REPRODUCTIVE BIOLOGY AND SURVIVAL OF BOLL WEEVIL ON *CIENFUEGOSIA DRUMMONDII* IN SOUTH TEXAS

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Abstract

Cienfuegosia drummondii is a malvaceous plant found in rangeland habitat in South Texas counties bordering the Gulf of Mexico. New knowledge was generated on this alternate host of the boll weevil, including delineation of plant habitat, fruiting phenology, seasonal occurrence and degree of infestation by boll weevil, and reproductive suitability for boll weevil. We found that *C. drummondii* can provide early season oviposition sites for boll weevil about 45 days prior to availability of cotton squares susceptible for oviposition, and that flower buds and fruit capsules of *C. drummondii* can be available for about four months after cotton stalk destruction deadlines. Boll weevil infestation of *C. drummondii* varied considerably between field sites and years, with the highest percent recorded after the regulated cotton production season. In the laboratory, weevils were reared for 4 generations when provided only buds and capsules of *C. drummondii*. In an outdoor screenhouse study, percent weevil survival from egg to adult on *C. drummondii* and cotton was 25.0 and 69.6, respectively. Seasonal populational increment of boll weevil on *C. drummondii* is unlikely, if not impossible most years, due to the host's fruiting phenology; however, there are windows for infestation, generally early and late, that could act as as a bridge to sustain weevil populations when cotton is not available as a host.

Introduction

The North American distribution of *Cienfuegosia drummondii*, a member of the Malvaceae, is apparently restricted to clayey, poorly-drained soils in the coastal counties of the Lower Rio Grande Valley and Coastal Bend of Texas (Fryxell 1979, Burke and Clark 1976). These Coastal Prairie soils (Victoria, Orelia, and Raymondville series) are especially suitable for production of cotton and grain sorghum, and a large percentage has been converted to such use. However, thousands of acres serve as rangeland for livestock production or are contained in private and public refuges.

Cienfuegosia drummondii is a known reproductive host of the boll weevil, *Anthonomus grandis* Boheman (Lukefahr and Martin 1962). Burke and Clark (1976) conducted a three-year survey in the Texas Coastal Bend and recorded boll weevils infesting *C. drummondii* in Kleberg, Nueces, San Patricio, and Refugio counties. These counties are included in the South Texas/Winter Garden Boll Weevil Eradication Zone. Due to the potential for *C. drummondii* to serve as a resource for reproducing boll weevils, it is important to better understand this host plant/pest relationship and determine its significance to boll weevil population dynamics. The objectives of our study were to identify areas of *C. drummondii* habitat, monitor plant reproductive growth, determine the seasonal incidence and degree of weevil infestation in selected *C. drummondii* sites, and evaluate certain aspects of the reproductive fitness of *C. drummondii* as a host of boll weevil.

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Materials and Methods

County soil maps were used to identify locations with soil types that could harbor *C. drummondii* in the Lower Rio Grande Valley and the Coastal Bend. Periodic surveys consisted of vehicular travel to potential areas and ground inspections to verify the presence of *C. drummondii*. Latitude and longitude were recorded with a hand held GPS device for locations containing *C. drummondii* populations.

Monitoring of six plots containing *C. drummondii* plants on the Welder Wildlife Foundation Refuge (WWFR) in San Patricio Co. was conducted from 1997-99. Ten to 25 plants per plot were randomly selected each sampling date and monitored bi-weekly. All floral buds and seed capsules were counted and removed from sampled plants and taken to the laboratory for determining weevil infestation. Weekly monitoring of adult boll weevil was made with 10 pheromone traps located along the WWFR main entrance road (~1.5 mi) throughout the entire year.

Five sites near Taft and Gregory, San Patricio Co., and westernmost Aransas Co. were sampled intermittently (dependent on fruiting structure availability) during 1999-2000. Floral buds and seed capsules were collected at random from plants and taken to the laboratory to determine boll weevil infestation status.

Approximately 200 *C. drummondii* plants were removed from a site near Taft in San Patricio Co. and transplanted to establish a small field plot in Weslaco, Hidalgo Co. Infestation monitoring at weekly intervals of plants in this plot began 26 May 1999. Floral buds and seed capsules attached to the plants were removed and abscised reproductive forms were collected and taken to the laboratory for inspection under a dissection microscope.

For the laboratory study on the reproductive suitability of *C. drummondii*, boll weevils were obtained from 4 sources: 1) adults from pheromone traps; 2) adults eclosing from field-collected cotton squares infested with boll weevil immatures; 3) adults eclosing from field-collected *C. drummondii* buds and capsules infested with boll weevil immatures; and 4) adults eclosing from *C. drummondii* buds and capsules infested with progeny of weevils from source 3. Adults from source 1 were captured 25-29 March 1999 at Progreso, TX. Cultivated cotton near this vicinity was at the pre-squaring stage, however it can not be excluded that weevils from source 1 had not feed upon reproductive structures of volunteer or regrowth cotton from the preceding year. Regardless, the adult feeding history of weevils from the other three sources was known not to include cotton because these weevils eclosed in a laboratory environment. Each source of weevils was maintained separately. Both sexes were held together for mating and provisioned with *C. drummondii* buds and capsules for 5 days. Females (sexed according to Agee 1964) from each of the four sources were then maintained individually in 1oz. plastic cups. One or two floral buds and/or green fruit capsules of *C. drummondii* were provided daily (or as fruit became available) to individually caged mated females from the 4 sources until death of the female. After 24 h, fruit structures that exhibited evidence of oviposition were removed and held individually in 1 oz. cups. The fruiting structures were examined approximately two weeks later by recording boll weevil life stage attained and status.

To obtain estimates of the generational mortality of boll weevil in cotton and *C. drummondii*, we established cohorts and developed life tables. In a screenhouse (48' X 48'), two plots each of *C. drummondii* and cotton were established. Each plot consisted of 6 rows (38" spacing) 20 feet in length. Six females were placed in each plot 23 JUN. The source of the females originated from field collected cotton squares infested with boll weevil immatures. Infested squares were brought into the laboratory and weevils were removed from squares as pupae. Upon emergence, both sexes were grouped together for 48 hrs and fed cotton squares. After an additional 4 days, adults were sexed and females were taken to the screenhouse cage for release. Beginning at anthesis, approximately 20 flower buds and/or fruit in each host plot with suspected oviposition punctures were marked by attaching a string and paper tag to the peduncle of each fruiting form. After approximately two weeks (sufficiently long for all mortality factors to be expressed or for adult weevils to emerge from infested forms), the tagged forms were collected (either from the plant or from the ground) and inspected in the laboratory to determine if and at what life stage any mortality occurred. Beginning cohort dates were 27 JUN, 05 JUL, 11 JUL, and 20 JUL 2000. The cause of the mortality was determined according to the method described by Sturm and Sterling (1986). Life table analysis was used to measure stage specific mortality. The l_x (proportion surviving beginning life stage *x*) and d_x (proportion dying during stage *x*) statistics were calculated according to Harcourt (1969). The effect of parasitism by larval parasitoids, predation by ants, and unexplained mortality were evaluated by calculating stage and factor specific mortality rates (d_x) and indispensable mortality (Ind_x), calculated according to Southwood (1978). Unexplained mortality included death of immatures due to desiccation or thermal heating.

Results and Discussion

Cienfuegosia drummondii populations were found in 2 sites in Cameron, 1 in Willacy, 4 in Kleberg, 11 in Aransas, 10 in Refugio, and 34 in San Patricio counties (Figure 1). Populations varied considerably from very sparse to high density. All sites with mallow plants were encountered within about 20 yards of vehicular access roads, usually along perimeters of large ranches or refuges. No surveys were conducted further into the interiors of these areas, but it appears likely that distribution is quite widespread and common in appropriate soil types, especially in the gulf prairies of the Coastal Bend. No plants were found in cultivated or fallow crop land, and only rarely in areas which have undergone severe disturbance (particularly root plowing) of the top soil.

At one site (San Patricio County Road 96), fruit capsules were present on 15 March 1999 and on 01 March the following year. Fruit were also present until late December in all years of the study. Thus, *C. drummondii* can provide early season oviposition sites for boll weevil about 45 days prior to availability of cotton squares susceptible for oviposition, and flower buds and fruit capsules of *C. drummondii* can be available for about four months after cotton stalk destruction deadlines. Reproductive growth of *C. drummondii* was greatly influenced by soil moisture and was highest during early spring and early fall precipitation periods (Figure 2). Drought conditions during summer and early fall caused near cessation in reproductive growth. This low reproductive growth period occurs when boll weevil captures are highest. During 1997-1999, no buds or capsules from the WWFR plots were found to be infested by boll weevil, and only one adult weevil (1998) was encountered on sampled plants.

In 1999, weevil infestation (eggs and/or larvae) was detected at only 2 of 5 rangeland/brush sites sampled in San Patricio and Aransas counties. Table 1 indicates only those dates for which infestations were encountered at Taft and Gregory. Percent infestation was very low (0 to 5.6 %), similar to that reported for 1998 (see Coleman *et al*. 1999). However, in 1999, infestation was also detected prior to, during, and after the cotton season, while in 1998, infestation was observed only in November and December. In 2000, weevil infestation was detected at 3 of 5 sites in San Patricio and Aransas counties. Only dates for which infestations were positive are indicated in Table 2. Again, percent infestation was very low with the highest recorded being 4.6%. All infestation detected was during the cotton growing season, however, the two dates reported for July at the Reynolds site occurred at the time of cotton cutout and probably resulted from weevils migrating from cotton.

In 1999, at the small field plot established in Weslaco, Hidalgo county, natural infestation occurred from June until December (Table 3) and was recorded during all sample collection dates. In the Lower Rio Grande Valley (LRGV), F_2 weevil migration from cotton usually starts about the first week in June, so it is likely that the source of weevils infesting this *C. drummondii* field plot was from nearby cotton fields. Infestation in Hidalgo county was much higher than that recorded for San Patricio and Aransas counties in the Coastal Bend. This is to be expected as weevils have been greatly suppressed by the Texas Boll Weevil Eradication program in the Coastal Bend whereas no eradication program is being conducted in the LRGV.

The mean longevity and number of days of oviposition under laboratory conditions of female weevils from four sources provided only with flower buds and seed capsules of *C. drummondii* for food and oviposition is shown in Table 4. Females obtained from field collections of infested cotton squares lived an average of 59.2 days and oviposited an average of 16.6 days when provided only *C. drummondii*. Longevity and number of oviposition days of females obtained from pheromone traps was about half that of females eclosing from field collected squares. Females obtained from infested *C. drummondii* fruit forms (either as F_1 or F_2) generally lived less and oviposited for fewer days than weevils from the other two sources. This is probably indicative of the decreased host suitability of *C. drummondii* as compared to cotton.

Results for life table analyses of all pooled boll weevil cohorts in the outdoor screenhouse show that weevil survival from egg to adult in the *C. drummondii* plots was 25.0 percent while that in the cotton plots was 69.6 percent (Table 5). Egg mortality was 27.4 and 3.6 percent in *C. drummondii* and cotton fruit structures, respectively. The higher mortality for eggs in *C. drummondii* may be attributable to selection of nearly mature capsules by boll weevil for oviposition. In both hosts, the highest mortality occurred during the 3rd instar, with the tropical fire ant, *Solenopsis geminata*, the major cause. Apparent mortality during this stage was 55.8 and 27.1 percent in *C. drummondii* and cotton, respectively. Third instar indispensable mortality (Ind_x) [defined as that part of the generation mortality that would not occur, should the mortality factors involved (ants, parasitism, or desiccation/thermal death) be removed from the life system] was 31.5 and 25.8 percent in *C. drummondii* and cotton, respectively. Though weevil survival from egg to adult in *C. drummondii* was only about 1/3 that recorded in cotton, these data indicate that this host plant is capable of producing, if only intermittently, low level populations of boll weevils that could potentially infest cotton.

In summary, we found that *C. drummondii* can provide oviposition sites for boll weevil from early March through December. Cotton, in compliance with planting and stalk destruction deadlines, typically provides reproductive sites only from about mid-April to mid-September. The degree of boll weevil infestation varied between field sites and years. Laboratory results indicate that boll weevil can become reproductive on *C. drummondii* without feeding on cotton pollen. Populational increment of boll weevil on *C. drummondii* is unlikely, if not impossible most years, due to the host's fruiting phenology; however, there are windows for infestation, generally early and late, that could act as bridging or sustainable populations when cotton is not available as a host. *Cienfuegosia drummondii* obviously represents a potential resource for reproducing weevils, but the value of this species in population recruitment and survival of boll weevil requires more study.

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Table 1. Percent infestation of flower buds and seed capsules of *Cienfuegosia drummondii* by boll weevil for selected dates in 1999 near Taft and Gregory in San Patricio, Co.

Date	Flower buds	Seed capsules	Combined forms	No. forms inspected
01/08	0.0	5.6	1.0	100
05/06	4.3	1.2	1.9	108
07/15	0.0	0.2	0.1	769
10/13	3.9	0.0	2.4	84

Table 2. Percent infestation of flower buds and seed capsules of *Cienfuegosia drummondii* by boll weevil for selected dates in 2000 in San Patricio, Co.

Date	Site	Flower buds	Seed capsules	Combined forms	No. forms inspected
04/27	Gregory	0.8	0.6	0.6	1290
05/04	Gregory	0.0	0.3	0.3	674
05/12	Gregory	4.3	0.2	0.6	871
05/25	Gregory	1.3	0.0	0.5	196
06/01	Taft	0.0	0.3	0.2	408
06/08	Taft	2.8	0.0	0.3	366
07/06	Reynolds	4.0	4.6	4.3	373
07/12	Reynolds	0.6	1.0	0.8	370

Table 3. Percent infestation of flower buds and seed capsules of *Cienfuegosia drummondii* by boll weevil in 1999 at Weslaco, Hidalgo Co.

Date	Flower buds	Seed capsules	Combined forms	No. forms inspected
06/09	0.0	0.0	0.0	241
06/23	23.8	6.4	11.9	478
06/30	33.9	7.6	30.4	984
07/07	22.4	10.7	19.2	203
07/14	12.0	12.2	12.0	415
07/28	22.2	23.0	22.4	245
08/04	23.7	27.3	24.4	119
08/25	31.9	23.1	29.2	130
09/01	23.4	17.8	21.1	289
09/08	23.0	12.3	18.3	131
09/15	40.5	20.0	33.3	57
09/22	23.4	20.0	21.5	144
09/29	35.7	37.0	36.6	101
10/06	14.6	32.3	25.2	103
10/13	9.4	6.0	6.7	165
10/27	3.2	10.0	6.6	61
11/17	9.4	0.0	3.9	77
12/01	7.1	7.1	7.1	28

Table 4. Mean longevity and number of days of oviposition under laboratory conditions of female weevils from four sources provided only with flower buds and seed capsules of *Cienfuegosia drummondii* for food and oviposition.

Weevil Source (n)	Longevity (d)	Oviposition Days
Pheromone traps (37)	33.5 ± 27.9	8.1 ± 9.5
Cotton squares (26)	59.2 ± 26.6	16.6 ± 10.0
Cienfuegosia F_1 (48)	23.9 ± 9.4	6.9 ± 6.0
Cienfuegosia F_2 (12)	29.1 ± 13.2	2.0 ± 1.4

Table 5. Life table analysis from pooled boll weevil cohorts in screenhouse study. For cotton, n=138; *C. drummondii*, n=84.

	l_x %		q_x %		Ind_x %	
Stage x	Cotton	C.d.	Cotton	C.d.	Cotton	C.d.
Egg	100.0	100.0	3.6	27.4	2.6	9.4
Instar 1	96.4	72.6	0.0	6.6	0.0	1.8
Instar 2	96.4	67.9	0.0	8.8	0.0	2.4
Instar 3	96.4	61.9	27.1	55.8	25.8	31.5
Pupa	70.3	27.4	1.0	8.7	0.7	2.4
Adult	69.6	25.0	-	-	-	-

l_x is survival from egg to stage x.
q_x is mortality occurring during stage x.
Ind_x is indispensable mortality occurring during stage x.
C.d. is *Cienfuegosia drummondii*

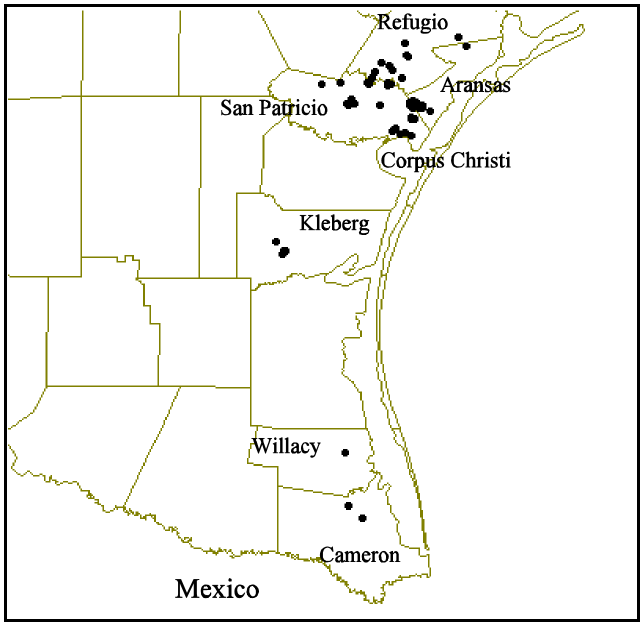

Figure 1. Locations (denoted by black dots) of *C. drummondii* populations in the South Texas counties of Cameron, Willacy, Kleberg, San Patricio, Aransas, and Refugio.

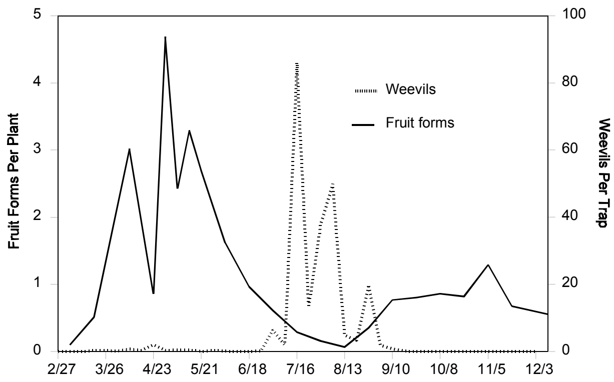

Figure 2. Seasonal phenology of *Cienfuegosia drummondii* reproductive growth and boll weevil captures at Welder Wildlife Refuge averaged for the years 1997-1999.