United States Department of Agriculture

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FINAL STUDY REPORT
Lockeford Plant Materials Center
Lockeford, California

Milkweed Establishment in California's Central Valley: III. Comparison of *Asclepias eriocarpa, Asclepias fascicularis,* and *Asclepias speciosa* by Transplants

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ABSTRACT

Viable populations of milkweed species in California are important breeding sites for monarch butterflies. Milkweeds are herbaceous perennials and the Xerces Society observed poor survival of milkweed transplants in plantings. The objective of this replicated study was to compare establishment of three species of milkweed: woollypod milkweed, (*Asclepias eriocarpa)*, narrow-leaf milkweed (*Asclepias fascicularis*), and showy milkweed (*Asclepias speciosa*), from transplants at three planting dates. The planting site at the Lockeford Plant Materials Center was solarized in the summer of 2017. The study was a randomized block design with four replications. Transplants were planted in a single row of 12 plants in each block at a 12-inch spacing on October 24, 2017, March 26 and May 16, 2018. Evaluations were conducted during 2018 and 2019 for emergence and survival, plant height, disease resistance and insect resistance. The fall transplanted narrowleaf milkweed and late spring transplanted showy milkweed had good survival compared to fall transplanted woollypod milkweed. In 2019, shoot emergence of showy milkweed weed was first to appear with fair to moderate emergence. Narrowleaf milkweed emerged in late June and had poor to fair survival rates compared to woollypod milkweed and showy milkweed. By late July 2019, fall transplanted showy milkweed was the tallest and had the highest survival rates across all transplanted plots.

INTRODUCTION

Milkweed species are the primary larval host for the caterpillars of monarch butterflies (*Danaus plexippus*) which are critically endangered (Pelton et al., 2019). Western populations of the monarch butterflies overwinter on the California Coast and in recent years have seen a catastrophic decline (Pelton, 2017; Xerces Society, 2020). The Xerces Society organizes annual Thanksgiving counts in the overwintering groves and in 2018, less than 30,000 butterflies were counted, a 99% drop since 1997 (Pelton et al., 2019). Conservation of the monarch butterfly requires milkweed plants for the butterflies to lay their eggs on throughout their breeding range, as they set out from the California coast each spring on their annual migration, There are numerous, overlapping generations of monarch butterflies each year as they complete their migration throughout California, into Nevada and Idaho, returning to their overwintering sites along the California Coast late in the fall (Borders, 2012).

The migratory route for monarch butterflies leads across California's Central Valley. This area is very fertile and intensively farmed resulting in massive loss of native habitat, including

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milkweeds, to cultivation, herbicides and insecticides (Halsch et al., 2020; Pleasants and Oberhauser, 2012). A year-round population model showed that losses to breeding sites had four times the impact of loss as did the loss of overwintering sites (Flockhart et al., 2015). The historic importance of California's Central Valley milkweed populations for egg laying and successful survival of monarch populations has only recently been realized (Espeset et al., 2016).

Increased milkweed plantings are vital for monarch butterfly survival and the Xerces Society includes milkweed species in their hedgerow and pollinator plantings (Borders and Lee-Mader, 2014). Observations by the Xerces Society of California pollinator plantings indicated that milkweed transplants were less likely to establish than other pollinator plants and milkweed transplants in other regions (Borders and Lee-Mader, 2014). Late fall is considered the optimum time to plant hedgerow and pollinator plantings in California's Mediterranean climate. However, dormant milkweed transplants planted in the late fall grew poorly in Xerces' previous plantings.

Milkweed species are herbaceous perennials in the *Asclepiadaceae* (Milkweed) family. New shoots emerge each spring from underground rhizomes, and dieback each fall (Rosatti and Hoffman, 2017). This study focused on three common species: woollypod milkweed*),* narrow leaved milkweed*),* and showy milkweed. Descriptions of these species and their distribution are available from multiple sources (Borders, 2012; Bullard, et al., 2020; Rosatti and Hoffman, 2017). Transplants of all three species are propagated from seed (Bartow, 2006; Leigh et al., 2006 a and b; Skinner, 2008 and Tilley, 2016). In California, all three species are commercially available in nurseries. In this study, the transplants were provided by Hedgerow Farms (Winters, CA).

The objective of this study was to compare transplant establishment for three milkweed species woollypod milkweed, narrow leaved milkweed, and showy milkweed planted at three different times of year (fall, early spring, and late spring).

MATERIALS AND METHODS

The milkweed establishment trial was conducted over two years (2017-2019) at the Lockeford Plant Materials Center (CAPMC). The CAPMC is located on the eastern side of the San Joaquin Valley in central California and sits on a historical flood plain on the west bank of the Mokelumne River. The soil series is a Columbia fine sandy loam on 0 to 2 percent slopes. It is a very deep, well-drained soil with pH ranging from moderately acid to slightly alkaline. The mean annual maximum temperature in this area is 73.6°F and minimum temperature is 46°F (WRCC, 2018). The mean annual precipitation is 17.24 inches, mainly occurring between the months of December and March (WRCC, 2018). Precipitation totals were just below average (16.8 inches) between September 1, 2017 and August 1, 2018 and were above average (24 inches) between September 1, 2018 and August 1, 2019 shown in Figure 1 (WWG, 2019).

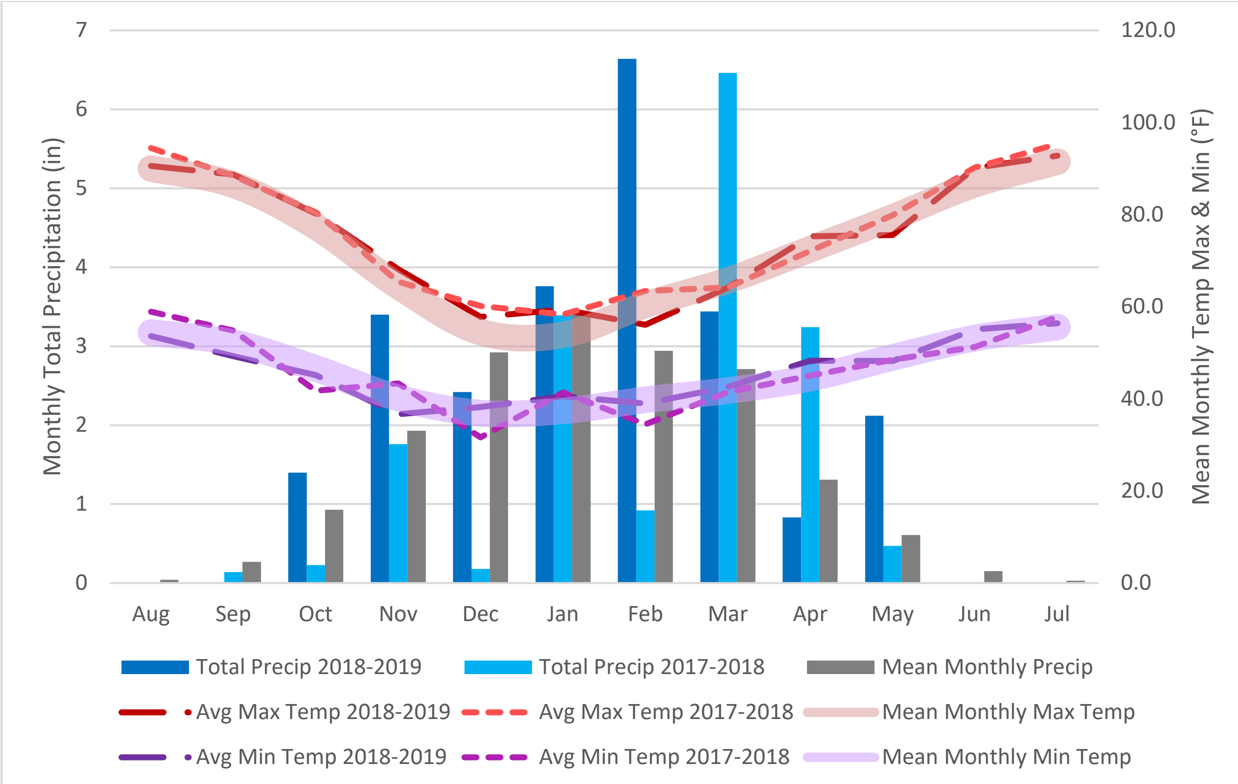

Figure 1. Mean minimum and maximum temperatures in the 2017/2018 and 2018/2019 growing seasons generally followed annual averages. Total precipitation was just below average in 2017/2018 and above average in 2018/2019. Monthly weather data from September through August was provided from Western Weather Group Lockeford Weather Station located directly across the river from the CAPMC. Average weather summaries from 1893-2015 for the Lodi area were provided from Western Regional Climate Center.

Site Preparation

Site preparation began in June 2017. Weeds and remaining residue from the previous fall planted cover crop were disked. The area was chisel plowed and cultipacked to prepare a firm seed bed and smooth solarization surface. Sprinkler handlines were laid to provide adequate soil moisture prior to solarization. The UV-treated, 4 mm plastic was installed in June for maximum solar incidence for weed control. The solarization treatment effectiveness was marginal as nutsedge (*Cyperus spp*.) was growing under the plastic. Nutsedge was dug up and removed prior to planting and additional harrowing and cultipacking was also required to control the germinating weeds prior to planting the milkweed trial. Recycled solarization plastic was used for this project resulting in patching together multiple small pieces of plastic which may have decreased the efficacy of this usually effective site preparation method.

Planting Materials

Milkweed transplants were provided by Hedgerow Farms (Winters, CA) for all three species evaluated. Transplants for early fall, early spring and late spring plantings distributed by Hedgerow Farms were propagated by Valley Transplant Nursery (Acampo, CA).


Figure 2. Fall transplant tray with woollypod (left), narrow-leaf (center), and showy milkweed (right) plugs.

Experimental Design
The experimental design was Randomized Complete Block Design with four replications. The blocks were oriented to remove variation due to a slight moisture and soil texture gradient.

Transplant Establishment
The study also evaluated the success of transplants established at three different planting times. Transplants were in a single row for each planting date with 12 well rooted, 1-inch x 1-inch x 2.5-inch plug transplants for each unit, planted at a 12-inch spacing (Figure 2).
Planting times were:

1. Transplant planting mid-fall (October 25, 2017, prior to plant dormancy).
2. Transplant planting in early spring (March 26, 2018, dormancy). Woollypod milkweed transplants were not available for this planting time.
3. Transplant planting in late spring (May15, 2018, after plants break dormancy).

Irrigation
Drip irrigation was applied for milkweed establishment during the first year of the study. Each transplant row had a drip line, with a milkweed at each emitter. Irrigation sets were run at the time of planting the transplants (October, March and May), as well as once in June and once in July.

Weed Control
Weed control during the first year was primarily hand hoeing. This technique was extremely time consuming. The transplants were small, fragile, and looked similar to hairy fleabane (*Conyza (Erigeron) bonariensis* and horseweed (*C. canadensis* two very common wind dispersed weeds in the Central Valley (Calflora, 2020; DiTomaso and Healy, 2007). To control weeds, a broad-spectrum herbicide was applied in the spring of 2018 (prior to planting the transplants) and

in the winter while the fall planted milkweeds were dormant. A pre-emergent herbicide was applied in winter of 2019.

Evaluations
Several evaluations were collected during the 2018 and 2019 growing seasons following National Plant Materials Center protocols, including: Emergence/survival, plant height, disease resistance and insect resistance.

Emergence/survival was defined as how well the species emerged after dormancy and how well it survived over the summer. Emergence/survival was visually evaluated every 7 days during the initial emergence/transplant period and then every 14 days over the summer. Emergence/survival was rated on a 0 - 4 scale, where 0 = poor (<25% emergence/survival), 1 = fair (30 – 45% emergence/survival), 2 = moderate (50 - 65% emergence/survival), 3 = good (70 - 80% emergence/survival), and 4 = excellent (90 - 100% emergence/survival). Plant height was defined as the average height of lush canopy growth. Plant height was collected in inches from the base of the plant to the top of the inflorescence every 30 days from three random locations within each plot. Disease and insect resistance were visual estimates of foliar diseases and insect damage. Plots were rated every 14 days on a 0 - 5 scale, where 0 = no damage and 5 = severe damage.

Statistical Analysis
Statistical analysis was completed on the evaluations collected from the 2018 and 2019 growing seasons using Statistix 10 (Analytical Software, Tallahassee, FL). Ordinal data (Emergence/survival and diseases and insect resistance) was analyzed using Kruskal-Wallis one-way analysis of variance (AOV) and Dunn's All-Pairwise Comparisons Test to separate means at the 5% level. Analysis was done on quantitative plant measurements (plant height) using the analysis of variance (AOV) procedure for a randomized complete block design (RCBD) along with Tukey's 1 Degree of Freedom test for non-additivity. Values that were not normally distributed were transformed using logarithmic expression. Significant means were separated with Tukey's Honestly Significant Difference (HSD) All-Pairwise Comparisons Test at the 5% level.

RESULTS AND DISCUSSION

Three milkweed species were evaluated throughout the 2018 and 2019 growing seasons for emergence and survival, height, and disease and insect resistance.

The fall transplanted milkweed species were evaluated starting in late March 2018 for emergence and survival. Early and late spring transplants were evaluated for survival after their transplant dates. By early June, there were significant differences between survival rates across species and transplanting dates. The fall transplanted narrow leaf milkweed and late spring transplanted showy milkweed had significantly higher survival rates (excellent survival) than fall transplanted woollypod milkweed (poor survival) (Table 1). By mid-September 2018, late spring transplanted showy milkweed still had excellent survival rates. In 2019, shoot emergence evaluations started in early April. All three transplant dates of showy milkweed were the first to appear with fair to moderate emergence (Table 2). By early May 2019, all other species and transplant dates had emerged, except for the late spring narrow leaf milkweed transplants, which did not emerge until late June and had only poor to fair survival rates. In late July 2019, fall transplanted showy milkweed had the highest survival rates across all transplanted plots (good survival) and significantly higher survival rates than the late spring narrow leaf milkweed transplants (poor to fair survival).

Throughout the 2018 growing season, the late spring transplanted woollypod milkweed was significantly shorter in height across all plots (Table 3 and Figure 3). From June to early July 2018, fall transplanted narrow leaf milkweed was tallest in height, at 13.7 inches. Unfortunately, due to a weed identification error, some of the fall transplanted narrow leaf milkweed plots were cut in mid-July, causing the fall transplanted showy milkweed to be the tallest in height. By mid-September 2018, fall planted showy milkweed was 19 inches tall, while fall planted woollypod milkweed was significantly shorter, at 11 inches. In 2019, showy milkweed was significantly taller than narrow leaf milkweed and the woollypod milkweed transplants (Table 4 and Figure 4). Early and late spring transplanted narrow leaf milkweed did not start emerging until May and late June, respectively. Numerical trends show that fall transplanted showy milkweed stood the tallest in height throughout the 2019 growing season.

Insect damage was not detected until mid-July in 2018. Insect damage on the milkweed transplants was from oleander aphid infestations. There were no significant differences in insect resistance between plots. By early August, all transplant plots had slight insect damage and by mid-September all plots showed moderately severe to severe insect damage. Disease, in the form of black sooty mold, appeared due to the large amounts of sticky honeydew produced by the aphids. Disease first appeared in mid-June in 2018 in early spring and late spring transplants. Disease damage was significantly higher on late spring transplanted narrow leaf milkweed (moderate damage) than on early spring transplanted showy milkweed (none to slight damage) and all three fall transplanted species (no damage) from mid-June to mid-August 2018 (Table 5). From late August to mid-September, there were no significant differences in disease resistance and all transplant plots had moderately severe to severe disease damage.

In 2019, insect damage was detected in late June with slight damage on almost all plots. No significant differences were seen in insect damage throughout the year. However, numerical trends show that late spring transplanted narrow leaf milkweed had only slight insect damage compared to all the other transplant plots with moderate insect damage from late July to mid-September. Disease damage appeared on the transplant plots in mid-July, 2019. Fall and early spring transplanted showy milkweed had significantly lower disease damage (none to slight) than fall transplanted narrow leaf milkweed (moderate damage) from mid-June until mid-August. By late August, there were no significant differences and all plots had moderate to moderately severe disease damage.

These results indicate that fall transplanted woollypod milkweed struggles during the first year of establishment but survives into the second year with attention and intensive management. Fall transplanted narrow leaf milkweed does well during the first year of establishment, however, if disease and insect pressure are high, the survival rate will drop dramatically due to its lower pest resistance. Similar to woollypod milkweed, showy milkweed fall transplants are slow to establish but survive to the second growing season. In contrast, late spring planted showy milkweed transplants readily established during the first growing season with irrigation. Once established, the fall and late spring planted showy milkweed plots had higher survival rates and were more insect and disease resistant than the other transplanted milkweed species in this trial. Showy milkweed transplants were also taller in the second year, which can indicate a greater ability to compete with weeds earlier in the growing season. Any control measures used must be non-toxic to monarch butterflies and caterpillars, as well as taking into consideration effects on the many other beneficial insects foraging and sheltering in monarch habitat.

Transplant establishment and survival rates of all three species can be improved with supplemental irrigation and intensive weed management during the first year. Using a pre-emergent herbicide or mulching is highly recommended to cut back on hours of weeding labor. Also, scouting for insect and disease presence early in the growing season is highly recommended.

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Table 1. Emergence/survival evaluations of three transplanted milkweed species planted in fall (October), early spring (March) and late spring (May) at the Lockeford Plant Materials Center, CA 2018.

Transplant Milkweed - 2018 Emergence and Survival Evaluations

Species	Planting Type	Planting Date	Emergence/ Survival[¥]								
			5/24/2018	6/6/2018	6/11/2018	6/18/2017	7/5/2018	8/1/2018	8/15/2018	8/30/2018	9/12/2018
Asclepias eriocarpa	Fall Transplant	10/25/2017	0.5 b	0.5 b	0.8 b	1.5 a[c]	1.5 b	1.3 b	1.3 b	1.5 a	1.5 b
Asclepias fascicularis	Fall Transplant	10/25/2017	4.0 a	4.0 a	4.0 a	4.0 a	3.8 ab	3.5 ab	3.5 ab	3.3 a	3.5 ab
Asclepias speciosa	Fall Transplant	10/25/2017	2.8 ab	3.0 ab	3.3 ab	3.5 a	3.5 ab	3.5 ab	3.3 ab	3.3 a	3.3 ab
Asclepias fascicularis	Early Spring Transplant	3/26/2018	4.0 a	3.8 ab	3.8 ab	3.8 a	3.8 ab	3.5 ab	3.0 ab	3.3 a	3.3 ab
Asclepias speciosa	Early Spring Transplant	3/26/2018	3.5 ab	3.5 ab	3.5 ab	3.5 a	3.5 ab	3.5 ab	3.3 ab	3.3 a	3.0 ab
Asclepias eriocarpa	Late Spring Transplant	5/15/2018	3.3 ab	2.5 ab	2.0 ab	1.9 a	2.6 ab	2.5 ab	2.5 ab	2.5 a	2.3 ab
Asclepias fascicularis	Late Spring Transplant	5/15/2018	4.0 a	3.5 ab	3.3 ab	3.8 a	4.0 a	3.0 ab	2.8 ab	3.0 a	2.8 ab
Asclepias speciosa	Late Spring Transplant	5/15/2018	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a
Mean			3.3	3.0	2.9	3.1	3.3	3.0	2.9	2.9	2.9
SD[#]			1.2	1.3	1.5	1.3	1.2	1.2	1.2	1.2	1.2

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at $P < 0.05$.

[c]There were significant differences in ranks between cultivars according to Kruskal-Wallis one-way analysis of variance, but no separation of the ranks was achieved with Dunn's all pairwise comparison test.

[¥]Emergence/Survival rated on the following scale: 0=poor (<25% germination), 1=fair (30-45%), 2=moderate (50-65%), 3=good (70-85%), 4=excellent (90-100%).

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Table 2. Emergence/survival evaluations of three transplanted milkweed species in fall (October), early spring (March) and late spring (May) at the Lockeford Plant Materials Center, CA 2019.

Transplant Milkweed - 2019 Emergence and Survival Evaluations												
Species	Planting Type	Planting Date	Emergence/ Survival[¥]									
			4/5/2019	4/12/2019	5/10/2019	5/23/2019	6/20/2019	6/27/2019	7/8/2019	7/30/2019	8/16/2019	9/19/2019
Asclepias eriocarpa	Fall Transplant	10/25/2017	0.0 b	0.0 a	0.3 a	0.5 ab	0.5 bc	0.8 ab	1.3 a[c]	1.0 ab	1.0 a[c]	1.0 a[c]
Asclepias fascicularis	Fall Transplant	10/25/2017	0.0 b	0.0 a	0.3 a	0.8 ab	2.5 abc	2.3 ab	2.0 a	2.0 ab	1.0 a	1.0 a
Asclepias speciosa	Fall Transplant	10/25/2017	1.8 a	2.5 a	3.5 a	3.3 ab	3.5 ab	3.5 a	3.5 a	3.0 a	2.5 a	2.5 a
Asclepias fascicularis	Early Spring Transplant	3/26/2018	0.0 b	0.0 a	0.3 a	0.5 ab	1.8 abc	2.3 ab	2.3 a	1.8 ab	0.0 a	0.0 a
Asclepias speciosa	Early Spring Transplant	3/26/2018	0.8 ab	1.0 a	2.5 a	2.8 ab	3.0 abc	3.0 ab	3.3 a	2.8 ab	2.5 a	2.5 a
Asclepias eriocarpa	Late Spring Transplant	5/15/2018	0.0 b	0.0 a	0.1 a	0.3 b	1.3 abc	1.1 ab	1.1 a	1.0 ab	0.8 a	0.8 a
Asclepias fascicularis	Late Spring Transplant	5/15/2018	0.0 b	0.0 a	0.0 a	0.0 b	0.3 c	0.5 b	0.5 a	0.5 b	0.0 a	0.0 a
Asclepias speciosa	Late Spring Transplant	5/15/2018	0.8 ab	1.8 a	3.8 a	3.8 a	3.8 a	3.3 ab	3.5 a	2.8 ab	2.5 a	2.5 a
Mean			0.4	0.6	1.2	1.3	2.0	1.9	2.1	1.7	1.2	1.2
SD[#]			0.8	1.0	1.6	1.5	1.4	1.4	1.3	1.2	1.2	1.2

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at $P<0.05$.

[c]There were significant differences in ranks between cultivars according to Kruskal-Wallis one-way analysis of variance, but no separation of the ranks was achieved with Dunn’s all pairwise comparison test.

[¥]Emergence/Survival rated on the following scale: 0=poor (<25% germination), 1=fair (30-45%), 2=moderate (50-65%), 3=good (70-85%), 4=excellent (90-100%).

Table 3. Height measurements of three transplanted milkweed species collected in fall (October), early spring (March) and late spring (May) at the Lockeford Plant Materials Center, CA 2018.

Transplant Milkweed - 2018 Height Evaluations

Species	Planting Type	Planting Date	Height (inches)					
			5/24/2018	6/18/2017	7/5/2018	7/16/2018	8/15/2018	9/12/2018
Asclepias eriocarpa	Fall Transplant	10/25/2017	2.8 ab	2.9 de	4.0 de	4.7 cd	9.3 bc	11.0 c
Asclepias fascicularis	Fall Transplant	10/25/2017	4.5 a	8.3 a	13.7 a	N/A -	14.3 ab	17.2 ab
Asclepias speciosa	Fall Transplant	10/25/2017	4.0 a	6.1 b	10.5 ab	12.7 a	18.0 a	19.0 a
Asclepias fascicularis	Early Spring Transplant	3/26/2018	2.9 ab	5.1 bc	8.1 bc	9.3 ab	13.3 ab	13.1 bc
Asclepias speciosa	Early Spring Transplant	3/26/2018	3.5 a	5.6 bc	9.0 bc	10.3 ab	13.1 ab	13.3 bc
Asclepias eriocarpa	Late Spring Transplant	5/15/2018	1.8 b	2.0 e	1.8 e	2.5 d	4.4 c	5.8 d
Asclepias fascicularis	Late Spring Transplant	5/15/2018	3.0 ab	3.8 cd	4.3 de	5.5 cd	9.7 bc	9.2 cd
Asclepias speciosa	Late Spring Transplant	5/15/2018	4.3 a	4.8 bcd	6.3 cd	8.0 bc	8.9 bc	10.7 cd
Mean			3.2	4.5	6.6	6.9	10.6	11.7
SD#			1.2	2.1	4.2	4.2	5.3	5.2

#Standard deviation

*Means in columns followed by the same letters are not significantly different at *P* <0.05.

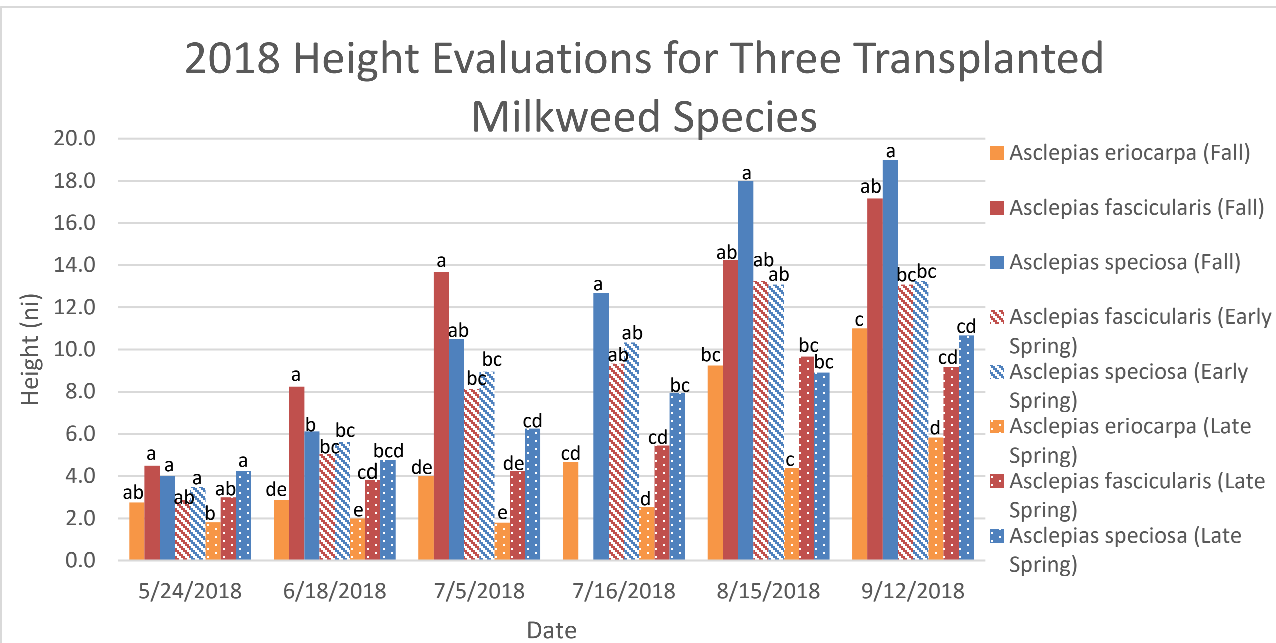

Figure 3. Differences in height across woollypod milkweed (*Asclepias eriocarpa*), narrow leaved milkweed (*Asclepias fascicularis*), and showy milkweed (*Asclepious speciosa)* transplants in 2018. The late spring woollypod milkweed were significantly shorter than all other transplants throughout the 2018 growing season using Tukey's HSD at the 5% level. Columns with the same letters are not significantly different at *P*<0.05.

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Table 4. Height measurements of three transplanted milkweed species collected in fall (October), early spring (March) and late spring (May) at the Lockeford Plant Materials Center, CA 2019.

Transplant Milkweed - 2019 Height Evaluations							
Species	Planting Type	Planting Date	Height (inches)				
			4/25/2019	5/23/2019	6/27/2019	7/23/2019	8/23/2019
Asclepias eriocarpa	Fall Transplant	10/25/2017	4.3 bc	4.9 cd	11.3 bc	12.5 bc	10.5 b
Asclepias fascicularis	Fall Transplant	10/25/2017	3.3 c	8.4 bc	17.6 ab	21.0 ab	19.3 ab
Asclepias speciosa	Fall Transplant	10/25/2017	9.4 a	22.1 a	36.9 a	42.2 a	45.3 a
Asclepias fascicularis	Early Spring Transplant	3/26/2018	N/A -	4.4 cd	11.4 bc	12.8 bc	10.4 b
Asclepias speciosa	Early Spring Transplant	3/26/2018	8.3 a	17.1 a	29.8 a	31.8 a	32.4 a
Asclepias eriocarpa	Late Spring Transplant	5/15/2018	1.7 c	2.6 d	6.9 c	8.9 c	7.8 b
Asclepias fascicularis	Late Spring Transplant	5/15/2018	N/A -	N/A -	5.8 c	7.0 c	10.6 b
Asclepias speciosa	Late Spring Transplant	5/15/2018	6.7 ab	15.9 ab	29.5 a	28.2 a	34.5 a
Mean			5.8	9.8	18.3	20.3	21.1
Std. dev[#]			3.3	7.9	12.2	12.9	15.0

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at $P<0.05$.

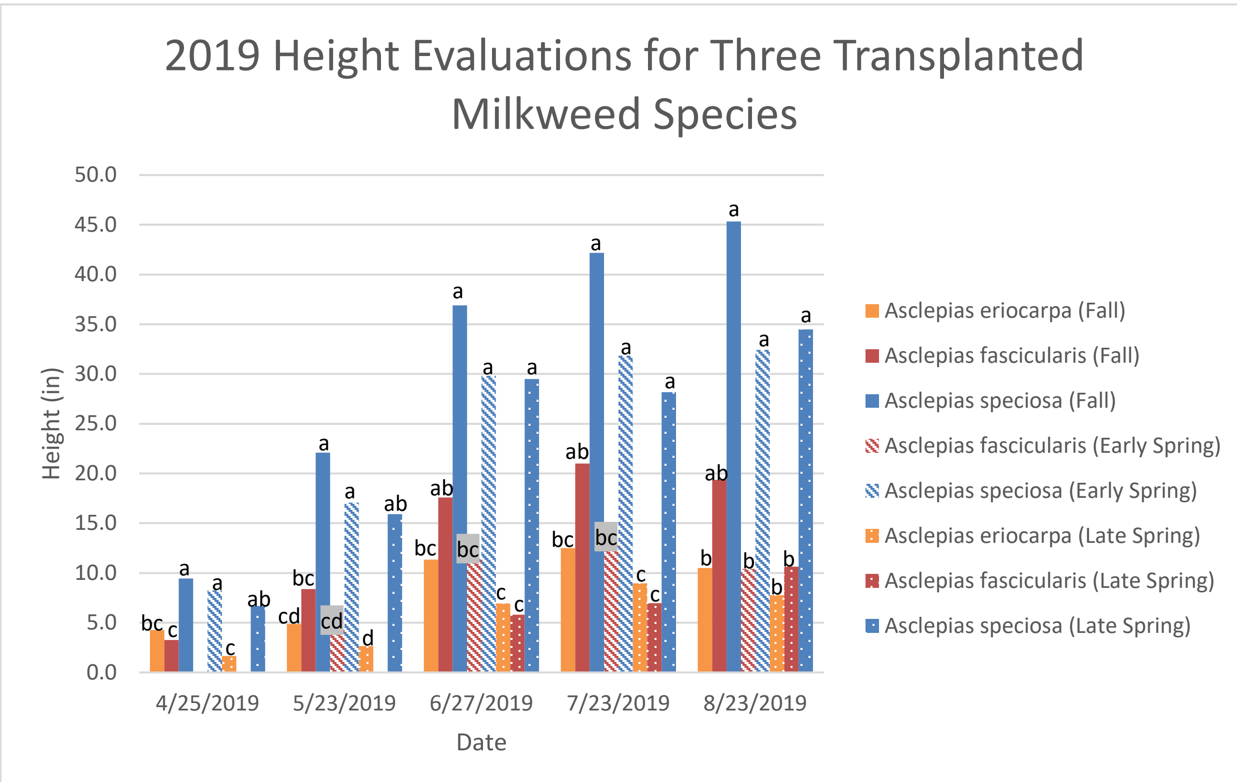

Figure 4. Differences in height across woollypod milkweed (*Asclepias eriocarpa*), narrow leaved milkweed (*Asclepias fascicularis*), and showy milkweed (*Asclepious speciosa)* transplants in 2019. The fall transplanted showy milkweed were numerically taller than all other transplants throughout the 2019 growing season. Columns with the same letters are not significantly different at $P<0.05$.

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Table 5. Disease and insect evaluations of three transplanted milkweed species in fall (October), early spring (March) and late spring (May) at the Lockeford Plant Materials Center, CA 2018.

Transplant Milkweed - 2018 Disease and Insect Evaluations

Species	Planting Type	Planting Date	Disease Resistance[£]						Insect Resistance[£]				
			6/18/2018	7/5/2018	8/1/2018	8/15/2018	8/30/2018	9/12/2018	7/16/2018	8/1/2018	8/15/2018	8/30/2018	9/12/2018
Asclepias eriocarpa	Fall Transplant	10/25/2017	0.0 b	0.0 b	0.0 b	0.5 ab	3.3 a	3.8 a	0.0 a	0.3 a	2.0 a	3.5 a	4.3 a
Asclepias fascicularis	Fall Transplant	10/25/2017	0.0 b	0.5 ab	0.0 b	0.0 b	2.8 a	3.8 a	N/A a	0.0 a	1.5 a	4.0 a	4.8 a
Asclepias speciosa	Fall Transplant	10/25/2017	0.0 b	0.0 b	0.0 b	0.0 b	3.0 a	4.0 a	0.0 a	1.0 a	2.0 a	3.3 a	4.5 a
Asclepias fascicularis	Early Spring Transplant	3/26/2018	1.5 ab	1.0 ab	1.0 ab	2.3 ab	4.0 a	4.8 a	0.0 a	1.0 a	3.3 a	4.0 a	5.0 a
Asclepias speciosa	Early Spring Transplant	3/26/2018	0.3 b	0.5 ab	0.0 b	0.0 b	2.8 a	4.0 a	0.3 a	0.8 a	2.3 a	3.5 a	4.5 a
Asclepias eriocarpa	Late Spring Transplant	5/15/2018	1.6 ab	0.8 ab	0.8 ab	1.1 ab	3.1 a	3.4 a	0.4 a	0.9 a	2.1 a	3.3 a	3.8 a
Asclepias fascicularis	Late Spring Transplant	5/15/2018	3.0 a	2.0 a	2.3 a	2.8 a	4.0 a	5.0 a	0.5 a	1.3 a	2.8 a	4.5 a	5.0 a
Asclepias speciosa	Late Spring Transplant	5/15/2018	1.5 ab	0.3 b	0.0 b	0.0 b	2.3 a	3.5 a	1.3 a	1.5 a	2.5 a	3.5 a	4.5 a
Mean			1.1	0.6	0.5	0.9	3.1	3.9	0.3	0.8	2.3	3.6	4.4
SD[#]			1.1	0.7	0.8	1.2	1.0	1.0	0.8	0.7	0.9	0.7	0.9

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at *P* <0.05.

[£]Disease/Insect Resistance rated on the following scale: 0=no damage, 1=slight damage, 3=moderate damage, 5=severe damage.

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Table 6. Disease and insect evaluations of three transplanted milkweed species in fall (October), early spring (March) and late spring (May) at the Lockeford Plant Materials Center, CA 2019.

Transplant Milkweed - 2019 Disease and Insect Evaluations

Species	Planting Type	Planting Date	Disease Resistance£					Insect Resistance£					
			6/27/2019	7/8/2019	7/16/2019	8/16/2019	9/19/2019	6/27/2019	7/8/2019	7/16/2019	7/30/2019	8/16/2019	9/19/2019
Asclepias eriocarpa	Fall Transplant	10/25/2017	0.0 a	1.0 a	1.5 ab	4.0 ab	4.0 a	0.8 a	1.3 a	2.5 a	2.8 a	3.3 a	3.0 a
Asclepias fascicularis	Fall Transplant	10/25/2017	1.8 a	1.3 a	2.8 a	4.8 a	3.0 a	1.8 a	2.3 a	2.8 a	2.8 a	3.0 a	3.0 a
Asclepias speciosa	Fall Transplant	10/25/2017	0.0 a	0.0 a	0.5 b	2.8 b	3.5 a	0.0 a	0.8 a	1.5 a	2.8 a	3.0 a	3.0 a
Asclepias fascicularis	Early Spring Transplant	3/26/2018	1.8 a	1.3 a	2.8 a	4.5 ab	3.3 a	1.8 a	2.3 a	2.8 a	3.0 a	3.0 a	3.5 a
Asclepias speciosa	Early Spring Transplant	3/26/2018	0.0 a	0.0 a	1.0 ab	3.3 ab	3.8 a	0.3 a	1.5 a	2.0 a	3.0 a	3.3 a	3.8 a
Asclepias eriocarpa	Late Spring Transplant	5/15/2018	0.0 a	0.5 a	1.5 ab	3.7 ab	3.7 a	0.8 a	1.5 a	1.7 a	2.8 a	3.0 a	3.0 a
Asclepias fascicularis	Late Spring Transplant	5/15/2018	1.0 a	0.6 a	1.0 ab	1.2 ab	2.0 a	1.2 a	0.6 a	1.0 a	0.0 a	0.6 a	1.0 a
Asclepias speciosa	Late Spring Transplant	5/15/2018	0.3 a	0.3 a	0.3 b	2.8 b	4.0 a	0.0 a	1.0 a	1.3 a	2.3 a	3.0 a	3.5 a
Mean			0.5	0.6	1.4	3.7	3.5	0.8	1.5	1.9	2.6	3.1	3.3
SD#			0.9	0.7	1.0	0.9	1.0	0.9	0.7	0.8	0.8	0.5	0.7

#Standard deviation

*Means in columns followed by the same letters are not significantly different at $P<0.05$.

£Disease/Insect Resistance rated on the following scale: 0=no damage, 1=slight damage, 3=moderate damage, 5=severe damage.

Figure 5. Woollypod milkweed fall transplant, August 2018.

Figure 6. Woollypod milkweed fall transplant plot, May 2019.

Figure 7. Narrow leaf milkweed fall transplant, August 2018.

Figure 8. Narrow leaf milkweed fall transplant plot, May 2019.

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Figure 9. Showy milkweed fall transplant, August 2018.


Figure 10. Showy milkweed fall transplant plot, May 2019.

CONCLUSION

Two years of evaluations of three milkweed species transplanted at three different times of year indicate that transplanting establishment and success is more dependent on species and site preparation than on the planting season. Fall and late spring showy milkweed had higher survival rates and were more insect and disease resistant than the other transplanted milkweed species in this trial. Showy milkweed fall transplants were slow to establish but had good survival rates during the second growing season. With irrigation, the late spring showy milkweed transplants readily established during the first growing season. Their taller stature may also allow them to compete with weeds earlier in the growing season. Woollypod milkweed is difficult to establish in the first year but can rebound with proper management and care. Narrow leaf milkweed establishes relatively quickly during the first year, however, survival rates are dramatically reduced if disease and insect pressure are high.

Milkweed transplant establishment and survival rates can be greatly improved with the addition of supplemental irrigation and intensive weed management during the first year of installation. It is highly recommended that a pre-emergent herbicide or mulching be used to assist in weed control measures. Early scouting for insect and disease is also highly recommended.

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