Striga asiatica

(Witchweed)

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Background Information

Common Names:
Witchweed, red witchweed, Asiatic witchweed, buri, common mealie witchweed, isona weed, Matabele flower, mealie poison, mealie witchweed, scarlet lobelia, yaa mae mot

Scientific Name:
Striga asiatica (L.) Kuntze

Synonyms:
Buchnera asiatica L., *Stiga hirsuta* Benth., *Striga coccinea* Benth., *Striga lutea* Lour., *Striga parvula* Miq., *Striga pusilla* Hochst., *Striga spanogheana* Miq., *Striga zangebarica* Klotzsch

Taxonomy:
Kingdom: Plantae; Class: Magnoliospida;
Order: Lamiales; Family: Orobanchaceae

Primary Crop Hosts:
Maize (*Zea mays*), rice (*Oryza sativa* L.), sorghum (*Sorghum spp.*), millets (*Pennisetum* spp., *Panicum* spp., *Eleusin* spp., *Digitaria* spp., etc.), sugarcane (*Saccharum spp.)*

Figure 1. Witchweed, *Striga asiatica* (L.). Photograph from USDA APHIS PPQ Archive, USDA APHIS PPQ, Bugwood.org. http://www.forestryimages.org/browse/detail.cfm?imgnum=1148114#sthash.38odDuRw.dpuf

Introduction

Striga asiatica is amongst the world's worst weeds (Holm et al. 1997), reducing the value of grain crops, particularly in Africa. *Striga asiatica* is an obligate parasite, drawing moisture, nutrients and photosynthate from its graminoid host plants (mostly C_3 plants) (Figure 1). Host plants are typically subsistence crops, including wheat, corn (maize), sorghum, rice, sugarcane and cowpeas. *Striga asiatica* is typically found in dry, infertile soils in semi-arid tropical grasslands and savannahs (Cochrane and Press 1997). Thus, its effects are disproportionately felt by poorer farmers on marginal lands. *Striga* spp. are prolific seed producers. The fine dust-like seed can last more than 15 years, and consequently, eradication and control attempts are extremely difficult and prolonged.

As with other *Striga* spp., *S. asiatica* reduces crop yields by extracting water, nutrients (particularly nitrogen), and photosynthate from the root system of its host plant, resulting in stunting and yield reduction (Musselman 1980).

Known Distribution

Striga asiatica is the most widespread of the 42 or so *Striga* species (Cochrane and Press 1997). It is native to sub-Saharan Africa, and many countries in tropical Asia (Figures 2, 3). It has been introduced to the USA (North Carolina, South Carolina), New Zealand, Papua New Guinea, and most recently Australia. The distribution records in Northern Sudan reported by Cochrane and Press (1997), the Namibian records noted in GBIF, and the Egyptian report by Zahran and Willis (1992) are all presumably reliant on irrigation.

Description and Biology

Striga asiatica is an annual obligate hemiparasite of monocotyledonous plants. It reproduces by seed, producing tens of thousands of minute seeds per plant (Musselman and Parker 1981). The seeds are quite cold-tolerant, able to withstand prolonged storage at -7 °C (Patterson 1990). However, the minimum temperature for germination is a

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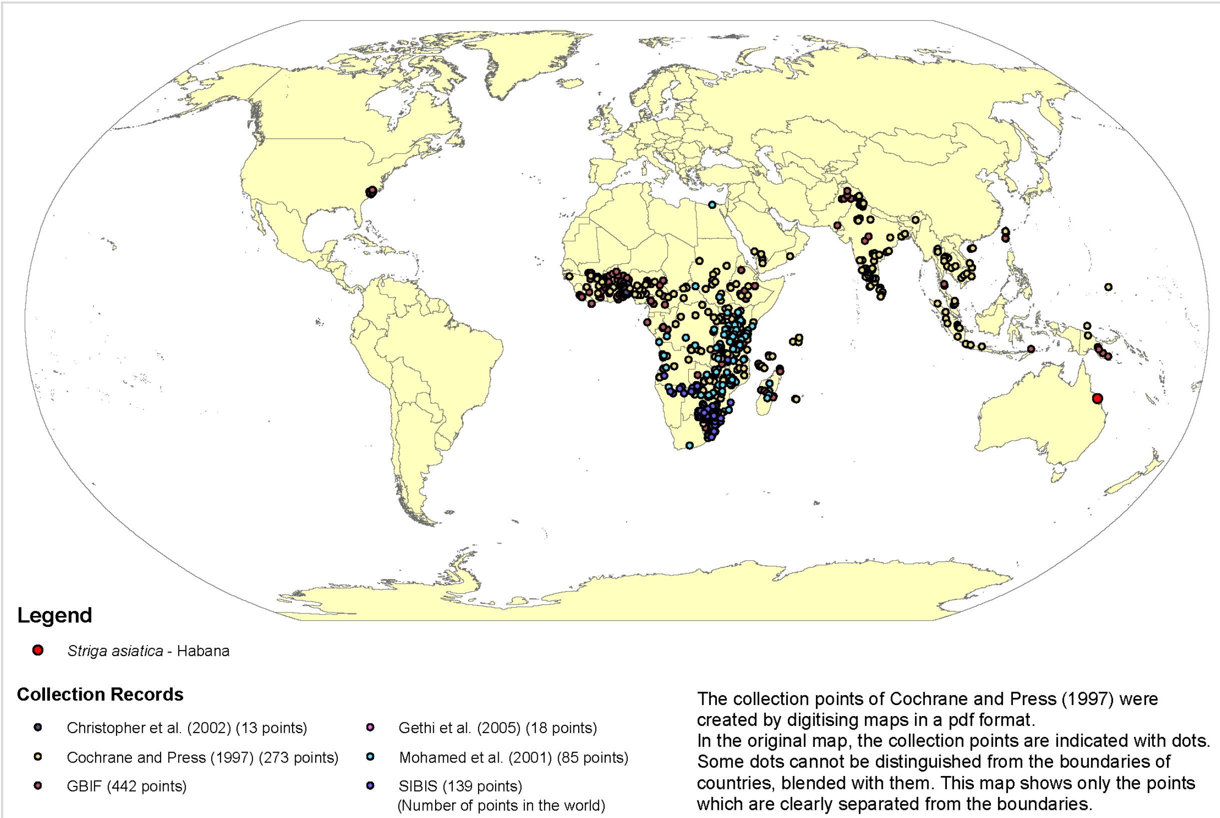

Figure 2. Collection records of *Striga asiatica* worldwide.

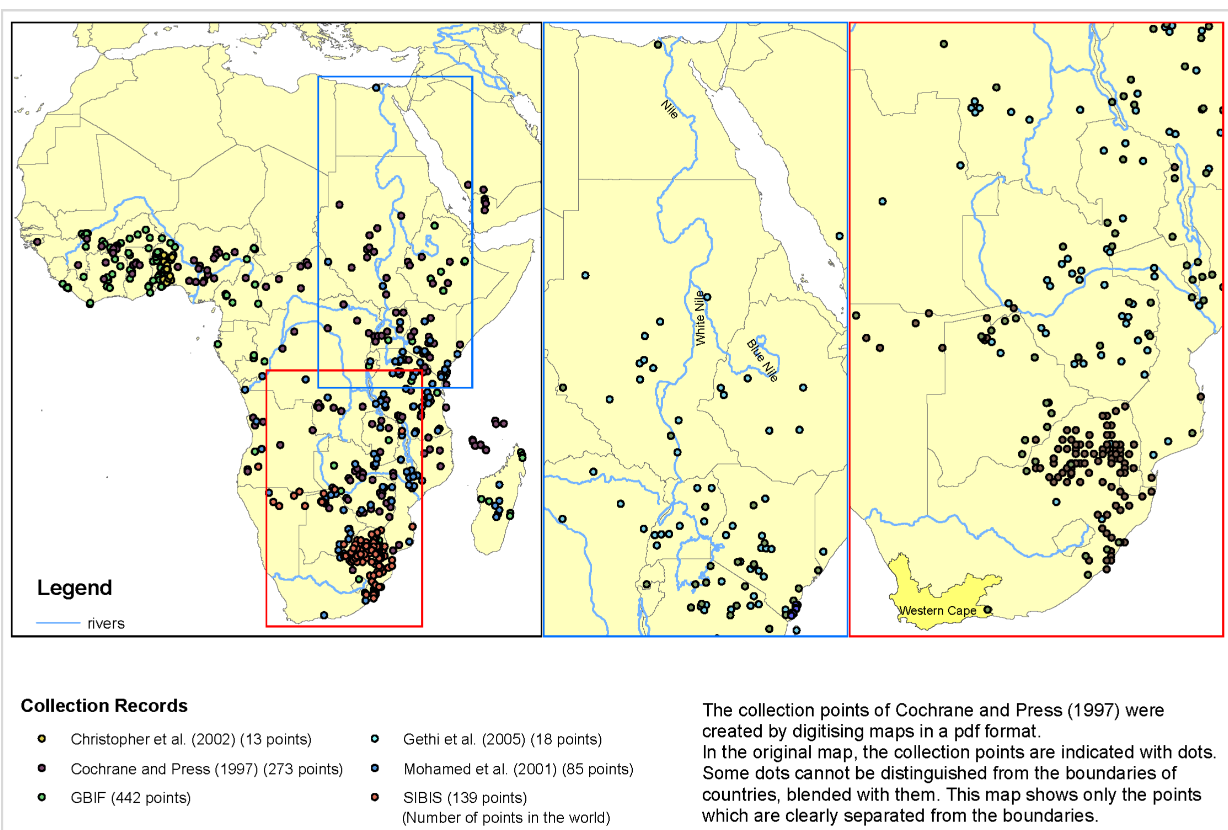

Figure 3. Collection records of *Striga asiatica* in Africa.

relatively high 20 °C and the optimum temperature for growth appears to be approximately 32 °C (Patterson et al. 1982). Raynal-Roques (1987) notes that *S. asiatica* can withstand temporary water-logging.

Seedlings are not visible above ground, but have white succulent shoots that attach to host roots via a horstorium. By this means the parasitic plant develops underground until it produces a stem that surfaces. The above ground parts of mature plants have green foliage sparsely covered with coarse, short, white, hairs. Plants are normally 15-30 cm tall but can grow to 60 cm. Small flowers (less than 1.5 cm in diameter) occur in summer and fall, with colours varying regionally, from red, orange, or yellow in Africa to pink, white, yellow, or purple in Asia. The flowers develop into swollen seeds pods, each containing thousands of microscopic seeds. Dispersal is primarily by wind or water, or by human movement of soil, plants, or machinery (CDFA 2006).

Host Crops and Other Plants

Primary crop hosts include wheat, corn (maize), sorghum, rice, and sugarcane. However, *S. asiatica* is also known to infest other grasses and some broadleaf crops (e.g. sunflower, tomatoes, and some legumes) (CDFA 2006, GISD 2006).

Potential Distribution

CLIMEX (Sutherst et al. 2007) was used to fit a niche model to estimate the potential distribution and relative abundance of *S. asiatica* based on distribution records and knowledge gleaned regarding its biology from the published literature and a variety of databases. The model was fitted to the known distribution in Africa, and then checked against all known distribution records elsewhere in the world. The model parameters are given in Table 1.

The lower soil moisture limit for growth (SM0) was set to 0.1 to accord with permanent wilting point (Kriticos et al. 2003). High humidity inhibits the ability of *S. asiatica* to grow (Egley 1971), hence the upper limit for optimum growth was set to 1 to accord with field capacity. Noting the observation by Raynal-Roques (1987) that *S. asiatica* could tolerate occasional water-logging, the upper soil moisture limit for growth (SM3) was set to 1.5.

The temperature response of *S. asiatica* appears to affect both the relative suitability of a location for growth, and also its cold tolerance limits. The minimum temperature for development was set at 20 °C, and the optimal temperature range for growth at 30 °C to 34 °C (Patterson et al. 1982). The upper limit for growth was set to 42 °C.

Striga asiatica was reported by Mohamed et al. (2001) as being present on the southeastern border of the Western Cape in South Africa. This record did not appear in a subsequent paper by Mohamed et al. (2006) modelling the potential distribution of *S. asiatica*. In addition, there is no mention of this species in the Western Cape flora

Table 1. CLIMEX Parameter Values for *Striga asiatica*

Parameter	Description	Value
Moisture		
SM0	lower soil moisture threshold	0.1
SM1	lower optimum soil moisture	0.6
SM2	upper optimum soil moisture	1
SM3	upper soil moisture threshold	1.5
Temperature		
DV0	lower threshold	20 °C
DV1	lower optimum temperature	30 °C
DV2	upper optimum temperature	34 °C
DV3	upper threshold	42 °C
Cold Stress		
TTCS	cold stress temperature threshold	5°C
THCS	temperature threshold stress accumulation rate	-0.001 week^{-1}
Dry Stress		
SMDS	soil moisture dry stress threshold	0.1
HDS	stress accumulation rate	-0.025 week^{-1}
Wet Stress		
SMWS	soil moisture wet stress threshold	1.5
HWS	stress accumulation rate	0.002 week^{-1}
Threshold Heat Sum		
PDD	number of degree-days above DV0 needed to complete one generation	210 °C days
Irrigation Scenario		
	2.5 mm day^{-1} as top-up throughout the year	

(Smithies 2000). We assume that this record was originally incorrectly geo-coded too far to the west. Apart from this record, the coldest records of *S. asiatica* appear to be several locations in South Africa. A damaging temperature cold stress model was fitted to preclude *S. asiatica* from invading the highlands of Lesotho, from where it has not been recorded. Its modelled range is also limited by a combination of the lack of opportunity for growth when temperatures fall below 20 °C and a need for a minimum annual heat sum.

The Dry Stress threshold was set to 0.1 (as for SM0), where we might expect that host plants would start experiencing drought stress. The accumulation rate (HDS) was set -0.025 week-1 to allow marginal persistence throughout the rainfed cropping zone of sub-Saharan Africa.

Noting the reported ability of *S. asiatica* to withstand some water-logging, the wet stress threshold was set to 1.5, the same value as SM3. The accumulation rate (HWS) was set to reduce the suitability of excessively wet areas, but not precluding *S. asiatica* from any parts of Africa.

The minimum annual heat sum to complete a generation was set to 210 degree days above 20 °C. This allows *S. asiatica* to persist at the coldest known recorded locations in South Africa. Using this limit made some sites in the Himalayas unsuitable for *S. striga*, but the modelled temperatures at these locations never exceeded the growth threshold.

There are a number of records in Sudan, Egypt, Yemen, Saudi Arabia, Pakistan, and India that appear to be climatically unsuitable under a natural rainfall regime. When investigated using Google Earth, each of these records falls in a location used for irrigated cropping. To assess the invasion risks from *S. asiatica*, we used knowledge of the global irrigation patterns indicated by Siebert et al. (2005) to combine a CLIMEX natural rainfall scenario and an annual top-up irrigation scenario of 2.5 mm per day. The model provides a good fit to the African data (Figure 4), although a few recorded locations in Sudan do not fall within the climate modelled as suitable with this irrigation scenario.

Globally, the model accords with all known location records (Figure 5), taking into account the need to consider the effects of irrigation near the xeric range margins. The fit in Asia (Figure 6) provides independent validation of the model. The misfit of the extreme high altitude Himalayan records probably indicates a precision mismatch between the location records and the climate surface data (Kriticos and Leriche 2009). The known locations in the USA fall within the model, but are too few in extent to be used for validation.

The model suffers from a lack of observations of growth in response to temperature. The temperature responses are taken solely from germination data, which may not represent the entire response of the plant. This deficien-

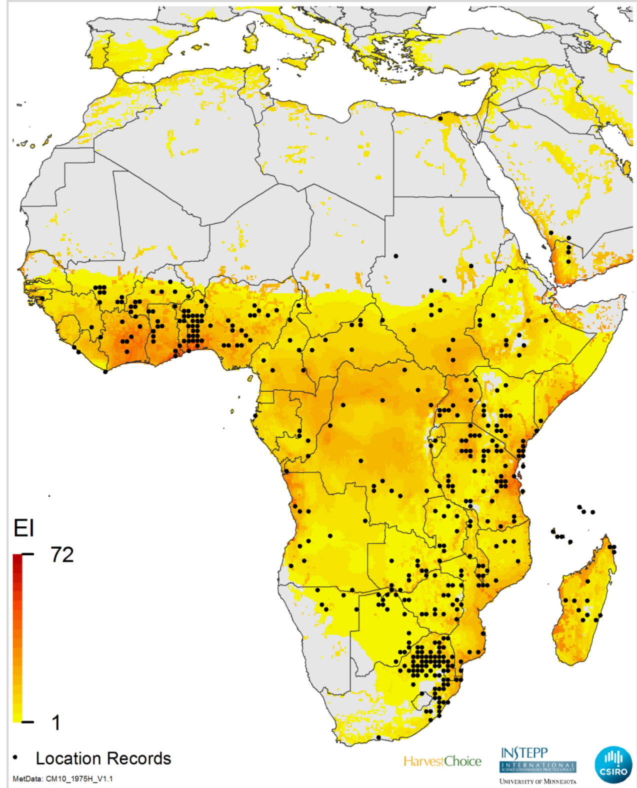

Figure 4. Modelled climate suitability of Africa for *Striga asiatica* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records are from Christopher et al. (2002), Cochrane and Press (1997), Gethi et al. (2005), Mohammed et al. (2001), GBIF and SIBIS.

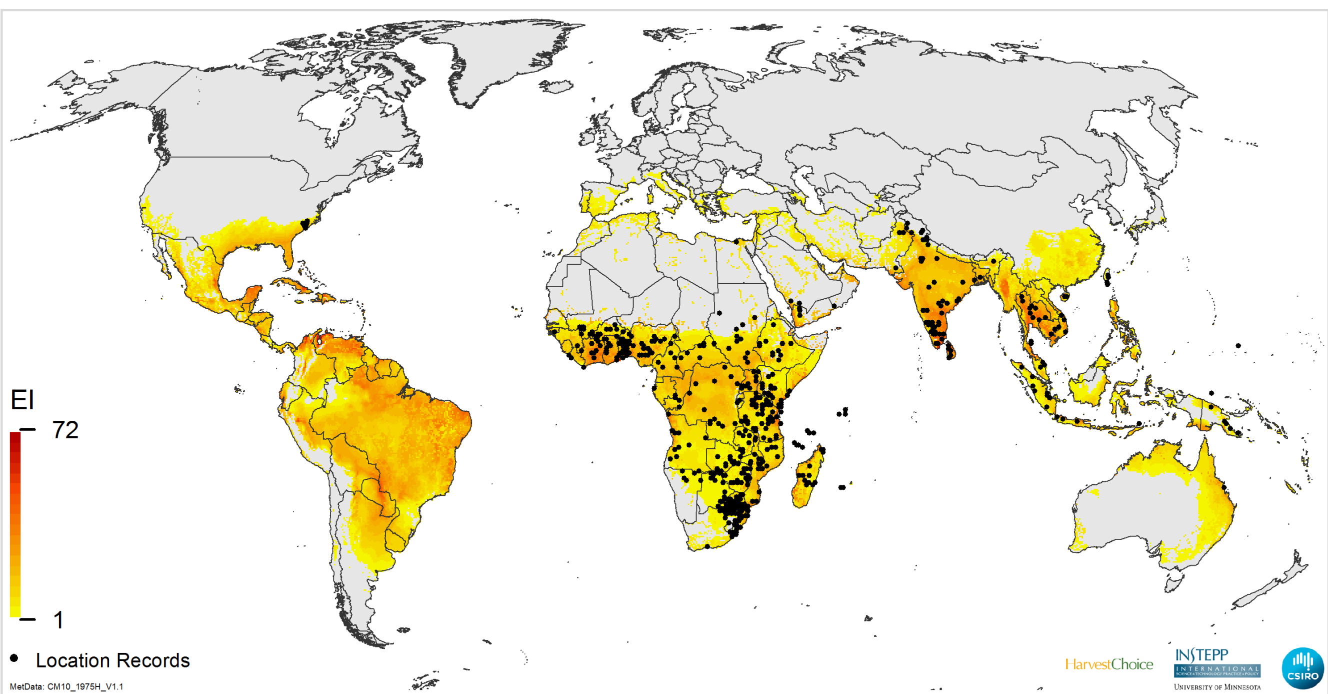

Figure 5. Modelled global climate suitability for *Striga asiatica* as a composite of natural rainfall and irrigation based on then irrigation areas identified in Siebert et al. (2005). Location records are from Christopher et al. (2002), Cochrane and Press (1997), Gethi et al. (2005), Mohammed et al. (2001), GBIF and SIBIS.

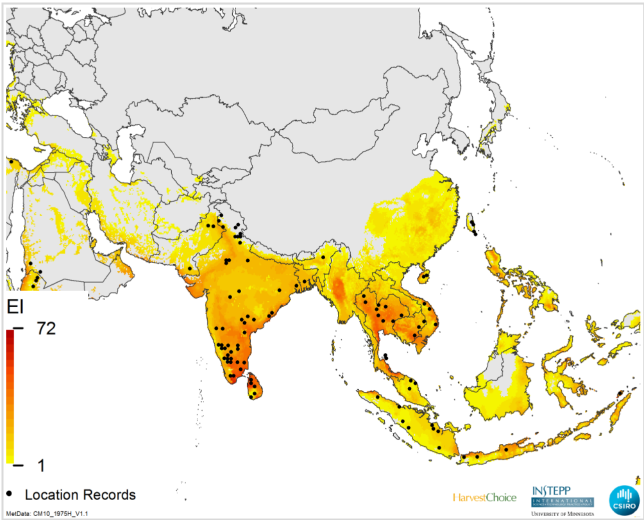

Figure 6. Modelled climate suitability of Asia for Striga *asiatica* as a composite of natural rainfall and irrigation based on then irrigation areas identified in Siebert et al. (2005). Location records are from Cochrane and Press (1997) and GBIF.

cy probably has little impact on the potential geographical range of the plant, but could alter the relative climate suitability within the range boundaries.

It is likely that *S. asiatica* could suffer from hot-wet stress, probably associated with biotic factors (pathogens, competition, etc.). Hot-wet stress has not been used in this model, but it could reduce the suitability of warm, wet areas such as the Democratic Republic of Congo and Australia's Wet Tropics.

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