

Opening a Window on Southwestern Monarchs: Fall Migrant Monarch Butterflies, Danaus plexippus (L.), Tagged Synchronously in Southeastern Arizona Migrate to Overwintering Regions in Either Southern California or Central Mexico

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OPENING A WINDOW ON SOUTHWESTERN MONARCHS: FALL MIGRANT MONARCH BUTTERFLIES, *DANAUS PLEXIPPUS* (L.), TAGGED SYNCHRONOUSLY IN SOUTHEASTERN ARIZONA MIGRATE TO OVERWINTERING REGIONS IN EITHER SOUTHERN CALIFORNIA OR CENTRAL MEXICO

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ABSTRACT. During 2014-16, extensive field studies were conducted on wild migrating monarch butterflies (*Danaus plexippus*) at origin (southeast Arizona) and destination (California) locations. From a total of 3194 monarchs tagged, 44 (1.4%) were recovered at distances from 789 to 1193 km (California) and 1631 to 1736 km (Mexico). Thirty two (1.0%) monarchs were recovered in California and 12 (0.4%) in Mexico. In 2016, the year with the majority of tagged butterflies, 1810 monarchs were tagged and 23 (1.3%) recovered: 14 (0.8%) in California and 7 (0.4%) in Mexico. For the first time wild monarchs tagged in the same location and on the same day, were recovered at overwintering sites in both California and Mexico. This discovery indicates that monarch migration dynamics in the western United States are more complex than previously known and is supportive of a long-held hypothesized connection between eastern and western populations.

Additional key words: Monarch butterfly, MonarchQuestAZ, migration, synchronously tagged monarchs, overwintering regions, concentrated nectar resource areas, *Asclepias subverticillata, Helianthus annuus*

Every fall across much of the North American landscape, monarch butterflies, Danaus plexippus (L.) in the east and west, begin migratory flights to two main overwintering regions in the United States and Mexico (Urquhart & Urquhart 1977, Brower 1995, Howard & Davis 2009). The use of adhesive tags applied to the wings of captured butterflies allows individuals recovered at overwintering destinations to be traced back to a specific tagging locality. Previous and ongoing tagging studies have attempted to track western monarchs through their flyways during both fall migrations and spring remigrations (Nagano et al. 1993, Marriott 1994, Morris et al. 2015, James et al. 2018). Additionally, isotopic analyses of butterflies continue to provide indirect evidence of the origins of both eastern and western monarchs (Yang et al. 2016, Flockhart et al. 2017).

Until recently, the dynamics of monarch migration in southeastern Arizona had been poorly known. Abundant and stable seasonal populations have consistently thrived during mid-to-late summer and throughout the fall (Bailowitz & Brock 1991, Brower & Pyle 2004, Morris et al. 2015). During fall, monarchs in this region enter reproductive diapause and exclusively consume nectar rather than mating prior to their migratory flights (Herman 1981, Brower et al. 2006). As part of the Morris et al. (2015) study I tagged more than 5000 monarchs individually from 2006-2013 resulting in numerous recoveries from both Mexico and California, including the first wild monarchs recovered in California (237V in 2009) and Mexico (157X in 2008) from Arizona (Billings 2008) (Morris et al. 2015, p100, Table 6).

MonarchQuestAZ was established in 2014 and fieldwork commenced with the principal objective of extensive tagging in southeastern Arizona and tracking recoveries in California and Mexico. During the fall seasons of 2014–2018, more than 5200 wild monarchs were tagged. Achieving a better understanding of the unique two-way migratory dynamic and what causes monarchs to fly west-northwest to California or southsoutheast to Mexico, is the main goal of this project. On a larger scale, the factors that might influence migratory direction on the basis of demographic connections between the eastern and western population are also emphasized. This present study describes a novel migratory phenomenon that was recorded during the 2016–17 season.

MATERIALS AND METHODS

Study sites

Monarchs were tagged at six major localities in southeastern Arizona (Table 1, Fig. 4). This corner of the state features rich upper elevation grasslands, lush floodplain habitats and seasonal nectar corridors adjacent to the Santa Cruz and San Pedro River watersheds. These localities account for nearly 95% of all monarchs tagged during the 2014, 2015, and 2016 seasons, and are the origin of all MonarchQuestAZ recoveries. Of these six localities, four (hereafter primary sites) accounted for 89.5% of all monarchs tagged since 2014, and 99.1% of monarchs tagged in 2016 (Table 1, Fig. 4). Three of the four primary sites are major breeding habitats and all are concentrated nectar resource areas. Each is characterized by a unique flora, with a dominant nectar plant species emerging



FIG. 1. Large, dense monarch butterfly cluster on Monterey Cypress, at Lighthouse Field State Beach, Santa Cruz, California

during the migratory period. Primary sites (with nectar plant spp.) include Elgin (Bidens laevis (L.) Britton, Sterns & Poggenb.), Canelo (Carduus nutans (L.) K. Zouhar), Saint David Cienega (Helianthus annuus (L.) and Hereford (H. annuus). All are located in Santa Cruz and Cochise counties. It should be noted that the milkweed host plant (Asclepias subverticillata (L.) A. Gray) also provides ample nectar at three sites during the early portion of the fall season (Fig. 2). These four sites comprise approximately 315 hectares and occur between elevations of 1115-1509 m. The two nonprimary sites in the study area are Marijilda Wash, Pinaleño Mountains (Graham County) and the Lazy J2 Ranch, Santa Rafael Valley (Santa Cruz County) (Table 1, Fig. 4).

Fieldwork

Monarch tagging and recovery occurred during August 2016 through January 2017. Forty-two days (0700–1730 h on average) were spent tagging monarchs in southeastern Arizona (28 Aug-12 Oct) (Table 2). A total of 71 field days were spent in coastal California from Ventura to Santa Cruz, during the tag tracking and recovery season (9 Nov-15 Dec, 24 Dec-26 Jan). The first of these tag-tracking missions began in 2015. It should be noted that all fieldwork methodology and protocols during the 2016 season remained consistent with those of 2014-2015. California's coastal overwintering region served as an effective training ground for developing skills at finding, scanning, and counting monarch clusters at over 75 sites (Nagano & Lane 1985, Lane 1993, Frey 1995, Meade 1999, Leong et al. 2004, Monroe et al. 2014, Pelton et al. 2016). All tag recoveries from the overwintering sanctuaries in Mexico were reported by third-party collectors purchasing tags, from the United States (Wikle 2016).



FIG. 2. Lush patch of the predominant host milkweed species in southeast Arizona, Asclepias subverticillata; shown here at Saint David Cienega.

The MonarchQuestAZ tagging system utilizes highly visible, bright fluorescent orange tags produced by the Miles Label Company of Cortaro, AZ, applied ventrally to both hindwings (Fig. 3). These are based on an adhesive-backed, circular fluorescent paper tag measuring 9.525mm in diameter, weighing 0.01g, and sealed with a laminate film. Large, bold lettering of serial numbers, plasticity to conform to the butterfly's wing and good adhesion are additional attributes. Wild monarchs were tagged during the portion of the fall season immediately preceding and following the southeastern Arizona migration window. This period ranged from the third week in August through the end of October. The collective earlier experience of tagging monarchs through summer and fall helped to roughly establish this "migration window", as recoveries accumulated over time (Morris et al. 2015). Only fresh, robust butterflies deemed capable of successful



FIG. 3. Close-up view of MonarchQuestAZ B488, a female, with fluorescent orange tags.

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migration were tagged. Visual surveys were conducted with binoculars, or a zoom lens, without disrupting butterfly behavior. Field days rotated between primary sites as much as possible to avoid consecutive visitation of particular sites and minimize disturbance to local monarchs. Monarchs were handled with care and released at the same location of capture.

RESULTS

Fall 2016 monarch tagging season.

A total of 1810 field-collected monarchs were tagged during fall 2016 which was substantially greater than the number tagged in each of the previous two seasons. (Table 1). This resulted in an average of 43.1 monarchs tagged per day in 2016 compared to 32.2 (2014) and 6.8 (2015). The strong resurgence of monarchs in 2016 was in sharp contrast to the apparent population crash of 2015 (Billings 2016) and amounted to 56.7% of the total of all monarchs tagged over three seasons (3194) (Table 1).

Fall-to-winter 2016–2017 tagged monarch tracking and recovery season.

A total of 23 monarchs (1.3%) were recovered from the 2016 fall tagging season (Tables 2 & 3, Fig. 4). The majority of these recoveries (14) were found along the California coast at overwintering cluster sites, westnorthwest of their release points in southeastern Arizona. Eleven coastal recovery sites ranged from the Ballona Wetlands near Marina Del Ray in the south, to the Monterey pine forests of Cambria to the north, spanning a distance of 304 km (Table 3, Fig. 4). Eight of these 14 recoveries occurred in San Luis Obispo (SLO) County, from Arroyo Grande north to Cambria. Five were found along the southern section of the central coast, to Carpinteria, in Santa Barbara (SB) County. The 2016 recovery total also included the first and only monarch ever recovered in Nevada originating from southeastern Arizona (C0947), and a short regional flight (C0468) (Table 3).

Flights to the south-southeast in 2016 resulted in seven recoveries at the overwintering sites in the Transverse Neovolcanic Range of central Mexico. Of these, four were recovered at El Rosario, two at Cerro Pelón, and one at Sierra Chincua (Tables 3 & 4, Fig. 4). These flights measured between 1631–1704 km, compared with California flights of 789–1117 km (Table 3, Fig. 4). All four primary sites of southeastern Arizona recorded migratory recoveries from these widely separated regions of the United States and Mexico during 2016-2017 (Tables 2, 3 & 4, Fig. 4).

The winter 2016–2017 MonarchQuestAZ California coastal tag tracking mission found eight of the 14 recoveries from California with the remainder found by other site visitors. Seven of these recoveries were made on the first expedition (9 Nov–15 Dec) at sites in San Luis Obispo County. From the north, two were found in

TABLE 1. A comparison of the 2014, 2015, and 2016 MonarchQuestAZ tagging seasons, showing the four primary sites, within the six major monarch-tagging localities.

			Tagged	Monarch B	utterflies				
Tagging Site		2014		2015		2016		Site Totals	
A. Elgin		356		152		546		1054	
B. Canelo		345		76		357		778	
C. St. David		72		44		473		589	
D. Hereford		3		17		418		438	
E. San Rafael V.		88		2				90	
F. Marijilda Wash				80				80	
Totals for Six Major Localities	(+%>)	864	99.3% of Total	371	72.2% of Total	1794	99.1% of Total	3029	94.8% of Total
Totals for Four Primary Sites A–D	(+%>)	776	89.2% of Total	289	56.2% of Total	1794	99.1% of Total	2859	89.5% of Total
Percentage of Overall Totals		2014 Season Totals	27.2%	2015 Season Totals	16.1%	2016 Season Totals	56.7%	Overall Totals	100%
Tagged Monarchs:		870		514		1810		3194	
Field Days:		27		75		42		144	
Tags per Day:		32.2		6.85		43.1		22,2	

TABLE 2. Summary of tagged *Danaus plexippus* through MonarchQuestAZ 2016 field season from the four primary sites of southeastern Arizona {Bracketed numbers are re-sighted/re-captured monarchs tagged on the previous day, or earlier}. Recovered monarchs' destinations: CA = California, MX = Mexico, AZ = Arizona, NV = Nevada. Tagged monarchs from other sites: ¹ Bog Hole Wildlife Area (12), ² Bog Hole Wildlife Area (3), ³ Canelo/private ranch (1). These 16 + 1794 (from A–D) = season total of 1810.

Tagging Date	Site A	Site B	Site C	Site D
	Elgin	Canelo	St. David C	Hereford
30 July				-Site Recon-
28 August ¹		5		
30 August			16	
1 September				68
2 September ²		18		
5 September				41
6 September		15	22	
8 September				45 (3)
9 September		13 (3)	CA 32	
10 September				46(4)
11 September			ca 69	
12 September		17	ca 34	
13 September				AZ CA MX CA $49(1)$
14 September			40 (2)	
15 September	мх 17	28(5)		
16 September				56 (3)
17 September	19	26 (2)		
18 September				CA MX 44 (6)
19 September	15(1)	34 (3)		
20 September			CA CA 43	
21 September	18 (1)	55(4)		
22 September	NV 16	43 (5)		
23 September	CA 16		ca 21 (2)	
24 September	CA 10 (1)	CA MX 53 (3)		
25 September	54(5)			
26 September				-Rained Out-
27 September				39(1)
28 September			73	
29 September	6	45		
30 September			10(1)	21(4)
1 October			мх 50	
2 October	мх 25 (1)			9(2)
3 October			мх 46 (1)	
4 October	63 (2)			
5 October	CA 76 (4)			
6 October	ca 73 (9)			
7 October ³		5	12 (3)	
8 October	35 (4)			
9 October	9 (3)		5	
10 October	33 (4)			
11 October	34(5)			
12 October	27 (7)			
Totals	546 (48)	357 (25)	473 (9)	418 (24)



FIG. 4. Map shows southeastern Arizona monarch butterflies'' migratory flight corridors to opposite overwintering regions of California and Mexico from the same day and site. The numbers and letters shown correspond to those listed in Table 3.

Mexican stat bars correspc	es: Mex = Mexic onds with flight	co, Mch = Mic paths (by date)	hoacán. (All on Figure 4	the site	s within the Ta	gging and Rec	overy Site columns are ide	sutified in the	site legends of	Figure 4). Text	with colored
Tagging Date	Tagging Site (Fig.4)	County (Arizona)	Tag	Sex	Recovery Site (Fig.4)	County or State	Recoverer	Recovery Date	Distance Flown (km)	Compass Bearing (°)	Direction
2Sept14	В	SC	A0061	Μ	63	SLO	Cynthia Dunn	240ct14	1104	295	WNW
9Sept14	В	SC	A0147	Μ	10	SB	Jessica Griffiths	18 Dec 14	931	290	WNW
9Sept14	В	SC	A0170	Μ	1	Mnty	David James	2Jan 15	1611	298	WNW
9Sept16	C	Cch	C0286	Ы	ę	SLO	Joe Billings	24 Nov 16	1089	292	WNW
11Sept16	C	Cch	C0405	Μ	11	SB	Charis van der Heide	200ct16	938	288	WNW
12Sept14	C	Cch	A0254	Μ	9	SLO	Cal Poly-SLO	14Nov14	1031	291	WNW
12Sept16	C	Cch	C0450	Μ	ю	SLO	Joe Billings	18Nov16	1057	292	WNW
13Sept14	Е	SC	A0259	Μ	9	SLO	Paul Cherubini	5Nov14	1019	294	WNW
13Sept14	C	Ceh	A0268	Μ	9	SLO	Paul Cherubini	270ct14	1031	291	WNW
13Sept16	D	Ceh	C0468	Μ	16	Ceh	Mary Jo Ballator	20Sept16	14	255	WSW
13Sept16	D	Cch	C0481	Ц	υ	SLO	Joe Billings	17Nov16	1087	294	WNW
13Sept16	D	Cch	C0485	Μ	17	Mch	Diego G. Martinez	2Mar17	1631	143	SSE
13Sept16	D	Cch	C0502	Μ	6	SB	Jessica Griffiths	$20 \mathrm{Decl}6$	1001	290	WNW
15Sept16	Υ	SC	C0589	Μ	19	Meh	Alvaro G. Martinez	1Mar17	1681	143	SSE
18Sept16	D	Cch	C0706	Μ	S	SLO	Joe Billings	25Nov16	1117	294	WNW
18Sept16	D	Cch	C0707	Μ	18	Mex	Pato Moreno	Jan2017	1660	144	SSE
20Sept14	Α	SC	A0480	Μ	9	SLO	Paul Cherubini	270ct14	1020	292	WNW
20Sept16	C	Ceh	C0786	Μ	7	SLO	Joe Billings	6 Dec 16	1026	290	MNW
20Sept16	C	Ceh	C0795	Μ	×	SB	Jessica Griffiths	16Jan17	1014	288	MNW
22Sept14	В	SC	A0533	Ч	9	SLO	Robert Mancuso	1Nov14	1019	293	WNW
22Sept14	В	SC	A0536	Μ	9	SLO	David James	31Dec14	1019	293	WNW
22Sept14	В	SC	A0551	Μ	12	SB	Jessica Griffiths	7Jan15	006	291	WNW
22Sept14	В	SC	A0554	Ν	9	SLO	Cal Poly-SLO	14Nov14	1019	293	WNW

TABLE 3. Summary of monarch migration recoveries of tagged *Danaus plexippus* from southeastern Arizona for the MonarchQuestAZ 2014, 2015, and 2016 seasons. A total of 46 tagged monarchs were recovered out of the total number tagged (3194), for an overall recovery rate of 1.44%. Tagging and recovery data in representative colors designate

TABLE 3.	Continued.										
Tagging Date	Tagging Site (Fig.4)	County (Arizona)	Tag	Sex	Recovery Site (Fig.4)	County or State	Recoverer	Recovery Date	Distance Flown (km)	Compass Bearing (°)	Direction
22Sept16	Α	SC	C0947	Μ	15	Clark	Justin Streit	70ct16	669	320	NW
23Sept15	В	SC	B0161	М	13	Ven	Joe Billings	$26 \mathrm{Dec} 15$	867	290	WNW
23Sept16	C	Cch	C0975	Μ	9	SLO	Carole Colquehoun	$11 \mathrm{Dec} 16$	1031	291	WNW
23 Sept16	А	SC	C0981	Ч	ũ	SLO	Joe Billings	1Dec16	1048	293	WNW
24Sept14	В	$_{\rm SC}$	A0600	Μ	19	Mch	Simon Cruz	4Feb 16	1678	142	SSE
24Sept16	В	SC	B0688	<u>а</u> .	12	SB	Jasmine James	19Nov16	896	291	WNW
24Sept16	В	SC	B0713	Ŀı	19	Mch	Salvador Garcia	1Mar17	1678	142	SSE
24Sept16	Α	SC	B0726	Μ	14	LA	Jonathan Coffin	23Nov16	789	289	WNW
26Sept14	А	SC	A0633	Ч	9	SLO	Cal Poly-SLO	15Nov14	1020	292	WNW
26Sept15	А	SC	B0183	М	13	Ven	Joe Billings	$21 \mathrm{Dec} 15$	869	290	WNW
26Sept15	А	SC	B0191	М	7	SLO	Jessica Griffiths	21Nov15	1015	292	WNW
27Sept14	Ъ	SC	A0707	М	19	Mch	Simon Cruz	4Feb 16	1673	142	SSE
28Sept14	А	SC	A0753	Μ	12	SB	Jessica Griffiths	4Dec14	897	290	WNW
10ct16	C	Ceh	B0996	Μ	18	Mex	Pato Moreno	Jan2017	1704	144	SSE
20ct16	А	SC	B0650	Μ	19	Mch	Ana Maria Valdez	Mar2017	1681	143	SSE
30ct16	U	Ceh	B0672	Μ	19	Mch	Hortensia M. Moreno	1Mar17	1685	144	SSE
50ct16	Α	SC	0185	Ч	4	SLO	Joe Billings	16Nov16	1062	294	WNW
60ct15	В	SC	B0290	Μ	19	Mch	Jose Martinez Cruz	7Mar16	1678	142	SSE
60ct16	Α	SC	0291	Μ	10	SB	David James	19Nov16	932	289	WNW
260ct15	Ч	Ghm	B0357	Μ	19	Mch	Hermilo Gonzales	Mar2017	1736	147	SSE
270ct15	Ч	Ghm	B0397	Μ	17	Mch	Diego G. Martinez	2Mar17	1726	147	SSE
(2014)	ł	I	Un-ID-ed	ł	13	Ven	David F. Marriott	18Nov14	$870 \pm$	290	WNW
(2014)	1	1	Un-ID-ed	1	1	Mnty	David James	2Jan15	$1193\pm$	298	WNW
Mean (±SE)	Flight Distan	:eo:							1152.74 ± 53.3	~	



FIG. 5. One of four recovered monarchs tagged at Hereford on 13 September, C0481 in a cluster at the Morro Bay Golf Course, on 17 November 2016.

Cambria, one above Cayucos, three at sites in Morro Bay and one to the southeast in Arroyo Grande (Table 3, Fig. 4). A single tagged monarch sighted in Santa Barbara County, near Gaviota (Jessica Griffiths, pers. comm.) was tracked down during the return trip (24 Dec-26 Jan).

Migratory flights of synchronously tagged monarchs to California and Mexico.

September 13, 2016

Of the 49 butterflies tagged on this day at Hereford, Arizona, (tagging site D, Fig. 4) three made long distance flights to overwintering destinations in California and Mexico. C0481was recovered in Morro Bay, California on 17 November (1087 km) (Table 3, Figs. 4 & 5). C0485 tagged several hours later, flew 1631 km south-southeast to the Sierra Chincua monarch sanctuary of Michoacán, Mexico (Table 3, Fig. 4). The last recovered monarch tagged late in the day (C0502) was sighted on 20 December, in a stony seaside canyon east of Gaviota State Beach, California, after a flight of 1001 km west-northwest (Table 3, Fig. 4).

September 18, 2016

Two monarch butterflies of the 44 tagged on 18 September at tagging site D (Hereford), were recovered in California and Mexico: At 0929 h C0706 was released and recovered 1117 km west-northwest, more than nine weeks later (25 November) in the Monterey pines of Cambria, California. The fate of C0707, tagged at 0940 h, was not known until January 2017. It was found 1660 km south-southeast of Hereford, at the Cerro Pelón monarch sanctuary of Mexico by a horseback patrolman (Tables 3 & 4, Figs. 4 & 6–8).

September 24, 2016

Two monarchs of 53 tagged at Canelo (tagging site B, Fig. 4) were recovered in California and Mexico. B0688 was discovered on 19 November in an overwintering cluster along a creek behind an apartment complex in Carpinteria, California, after a west-northwest flight of 896 km. The fate of B0713 was not known until the tag was returned in March 2017 through a third-party collector (Diane Pruden, pers. comm.). This butterfly flew 1678 km south-southeast to reach the El Rosario monarch sanctuary of Michoacán (Table 3, Fig. 4).

DISCUSSION

Southeastern Arizona lies in an area of North America where there is a unique migratory dynamic of monarch butterflies. Fall flights of wild monarch butterflies to both coastal California and central Mexico



FIGS. 6–8. Left-to-right: Pre-release photo of C0707 at Hereford on 18 September 2016 / C0707 tag found at Cerro Pelón, Mexico in January 2017 (Photo by Pato Moreno) / C0706 discovered in pine stand at the Fiscalini Ranch Preserve of Cambria, California on 25 November 2016.

TABLE 4. Migratory destinations of recovered tagged <i>Danaus plexippus</i> from southeastern Arizona over three MonarchQuestAZ
seasons (2014-2016). Values in parentheses represent 2016 season recoveries. ° Includes single recovery from Nevada (C0947)
°° Includes single recovery from Arizona (C0468).

Major Tagging Localities	California Recoveries	Mexico Recoveries	Totals
A) Elgin	9 (4)	2 (2)	12° (7°)
B) Canelo	9 (1)	3 (1)	12 (2)
C) St. David	8 (6)	2 (2)	10 (8)
D) Hereford	3 (3)	2 (2)	6** (6**)
E) San Rafael	1 —	1 —	2 —
F) Marijilda		2 —	2 —
Generic Tags	2 —		2 —
Totals:	32 (14)	12 (7)	46 (23)

* Includes single recovery from Nevada (C0947).

** Includes single recovery from Arizona (C0468).

have been recorded sporadically from 2008–2013 (Morris et al. 2015) and every season since 2014 (Tables 3 & 4, Fig. 4). In 2016, 14 individual tagging dates in September produced recoveries from both of these regions (Table 2). Multiple recoveries from a single tagging date at the same site occurred on seven occasions from 2014–2016 (Table 3, Fig. 4). Prior to 2016, there were three separate events of two to four recoveries recorded from the same date and site. All were found at California coastal overwintering sites. However, not until 2016 were synchronously tagged monarchs discovered flying to opposite overwintering regions. To the best of my knowledge, this is a unique and unprecedented phenomenon, undocumented among wild tagged monarch butterfly records.

The primary goal of the MonarchQuestAZ project in southeast Arizona is to tag as many wild monarch butterflies that fit migratory-eligible criteria, over the length of the fall season. The timing of migration in this case, has been shown to influence overwintering flight destination. Monarchs tagged during the early period (2 Sept-20 Sept) were more likely than those tagged during the middle (22 Sept-6 Oct) or late (7 Oct-27 Oct) periods, to be recovered in California (Table 3). Two monarchs tagged near the end of October that made it to Mexico, were the only ones recovered during the late period. Interestingly, in 2016, three Mexican monarch recoveries showed up in the early period, for the first time (Table 3, Fig. 4). These represented a portion of the highest number of recoveries (7) from the Mexican sanctuaries to-date (Tables 2 & 3, Fig. 4).

Besides the timing of migration, there are several other factors to consider in interpreting this phenomenon. Because the number of recovered monarchs is so small (1.3%), it may not accurately represent the migratory behavior of the overall population. One of the inherent limitations is in the comparison of recovery data from Mexico versus California. The difficulty and uncertainty of recovering tags in the alpine fir forests of the Mexican preserves becomes overwhelming due to the teeming millions of monarchs converging in dense masses upon cluster trees. In stark contrast, the far more compact and sparsely populated sites of coastal California can be thoroughly explored given substantial time and effort. Therefore, the ratio of recoveries between the two overwintering locations cannot be evaluated to produce meaningful comparative results.

Pyle defines the concept of "vanishing bearings" as: "the direction of disappearance that enables observers to plot or follow an animal's movements" (Pyle 1999). Vanishing bearings of released monarchs are always recorded in instances when butterflies demonstrate gradually ascending directional flights sustained until no longer visible. However, these definitive flights are not observed often enough to be given significant consideration. The bearings of the two latest tagged monarchs (26 & 27 Oct) that flew up high on a southward vector above the Marijilda Wash in 2015, were later confirmed by returned tags from Mexico (Billings 2016) (Table 3, Fig. 4). However, none of the eight monarchs making dual regional migratory flights in 2016 (Table 3, Fig. 4) exhibited clear vanishing bearings. The overwhelming majority of monarchs tagged in the field resume their normal behaviors upon release. After a brief escape flight, they usually return to nectaring, or sometimes take refuge in a temporary roost tree.

Recent genetic studies of monarch populations indicate gene flow and some mixing of butterflies from east and west, with very little genetic differentiation found between monarchs of both regions of North America (Lyons et al. 2012, Zhan et al. 2014). Whether monarchs may be genetically predisposed towards a west-northwest or south-southeast flight direction from southeastern Arizona unknown. is Further advancements in the use of isotopic analyses may help to shed light in this area (Yang et al. 2016, Flockhart et al. 2017). In terms of natal origin, it is strongly suspected that the vast majority of monarchs from this region arise from local breeding habitats. While small numbers of monarchs from elsewhere, passing through, are likely to be present. There has never been a tag recovered from within these primary southeastern Arizona sites, from another region.

It is simply not possible to know with any clarity all of the factors that may have an influence upon flight direction. While weather conditions are recorded daily on fall tagging sites, there is no way of knowing local conditions at the exact time of departure for each tagged butterfly. One aspect of long-term recovery data is abundantly clear: monarchs tagged in southeastern Arizona have never been resignted nor recaptured at the original locality beyond the initial day of tagging. The consistency of this trend suggests a departure soon after release, but whether that occurs later the same day, or the next morning, is unknown.

Examination of all the factors, and possible explanations for this unique phenomenon of monarchs migrating to both overwintering regions from the same day and site, it is important to emphasize the value of the methodology employed: a maximal full-time field presence tagging monarchs over an entire season, followed up by rigorous searching and tracking tagged monarchs in California, has been essential in enabling this phenomenon to be revealed. Therefore, I believe the continuation of these sustained efforts, along with related field studies, will provide the best possibility of attaining a fuller understanding of this two-way migratory dynamic of wild monarch butterflies in Arizona. It is hoped that a nano-transmitter, with negligible weight can someday be installed underneath tags, or otherwise attached, to show real time dispersal of all monarchs. The long-term continuation of effective

fieldwork, together with research results should ultimately provide a major contribution towards the fulfillment of the further goal of conservation of southeastern Arizona primary monarch sites.

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