	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
57 <i>Cynodon dactylon</i>	TCGTGACCCGTGATGA	AAACAAACCGTGAACCTGTACCTATGCTGCCCGGT	GATGGGCTT			
58 <i>Griffithsochloa multifida</i>	TCGTGACCCGTGACCA	AAAAAGACCGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
59 <i>Hilaria ciliata</i>	TYGTGACCCGTGACCA	AAGCAGACCTGTGAATTTGTCATCCATGCTGCCCGGT	GATGGGTCTT			
60 <i>Leptochloa dubia</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
61 <i>Microchloa kunthii</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
62 <i>Opizia bracteata</i>	TCGTGACCCGTGATCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
63 <i>O. stolonifera</i> (2375)	TCGTGACCCGTGATCAATCA	AAATAGACCTGTGAATATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
64 <i>O. stolonifera</i> (2423)	TCGTGACCCGTGATCAATCA	AAATAGACCTGTGAATATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
65 <i>Pentarrhaphis polymorpha</i>	CCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
66 <i>P. scabra</i>	CTGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
67 <i>Pleuraphis mutica</i>	TCGTGACCCGTGACCA	AAGTAGACCTGTGAATTTGTCATCCATGCTGCCCGGT	GATGGGTCTT			
68 <i>P. rigida</i>	TCGTGACCCGTGACCA	AAGTAGACCTGTGAATTTGTCATCCATGCTGCCCGGT	GATGGGTCTT			
69 <i>Pringleochloa stolonifera</i> (2412)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
70 <i>P. stolonifera</i> (2642)	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
71 <i>Soderstromia mexicana</i>	TCGTGACCCGTGACCA	AAATAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			
72 <i>Tragus racemosus</i>	TCGTGACCCGTGACCA	AAACAGACCTGTGAACATGTTATCCATTCTGCCCGGT	GATGGGTCTT			

[illegible]

Appendix 1. Continued.

	170	180	190	8+	200	10+	210	220	230
	+6	.	++7	.	++++9	.	+11	+12	.
1 <i>Aegopogon cenchroides</i>	TGGCGTCAAGGAAACTGAT	—ATTGC—TT—	—GTTTGGGG—CC—A—	—CGTTCGGCTTGCCGGA					
2 <i>A. tenellus</i>	TGGCGTCAAGGAAACTGAT	—ATTGC—TT—	—GTTTGGGG—CA—A—	—TGTTCCGGCTTGCCGGA					
3 <i>Bouteloua alamosana</i>	TGGCGTCAAGGAACACTGAT	—GCTGTCAT—	—GCACATG—TG—T—	—TGACCCGGCTTGCCGGA					
4 <i>B. americana</i>	TGGCGTCAAGGAACACTGAT	—TGCTGTCAT—	—GCACATG—TG—T—	—TGACCCGGCTTGCCGGA					
5 <i>B. annua</i>	—GGMGTCAGGAACACTGAT	—ATTCTGCCTT—	—GCAAGGG—TG—T—	—GGATTGGCTTGCTCGGT					
6 <i>B. aristoides aristoides</i>	—GGCGTCAAGGAACACTTAT	—ATTGTACCTT—	—GCATGGG—TG—T—	—GGATTGGCTTGCTCGGT					
7 <i>B. aristoides arizonica</i>	—GGCGTCAAGGAACACTTAT	—ATTCTACCTT—	—GCATGGG—TG—T—	—GGATTGGCTTGCCGGT					
8 <i>B. barbata barbata</i>	CGGCGTCAAGGAACACTGAA	—GCTGCCTTTGCTCGCACGGT	—TG—T—	—GGACCCGGCTTGCCGGT					
9 <i>B. barbata rothrockii</i>	CGGCGTCAAGGAACACTGAA	—GCTGCCTTTGCTCGCACGGT	—TG—T—	—GGACCCGGCTTGCCGGT					
10 <i>B. breviseta</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACGG—TG—T—	—GGCCCGCTTGCCGGT					
11 <i>B. chasei</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACATG—GG—C—	—GGACCCGGCTTGCCGGT					
12 <i>B. chihuahuana</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACGGG—CG—G—	—TGACCCGGCTTGCCGGC					
13 <i>B. chondrosioides</i>	TAGCGTCAAGGAACACTTAG	—GTTGCCTA—	—GCACGGG—CA—G—	—GTACCAGCTTGCTGGT					
14 <i>B. curtispindula caespitosa</i> (2449)	TGGCGTCAAGGAACACTGAT	—GCTGCCGT—	—GCATGGG—TG—T—	—GGACCCGGCTTGCTGGT					
15 <i>B. curtispindula caespitosa</i> (2500)	TGGCGTCAAGGAACACTGAT	—GCTGCCGT—	—GCATGGG—TG—T—	—GGACCCGGCTTGCTGGT					
16 <i>B. curtispindula tenuis</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCAT—	—GCATGGG—CG—T—	—GGACCCGGCTTGCTGGT					
17 <i>B. elata</i>	CGGCGTCAAGGAACACTGAA	—CCTT—GCTTGACCGT	—TC—T—	—GGACTGGCTTGCCGGT					
18 <i>B. eludens</i> (2272)	AGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACGGG—CA—G—	—GGACTGGCTTGCTGGT					
19 <i>B. eludens</i> (2452)	AGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACGGG—CA—G—	—GGACTGGCTTGCTGGT					
20 <i>B. eriopoda</i> (2461)	—GGCGTCAAGGAACACTGAT	—ATGCTACCTT—	—GCATGGG—CG—T—	—GGACCCGGCTTGCTCGGT					
21 <i>B. eriopoda</i> (1340)	—GGCGTCAAGGAACACTGAT	—ATGCTACCTT—	—GCATGGG—CG—T—	—GGACCCGGCTTGCTCGGT					
22 <i>B. eriostachya</i>	—GGCGTCAAGGAACACTGAT	—ATGCTACCTT—	—GCATGGG—CG—T—	—GGACCCGGCTTGCTCGGT					
23 <i>B. gracilis</i> (2460)	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACAAG—TG—C—	—GGACCCGGCTTGCCGGT					
24 <i>B. gracilis</i> (1349)	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACAAG—TG—C—	—GGACCCGGCTTGCCGGT					
25 <i>B. hirsuta glandulosa</i>	—GGCGTCAAGGAACACTGAT	—GCTTCTT—	—GCATGGG—AG—T—	—GGACCCGGCTTGCCGGT					
26 <i>B. hirsuta hirsuta</i>	—GGCGTCAAGGAACACTGAT	—GCTTCTT—	—GCATGGG—AG—T—	—GGACCCGGCTTGCCGGT					
27 <i>B. johnstonii</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACGGG—CG—G—	—TGACCCGGCTTGCCGGC					
28 <i>B. juncea</i> (8856)	TGGCGTCAAGGAACACTGAT	—GAAGCCTT—	—GTACAGG—TG—G—	—GCACCCGGCTTGCCGGT					
29 <i>B. juncea</i> (8862)	TGGCGTCAAGGAACACTGAT	—GAAGCCTT—	—GTACAGG—TG—G—	—GCACCCGGCTTGCCAGT					
30 <i>B. karwinskii</i>	TGGCGTCAAGGAAACTGAT	—GCTGCGT—	—GCACGGA—CG—G—	—GGACCCGGCTTGCCGGC					
31 <i>B. kayi</i>	TGGCGTCAAGGAACACAGAT	—ATTGCCTT—	—GCGTGGGG—CG—T—	—GGACTGGCTTGCCGGT					
32 <i>B. media</i>	TGGCGTCAAGGAACACTGAT	—GCAGCCAT—	—GCATGAG—TG—T—	—GGACCCGGCTTGCCGGT					
33 <i>B. parryi parryi</i>	CGGCGTCAAGGAACACTGAA	—TCTACCTT—GCTCGCACGGT	—TT—T—	—GGACTGGCTTGCCAGT					
34 <i>B. pectinata</i>	—GGCGTCAAGGAACACTGAT	—GCTTCTT—	—GCACGGG—AG—T—	—GGACCCGGCTTGCCGGT					
35 <i>B. radicata</i>	TGGCGTCAAGGAACACTGAT	—GCTGTCAT—	—GCACATG—TG—T—	—TGACCCGGCTTGCCGGA					
36 <i>B. ramosa</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACGG—TG—T—	—GGCCCGCTTGCCGGT					
37 <i>B. repens</i>	TGGCGTCAAGGAACACTGAT	—GCTGTCAT—	—GCACATG—TG—T—	—TGACCCGGCTTGCCGGA					
38 <i>B. rigidiseta</i>	TGGCGTCAAGGAACACTGAT	—GATGCCTT—	—GCACGGG—CG—T—	—GGTCCGGCTTGCCGGT					
39 <i>B. scorpioides</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACATG—GG—C—	—GGATTGGCTTGCCGGT					
40 <i>B. simplex</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCTT—	—GCACATG—GG—C—	—GGACTGGCTTGCCGGT					
41 <i>B. triaena</i>	CGGCGTCAAGGAACACTGAT	—GCTGTGAT—	—GCATGGG—CG—T—	—GGACTGGCTTGCCGGT					
42 <i>B. trifida</i> (2465)	TGGCGTCAAGGAACACAGAT	—ATTGCCTT—	—GCGTGGGG—TG—T—	—GGACTGGCTTGCCAGT					
43 <i>B. trifida</i> (2902)	TGGCGTCAAGGAACACAGAT	—ATTGCCTT—	—GCGTGGGG—TG—T—	—GGACTGGCTTGCCAGT					
44 <i>B. uniflora coahuilensis</i>	TGGCGTCAAGGAACACTGAT	—GCTGCGAT—	—GCATGGG—CG—T—	—GGACTGGCTTGCCGGT					
45 <i>B. uniflora uniflora</i>	CGGCGTCAAGGAACACTGAT	—GCAGCCAT—	—GCACGGG—TG—T—	—GGATCGGCTTGCTGGT					
46 <i>B. warnockii</i>	TGGCGTCAAGGAACACTAAT	—GCTGCGAT—	—GCATGGG—CG—T—	—GGACTGGCTTGCCGGT					
47 <i>B. williamsii</i>	TGGCGTCAAGGAACACTGAT	—GCTATCAT—	—GCACATG—TG—T—	—TGACCCGGCTTGCCGGA					
48 <i>B. curt. caes. X B. unif. coah.?</i>	TGGCGTCAAGGAACACTGAT	—GCTGCCGT—	—GCATGGG—TG—T—	—GGACCCGGCTTGCTGGT					
49 <i>Buchloë dactyloides</i>	AGGCGTCAAGGAACACTGAT	—GCTGTCTT—	—GCACGGG—CA—G—	—GGACCCGGCTTGCTGGT					
50 <i>Buchlomimus nervatus</i>	TGGCGTCAAGGAACACTGAT	—GATGCCTT—	—GAATGGG—TG—T—	—GGTCCGGCTTGCTGGT					
51 <i>Cathestecum brevifolium</i>	AGGCGTCAAGGAACACTGAT	—GATGTCTT—	—GCACGGG—TT—G—	—GGACTGGCTTGCTCGT					
52 <i>C. varium</i>	AGGCGTCAAGGAACACAGAT	—GATGTCTT—	—GCACAGG—TT—G—	—GGACTGGCTTGCTCGT					
53 <i>Chloris virgata</i>	TGGCGTCAAGGAAACATAT	—GTTGCCTT—	—GCTTGGGG—CT—G—	—TGATCGGCTTGCCGGA					
54 <i>Cyclostachya stolonifera</i> (2206)	TGGCGTCAAGGAACACAGAT	—TGG—	—GCATAGG—TG—T—	—CAACTCGCATGCGGGT					
55 <i>C. stolonifera</i> (2601)	TGGCGTCAAGGAACACAGAT	—TGG—	—GCATAGG—TG—T—	—CAACTCGCATGCGGGT					
56 <i>C. stolonifera</i> (3044)	TGGCGTCAAGGAACACAGAT	—TGG—	—GCATAGG—TG—T—	—CAACTCGCATGCGGGT					
57 <i>Cynodon dactylon</i>	TGGCGTCAAGGAGAACTAAT	—GTTGCCTT—	—GCTTGGGG—CC—T—	—CGGCCGGCTTGCCGGA					
58 <i>Griffithsochloa multifida</i>	AGGTGTCAAGGAACACTGAT	—GCTGCCTT—	—GCATGGG—CT—G—	—GGCTGGCTTGCTGGT					
59 <i>Hilaria ciliata</i>	TGGTGCAGGAAGAC—AAT—	—CTTTGCTTT—	—GTGCAGTG—TGATGTGTCCGGCATGCTGGG						
60 <i>Leptochloa dubia</i>	TGGCGTCAAGGAAAAGTAAT	—ATTGCCTT—	—GCCCAGGG—TG—A—	—CGACTGGCTTGCTGGA					
61 <i>Microchloa kunthii</i>	TTGCGTCAAGGAAAACAAAT	—ATTGCCTT—	—GCTTGGGGGCA—A—	—TGCTGGCTTGCCGGA					
62 <i>Opizia bracteata</i>	TGGCGTCAAGGAATACCAAG	—GTTGCCTT—	—GCACGGG—TG—GA—	—GGACTGGCTTGCCGTG					
63 <i>O. stolonifera</i> (2375)	TGGCGTCAAGGAACACTAAG	—GTTGCCTT—	—GCATGGG—G—	—GGACTGGCTTGCTGT					
64 <i>O. stolonifera</i> (2423)	TGGCGTCAAGGAACACTAAG	—GTTGCCTT—	—GCATGGG—G—	—GGACTGGCTTGCTGT					
65 <i>Pentarrhaphis polymorpha</i>	ACGCGTCAAGGAACACTGAT	—GATGCATT—	—GCACAGG—TA—G—	—GGATTGGCTTGCTTGT					
66 <i>P. scabra</i>	AGGCGTCAAGGAACACTCAT	—GATGCCCTT—	—GCACAGG—TA—G—	—GGATTGGCTTGCTTGT					
67 <i>Pleuraphis mutica</i>	TGGCGTCAAGGAAGACTAAT	—TATTGCTTT—	—GTGCATTG—CGGATGTGTCCGGCATGCCGGG						
68 <i>P. rigida</i>	TGGCGTCAAGGAAGACTAAT	—TATTGCTTT—	—GTGCATTG—CGGATGTGTCCGGCATGCCGGG						
69 <i>Pringleochloa stolonifera</i> (2412)	CGGCGTCAAGGAACACTGAT	—GATGCCTT—	—GCACGGG—TG—T—	—GGTCCAGCTTGCTGAT					
70 <i>P. stolonifera</i> (2642)	CGGCGTCAAGGAACACTGAT	—GATGCCTT—	—GCACGGG—TG—T—	—GGTCCAGCTTGCTGAT					
71 <i>Soderstromia mexicana</i>	AGGTGTCAAGGAACACTAAT	—GCTGCATT—	—GCATGGG—AG—G—	—GG—CCRGCTTGCTGGT					
72 <i>Tragus racemosus</i>	TGGCGTCAAGGAACACTTGT	—TTTGCAGT—	—ACTCGGG—AA—A—	—CGATCGGCTTGCCGAA					

240	250	260	270	280	290	300	310	320	330
+13.		+++14		*					
CTAA—CCCTAG—	GCAGTGATGATATG—	CTA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
CTAA—CCCCGG—	GCTGTGATGACATG—	GTA—	A—	TCAA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
GCCA—ACCTCG—	T—GCATCGATTATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—ACCTTG—	T—GCATCGATTATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTA—	T—GCAAGAATTATGTG—	ATA—	A—	ACCT—CAAGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTC—	T—GCAAGAAATATGTG—	ATA—	A—	ACCT—CAAGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTC—	T—GCAAGAAATATGTG—	ATA—	A—	ACCT—CAAGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTCG—	T—GCAGCAAAATATGTT—	AAC—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTCG—	T—GCAGCAAAATATGTT—	AAC—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCG—	T—GCAGCGAAT—	G—	TTA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA				
TCCA—CCCTTG—	T—GCAACGATTATCTA—	TTA—	A—	ACAA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCG—	T—GCAGCGAATATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCT—CTCTTG—	T—GCATCAATGATCTTCTGATATA—	A—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTTGCATCGATGAAGAACGTAGCAA					
TCCA—CATTTA—	T—GCAGCGACTATGCG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CATTTA—	T—GCAACGACTATGCG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCG—	T—GCAGCGACTATGCG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCATCG—	T—GCAGCGGATAAGTT—	AAC—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTTG—	T—GCAACGATGATCTG—	ATA—	A—	TCCT—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTTG—	T—GCAACGATGATCTG—	ATA—	A—	TCCT—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTT—	T—GCAAGAATTATCTG—	ATA—	A—	TCCT—CAAGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTT—	T—GCAAGAATTATCTG—	ATA—	A—	TCCT—CAAGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCTTT—	T—GCAAGAATTATCTG—	ATA—	A—	TCCT—CAAGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTTG—	C—GCAACGATTATCAA—	TTA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTTG—	C—GCAACGATTATCAA—	TTA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TTCA—CCTTG—	T—GCAATGATTATATG—	ATA—	G—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TTCA—CCTTG—	T—GCAATGATTATATG—	ATA—	G—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCG—	T—TCAGCGATTATATG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—GCCTCG—	T—GCAGCGATGATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—GCCTCG—	T—GCAGCGATGATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTTG—	T—GCAGCGATTATCTT—	TTA—	A—	TCCAACATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
CGCA—CCCTCG—	T—GCAGCGATGATATG—	TTA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCA—	T—GCAGCGACTACCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CTATCG—	T—GCAGCGAAATATGTT—	AAC—	A—	TCCA—CATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TACA—CCTTG—	T—GCAATGATTATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
GCCA—ACCTTG—	T—GCATTGATTATCTT—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCG—	T—GCAGCGAAT—	G—	TTA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA				
GCCA—ACCTTG—	T—GCATTGATTATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCACG—	T—GCAGCGATGATCTG—	ATA—	A—	TCCA—CATGACTCTCGGCAACGGATATCTTGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCTA—CCCTTG—	T—GCAAAAAAATCTA—	TTA—	A—	TCCA—CATGACTCTTGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCTA—CCCTTG—	T—GCAAAAAAATTTCTA—	TTA—	A—	TCCA—CATGACTCTTGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAA					
TCCA—CCCTCG—	T—GCAGCTACAAATTTG—	ATA—	A—	CCCA—CATG					

Appendix 1. Continued.

	340	350	360	370	380	390
1 <i>Aegopogon cenchroides</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
2 <i>A. tenellus</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
3 <i>Bouteloua alamosana</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
4 <i>B. americana</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
5 <i>B. annua</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
6 <i>B. aristidoides aristidoides</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
7 <i>B. aristidoides arizonica</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
8 <i>B. barbata barbata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
9 <i>B. barbata rothrockii</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
10 <i>B. breviseta</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
11 <i>B. chasei</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
12 <i>B. chihuahuana</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
13 <i>B. chondrosioides</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
14 <i>B. curtipendula caespitosa</i> (2449)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
15 <i>B. curtipendula caespitosa</i> (2500)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
16 <i>B. curtipendula tenuis</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
17 <i>B. elata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
18 <i>B. eludens</i> (2272)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
19 <i>B. eludens</i> (2452)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
20 <i>B. eriopoda</i> (2461)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
21 <i>B. eriopoda</i> (1340)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
22 <i>B. eriostachya</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
23 <i>B. gracilis</i> (2460)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
24 <i>B. gracilis</i> (1349)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
25 <i>B. hirsuta glandulosa</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
26 <i>B. hirsuta hirsuta</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
27 <i>B. johnstonii</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
28 <i>B. juncea</i> (8856)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
29 <i>B. juncea</i> (8862)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
30 <i>B. karwinski</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
31 <i>B. kayi</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
32 <i>B. media</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
33 <i>B. parryi parryi</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
34 <i>B. pectinata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
35 <i>B. radicata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
36 <i>B. ramosa</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
37 <i>B. repens</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
38 <i>B. rigidiseta</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
39 <i>B. scorpioides</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
40 <i>B. simplex</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
41 <i>B. triaena</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
42 <i>B. trifida</i> (2465)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
43 <i>B. trifida</i> (2902)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
44 <i>B. uniflora coahuilensis</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
45 <i>B. uniflora uniflora</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
46 <i>B. warnockii</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
47 <i>B. williamsii</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
48 <i>B. curt. caes. X B. unif. coah.?</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
49 <i>Buchloë dactyloides</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
50 <i>Buchlomimus nervatus</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
51 <i>Cathestecum brevifolium</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
52 <i>C. varium</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
53 <i>Chloris virgata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
54 <i>Cyclostachya stolonifera</i> (2206)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
55 <i>C. stolonifera</i> (2601)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
56 <i>C. stolonifera</i> (3044)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
57 <i>Cynodon dactylon</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
58 <i>Griffithsochloa multifida</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
59 <i>Hilaria ciliata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
60 <i>Leptochloa dubia</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
61 <i>Microchloa kunthii</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
62 <i>Opizia bracteata</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
63 <i>O. stolonifera</i> (2375)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
64 <i>O. stolonifera</i> (2423)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
65 <i>Pentarrhaphis polymorpha</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
66 <i>P. scabra</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
67 <i>Pleuraphis mutica</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
68 <i>P. rigida</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
69 <i>Pringleochloa stolonifera</i> (2412)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
70 <i>P. stolonifera</i> (2642)	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
71 <i>Soderstromia mexicana</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				
72 <i>Tragus racemosus</i>	AATGCGATACCTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGT	TTTTGAACGCAAGTTGCGCC				

Appendix 1. Continued. Extended.

400	410	420	430	440	450	460	470	480	490
				*	.	+15		+++16	+17.
CGAGGCCTTCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCAACAT							GCCCTAT-GT	TGGTTGGGACGTGGTAT	
CGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCAACAT							GCCCTAT-GT	TGGTTGGGACGTGGTAT	
CGAGGCCTTCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCAATCCA							ACATGTT-GA	GGATGAGGATGTGGTAT	
CGAGGCCTTATGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCAATCCA							ACATGTT-GA	GGATGAGGATGTGGTAT	
TGAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-TCACCTCTT							CCAT	TTTGTGGATGTGGTAT	
TGAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-TCACCTCTT							CCAT	TTTGTGAATGTGGTAT	
TGAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-TCACCTCTT							CCAT	TTTGTGGATGTGGTAT	
CGAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCAATCCA							TCACGGT-GG	TGATGAGGAAGTGGTAT	
CAAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCAATCCA							TCACGGT-GG	TGATGAGGAAGTGGTAT	
CGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCATCCA							TCAC	GATGAGGAAGTGGTAT	
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TGAGGCCACCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCATCCG							TCACATT-GA	GGATGAGGAAGTGGTAT	
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CGAGACCTTCTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCATCCA							TCATGTT-GA	TGATGAGGATGTGGTTT	
TGAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCACACCTT							CAAT	TTTGTGGATGTGGTAT	
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TAAGGCCTTCTGGTCAAGGGCACGTCTGCCTGGGCGTCACGCCAATAGACACT-CCCCATCCA							TCATGTC-GA	TGATGAGGATGTGGTTT	
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CGAGACCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAGACACT-CCCT-TCCA							CCATATT-GA	TGATGGGATGTGGTAT	
CGAGGCCTTCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAGACACT-CCCTATCCA							TCTAGGT-TA	AGATCGGGAAGTGGTAT	
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TGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCATCCA							TCACATT-GTTTGTGGATGAGGAAGTGGTAT		
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CGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CC-CATCTA							TCATGTT-GA	TGTTGAGGATGTGGTTT	
TAAGGCCTTTTGGCCAAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCACACCAA							CTCT	GGTATGGACGTGGTGT	
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CGAGGTCTTTTGGCCGAGGGCACGTCTGCCTGGGCGTCACGTCAATAGACACT-CCGTATCAA							TCAT	TTTGGAGGAAGTGGTAT	
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TGAGACCATTTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCAATCAA							CCAT	TTTGTGGATGTGGTAT	
CAAGGCCTTTTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCACACAAA							TCCC	GGTCTGGACGTGGTGT	
TGAGGCCTTTTGGCTGAGGGCACGTCTGCCTGGGCGTCACGTCAAAAAGGCACT-CCGCACAAAAACATGGT								GGTCAGGATGTGGTGT	
TGAGTCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAGAGGCACT-CC-CATCC							TATCATA-TA	GGATGAGGAAGTGGAAAT	
TGAGACCTTCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAGGCACT-CCCAATCAA							TATCATT-GA	GGATGAGGAAGTGGTAT	
TGAGACCTTCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAGGCACT-CCCAATCT							TATCATT-GA	GGATGAGGAAGTGGTAT	
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TGAGACCTTATGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGTCACT-CCCTATCCA							TCATGTT-CA	TGATCGGGATGTGGTAT	
TGAGACCTTATGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGTCACT-CCCTATCCA							TCATGTT-CA	TGATCGGGATGTGGTAT	
CGAGGCCTTTTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCAATA								AGGATGTGGTTT	
CGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAGACACT-CCCCACCAA							TCTT	GGTGTGGATGTGGTAT	

Appendix 1. Continued.

	500	510	520	530	540	550	560
		+++18	+++19				
1 <i>Aegopogon cenchroides</i>	TTAGCCCCTCGT	GCC-AT-T	GGGC-GCGGTGGGCACAAGTTGGGG	CTGCCGCGAG-TGC			
2 <i>A. tenellus</i>	TTGGCCCCCTCGT	GCC-GT-T	GGGC-GCGGTGGGCACAAGTTGGGG	CTGCCGCGAG-TGC			
3 <i>Bouteloua alamosana</i>	TTGGCTCCCCGTCGTGCT	TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGCTGGCGG-TGC			
4 <i>B. americana</i>	TTGGCTCCCCGTCGTGCT	TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGCTGGCGG-TGC			
5 <i>B. annua</i>	TTGGCTCCCCAT	GCC-TC-T	AGGC-ATGGAGGGCCCTAAGTAGGGG	ATGCTAGTGA-TGC			
6 <i>B. aristoides aristoides</i>	TTGGCTCCCCAT	GCC-TC-T	AGGC-ATGGAGGGCCCTAAGTAGGGG	ATGCTAGTGA-TGC			
7 <i>B. aristoides arizonica</i>	TTGGCTCCCCAT	GCC-TC-T	AGGC-ATGGAGGGCCCTAAGTAGGGG	ATGCTAGTGA-TGC			
8 <i>B. barbata barbata</i>	TTGGCTCCTCGT	GCA-TC-T	GTGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
9 <i>B. barbata rothrockii</i>	TTGGCTCCCCGT	GCA-TC-T	GTGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
10 <i>B. breviseta</i>	TTGGCTCCCCGT	GCA-TC-T	ATGT-ACGGAGGGCCCTAAGTTGGGG	CTGTCGGCGG-TGC			
11 <i>B. chasei</i>	CTGGCTCCCCAT	GCA-TC-A	ATGC-GTGGTGGGCCCTAAGTTGGGG	TTGCCGCGCG-TGC			
12 <i>B. chihuahuana</i>	TTGGCTCCCCAT	GTA-TC-T	ATGC-GCGGAGGGCCCTAAGTTGGGG	CTGTCGGCGG-TGC			
13 <i>B. chondrosioides</i>	TTGGCTCCTCAT	GCA-TC-T	AGTT-TTGGAGGGCCCTAAGTTGGGG	CTGCCGCGGT-TGT			
14 <i>B. curtipendula caespitosa</i> (2449)	TTGGCTCCCCGT	GCT-TT-T	ATGT-GCGGAGGGCCCAAGTTGGGG	CTGCCGTGTG-TGC			
15 <i>B. curtipendula caespitosa</i> (2500)	TTGGCTCCCCGT	GCT-TT-T	ATGT-GCGGAGGGCCCAAGTTGGGG	CTGCCGTGTG-TGC			
16 <i>B. curtipendula tenuis</i>	TTGGCTCCCCGT	GCT-TT-T	ATGT-GCGGAGGGCCCAAGTTGGGG	CTGCCGTGTG-TGC			
17 <i>B. elata</i>	TTGGCTCCCCGT	GCA-AG-T	ACGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGGT-TGC			
18 <i>B. eludens</i> (2272)	TTGGCTCCCCGT	GCA-TG-T	AAAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGGT-TGC			
19 <i>B. eludens</i> (2452)	TTGGCTCCCCGT	GCA-TC-T	AAAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGGT-TGC			
20 <i>B. eriopoda</i> (2461)	TTGGCTCCCCCT	GCC-TC-T	AGGC-ATGGGGGGCCCTAAGTATGGG	ATGCTGATGA-TGC			
21 <i>B. eriopoda</i> (1340)	TTGGCTCCCCCT	GCC-TC-T	AGGC-ATGGAGGGCCCTAAGTATGGG	ATGCTGATGA-TGC			
22 <i>B. eriostachya</i>	TTGGCTCCCCCT	GCC-TC-T	AGGC-ATGGAGGGCCCTAAGTATGGG	ATGCTGATGA-TGC			
23 <i>B. gracilis</i> (2460)	TTGGCTCCCCGT	GCA-TC-A	ATGC-ACGGTGGGCCCTAAGTTGGGG	TTGCCGCGCG-TGC			
24 <i>B. gracilis</i> (1349)	TTGGCTCCCCGT	GCA-TC-A	ATGC-AYGGTGGGCCCTAAGTTGGGG	TTGCCGCGCG-TGC			
25 <i>B. hirsuta glandulosa</i>	TTGGCTCCTTGT	G-TG-T	AGTC-ACAGAGGGCCCTAAGTACGGG	CTGCCGCGGT-TGC			
26 <i>B. hirsuta hirsuta</i>	TTGGCTCCTTGT	G-TG-T	AGTC-ACAGAGGGCCCTAAGTACGGG	CTGCCGCGGT-TGC			
27 <i>B. johnstonii</i>	TTGGCTCCCCGT	GTA-TC-T	ATGC-GCGGAGGGCCCTAAGTTGGGG	CTGTCGGCGG-TGC			
28 <i>B. juncea</i> (8856)	TTGGCTCCTCGT	GCA-TC-T	ACGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
29 <i>B. juncea</i> (8862)	TTGGCTCCTCGT	GCA-TC-T	ACGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
30 <i>B. karwinski</i>	TTGGCTCCCCGT	GCA-TC-T	AGGC-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
31 <i>B. kayi</i>	TTGGCTCCCCGT	GCA-TC-T	AGGT-GCGGTGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
32 <i>B. media</i>	TTGGCTCCCCGT	GCT-TC-T	GTGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGGT-TAC			
33 <i>B. parryi parryi</i>	TTGGCTCCCCGT	GCC-TC-T	GCGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
34 <i>B. pectinata</i>	TTGGCTCCCCGT	GAA-TT-T	AGGC-GCGGAGGGCCCTAAGTAGGGG	CTGCCGCGCG-TGC			
35 <i>B. radicata</i>	TTGGCTCCTGTCGTGCT	TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGCTGGCAG-TGC			
36 <i>B. ramosa</i>	TTGGCTCCCCGT	GCA-TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGTCGGCGG-TGC			
37 <i>B. repens</i>	TTGGCTCCCCGT	GCA-TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGCTGGCGG-TGC			
38 <i>B. rigidiseta</i>	TTGGCTCCCCGT	GCA-TC-A	CGAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
39 <i>B. scorpioides</i>	TTGGCTCCCCGT	GCA-TC-TGATATGT	ACGGTGGGCCCTAAGTTGGGG	CTGCTGGCGG-TGC			
40 <i>B. simplex</i>	TTGGCTCCCCGT	GCA-TC-TGATATGT	ACGGTGGGCCCTAAGTTGGGG	CTGCTGGCGG-TGC			
41 <i>B. triaena</i>	TTGGCTCCCCGT	GCT-TT-T	TTATGT-GCGGAGGGCCCAAGTTGGGG	TTGCCGTGTG-TGC			
42 <i>B. trifida</i> (2465)	TTGGCTCCTCGT	GCA-TC-T	AGGT-GCGGTGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
43 <i>B. trifida</i> (2902)	TTGGCTCCTCGT	GCA-TC-T	AGGT-GCGGTGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
44 <i>B. uniflora coahuilensis</i>	TTGGCTCCCCGT	GCT-TT-T	ATGT-GCGGAGGGCCCAAGTTGGGG	CTGCCGTGTG-TGC			
45 <i>B. uniflora uniflora</i>	TTGGCTCCCCGT	GCT-TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGTGTG-TGC			
46 <i>B. warnockii</i>	TTGGCTCCCCGT	GCT-TT-T	ATGT-GCGGAGGGCCCAAGTTGGGG	CTGCCGTGTG-TGC			
47 <i>B. williamsii</i>	TTGGCTCCCCGT	GCT-TC-T	ATGT-GCGGAGGGCCCTAAGTTGGGG	CTGCCGTGTG-TGC			
48 <i>B. curt. caes. X B. unif. coah.?</i>	TTGGCTCCCCGT	GCT-TT-T	ATGT-GCGGAGGGCCCAAGTTGGGG	CTGCCGTGTG-TGC			
49 <i>Buchloë dactyloides</i>	TTGGCTCCCCGT	GCA-TG-T	AAAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
50 <i>Buchlomimus nervatus</i>	TTGGCTCCCCRT	GCT-TC-T	ACAC-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
51 <i>Cathestecum brevifolium</i>	TTGGCTCCCCGT	GCA-TG-T	AAAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
52 <i>C. varium</i>	TTGGCTCCCCGT	GCA-TG-T	AAAC-GCGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
53 <i>Chloris virgata</i>	TTGGCCCCCAT	ACC-AC-A	TGGTTATGATGGGCTTAAGATGTGG	CTATCGGCAGGTGC			
54 <i>Cyclostachya stolonifera</i> (2206)	TTGGCTCCCCGT	GTC-TG-T	AGGT-GCGGTGGGCCCAAGTTGGGG	CTGTCGGCGG-TGC			
55 <i>C. stolonifera</i> (2601)	TTGGCTCCCCGT	GTC-TG-T	AGGT-GCGGTGGGCCCAAGTTGGGG	CTGTCGGCGG-TGC			
56 <i>C. stolonifera</i> (3044)	TTGGCTCCCCGT	GTC-TG-T	AGGT-GCGGTGGGCCCAAGTTGGGG	CTGTCGGCGG-TGC			
57 <i>Cynodon dactylon</i>	TTGGCCCCCAT	TCC-AT-A	GTGT-ATGGTGGGCCCAAGAGGAGG	CTGCCGCGCG-TGC			
58 <i>Griffithsochloa multifida</i>	TTGGCTCCCCGT	GCA-TG-T	TAAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
59 <i>Hilaria ciliata</i>	ATGGCTCCTCCC	ACT-G	TGGC-AGGGTGAGCTCAAAGTCGGG	CTGTTGGGGC-TGC			
60 <i>Leptochloa dubia</i>	TTGGCCCCCTAA	GCC-GC-A	AGGT-GTGGTAGGCCAAAGATGGGG	CTGCCGCGCG-TGC			
61 <i>Microchloa kunthii</i>	TTGGCCCCCAT	CCT-AAAT	CGGT-GTGGTGGGCCCAAGATGCGG	CTGCCGCGCG-TGC			
62 <i>Opizia bracteata</i>	TTGGCTCCTCGT	GCG-TG-T	AGAA-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
63 <i>O. stolonifera</i> (2375)	TTGGCTCCTCGT	TTC-AT-T	AGAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGT			
64 <i>O. stolonifera</i> (2423)	TTGGCTCCTCGT	TTC-AK-T	AGAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGT			
65 <i>Pentarrhaphis polymorpha</i>	TTGGCTCCTCGG	GCA-TG-T	AAAC-ACGGAGGGCCCTAAGTTGGGG	CTGCCGCGCG-TGC			
66 <i>P. scabra</i>	TTGGCTCCCCGT	GCAATG-T	AAAC-ATGGAGGGCCCAAGTTGGGG	CTGCCGCGCG-TGC			
67 <i>Pleuraphis mutica</i>	ATGGCTCCTCAT	GCC-CC-C	CGGC-ATGGTGAGCTTAAAGTTGGG	CTGCCGCGCG-TGC			
68 <i>P. rigida</i>	ATGGCTCCTCGT	GCC-CC-C	CGGC-ATGGTGAGCTTAAAGTTGGG	CTGCCGCGCG-TGC			
69 <i>Pringleochloa stolonifera</i> (2412)	TTGGCTCCCCRT	GCA-TC-T	AGAC-GCGGAGGGCCCTAAGTTGGG	CTGCCGCGCG-TGC			
70 <i>P. stolonifera</i> (2642)	TTGGCTCCCCAT	GCA-TC-T	AGAT-GCGGAGGGCCCTAAGTTGGG	CTGCCGCGCG-TGC			
71 <i>Soderstromia mexicana</i>	TTGTCCCCCGT	GCA-TG-T	AAAC-ACGGAGGGCCCTAAGTTGGG	CTGCCGCGGTG-TGC			
72 <i>Tragus racemosus</i>	TTGGCCCCCTCGT	TCC-TT-A	TGGC-ACGGTGGGCCCAAGTTAGGG	CTGCCGCGCG-TGC			

[illegible]

Appendix 1. Continued.

	670	680	690	700	Unaligned length
	++28 . ++29 .			+30 .	
1 <i>Aegopogon cenchroides</i>	C—CCACG—G—ATCGAAGTGCAC—A—	TCGTTTCGAACCGCGA	605		
2 <i>A. tenellus</i>	C—CATG—G—ATCGAAGAGCAC—A—	TCGTTTCGAACCGCGA	604		
3 <i>Bouteloua alamosana</i>	C—CATG—T—ACCGAAGCGGAC—A—	TTGCTCGGACCGCGA	599		
4 <i>B. americana</i>	C—CATG—T—ACCGAAGCAGAC—A—	TTGCTCGGACCGCGA	601		
5 <i>B. annua</i>	C—CATG—T—ACCGAAGCCAC—T—	TTGCTCGGACCGCGA	590		
6 <i>B. aristidoides aristidoides</i>	C—CATG—T—ACCGAAGCCAG—T—	TTGMTTCGGACCGCGA	590		
7 <i>B. aristidoides arizonica</i>	C—CATG—T—ACCGAAGCCAC—T—	TTGCTCGGACCGCGA	590		
8 <i>B. barbata barbata</i>	C—CATG—TAAACCGAAGTGCAT—T—	TCACTCGGACCGCGA	595		
9 <i>B. barbata rothrockii</i>	C—CATG—TAAACCGAAGTGCAT—T—	TCACTTCGGACCGCGA	595		
10 <i>B. breviseta</i>	C—CATG—T—ACCGAAGTGGAC—A—	TCGCTTCGGACCGCGA	586		
11 <i>B. chasei</i>	C—CAAG—T—ACCGAAGCGCTT—G—	ACGCTTCGGACCGCGA	594		
12 <i>B. chihuahuana</i>	C—CTTG—T—ACCGAAGCGAGC—A—	TCGCTTCGGACCGCGA	594		
13 <i>B. chondrostoides</i>	C—CATG—T—ACC—AAAAGCAT—G—	TTGCTTCGGATCGCGA	595		
14 <i>B. curtipendula caespitosa</i> (2449)	C—CCCATG—C—TCCAAAGCACAT—A—	TCRCTTCGGACCGCGA	602		
15 <i>B. curtipendula caespitosa</i> (2500)	C—CCCATG—C—TCCAAAGCACAT—A—	TCGCTTCGGACCGCGA	602		
16 <i>B. curtipendula tenuis</i>	C—CATG—C—TCCAAAGCACAC—A—	TCGCTTCGGACCGCGA	597		
17 <i>B. elata</i>	C—CATG—T—ACCGAAGTGTAC—A—	TCACTTCGAACCGCGA	589		
18 <i>B. eludens</i> (2272)	C—CATA—T—ACTGAAGAGCAC—A—	TTGCTTCAGACCGCGA	599		
19 <i>B. eludens</i> (2452)	C—CATA—T—ACTGAAGAGCAC—A—	TTGCTTCAGACCGCGA	599		
20 <i>B. eriopoda</i> (2461)	C—CACA—T—ACTGAAGCGCAC—A—	TTGCTTCGGACCGCGA	589		
21 <i>B. eriopoda</i> (1340)	C—CACA—T—ACTGAAGCGCAC—A—	TTGCTTCGGACCGCGA	589		
22 <i>B. eriostachya</i>	C—CACA—T—ACTGAAGCGCAC—A—	TTGCTTCGGACCGCGA	589		
23 <i>B. gracilis</i> (2460)	C—CAAG—T—ACCGAAGCGCTT—GTTGACGCTCGGACTGCGA		600		
24 <i>B. gracilis</i> (1349)	C—CAAG—T—ACCGAAGCGCTT—GTTGACGCTCGGACTGCGA		600		
25 <i>B. hirsuta glandulosa</i>	C—CATG—T—ACCGAATAGTAC—A—	TTGCTTCGGACCGCGA	586		
26 <i>B. hirsuta hirsuta</i>	C—CATG—T—ACCGAATAGTAC—A—	TTGCTTCGGACCGCGA	586		
27 <i>B. johnstonii</i>	C—TTG—T—ACCGAAGCGAGC—A—	TCGCTTCGGACCGCGA	592		
28 <i>B. juncea</i> (8856)	C—CATG—T—ACCGAAGCACAC—A—	TTGCTTCGGACTGCGA	592		
29 <i>B. juncea</i> (8862)	C—CATG—T—ACCGAAGCACAC—A—	TTGCTTCGGACCGCGA	592		
30 <i>B. karwinskii</i>	C—CATG—T—ACCGAAGCGAAC—A—	TTGCTTCGGACCGCGA	597		
31 <i>B. kayi</i>	C—CATG—T—ACCAAAGCGCAC—G—	GCGCT—GGAACACGA	602		
32 <i>B. media</i>	C—CATG—C—ACCAAAGCGCAT—G—	TTGCTTCGGACCGCGA	596		
33 <i>B. parryi parryi</i>	C—CATG—TAAACCGAAGTGCAT—T—	TCACTTCGGACCGCGA	594		
34 <i>B. pectinata</i>	C—CATG—T—ACCGAATCGCAC—A—	TTGCTTCGGACCGCGA	588		
35 <i>B. radicata</i>	C—CATA—T—ACCGAAGCGCAC—A—	TTGCTTCGGACCGCGA	600		
36 <i>B. ramosa</i>	C—CATG—T—ACCGAAGTGGAC—A—	TTGCTTCGGACCGCGA	586		
37 <i>B. repens</i>	C—CATG—T—ACCGAAGCGGAC—A—	TTGCTTCGGACCGCGA	599		
38 <i>B. rigidiseta</i>	C—CATA—T—ACCGAAGCGCAC—A—	TAGCTTCGGACCGCGA	595		
39 <i>B. scorpioides</i>	C—CAAG—T—TGCGAAGCGCTC—G—	ACGCTTCGGACCGCGA	607		
40 <i>B. simplex</i>	C—CAAG—T—TGCGAAGCGCTC—G—	ACGCTTCGGACCGCGA	607		
41 <i>B. triaena</i>	C—CATG—C—TCCAAAGCACAT—A—	TTGCTTCGGACCGCGA	605		
42 <i>B. trifida</i> (2465)	C—CATG—T—ACCAAAGCGCAC—A—	ACGCT—TGACCACGA	601		
43 <i>B. trifida</i> (2902)	C—CATG—T—ACCAAAGCGCAC—A—	ACGCT—GGACCACGA	601		
44 <i>B. uniflora coahuilensis</i>	C—CATG—C—TCCAAAGCACAT—A—	TTGCTTCGGACCGCGA	603		
45 <i>B. uniflora uniflora</i>	C—CATG—C—ACCAATGCGCAT—A—	TTGCTTCGGACCGCAA	596		
46 <i>B. warnockii</i>	C—CATG—C—TCCAAAGCACAT—A—	TTGCTTCGGACCGCGA	602		
47 <i>B. williamsii</i>	C—CATG—T—ACCGAAGCGGAC—A—	TTGCTTCGGACCGCGA	599		
48 <i>B. curt. caes. X B. unif. coah.?</i>	C—CCCATG—C—TCCAAAGCACAT—A—	TCGCTTCGGACCGCGA	602		
49 <i>Buchloë dactyloides</i>	C—CATT—T—ACTGAAGAGCAC—A—	TTCTTCAGACCGCGA	599		
50 <i>Buchlomimus nervatus</i>	C—CATA—A—ACTGAAGCGTGC—A—	TAGCTCTGACCGCGA	596		
51 <i>Cathestecum brevifolium</i>	C—CATT—T—ATTGAAGAGCAT—A—	TTGCTTCAGACCGCGA	597		
52 <i>C. varium</i>	C—CATA—T—ATTGAAGAGCAT—A—	TTGCTTCAGACCGCGA	597		
53 <i>Chloris virgata</i>	C—CATG—G—TTTGTAGTGCAT—G—	CCGCTTCGGTCTGCGA	601		
54 <i>Cyclostachya stolonifera</i> (2206)	C—CATT—T—ACTGAGGCGTAA—G—	TAACCTCGGACCGCGA	588		
55 <i>C. stolonifera</i> (2601)	C—CATT—T—ACTGAGGCGTAA—G—	TAACCTCGGACCGCGA	588		
56 <i>C. stolonifera</i> (3044)	C—CATT—T—ACTGAGGCGTAA—G—	TAACCTCGGACCGCGA	588		
57 <i>Cynodon dactylon</i>	C—CATG—G—TTTGTAGCGTAT—G—	TAGCTTCGGACCGCGA	597		
58 <i>Griffithsochloa multifida</i>	C—CATA—T—ACC—AAGAGCTT—A—	TTGTTCAAACCGCGA	597		
59 <i>Hilaria ciliata</i>	C—CATTTA—TCCMAAGAAGAT—G—	TTTCTTCGGACCGCGA	615		
60 <i>Leptochloa dubia</i>	C—CTTG—G—TTTGTAGTGCAT—G—	TTGCTTCGAACCGCGA	597		
61 <i>Microchloa kunthii</i>	C—CATG—G—TTTGTGGCGCTT—G—	TCGCTTCGACCGCGA	603		
62 <i>Opizia bracteata</i>	CACCCATG—T—ACCGAA—TGCAT—G—	TCACTCGGATCGCGA	604		
63 <i>O. stolonifera</i> (2375)	C—CATG—C—TCTGAAACACAT—G—	TTGCTTCGGACCGCGA	599		
64 <i>O. stolonifera</i> (2423)	C—CATG—C—TCCGAAACACAT—G—	TTGCTTCGGACCGCGA	599		
65 <i>Pentarrhaphis polymorpha</i>	C—CATA—T—ACTGAAGAGCAC—A—	TTGCTTCAGACCGCGA	600		
66 <i>P. scabra</i>	C—CATA—T—ACTGAAGAGCAA—A—	TTGCTTCAGACCGCGA	606		
67 <i>Pleuraphis mutica</i>	C—CATT—A—TCCAAAGAACCT—G—	TTGCTTCGGACTGCGA	611		
68 <i>P. rigida</i>	C—CATT—A—TCCAAAGAACCT—G—	TTGCTTCGGACTGCGA	610		
69 <i>Pringleochloa stolonifera</i> (2412)	C—CATA—T—ACTGAAGCGTGC—A—	TAGCTTCGGACTGCGA	595		
70 <i>P. stolonifera</i> (2642)	C—CATA—T—ACTGAAGCGTGC—A—	TAGCTTCGGACTGCGA	595		
71 <i>Soderstromia mexicana</i>	C—CATA—T—ATTGAAGAGCACAA—	ATGCTTATACCGCGA	584		
72 <i>Tragus racemosus</i>	C—CATTAG—ACTGAAGCACAC—G—	TTGYTCGGACCGCGA	595		

Appendix 2. Pairwise distances (divergence) between ITS region sequences of representatives of *Bouteloua* and related and outgroup genera, calculated using PAUP. Numbers representing taxon names correspond to those in Appendix 1. Absolute distances (numbers of divergent sites) appear below the diagonal and mean distances (proportions of divergent sites to total sites) appear above the diagonal. Gaps and polymorphic states were excluded from the comparisons.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	—	0.036	0.185	0.192	0.217	0.221	0.219	0.196	0.203	0.161	0.204	0.169	0.206	0.202	0.203	0.194
2	22	—	0.192	0.199	0.221	0.226	0.224	0.201	0.208	0.163	0.204	0.173	0.213	0.212	0.214	0.204
3	110	114	—	0.013	0.143	0.148	0.147	0.134	0.134	0.092	0.146	0.093	0.142	0.126	0.126	0.122
4	114	118	8	—	0.143	0.148	0.146	0.139	0.139	0.099	0.148	0.101	0.145	0.129	0.129	0.124
5	127	129	84	84	—	0.024	0.025	0.176	0.176	0.143	0.169	0.149	0.165	0.150	0.148	0.148
6	129	132	87	87	14	—	0.012	0.181	0.181	0.148	0.174	0.156	0.167	0.156	0.155	0.155
7	128	131	86	86	15	7	—	0.181	0.181	0.144	0.174	0.154	0.168	0.155	0.153	0.151
8	115	118	79	82	102	105	105	—	0.010	0.092	0.147	0.128	0.181	0.150	0.153	0.150
9	119	122	79	82	102	105	105	6	—	0.095	0.150	0.132	0.177	0.150	0.153	0.148
10	94	95	54	58	83	86	84	53	55	—	0.117	0.077	0.148	0.111	0.113	0.104
11	121	121	87	88	99	102	102	86	88	68	—	0.141	0.173	0.168	0.167	0.167
12	100	102	55	60	87	91	90	75	77	45	83	—	0.150	0.120	0.122	0.110
13	121	125	83	85	95	96	97	105	103	85	101	87	—	0.149	0.149	0.144
14	120	126	75	77	88	92	91	88	88	65	100	71	87	—	0.002	0.022
15	121	127	75	77	87	91	90	90	90	66	99	72	87	1	—	0.023
16	115	121	73	74	87	91	89	88	87	61	99	65	84	13	14	—
17	104	107	72	76	95	97	95	37	39	46	89	70	104	87	89	84
18	107	110	68	71	86	91	90	89	89	68	91	67	80	87	86	84
19	107	110	68	71	86	91	90	89	89	68	91	67	80	87	86	84
20	119	123	77	78	39	39	40	98	98	77	94	81	94	91	90	86
21	120	125	77	78	38	38	39	98	98	78	95	82	94	91	90	86
22	121	124	79	80	39	39	40	98	98	76	96	78	95	90	89	85
23	117	121	83	84	101	103	103	84	84	63	29	81	101	95	94	95
24	117	121	83	84	100	102	102	84	84	63	28	81	100	95	94	95
25	109	111	80	82	78	81	77	95	97	71	100	76	99	86	85	83
26	108	110	80	82	78	81	77	94	96	70	100	75	98	86	85	82
27	98	102	54	59	86	88	87	76	78	50	82	14	87	71	72	67
28	106	111	64	68	92	94	94	92	90	64	92	68	81	80	81	78
29	106	111	64	68	92	94	94	92	90	64	92	68	81	80	81	78
30	96	99	58	61	77	82	81	75	77	42	73	40	76	72	73	66
31	100	101	80	86	99	100	100	86	85	61	81	73	95	87	89	83
32	118	118	68	72	84	88	87	84	82	61	89	64	77	39	40	37
33	118	121	84	88	100	101	101	27	29	60	94	81	108	90	92	92
34	99	100	59	61	64	67	66	75	75	53	79	53	82	74	73	69
35	114	118	15	15	85	88	87	86	86	64	91	65	83	80	80	77
36	94	95	53	57	82	85	83	54	56	3	67	45	83	64	65	60
37	114	118	9	13	87	90	89	82	85	59	90	61	86	77	77	76
38	103	102	70	76	86	88	85	86	88	58	94	60	90	84	85	80
39	128	132	91	92	104	108	107	97	96	76	47	89	109	107	106	104
40	133	135	92	93	107	111	110	96	95	74	44	88	109	102	101	99
41	122	126	82	82	97	98	99	96	96	73	106	75	92	35	36	31
42	103	104	83	89	106	106	106	92	93	62	82	79	98	92	94	91
43	103	104	82	88	106	104	104	92	93	63	86	78	101	91	93	90
44	114	120	72	74	89	90	91	88	88	61	97	65	85	22	23	18
45	121	119	68	74	86	90	89	87	85	64	95	66	82	45	46	41
46	114	120	72	74	89	89	90	88	88	61	98	65	86	24	25	20
47	113	117	7	13	86	87	86	83	83	58	92	61	87	79	79	77
48	120	126	75	77	88	92	91	89	89	65	100	71	87	0	1	13
49	104	102	74	76	93	99	98	95	97	72	95	72	87	88	87	84
50	109	110	77	82	97	98	95	95	95	66	99	69	98	84	85	83
51	114	116	78	81	92	95	96	102	102	81	105	86	94	98	97	97
52	117	117	76	79	92	93	94	100	100	80	100	86	95	94	93	94
53	110	113	130	129	140	140	139	128	126	116	128	123	130	135	136	132
54	118	120	94	95	109	111	112	98	100	82	97	90	111	104	104	103
55	118	120	94	95	109	111	112	98	100	82	97	90	111	104	104	103
56	119	121	95	96	110	112	113	100	102	84	99	92	113	106	106	105
57	105	103	122	125	131	134	133	123	125	107	111	116	124	128	129	124
58	107	109	80	83	95	97	97	95	95	76	100	78	91	92	91	91
59	143	138	137	142	149	150	149	149	148	128	150	137	152	144	144	143
60	97	97	118	121	132	134	134	116	118	102	120	110	118	123	124	120
61	110	109	122	122	140	143	142	132	132	124	132	126	120	129	130	126
62	123	127	87	91	97	96	97	98	98	78	101	81	78	96	98	97
63	121	126	94	94	103	101	102	115	113	87	110	88	78	96	95	96
64	121	126	92	92	101	99	100	115	113	87	110	86	77	95	94	95
65	113	116	81	84	92	96	94	108	108	84	107	87	90	98	97	101
66	121	124	85	87	96	95	92	108	108	91	110	92	91	102	101	102
67	130	128	131	134	140	141	141	133	133	121	130	129	142	137	137	134
68	129	127	129	132	140	141	141	133	133	119	131	125	143	134	134	131
69	128	128	88	90	94	94	91	101	99	82	110	86	95	95	96	95
70	131	131	89	91	97	97	94	102	100	83	112	89	95	96	97	96
71	112	114	93	95	110	111	110	112	110	94	117	90	101	106	105	100
72	91	87	103	106	114	117	115	110	111	92	109	101	119	117	118	115

Appendix 2. Extended.

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
0.179	0.180	0.180	0.204	0.205	0.207	0.197	0.197	0.187	0.185	0.167	0.180	0.180	0.162	0.167	0.199
0.184	0.185	0.185	0.211	0.214	0.212	0.204	0.204	0.190	0.188	0.173	0.188	0.188	0.167	0.168	0.199
0.123	0.114	0.114	0.131	0.131	0.135	0.139	0.139	0.137	0.137	0.092	0.108	0.108	0.097	0.134	0.114
0.130	0.119	0.119	0.133	0.133	0.136	0.141	0.141	0.140	0.140	0.100	0.115	0.115	0.102	0.145	0.121
0.165	0.147	0.147	0.066	0.065	0.066	0.172	0.170	0.133	0.133	0.148	0.158	0.158	0.131	0.169	0.143
0.169	0.155	0.155	0.066	0.065	0.066	0.175	0.174	0.138	0.138	0.151	0.162	0.162	0.140	0.171	0.150
0.165	0.153	0.153	0.068	0.066	0.068	0.175	0.174	0.132	0.132	0.150	0.162	0.162	0.138	0.171	0.148
0.063	0.151	0.151	0.170	0.170	0.170	0.143	0.143	0.164	0.163	0.131	0.158	0.158	0.128	0.147	0.143
0.066	0.151	0.151	0.170	0.170	0.170	0.143	0.143	0.168	0.166	0.134	0.154	0.154	0.131	0.145	0.140
0.080	0.116	0.116	0.133	0.134	0.131	0.108	0.108	0.122	0.120	0.086	0.110	0.110	0.072	0.104	0.104
0.153	0.153	0.153	0.161	0.163	0.164	0.049	0.047	0.171	0.171	0.139	0.156	0.156	0.123	0.137	0.150
0.120	0.113	0.113	0.139	0.141	0.134	0.137	0.137	0.131	0.129	0.024	0.116	0.116	0.068	0.124	0.108
0.180	0.137	0.137	0.163	0.163	0.165	0.172	0.171	0.172	0.170	0.150	0.140	0.140	0.130	0.162	0.132
0.149	0.146	0.146	0.155	0.155	0.153	0.159	0.159	0.147	0.147	0.120	0.135	0.135	0.121	0.146	0.065
0.152	0.144	0.144	0.153	0.153	0.152	0.158	0.158	0.145	0.145	0.122	0.137	0.137	0.122	0.150	0.067
0.144	0.141	0.141	0.147	0.147	0.145	0.159	0.159	0.142	0.140	0.114	0.132	0.132	0.111	0.139	0.062
—	0.144	0.144	0.160	0.160	0.159	0.151	0.151	0.150	0.148	0.123	0.145	0.145	0.120	0.137	0.139
84	—	0.000	0.135	0.135	0.135	0.147	0.147	0.138	0.138	0.115	0.098	0.098	0.089	0.141	0.138
84	0	—	0.135	0.135	0.135	0.147	0.147	0.138	0.138	0.115	0.098	0.098	0.089	0.141	0.138
92	79	79	—	0.003	0.008	0.159	0.157	0.115	0.115	0.138	0.150	0.150	0.123	0.161	0.138
92	79	79	2	—	0.010	0.160	0.159	0.116	0.116	0.138	0.151	0.151	0.125	0.161	0.140
91	79	79	5	6	—	0.162	0.160	0.113	0.113	0.134	0.148	0.148	0.121	0.154	0.137
88	88	88	93	94	95	—	0.000	0.164	0.164	0.137	0.146	0.149	0.119	0.136	0.145
88	88	88	92	93	94	0	—	0.164	0.164	0.137	0.146	0.149	0.119	0.136	0.145
86	81	81	67	68	66	96	96	—	0.000	0.133	0.151	0.151	0.114	0.156	0.138
85	81	81	67	68	66	96	96	0	—	0.131	0.151	0.151	0.113	0.156	0.137
71	68	68	80	80	78	81	81	77	76	—	0.121	0.121	0.073	0.122	0.117
84	58	58	87	88	86	86	86	88	88	71	—	0.003	0.107	0.132	0.124
84	58	58	87	88	86	88	88	88	88	71	2	—	0.107	0.132	0.124
70	53	53	72	73	71	71	71	67	66	43	63	63	—	0.118	0.111
80	84	84	94	94	90	81	81	91	91	72	78	78	70	—	0.136
81	82	82	81	82	80	86	86	81	80	69	73	73	66	81	—
38	88	88	96	96	96	91	91	96	96	82	90	88	79	89	88
71	60	60	55	56	52	77	77	44	43	57	66	66	46	70	67
81	72	72	76	76	78	87	87	79	79	62	72	72	62	84	72
47	67	67	76	77	75	64	64	70	69	50	61	61	39	60	58
78	72	72	81	81	83	86	86	83	83	60	71	71	62	88	73
81	57	57	78	78	77	88	88	76	76	62	66	66	56	81	76
97	98	98	100	101	102	50	50	105	105	91	101	101	84	88	97
96	102	102	100	102	101	51	51	106	106	92	99	99	83	90	92
94	94	94	96	97	95	105	105	94	93	80	86	86	76	93	44
84	88	88	99	101	98	81	81	95	95	77	83	81	74	26	85
84	90	90	99	101	98	85	85	95	95	76	84	82	73	26	86
84	83	83	88	89	87	97	97	84	83	69	78	78	64	84	36
79	80	80	85	86	84	93	93	84	83	71	77	77	69	89	20
84	85	85	88	89	87	97	97	84	83	69	78	78	64	84	36
75	75	75	78	78	80	88	88	83	83	57	71	71	64	82	73
88	87	87	91	91	90	95	95	86	86	71	80	80	72	88	39
89	33	33	84	85	85	93	93	83	83	73	73	73	63	96	86
85	67	67	84	85	85	94	94	83	83	71	68	68	66	94	78
96	38	38	88	89	89	104	104	90	90	84	74	73	75	97	94
95	36	36	87	88	87	101	101	91	91	84	71	70	72	91	91
124	123	123	131	133	130	120	119	133	133	124	115	117	128	112	129
94	100	100	103	105	99	98	98	103	103	90	101	101	91	81	98
94	100	100	103	105	99	98	98	103	103	90	101	101	91	81	98
96	102	102	104	106	100	100	100	104	104	92	101	101	93	83	100
118	119	119	127	128	125	114	113	125	124	118	113	113	116	107	120
89	35	35	86	87	87	96	96	84	84	81	75	75	67	99	90
143	143	143	148	149	149	151	151	144	144	139	138	138	139	134	141
112	112	112	130	132	128	117	116	125	124	112	109	109	108	100	119
125	122	122	135	136	134	135	134	135	135	125	121	121	127	114	124
92	78	78	97	98	94	99	99	94	93	86	83	82	76	88	89
105	88	88	98	98	98	107	107	95	94	89	98	97	84	100	92
104	89	89	98	98	98	107	107	95	94	86	97	96	82	100	91
98	36	36	91	91	91	104	104	93	93	88	69	68	75	102	98
101	45	45	94	94	94	108	107	97	97	91	79	77	83	105	104
134	134	134	135	136	137	135	134	131	131	128	128	130	125	123	131
132	133	133	134	135	136	134	133	131	131	124	126	128	124	121	128
90	74	74	90	90	90	108	108	91	91	83	82	84	81	100	96
92	78	78	92	92	92	111	111	94	94	86	83	85	84	102	97
108	55	55	97	98	96	114	114	97	97	91	86	86	84	107	101
110	100	100	109	111	111	108	108	105	105	103	103	103	95	92	114

Appendix 2. Continued.

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	0.201	0.169	0.192	0.161	0.192	0.174	0.215	0.224	0.205	0.172	0.172	0.192	0.204	0.192	0.190	0.202
2	0.206	0.171	0.199	0.163	0.199	0.172	0.222	0.227	0.212	0.174	0.174	0.202	0.201	0.202	0.197	0.212
3	0.143	0.100	0.025	0.091	0.015	0.118	0.153	0.154	0.138	0.140	0.138	0.121	0.114	0.121	0.012	0.126
4	0.150	0.104	0.025	0.097	0.022	0.128	0.154	0.156	0.138	0.150	0.148	0.124	0.124	0.124	0.022	0.129
5	0.173	0.109	0.145	0.141	0.148	0.147	0.177	0.182	0.165	0.181	0.181	0.151	0.147	0.151	0.147	0.150
6	0.174	0.114	0.150	0.146	0.153	0.150	0.184	0.189	0.167	0.181	0.178	0.153	0.153	0.151	0.148	0.156
7	0.174	0.112	0.148	0.143	0.152	0.145	0.182	0.187	0.168	0.181	0.178	0.155	0.152	0.153	0.147	0.155
8	0.045	0.129	0.146	0.094	0.139	0.147	0.165	0.163	0.163	0.157	0.157	0.150	0.148	0.150	0.141	0.151
9	0.049	0.129	0.146	0.097	0.145	0.150	0.163	0.162	0.163	0.159	0.159	0.150	0.145	0.150	0.141	0.151
10	0.104	0.091	0.109	0.005	0.101	0.099	0.130	0.126	0.125	0.106	0.108	0.104	0.110	0.104	0.099	0.111
11	0.160	0.135	0.153	0.115	0.152	0.159	0.079	0.074	0.178	0.139	0.145	0.163	0.160	0.165	0.155	0.168
12	0.139	0.091	0.110	0.077	0.103	0.102	0.150	0.149	0.127	0.134	0.132	0.110	0.112	0.110	0.103	0.120
13	0.186	0.142	0.142	0.144	0.147	0.154	0.186	0.186	0.157	0.167	0.172	0.145	0.140	0.147	0.149	0.149
14	0.153	0.126	0.134	0.109	0.129	0.141	0.180	0.171	0.059	0.155	0.153	0.037	0.076	0.040	0.133	0.000
15	0.156	0.124	0.134	0.111	0.129	0.143	0.178	0.169	0.060	0.158	0.157	0.039	0.077	0.042	0.133	0.002
16	0.156	0.117	0.129	0.103	0.128	0.135	0.174	0.166	0.052	0.153	0.152	0.030	0.069	0.034	0.129	0.022
17	0.065	0.123	0.139	0.082	0.134	0.139	0.166	0.164	0.161	0.144	0.144	0.144	0.136	0.144	0.128	0.151
18	0.150	0.102	0.121	0.114	0.121	0.096	0.164	0.171	0.158	0.148	0.152	0.139	0.134	0.143	0.126	0.146
19	0.150	0.102	0.121	0.114	0.121	0.096	0.164	0.171	0.158	0.148	0.152	0.139	0.134	0.143	0.126	0.146
20	0.166	0.094	0.130	0.131	0.138	0.134	0.171	0.171	0.164	0.170	0.170	0.150	0.145	0.150	0.133	0.155
21	0.166	0.096	0.130	0.133	0.138	0.134	0.172	0.174	0.165	0.173	0.173	0.152	0.147	0.152	0.133	0.155
22	0.166	0.089	0.133	0.129	0.142	0.132	0.174	0.172	0.162	0.168	0.168	0.148	0.143	0.148	0.137	0.153
23	0.155	0.131	0.146	0.109	0.144	0.148	0.084	0.085	0.176	0.136	0.143	0.163	0.156	0.163	0.148	0.159
24	0.155	0.131	0.146	0.109	0.144	0.148	0.084	0.085	0.176	0.136	0.143	0.163	0.156	0.163	0.148	0.159
25	0.166	0.075	0.135	0.120	0.142	0.130	0.179	0.181	0.160	0.163	0.163	0.143	0.144	0.143	0.142	0.147
26	0.166	0.073	0.135	0.119	0.142	0.130	0.179	0.181	0.159	0.163	0.163	0.142	0.142	0.142	0.142	0.147
27	0.141	0.098	0.105	0.086	0.102	0.105	0.154	0.156	0.136	0.131	0.129	0.117	0.121	0.117	0.097	0.120
28	0.154	0.113	0.122	0.105	0.120	0.112	0.171	0.168	0.146	0.141	0.143	0.132	0.130	0.132	0.120	0.135
29	0.151	0.113	0.122	0.105	0.120	0.112	0.171	0.168	0.146	0.138	0.139	0.132	0.130	0.132	0.120	0.135
30	0.134	0.078	0.104	0.067	0.104	0.094	0.141	0.139	0.128	0.125	0.123	0.107	0.116	0.107	0.107	0.121
31	0.152	0.119	0.141	0.103	0.148	0.137	0.148	0.151	0.156	0.043	0.043	0.141	0.150	0.141	0.138	0.148
32	0.150	0.114	0.121	0.099	0.123	0.128	0.163	0.155	0.074	0.143	0.145	0.060	0.034	0.060	0.123	0.065
33	—	0.134	0.153	0.106	0.150	0.148	0.180	0.182	0.168	0.159	0.159	0.153	0.155	0.153	0.145	0.155
34	78	—	0.102	0.086	0.105	0.101	0.150	0.151	0.138	0.135	0.135	0.119	0.114	0.119	0.107	0.126
35	90	60	—	0.104	0.030	0.126	0.158	0.159	0.148	0.146	0.145	0.133	0.119	0.133	0.030	0.134
36	61	50	61	—	0.099	0.099	0.131	0.128	0.123	0.105	0.106	0.103	0.104	0.103	0.097	0.109
37	88	62	18	58	—	0.130	0.158	0.159	0.141	0.150	0.148	0.124	0.121	0.124	0.023	0.129
38	87	59	75	58	77	—	0.170	0.172	0.155	0.142	0.144	0.138	0.135	0.138	0.128	0.141
39	106	88	94	77	94	101	—	0.018	0.187	0.145	0.152	0.173	0.165	0.173	0.161	0.180
40	107	89	95	75	95	102	11	—	0.186	0.148	0.155	0.168	0.156	0.168	0.163	0.171
41	99	81	88	72	84	92	112	111	—	0.167	0.165	0.028	0.082	0.028	0.143	0.059
42	93	79	87	61	89	84	86	88	99	—	0.012	0.152	0.153	0.152	0.143	0.157
43	93	79	86	62	88	85	90	92	98	7	—	0.150	0.155	0.150	0.141	0.155
44	90	70	79	60	74	82	103	100	17	90	89	—	0.065	0.003	0.126	0.037
45	91	67	71	61	72	80	98	93	49	91	92	39	—	0.069	0.123	0.076
46	90	70	79	60	74	82	103	100	17	90	89	2	41	—	0.126	0.040
47	85	63	18	57	14	76	96	97	85	85	84	75	73	75	—	0.133
48	91	74	80	64	77	84	107	102	35	93	92	22	45	24	79	—
49	96	69	79	72	78	69	106	106	91	98	101	86	84	88	81	88
50	92	70	80	64	81	36	112	108	96	91	94	84	80	86	83	84
51	100	70	79	82	83	78	114	117	100	98	100	92	90	94	81	98
52	98	70	77	77	83	75	110	113	99	88	90	91	89	93	79	94
53	127	124	133	117	136	121	137	136	140	121	123	135	136	134	134	135
54	101	88	97	82	94	103	106	106	104	89	89	98	104	99	98	105
55	101	88	97	82	94	103	106	106	104	89	89	98	104	99	98	105
56	103	89	98	84	95	105	108	108	106	91	91	100	106	101	99	107
57	129	112	129	107	130	112	129	130	129	115	117	126	132	124	127	128
58	93	68	83	76	87	71	109	109	99	102	106	87	91	89	87	92
59	146	141	143	127	145	140	161	162	148	137	137	142	142	142	142	144
60	117	107	122	99	122	117	130	133	121	103	103	117	121	117	122	123
61	134	127	123	123	125	130	141	143	128	119	121	125	134	123	127	129
62	100	79	95	81	94	88	107	107	98	92	89	94	93	91	93	97
63	113	83	97	88	99	97	112	115	100	101	98	92	98	89	99	96
64	113	82	95	88	97	97	112	115	99	101	98	91	97	88	97	95
65	105	74	83	83	87	75	110	115	109	102	105	97	90	98	88	98
66	107	80	88	90	92	80	115	120	112	106	106	101	98	102	92	102
67	134	127	134	122	138	130	145	148	132	128	128	131	136	129	134	137
68	134	125	132	120	136	127	143	146	129	126	126	128	133	126	132	134
69	99	77	86	80	95	45	112	115	104	105	104	96	94	98	93	95
70	101	80	87	81	96	48	114	116	106	107	106	98	95	100	94	96
71	111	86	97	95	100	84	120	121	104	110	111	98	103	98	98	106
72	113	93	108	91	111	97	117	119	118	98	98	114	117	113	107	117

Appendix 2. Continued. Extended.

49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
0.175	0.184	0.192	0.197	0.185	0.201	0.201	0.203	0.177	0.181	0.242	0.163	0.185	0.207	0.205	0.205
0.172	0.185	0.196	0.197	0.190	0.205	0.205	0.206	0.174	0.184	0.234	0.163	0.184	0.214	0.213	0.213
0.124	0.129	0.131	0.128	0.221	0.161	0.161	0.162	0.208	0.135	0.234	0.201	0.207	0.147	0.159	0.156
0.128	0.138	0.136	0.133	0.219	0.162	0.162	0.164	0.213	0.140	0.242	0.206	0.207	0.153	0.159	0.156
0.158	0.166	0.157	0.157	0.239	0.187	0.187	0.189	0.224	0.163	0.256	0.225	0.239	0.166	0.177	0.174
0.169	0.167	0.162	0.159	0.239	0.191	0.191	0.192	0.229	0.166	0.257	0.229	0.244	0.164	0.174	0.170
0.167	0.162	0.164	0.160	0.237	0.192	0.192	0.194	0.227	0.166	0.256	0.229	0.242	0.166	0.176	0.172
0.162	0.162	0.174	0.170	0.221	0.170	0.170	0.173	0.212	0.162	0.258	0.200	0.227	0.168	0.198	0.198
0.165	0.162	0.174	0.170	0.217	0.173	0.173	0.177	0.216	0.162	0.256	0.203	0.227	0.168	0.194	0.194
0.123	0.113	0.138	0.137	0.199	0.141	0.141	0.145	0.184	0.130	0.221	0.175	0.212	0.134	0.150	0.150
0.160	0.167	0.177	0.169	0.218	0.166	0.166	0.170	0.190	0.169	0.257	0.205	0.225	0.171	0.187	0.187
0.121	0.117	0.145	0.145	0.211	0.155	0.155	0.158	0.199	0.132	0.236	0.188	0.215	0.138	0.150	0.147
0.148	0.168	0.161	0.162	0.224	0.193	0.193	0.196	0.214	0.156	0.262	0.203	0.207	0.133	0.134	0.132
0.148	0.141	0.165	0.158	0.230	0.178	0.178	0.181	0.218	0.155	0.246	0.209	0.219	0.161	0.163	0.161
0.146	0.143	0.163	0.156	0.231	0.178	0.178	0.181	0.220	0.153	0.246	0.211	0.221	0.165	0.161	0.159
0.141	0.139	0.163	0.158	0.224	0.176	0.176	0.179	0.211	0.153	0.244	0.204	0.214	0.164	0.163	0.161
0.152	0.146	0.164	0.163	0.215	0.163	0.163	0.167	0.205	0.153	0.250	0.194	0.217	0.158	0.181	0.180
0.055	0.112	0.064	0.060	0.209	0.171	0.171	0.174	0.202	0.059	0.244	0.190	0.207	0.132	0.149	0.150
0.055	0.112	0.064	0.060	0.209	0.171	0.171	0.174	0.202	0.059	0.244	0.190	0.207	0.132	0.149	0.150
0.143	0.144	0.150	0.149	0.224	0.177	0.177	0.179	0.217	0.148	0.254	0.222	0.231	0.166	0.169	0.169
0.145	0.145	0.152	0.150	0.227	0.181	0.181	0.182	0.219	0.149	0.256	0.226	0.232	0.168	0.169	0.169
0.145	0.145	0.152	0.149	0.222	0.170	0.170	0.172	0.214	0.149	0.256	0.219	0.229	0.161	0.169	0.169
0.156	0.158	0.174	0.169	0.204	0.168	0.168	0.171	0.194	0.162	0.258	0.199	0.229	0.167	0.181	0.181
0.156	0.158	0.174	0.169	0.202	0.168	0.168	0.171	0.192	0.162	0.258	0.197	0.228	0.167	0.181	0.181
0.142	0.142	0.154	0.156	0.227	0.177	0.177	0.179	0.214	0.144	0.248	0.214	0.231	0.161	0.164	0.164
0.142	0.142	0.154	0.156	0.227	0.177	0.177	0.179	0.212	0.144	0.248	0.212	0.231	0.160	0.162	0.162
0.124	0.120	0.142	0.142	0.213	0.155	0.155	0.159	0.203	0.138	0.240	0.192	0.214	0.147	0.152	0.147
0.123	0.115	0.125	0.120	0.197	0.174	0.174	0.174	0.194	0.127	0.238	0.187	0.207	0.141	0.167	0.166
0.123	0.115	0.124	0.118	0.201	0.174	0.174	0.174	0.194	0.127	0.238	0.187	0.207	0.139	0.166	0.164
0.106	0.111	0.126	0.121	0.218	0.156	0.156	0.159	0.198	0.113	0.238	0.184	0.216	0.128	0.142	0.139
0.161	0.158	0.163	0.153	0.189	0.138	0.138	0.142	0.180	0.167	0.227	0.168	0.192	0.148	0.169	0.169
0.145	0.131	0.158	0.153	0.220	0.168	0.168	0.171	0.205	0.152	0.241	0.203	0.211	0.150	0.156	0.154
0.163	0.157	0.170	0.167	0.219	0.175	0.175	0.179	0.223	0.159	0.253	0.202	0.231	0.171	0.194	0.194
0.117	0.119	0.119	0.119	0.211	0.151	0.151	0.153	0.191	0.116	0.242	0.182	0.216	0.135	0.143	0.141
0.133	0.134	0.133	0.129	0.226	0.166	0.166	0.168	0.220	0.140	0.244	0.207	0.209	0.160	0.164	0.161
0.123	0.110	0.140	0.132	0.201	0.141	0.141	0.145	0.184	0.130	0.219	0.170	0.211	0.139	0.152	0.152
0.131	0.136	0.139	0.139	0.231	0.161	0.161	0.162	0.221	0.147	0.248	0.207	0.212	0.159	0.168	0.164
0.116	0.061	0.131	0.126	0.206	0.177	0.177	0.180	0.191	0.120	0.240	0.200	0.221	0.149	0.165	0.165
0.178	0.188	0.191	0.185	0.223	0.181	0.181	0.185	0.219	0.184	0.275	0.221	0.239	0.180	0.190	0.190
0.178	0.182	0.196	0.190	0.231	0.181	0.181	0.185	0.221	0.184	0.277	0.226	0.243	0.180	0.195	0.195
0.153	0.161	0.168	0.166	0.238	0.178	0.178	0.181	0.220	0.167	0.253	0.206	0.217	0.165	0.169	0.168
0.165	0.153	0.165	0.148	0.204	0.152	0.152	0.156	0.194	0.173	0.232	0.174	0.200	0.155	0.171	0.171
0.170	0.159	0.169	0.152	0.207	0.152	0.152	0.156	0.198	0.179	0.232	0.174	0.204	0.150	0.166	0.166
0.144	0.141	0.155	0.153	0.230	0.168	0.168	0.171	0.215	0.147	0.243	0.199	0.212	0.159	0.156	0.154
0.141	0.135	0.152	0.150	0.232	0.178	0.178	0.182	0.225	0.154	0.243	0.206	0.228	0.157	0.166	0.165
0.148	0.145	0.158	0.156	0.228	0.169	0.169	0.173	0.211	0.150	0.243	0.199	0.209	0.153	0.151	0.149
0.136	0.139	0.136	0.133	0.228	0.168	0.168	0.169	0.216	0.147	0.243	0.207	0.216	0.157	0.168	0.164
0.148	0.141	0.165	0.158	0.230	0.179	0.179	0.183	0.218	0.155	0.246	0.209	0.219	0.163	0.163	0.161
—	0.126	0.075	0.079	0.219	0.168	0.168	0.171	0.211	0.074	0.251	0.197	0.214	0.147	0.167	0.167
75	—	0.134	0.131	0.211	0.173	0.173	0.176	0.201	0.126	0.243	0.204	0.219	0.167	0.171	0.175
45	80	—	0.030	0.225	0.176	0.176	0.180	0.216	0.079	0.257	0.201	0.221	0.150	0.166	0.164
47	78	18	—	0.225	0.173	0.173	0.176	0.216	0.077	0.260	0.197	0.216	0.152	0.173	0.171
129	124	132	132	—	0.219	0.219	0.221	0.130	0.217	0.253	0.133	0.143	0.230	0.232	0.236
98	101	103	101	128	—	0.000	0.000	0.207	0.189	0.254	0.190	0.206	0.178	0.191	0.194
98	101	103	101	128	0	—	0.000	0.207	0.189	0.254	0.190	0.206	0.178	0.191	0.194
100	103	105	103	129	0	0	—	0.209	0.192	0.258	0.191	0.208	0.182	0.194	0.198
124	118	127	127	77	121	121	122	—	0.217	0.258	0.119	0.126	0.218	0.212	0.215
44	75	47	46	127	110	110	112	127	—	0.254	0.208	0.218	0.149	0.168	0.166
147	142	150	152	150	148	148	150	152	148	—	0.236	0.261	0.269	0.258	0.258
116	120	118	116	79	111	111	112	71	122	139	—	0.139	0.207	0.227	0.230
126	129	130	127	85	121	121	122	75	128	154	83	—	0.228	0.220	0.222
87	99	89	90	135	104	104	106	128	88	158	122	134	—	0.098	0.096
99	101	98	102	136	111	111	113	124	99	150	133	129	58	—	0.005
99	103	97	101	138	113	113	115	126	98	150	135	130	57	3	—
48	82	53	52	137	107	107	108	131	58	143	122	133	88	97	98
51	89	59	55	138	110	110	111	131	61	145	123	136	90	101	101
134	134	137	138	145	143	143	145	142	140	65	132	144	151	141	141
134	132	135	137	145	140	140	142	143	139	62	133	144	149	138	138
86	51	89	85	141	113	113	115	135	85	155	133	136	98	102	104
89	53	93	89	141	114	114	116	135	89	156	134	137	101	106	108
61	89	68	68	129	112	112	114	126	64	144	118	130	94	103	104
100	107	112	112	112	104	104	105	104	108	132	100	121	122	119	121

Appendix 2. Continued.

	65	66	67	68	69	70	71	72
1	0.190	0.203	0.219	0.217	0.216	0.221	0.195	0.154
2	0.195	0.208	0.215	0.214	0.216	0.221	0.198	0.147
3	0.136	0.143	0.222	0.219	0.148	0.150	0.161	0.176
4	0.141	0.146	0.227	0.224	0.152	0.153	0.165	0.181
5	0.157	0.164	0.239	0.239	0.161	0.166	0.192	0.195
6	0.164	0.162	0.240	0.240	0.161	0.166	0.193	0.200
7	0.160	0.157	0.240	0.240	0.156	0.161	0.192	0.197
8	0.184	0.184	0.229	0.229	0.172	0.174	0.197	0.190
9	0.184	0.184	0.229	0.229	0.169	0.171	0.193	0.192
10	0.143	0.155	0.207	0.204	0.141	0.142	0.164	0.158
11	0.180	0.185	0.221	0.223	0.186	0.189	0.203	0.187
12	0.147	0.155	0.221	0.214	0.146	0.151	0.157	0.174
13	0.154	0.155	0.243	0.244	0.163	0.163	0.178	0.206
14	0.164	0.171	0.233	0.228	0.160	0.162	0.184	0.200
15	0.163	0.169	0.233	0.228	0.162	0.163	0.182	0.201
16	0.169	0.171	0.228	0.222	0.160	0.162	0.173	0.196
17	0.168	0.173	0.232	0.229	0.154	0.158	0.191	0.192
18	0.060	0.075	0.228	0.226	0.124	0.131	0.095	0.171
19	0.060	0.075	0.228	0.226	0.124	0.131	0.095	0.171
20	0.155	0.160	0.230	0.229	0.154	0.158	0.169	0.187
21	0.155	0.160	0.232	0.230	0.154	0.158	0.171	0.190
22	0.155	0.160	0.234	0.232	0.154	0.158	0.168	0.190
23	0.174	0.181	0.229	0.228	0.182	0.187	0.197	0.184
24	0.174	0.179	0.228	0.226	0.182	0.187	0.197	0.184
25	0.159	0.166	0.224	0.224	0.156	0.161	0.169	0.180
26	0.159	0.166	0.224	0.224	0.156	0.161	0.169	0.180
27	0.149	0.154	0.220	0.213	0.141	0.146	0.159	0.178
28	0.117	0.133	0.219	0.216	0.139	0.140	0.150	0.177
29	0.115	0.130	0.223	0.219	0.142	0.144	0.150	0.177
30	0.126	0.139	0.212	0.211	0.136	0.141	0.146	0.162
31	0.171	0.176	0.207	0.203	0.169	0.172	0.186	0.155
32	0.165	0.175	0.223	0.218	0.162	0.164	0.175	0.195
33	0.179	0.182	0.231	0.231	0.169	0.172	0.195	0.196
34	0.126	0.136	0.216	0.213	0.131	0.137	0.150	0.159
35	0.139	0.148	0.228	0.224	0.145	0.146	0.168	0.184
36	0.142	0.154	0.209	0.205	0.137	0.139	0.166	0.156
37	0.146	0.154	0.234	0.231	0.160	0.162	0.173	0.189
38	0.126	0.134	0.221	0.216	0.076	0.081	0.146	0.166
39	0.184	0.193	0.246	0.243	0.189	0.192	0.208	0.200
40	0.193	0.201	0.251	0.248	0.194	0.195	0.209	0.203
41	0.183	0.188	0.224	0.219	0.175	0.178	0.180	0.201
42	0.172	0.178	0.215	0.212	0.177	0.181	0.191	0.166
43	0.177	0.178	0.215	0.212	0.176	0.179	0.193	0.166
44	0.163	0.169	0.222	0.217	0.162	0.165	0.170	0.195
45	0.151	0.165	0.231	0.226	0.159	0.160	0.179	0.200
46	0.164	0.171	0.219	0.214	0.165	0.168	0.170	0.193
47	0.148	0.154	0.228	0.224	0.157	0.158	0.170	0.183
48	0.164	0.171	0.233	0.228	0.160	0.162	0.184	0.200
49	0.080	0.085	0.228	0.228	0.145	0.150	0.105	0.171
50	0.138	0.149	0.228	0.224	0.086	0.089	0.154	0.183
51	0.089	0.099	0.233	0.230	0.150	0.157	0.118	0.191
52	0.087	0.092	0.235	0.233	0.143	0.150	0.118	0.191
53	0.233	0.234	0.244	0.244	0.241	0.241	0.224	0.189
54	0.183	0.188	0.244	0.239	0.194	0.196	0.196	0.178
55	0.183	0.188	0.244	0.239	0.194	0.196	0.196	0.178
56	0.185	0.190	0.247	0.242	0.197	0.199	0.199	0.180
57	0.223	0.223	0.239	0.241	0.231	0.231	0.219	0.176
58	0.097	0.103	0.239	0.237	0.144	0.150	0.111	0.185
59	0.244	0.248	0.107	0.102	0.266	0.268	0.252	0.224
60	0.207	0.208	0.222	0.224	0.227	0.229	0.205	0.169
61	0.226	0.231	0.242	0.242	0.232	0.233	0.226	0.204
62	0.148	0.152	0.255	0.252	0.166	0.171	0.163	0.208
63	0.164	0.171	0.241	0.235	0.173	0.180	0.179	0.204
64	0.166	0.171	0.241	0.235	0.177	0.183	0.181	0.208
65	—	0.052	0.234	0.233	0.145	0.151	0.121	0.186
66	31	—	0.236	0.234	0.141	0.148	0.119	0.198
67	138	139	—	0.013	0.244	0.247	0.238	0.216
68	137	138	8	—	0.240	0.245	0.238	0.215
69	86	84	143	141	—	0.002	0.156	0.192
70	90	88	145	144	1	—	0.161	0.195
71	70	69	137	137	90	93	—	0.202
72	109	116	128	127	112	114	116	—