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Geographic range extension of *Ustilago sporoboli-indici* on *Sporobolus natalensis* in Australia

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Abstract
Field surveys during 2021–2023 found that the leaf smut fungus *Ustilago sporoboli-indici* was widespread on *Sporobolus natalensis* from northern New South Wales to northern Queensland. The geographic range of *Ustilago sporoboli-indici* has extended to 1500 km following the first Australian record of *U. sporoboli-indici* in south-east Queensland in 2017. *Ustilago sporoboli-indici* was not observed on other cohabitating species of *Sporobolus.*

Keywords Giant Rat's tail grass · Biological control

Ustilago sporoboli-indici was first reported from Australia in 2017 on *Sporobolus natalensis* in south-east Queensland (Qld) (Vitelli et al. 2017). Previously *U. sporoboli-indici* was only known to occur in Africa (Eritrea, South Africa, Uganda, Zambia) and Asia (China, Philippines) on *S. africanus*, *S. indicus*, *S. indicus* var. *laxus* (syn. *S. natalensis*) and *S. pyramidalis* (Vánky 2003, 2011). *Ustilago sporoboli-indici* produces sori that appear as dark brown powdery striae in leaves, leaf sheaths and the stems of sterile shoots of several *Sporobolus* spp. (Vánky 2011; Vitelli et al. 2017). The discovery of *U. sporoboli-indici* in Qld was important as four of the five exotic weedy *Sporobolus* spp. found in Australia are known leaf smut hosts, i.e. *S. natalensis, S. pyramidalis, S. fertilis, S. africanus* but not *S. jacquemontii* (Bill Palmer, pers. comm.). These five species are rangeland weeds, with potential to spread across 30% of Australia, in regions with greater than 500 mm per annum rainfall (Bray and Officer 2007). The weedy *Sporobolus* grasses are frequently cohabitating with non-weedy Australian native species including *S. creber* and *S. elongatus* (Australasian Virtual Herbarium 2023), which were susceptible to *U. sporoboli-indici* in host specificity tests (Yobo et al. 2009). Some other native Australian *Sporobolus* spp. are less susceptible to infection by *U. sporoboli-indici*, namely *S. scabridus*, *S. sessilis* (Yobo et al. 2009) S. *laxus* (Rapley 2020).

Under Australian field conditions there is limited information about the impact of *U. sporoboli-indici* on plant biomass or seed production by the nine *Sporobolus* spp. that are known hosts (Vanky 2003). Observations from South African researchers looking for potential biological control agents for Giant Rat's Tail grass (*S. natalenis*) for introduction into Australia, found *U. sporoboli-indici* reduced plant size and seed production in *S. pyramidalis* (Yobo et al. 2009). The distribution and host range of *U. sporoboli-indici* on native and weedy *Sporobolus* spp. in Australia is poorly understood.

In New South Wales (NSW), a survey for *U. sporoboli-indici* on *S. pyramidalis* and *S. natalensis* was conducted at seven sites from Grafton to the Qld border from 10 to 11 Nov. 2021. The survey sites were selected based on the known distribution of *S. pyramidalis* and *S. natalensis* (Australian Virtual Herbarium, local council weeds officers) on the NSW North Coast. All specimens of *U. sporoboli-indici*, which included several symptomatic stems and leaves per site, were submitted to the Queensland Plant Pathology Herbarium (BRIP) for identification and inclusion in occurrence records. The presence of other grass species at the sites was recorded. Disease severity was measured as the percentage of tillers

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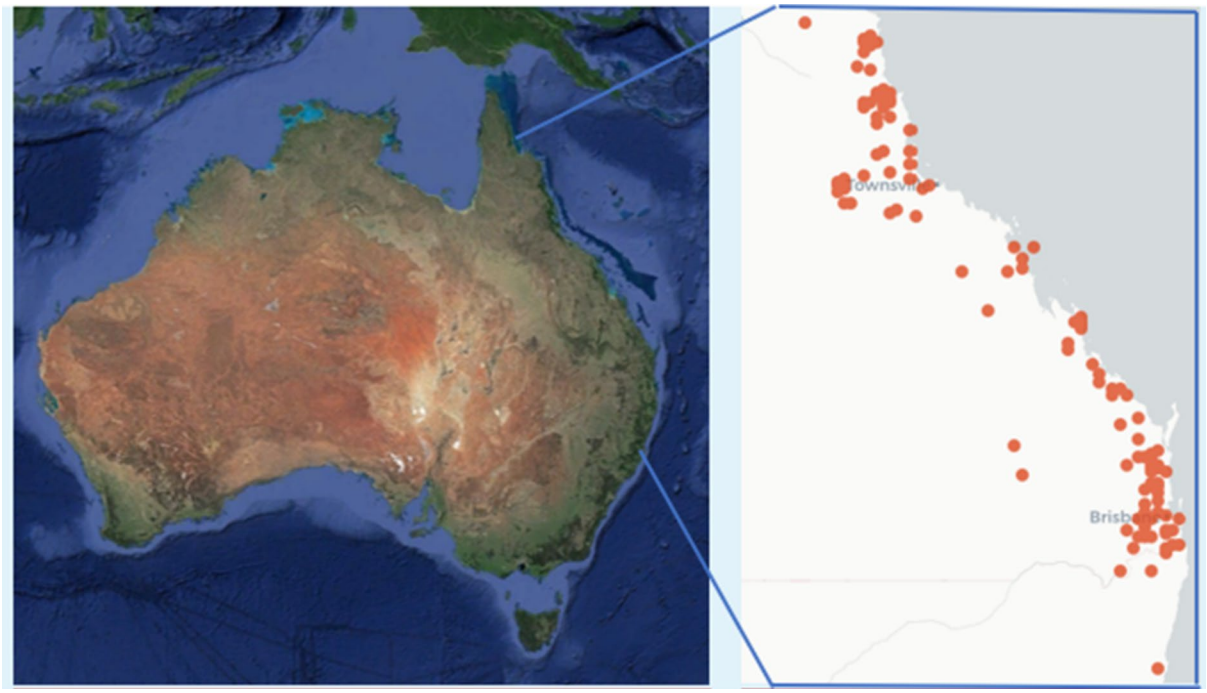

Fig. 1 Survey region within the Australian continent conducted in November 2021 and April 2023, and Atlas of Living Australia (n.d.) *Sporobolus natalensis* locations within that region

with sori on 100 randomly chosen plants per site, and rated, i.e., 0 = nil; 1 = 0–5%; 2 = 6–10%; 3 = 11–20%; 4 = 21–40%; 5 = 41–60%; 6 = 61–80%; 7 = 81–100%. The density of *S. natalensis* plants was measured as the percentage of plants per square m, and similarly rated as for disease severity. Sites varied in size from a few scattered *S. natalensis* plants to several over 110,000 tussocks per hectare. The sampling area for each site was adjusted accordingly, from 0.01 to 1 ha.

Table 1 Survey site details with *Ustilago sporoboli-indici* disease presence and severity rating

Site name	Latitude	Longitude	*Sporobolus natalensis* plant density[a]	Disease severity rating (STD)[b]	Comments
Casino	-28.8669	152.9897	4	6 (nd)	Paddock site has been frequently slashed
Conondale	-26.7216	152.6827	4	3.7 (0.92)	Paddock site
Glenwood	-25.9505	152.6024	6	3.0 (2.50)	Paddock site with more disease found in lower wetter areas
Takura	-25.3366	152.7289	3	0.3 (0.87)	Paddock site was sugar cane, more disease found further from the road and trees
Isis River	-25.2573	152.3677	2	0.6 (1.09)	Paddock site with *S. natalensis*
Kolonga	-24.7421	151.7158	6	2.3 (2.40)	Paddock site with flooding in last 4 weeks, *Brachiaria decumbens* understory
Mount Tom	-24.3818	151.6942	7	1.2 (1.67)	Known *S. natalensis* LS paddock site (2017), previous visits had much fewer seedheads
Taunton	-24.4479	151.7939	5	0.9 (1.49)	Known *S. natalensis* LS paddock site, two areas, the flats with light (2) and ridge with dense *S. natalensis*,native *S. elongatus* present
Nankin	-23.3882	150.6354	7	1.2 (1.74)	*S. natalensis* with understory of *Bothriochloa pertusa*
Canal Creek	-22.9831	150.4813	3	0.7 (1.26)	Paddock site with *S. natalensis* with understory of *Bothriochloa pertusa*
Herberton	-17.4108	145.3506	nd	nd	Roadside site

nd not determined

[a]*Sporobolus natalensis* plant density (% of surface area, m^2) using the ratings, 0 = nil; 1 = 0–5%; 2 = 6–10%; 3 = 11–20%; 4 = 21–40%; 5 = 41–60%; 6 = 61 = 80%; 7 = 81–100%

[b]Disease severity rating of *U. sporoboli-indici* sori on living tillers (assessed by the same 0–7 rating system as plant density) and STD - standard deviation

In Qld, similar surveys were conducted between Mar. 2022 and Apr. 2023 when *U. sporoboli-indici* symptoms were most likely to be observed. The surveys extended from the NSW border with Qld to Mareeba in north Qld (Fig. 1). The surveys were at locations adjacent to roads where *S. natalensis* was known to occur. Samples were collected approximately every 50 km longitudinally. The surveys were completed over 13 d at 84 sites along approximately 3200 km of road (Table 1).

In NSW, *U. sporoboli-indici* was found on *S. natalensis* at one of the seven sites west of Casino (Table 1). More than 70% of the infected plants had erumpent leaf and stem sori. The paddock had been frequently slashed in the past and was on a road with frequent interstate traffic between NSW and Qld. An additional assessment of this site and surrounding S. *natalensis* infestations is required to determine the extent and impact of *U. sporoboli-indici* in NSW.

In Qld, *U. sporoboli-indici* was found on *S. natalensis* at nine sites (Table 1). The most northerly extent of *U. sporoboli-indici* was near Herberton, 95 km southwest of Cairns.

Most of these sites were located close to the coast (Fig. 2). Plant density covered the range from 0 to > 80% surface area; median 1.0 (0–5%) and mode of 0 (Table 1). Disease severity ranged from 0.3 to 3.0 with median = 0.74 and mode = 0. Disease severity was low compared with previous observations since 2017 at known disease sites at Mount Tom and

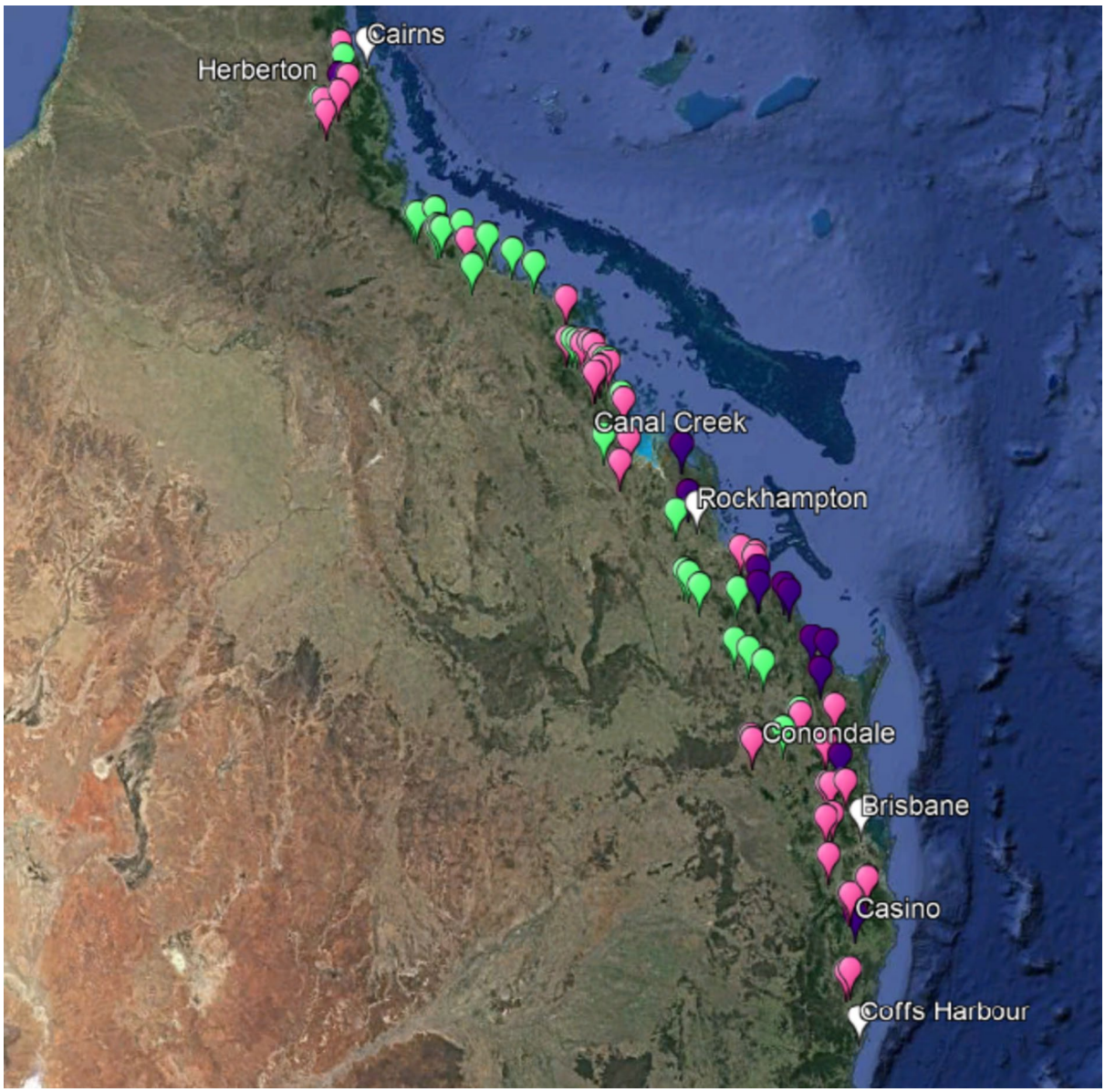

Fig. 2 *Ustilago sporoboli-indici* infection of *Sporobolus natalensis* survey sites from Northern NSW, Southern, Central and Northern Qld between 10 November 2021 and 23 April 2023. Icon colours: pink = *S. natalensis* present; purple = *S. natalensis* with *U. sporoboli-indici*; green = no *S. natalensis*; white = major towns and cities within survey area

Taunton. Additional research is required to measure the impact of disease severity on biomass and seed production by *S. natalensis*. A specimen of *U. sporoboli-indici* collected near Herberton in far north Qld in 2023 represented a geographic range extension in Australia (Figs. 1 and 3). The known range of *U. sporoboli-indici* in Australia currently extends 1500 km from northern NSW to far north Qld.

The impact of *U. sporoboli-indici* on plant biomass and seed production appeared to be dependent upon the seasonal conditions. In drier years, prior to the La Niña summers of 2020/2021 and 2021/2022, *U. sporoboli-indici* was observed to reduce seed head production and seed numbers in the field. There were high rainfall periods just prior to the Qld surveys in 2022 and *S. natalensis* plant size and seed head numbers seemed unaffected by the *U. sporoboli-indici.* The impact of severe storms and high rainfall on the development of leaf smut caused by *U. sporoboli-indici* has not been measured. After torrential rainfall in some areas of southeast Qld, e.g. Glenwood site, *U. sporoboli-indici* was abundant.

The low incidence of *U. sporoboli-indici* has remained unchanged at surveyed sites for at least 4 years. It seemed that *U. sporoboli-indici* is restricted to *S. natalensis* in the Australian environment. This indicates that *U. sporoboli-indici* has potential as a biological control agent for *S. natalensis* in Australia, especially if future research can identify management techniques that increase its impact.

Fig. 3 *Ustilago sporoboli-indici* infection of *Sporobolus natalensis* southwest of Herberton, Qld observed on 23/4/2023 (photo by Roger Shivas)

Table 2 List of uninfected flowering grass species found cohabiting with leaf smut (*Ustilago sporoboli-indici*) infected *S. natalensis* (*Sporobolus natalensis*) plants during 2021 and 2023 surveys. The genus and species included are ordered alphabetically within tribe and subfamily

Tribe	Species	Common name
Subfamily *Chloridoideae*		
Cynodonteae	*Brachyachne convergens* (F.Muell.) Stapf	Native couch
	Chloris gayana Kunth	Callide Rhodes
	C. truncata R.Br.	Windmill
	C. ventricosa R.Br.	Tall windmill
	Cynodon dactylon (L.) Pers.	Bermuda
	C. dactylon (L.) Pers. *var. aridus* J.R.Harlan & de Wet	Couch
	Dactyloctenium radulans (R.Br.) P.Beauv.	Button
	Eleusine indica (L.) Gaertn.	Crowsfoot
Eragrostideae	*Enneapogon robustissimus* (Domin) N.T.Burb.	Nineawn
	Eragrostis curvula (Schrad.) Nees	African lovegrass
	E. elongata (Willd.) J.Jacq.	Clustered lovegrass
Zoysieae	*Sporobolus actinocladus* F.Muell.	Ray
	S. africanus (Poir.) Robyns & Tournay	Parramatta
	S. australasicus Domin	Australian Dropseed
	S. caroli Mez	Fairy
	S. coromandelianus (Retz.) Kunth	Small Dropseed
	S. creber De Nardi	Slender Rat's Tail
	S. elongatus R.Br.	Slender Rat's Tail
	S. fertilis (Steud.) Clayton	Giant Parramatta
	S. jacquemontii Kunth	American Rat's Tail
	S. laxus B.K.Simon	Lax Rat's tail
	S. pyramidalis P.Beauv.	Giant Rat's Tail
	S. sessilis B.K.Simon	Tussocky Sporobolus
	S. virginicus (L.) Kunth	Sand Couch
	Zoysia macrantha Desv.	Prickly couch
Subfamily *Oryzoideae*		
Ehrharteae	*Microlaena stipoides* (Labill.) R.Br.	Weeping
Subfamily *Panicoideae*		
Andropogoneae	*Bothriochloa bladhii* (Retz.) S.T.Blake	Forest blue
	B. decipiens (Hack.) C.E.Hubb.	Pitted blue
	B. insculpta (Hochst. ex A.Rich.) A.Camus var. Bisset	Bisset blue
	B. pertusa (L.) A.Camus	Indian blue
	Chrysopogon fallax S.T.Blake	Golden beard
	Cymbopogon bombycinus (R.Br.) Domin	Silky oil
	C. refractus (R.Br.) A.Camus	Barbed wire
	Dichanthium aristatum (Poir.) C.E.Hubb.	Angleton
	D. sericeum (R.Br.) A.Camus	Queensland blue
Tribe	**Species**	**Common name**
	Eulalia aurea (Bory) Kunth	Silky browntop
	Heteropogon contortus (L.) P.Beauv. ex Roem. & Schult.	Black spear
	H. triticeus (R.Br.) Domin	Giant spear
	Ischaemum australe R.Br.	Large blue
	Saccharum officinarum L.	Sugarcane
	Schizachyrium fragile (R.Br.) A.Camus	Firegrass
	Sehima nervosum (Rottler) Stapf	Rat's Tail
	Sorghum x drummondii (Nees ex Steud.) Millsp. & Chase	Sudan

Table 2 (continued)

Tribe	Species	Common name
	S. plumosum (R.Br.) P.Beauv.	Plume sorghum
	Themeda avenacea (F.Muell.) Lugger	Tall oat
	T. quadrivalvis (L.) Kuntze	Grader
	T. triandra Forssk.	Kangaroo
Arundinelleae	*Arundinella nepalensis* Trin.	Reed
Paniceae	*Alloteropsis semialata* (R.Br.) Hitchc.	Cockatoo
	Axonopus compressus (Sw.) P.Beauv.	Carpet
	Cenchrus ciliaris L.	Buffel
	C. clandestinus (Hochst. ex Chiov.) Morrone	Kikuyu
	Digitaria brownii (Roem. & Schult.) Hughes	Cotton panic
	D. eriantha Steud.	Pangola
	D. milanjiana (Rendle) Stapf	Jarra digit
	Echinochloa polystachya (Kunth) Hitchc.	Aleman
	Hymenachne amplexicaulis (Rudge) Nees	Olive hymenachne
	Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs	Guinea
	M. maximus var. pubiglumis B.K.Simon & S.W.L.Jacobs	Green panic
	Melinis minutiflora P.Beauv.	Molasses
	Panicum coloratum L.	Bambatsi panic
	P. decompositum R.Br.	Native millet
	P. dilatatum Poir.	Paspalum
	P. mandiocanum Trin.	Broad-leaved paspalum
	Paspalum nicorae Parodi	Blue dawn
	Setaria incrassata (Hochst.) Hack.	Purple pigeon
	S. sphacelata (Schumach.) Stapf & C.E.Hubb.	Setaria
	S. surgens Stapf	Pigeon
	Urochloa brizantha (Hochst. ex A.Rich.) R.D.Webster	Mekong Briz™
	U. decumbens (Stapf) R.D.Webster	Signal
	U. humidicola (Rendle) Morrone & Zuloaga	Tully Humidicola
	U. mosambicensis (Hack.) Dandy	Sabi
Subfamily *Pooideae*		
Bromeae	*Bromus catharticus* Vahl	Prairie
Poeae	*Lolium multiflorum* Lam.	Italian rye

After *U. sporoboli-indici* was first observed in Australia in 2017, one of the major concerns was its potential impact on native *Sporobolus* spp. Seventy-five grass species that cohabitated with leaf smutted plants of *S. natalensis* were free of infection by leaf smut (Table 2). These uninfected species came from 4 grass subfamilies (*Chloridoideae*, *Oryzoideae*, *Panicoideae*, *Pooideae*) and nine tribes (*Andropogoneae, Arundinelleae, Bromeae, Cynodonteae, Ehrharteae, Eragrostideae, Paniceae, Poeae* and *Zoysieae*). There were 14 species from the *Zoysieae* tribe, of which 13 were *Sporobolus*. Our surveys did not find *U. sporoboli-indici* on the introduced species *S. pyramidalis*, *S. fertilis*, *S. africanus*, and *S. jacquemontii*, nor on the native *Sporobolus* species *S. creber* and *S. elongatus*. Under field conditions *U. sporoboli-indici* does not appear to infect native *Sporobolus* grasses.

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Declarations

Conflict of interest The authors have no conflict of interest to declare that are relevant to this article.

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