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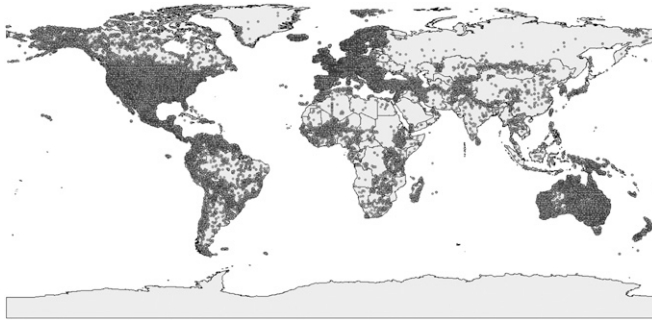


Fig. S3. Global distribution of 1,584,351 geo-referenced grass collections, accessed via the Global Biodiversity Information Facility web portal (<http://www.gbif.org/>).

Table S1. Node descriptions, bootstrap support, and climatic ranges for descendant species of C₃/C₄ nodes

Node description	ML bootstrap support values	# C ₃ species	# C ₄ species	C ₃ range MAT	C ₄ range MAT	C ₃ range T _{max}	C ₄ range T _{max}	C ₃ range T _{min}	C ₄ range T _{min}	C ₃ range T _{wettest}	C ₄ range T _{wettest}
Danthoniodeae/ Chloridoideae	61	71	148	4–19	8–28	10–29	16–34	–7–18	–7–25	2–22	5–29
Danth+Chloridoid/ Aristidoideae	83	219	43	4–28	12–28	10–34	21–32	–7–25	–2–24	2–29	12–29
C ₃ Centothecoideae/ Tristachya avenaceae	37	4	1	17–25	20–20	24–26	23–23	11–24	17–17	12–26	22–22
C ₃ Centothecoideae/ Loudetia simplex	39	3	1	15–18	25–25	26–27	28–28	3–7	22–22	18–20	24–24
<i>Streptostachys asperifolia</i> / Axonopus	51*	1	2	26–26	20–25	27–27	25–26	25–25	13–24	26–26	22–24
<i>Ichnanthus</i> / Axonopus +Paspalum	69*	7	28	20–26	16–25	22–27	18–28	13–25	6–23	21–26	17–26
<i>Steinchisma laxa</i> / Panicum decompositum	85*	1	1	21–21	24–24	27–27	26–26	13–13	22–22	25–25	25–25
<i>Steinchisma</i> / Steinchisma hians	96*	3	1	21–24	18–18	25–27	27–27	13–21	9–9	24–25	21–21
<i>Panicum pilosum</i> / Panicum amarum	70*	1	1	16–16	25–25	26–26	26–26	25–25	25–25	23–23	25–25
<i>Steinchisma</i> - <i>Hymanachne</i> / Leptocoryphium lanatum	67*	11	1	16–25	24–24	25–27	26–26	6–23	22–22	21–26	25–25
<i>Panicum mertensii</i> / Panicum caricoides	96*	1	1	26–26	26–26	27–27	28–28	25–25	24–24	26–26	26–26
<i>Panicum mertensii</i> - <i>caricoides</i> / Panicum stenodes	100*	2	1	26–26	26–26	27–28	27–27	25–25	24–24	26–26	26–26
<i>Apochloa chnoodes</i> / Panicum prionitis clade	94*	1	4	21–21	15–23	22–22	25–27	20–20	3–18	21–21	19–25
<i>Homolepis</i> etc./ Cyphonanthus discrepans	0*	11	1	15–26	26–26	22–28	28–28	3–25	25–25	19–26	26–26
X = 10 Paniceae/ Andropogoneae	46*	60	103	15–26	9–27	18–28	19–31	3–25	–4–25	17–26	10–30
<i>Homopholis proluta</i> / Panicum repens	100*	1	1	17–17	20–20	24–24	27–27	9–9	13–13	16–16	20–20
<i>Panicum</i> sp./ Echinochloa	0*	4	11	20–22	10–28	23–26	18–32	16–19	1–23	20–22	12–29
<i>Acroceras-Ottochloa</i> / Alloteropsis	0*	2	2	24–24	23–24	26–26	27–27	21–22	18–20	25–26	26–26
Forest shade clade/ Digitaria-Cenchrus-Setaria	0*	47	85	10–28	7–29	18–32	15–34	–2–24	–2–24	12–29	13–29
Centothecoideae +Panicoideae / Loudetiopsis chrysothrix	94	314	1	7–29	23–23	16–34	25–25	–4–25	20–20	10–30	24–24
<i>Isachne</i> / Eriachne	100	2	5	21–21	22–27	22–23	26–31	17–19	14–23	21–22	26–28

Because of high topological uncertainty within Panicoideae, this region of the tree was subjected to additional Bayesian sensitivity analyses. Bold lettering indicates the C₄ component of the sister taxa. Shaded pairs were removed for the 17-node analyses because of uncertainties either in character coding (*Steinchisma hians*) or in taxon identification from National Center for Biotechnology Information entries (remaining three). Temperature values are °C; precipitation values are mm^{–year}. MAT, mean annual temperature; ML, maximum likelihood; T_{max}, average temperature of the warmest month; T_{min}, average temperature of the coldest month; T_{wettest}, average temperature of the wettest month.

*The node is found within Panicoideae.

Table S2. Node descriptions, bootstrap support, and climatic ranges for descendant species of C₃/C₄ nodes

Node description	ML bootstrap support value	# C ₃ species	# C ₄ species	C ₃ range T _{seasonality}	C ₄ range T _{seasonality}	C ₃ range MAP	C ₄ range MAP	C ₃ range P _{seasonality}	C ₄ range P _{seasonality}
Danthoniodeae/Chloridoideae	61	71	148	0.3–9.4	0.8–10.8	237–3540	70–2601	0.14–0.75	0.20–1.4
Danth+Chloridoideae/Aristidoideae	83	219	43	0.3–10.8	0.7–9.5	70–3540	138–2293	0.14–1.42	0.19–1.5
C ₃ Centothecoideae/ <i>Tristachya avenaceae</i>	37	4	1	0.7–4.7	2.3–2.3	425–2906	1140–1140	0.34–0.62	1.13–1.13
C ₃ Centothecoideae/ <i>Loudetia simplex</i>	39	3	1	7.4–8.4	1.9–1.9	1187–1337	1019–1019	0.20–0.22	1.01–1.01
<i>Streptostachys asperifolia</i> /Axonopus	51*	1	2	0.8–0.8	0.6–4.4	2335–2335	1606–2288	0.38–0.65	0.63–0.63
<i>Ichnanthus</i> /Axonopus+ <i>Paspalum</i>	69*	7	28	0.5–4.4	0.7–7.3	1606–2823	499–3054	0.38–0.65	0.24–1.1
<i>Steinchisma laxa</i> / <i>Panicum decompositum</i>	85*	1	1	5.2–5.2	1.6–1.6	936–936	1979–1979	0.79–0.79	0.54–0.54
<i>Steinchisma</i> / <i>Steinchisma hians</i>	96*	3	1	1.6–5.2	6.5–6.5	936–1979	1239–1239	0.46–0.79	0.31–0.31
<i>Panicum pilosum</i> / <i>Panicum amarum</i>	70*	1	1	7.4–7.4	1.1–1.1	813–813	2496–2496	0.79–0.79	0.52–0.52
<i>Steinchisma</i> -Hymanachne/ <i>Leptocoryphium lanatum</i>	67*	11	1	1.1–7.4	1.4–1.4	813–2529	1931–1931	0.23–0.95	0.61–0.61
<i>Panicum mertensii</i> / <i>Panicum caricoides</i>	96*	1	1	0.9–0.9	1.0–1.0	1183–1183	914–914	0.65–0.65	1.2–1.2
<i>Panicum mertensii</i> - <i>caricoides</i> / <i>Panicum stenodes</i>	100*	2	1	0.9–1.0	1.0–1.0	914–1183	1844–1844	0.65–1.2	0.69–0.69
<i>Apochloa chnoodes</i> / <i>Panicum prionitis</i> clade	94**	1	4	0.5–0.5	3.6–8.3	1061–1061	1198–1919	0.46–0.46	0.20–0.73
<i>Homolepis</i> etc./ <i>Cyphonanthus discrepans</i>	0*	11	1	0.5–8.3	0.9–0.9	914–2520	1319–1319	0.20–1.2	0.42–0.42
X = 10 Paniceae/ <i>Andropogoneae</i>	46*	60	103	0.5–8.3	0.6–9.4	499–3054	409–2571	0.20–1.2	0.19–1.3
<i>Homopholis proluta</i> / <i>Panicum repens</i>	100*	1	1	5.6–5.6	5.1–5.1	486–486	1017–1017	0.24–0.24	0.64–0.64
<i>Panicum</i> sp./ <i>Echinochloa</i>	0*	4	11	1.8–3.8	3.0–8.9	1500–1803	429–1448	0.33–0.99	0.23–1.3
<i>Acroceras</i> - <i>Ottochloa</i> / <i>Alloteropsis</i>	0*	2	2	1.3–2.1	2.5–3.4	1806–2414	1051–1530	0.47–0.61	0.72–0.82
Forest shade clade/ <i>Digitaria-Cenchrus-Setaria</i>	0*	47	85	0.8–9.1	0.8–9.1	364–2417	258–3180	0.18–1.32	0.11–1.39
Centothecoideae+Panicoideae/ <i>Loudetiopsis chrysothrix</i>	94	314	1	0.5–9.4	1.8–1.8	258–3180	1296–1296	0.11–1.39	0.70–0.70
<i>Isachne</i> / <i>Eriachne</i>	100	2	5	0.8–2.1	1.9–5.5	1615–2527	491–1508	0.61–0.73	0.64–1.17

Because of high topological uncertainty within Panicoideae, this region of the tree was subjected to additional Bayesian sensitivity analyses. Bold lettering indicates the C₄ component of the sister taxa. Shaded pairs were removed for the 17-node analyses because of uncertainties either in character coding (*Steinchisma hians*) or in taxon identification from National Center for Biotechnology Information entries (remaining three). Temperature values are in °C; precipitation values are mm year⁻¹. MAP, mean annual precipitation; ML, maximum likelihood; P_{seasonality}, coefficient of variation of monthly average precipitation; T_{seasonality}, standard deviation of monthly average temperature.

*The node is found within Panicoideae.

Table S3. Independent contrast analyses across Bayesian posterior distribution of 7,001 Panicoideae topologies

Variable	Mean value of C ₃ node (±1 SE)	Mean value of C ₄ node (±1 SE)	Mean magnitude of contrast (C ₄ relative to C ₃)	# trees that were positive (P < 0.05)	# trees that were negative (P < 0.05)	# trees that were not different from zero (P < 0.05)	# trees with significant sign tests
MAT (°C)	22.3 (± 0.04)	21.3 (± 0.04)	−1.00	0	2	6,999	29 (−)
T _{max} (°C)	25.4 (±0.02)	26.0 (±0.02)	0.64	120	0	6,881	36 (+)
T _{min} (°C)	18.9 (±0.07)	16.0 (±0.07)	−2.83	0	320	6,681	33 (−)
T _{wettest} (°C)	23.1 (±0.04)	23.4 (±0.03)	0.26	0	0	7,001	0–
T _{seasonality}	2.35 (±0.03)	3.61 (±0.03)	1.27	768	0	6,233	1,256 (+)
MAP (mm year ⁻¹)	1762 (±7.3)	1361 (±4.5)	−400	0	5,442	1,559	1,961 (−)
P _{seasonality}	0.50 (±0.00)	0.62 (±0.00)	0.11	4,441	0	2,590	331 (+)

MAP, mean annual precipitation; MAT, mean annual temperature; P_{seasonality}, coefficient of variation of monthly average precipitation; T_{max}, average temperature of the warmest month; T_{min}, average temperature of the coldest month; T_{seasonality}, SD of monthly average temperature; T_{wettest}, average temperature of the wettest month.