JOURNAL OF
THE LEPIDOPTERISTS' SOCIETY

Volume 30 1976 Number 2

A STUDY OF THE PENINSULAR FLORIDA POPULATIONS OF THE MONARCH BUTTERFLY (*DANAUS P. PLEXIPPUS*; DANAIDAE)

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A number of contradictory reports have been published concerning the presence or absence of the monarch butterfly (*Danaus p. plexippus* (L.)) in the peninsular part of Florida (hereafter referred to as Peninsular Florida and being that portion of the State between Latitude 30°N–24°N) throughout the year. Some published reports indicate that the monarch butterfly is absent during the summer months while others report the presence of this species throughout the year (Urquhart, 1960). Brower (1961) reported breeding populations in January and throughout the spring and summer months (March through August).

To clarify this situation, since it forms an integral part of our complete investigation of the movements of this species throughout North America, a continuous study of the populations in Peninsular Florida was commenced in 1968 and carried out through 1973. The results of this six year study program are here presented.

PROCEDURE

With the active cooperation of our research associates (Urquhart, 1960) living in Florida, together with a number of field expeditions, a program of field observations, collecting of larvae, tagging of imagoes and recording of larval stages of development was set up in the following areas (Fig. 1): Area I (Orlando); Area II (Temple Terrace, Lithia, Palmetto, Bradenton, Sarasota); Area III (Fort Lauderdale, North Miami Beach, Homestead). Observations were made on the presence of imagoes and species of milkweed (*Asclepias*) at Area IV (Key Vaca and adjacent

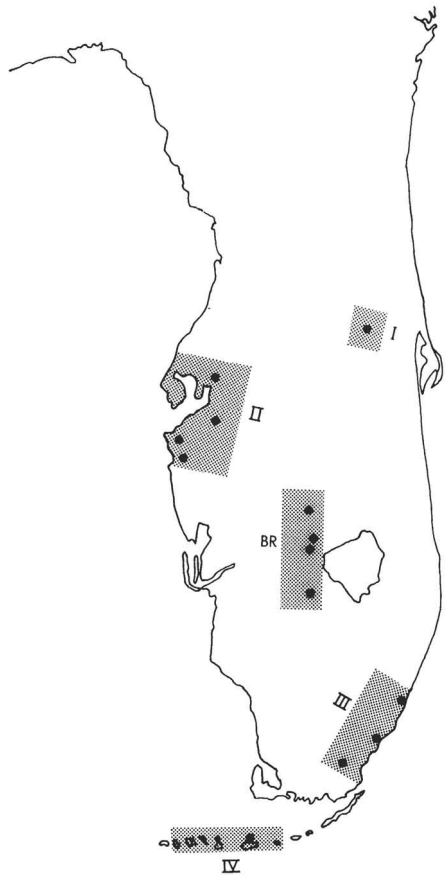

Fig. 1. Research areas: (I (Orlando); II (Temple Terrace, Lithia, Palmetto, Bradenton, Sarasota); III (Fort Lauderdale, North Miami Beach, Homestead); IV (Key Vaca); BR (area studied by Brower at Highland Hammock State Park, Lake Childs, Old Venus, 22 mi. SW Clewiston).

Keys). Larvae collected were reared (outdoors) to the imago stage and alar tagged (Urquhart, 1960) and released.

A specimen alar tagged and liberated at a particular time and later recaptured at some other place gave information as to the direction flown, distance travelled and the time interval involved. In addition, the total number of specimens tagged was recorded as well as the total of recaptures, in order to ascertain whether or not, in terms of percentage of recaptures, there was any significant movement within a given population.

RESULTS

Flight of Imagoes

During the autumnal migration, the majority of females in a moving population are in a state of ovarian dormancy (Urquhart, 1960). A small percentage of females, however, mate prior to moving southward or, in some cases, during the movement, and are capable of laying fertilized eggs on the milkweed plants of various species along the route of migration (Urquhart, 1960). It has been found that if these ovipositing females are kept under laboratory conditions, they will continue to lay their full complement of eggs. The female offspring, if maintained in the laboratory, do not enter a state of ovarian dormancy and hence will mate and lay viable eggs. Thus, a population of monarchs may be maintained in the laboratory throughout the year (Urquhart & Stegner, 1966). If, on the other hand, a female that is in the state of ovarian dormancy is held in the laboratory under ambient conditions, ovipositing does not take place nor do eggs develop in the ovaries, even after a period of five months. However, females in ovarian dormancy that were collected from the overwintering sites in California (Monterey) in January and held under ambient laboratory conditions developed eggs in the last week of February and laid viable eggs in March (Urquhart, 1960). As yet no significant research has been carried out as to the factors involved in initiating or depressing ovarian dormancy, although light period is suspected. Thus, a migrating population of monarch butterflies includes some gravid females and some in ovarian dormancy. In a particular area, such as Florida, one will encounter a population in which some of the individuals are part of a migrating population and capable of laying viable eggs; others may be in a state of ovarian dormancy and will continue their migration southward without ovipositing; while still others may be the offspring of ovipositing migrants, thus giving rise to what might be considered a "resident population."

As a result of the alar tagging program, which has been carried out in North America over the past 24 years, the release-recapture records indicate that a few migrants from eastern Canada and the eastern United States travel through Peninsular Florida (Fig. 2). One alar tagged migrant released in Grafton, Ontario, Canada was recaptured in Miami, Florida having flown south, a distance of 1223 mi. Another migrant alar tagged in Binghamton, New York was recaptured at Miami, Florida having flown south southwest, a distance of 1114 mi. A third migrant tagged at Port Hope, Ontario, Canada was recaptured in Havana, Cuba having flown south a distance of 1403 mi. A specimen tagged at Anna Maria, Florida in research Area II was recaptured in Miami, having flown

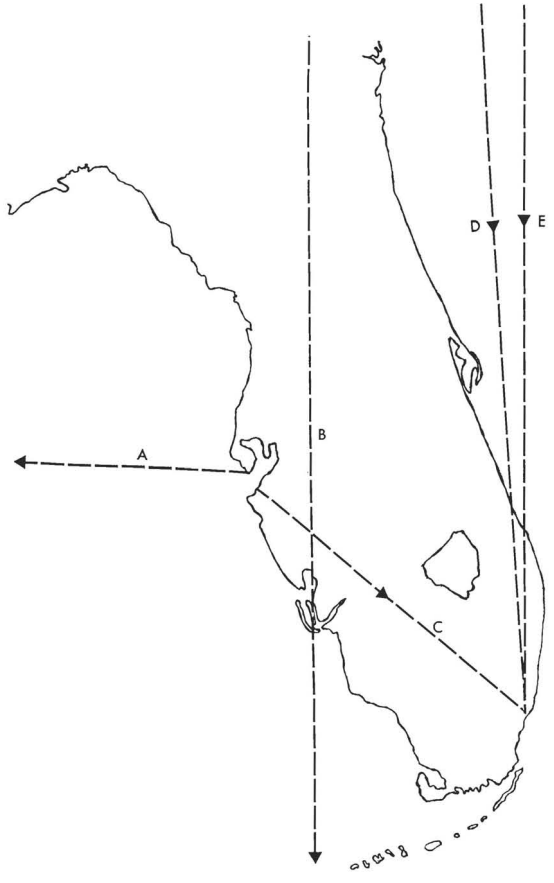

Fig. 2. Long distance migration records (release-recapture lines): (A) Miller Key to Kingsville, Texas; (B) Port Hope, Ontario, Canada to Havana, Cuba; (C) Anna Maria to Miami; (D) Grafton, Ontario, Canada to Miami; (E) Binghamton, New York to Miami.

southeast a distance of 195 mi. A migrant alar tagged at Miller Key in Area II was recaptured in Kingsville, Texas having flown a distance westward of 860 mi. All of these distances are measured as straight lines between the point of release and that of recapture. The actual route taken is, of course, not known.

Although two long flight records are reported for specimens alar tagged in Area II, most of the recaptures were for shorter distances and flights were in various directions (Fig. 3; Table 1).

Of a total of 4146 specimens tagged in Peninsular Florida, only 39

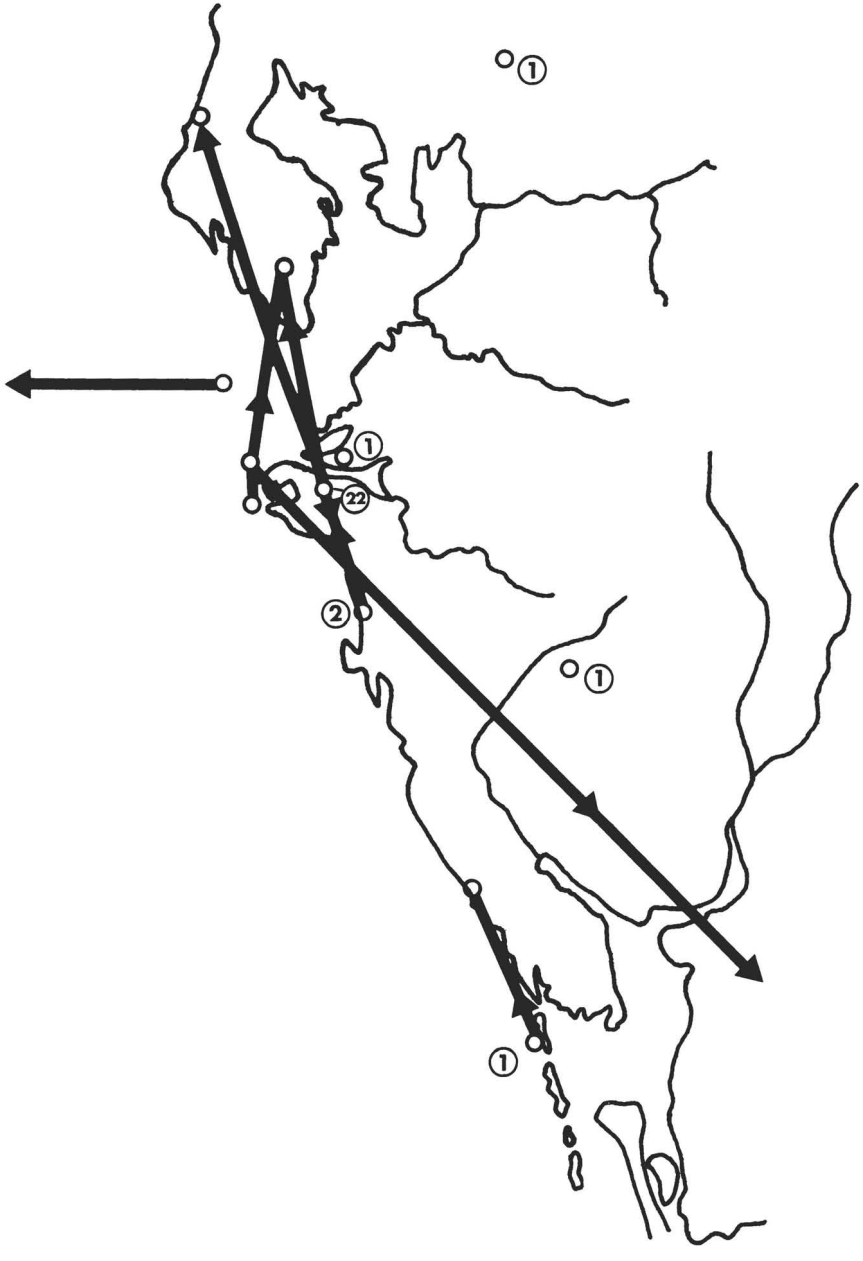

Fig. 3. Release-recapture lines for specimens tagged in Area II showing movement away from the area at various times of the year and the number of tagged specimens that were recaptured close to the site of tagging—indicated by a circle with enclosed number.

TABLE 1. Tagging results showing distances travelled, direction of flight and number of recaptures in each case.

Tagged at	Distance Travelled (Km)	Flight Direction	Number of Recaptures
Bradenton	0	0	22
Bradenton	28	WNW	1
Bradenton	13	SSE	2
Sarasota	16	N	1
Sarasota	0	0	2
Myakka State Park	0	0	1
Ft. Lauderdale	0	0	1
Coquina Beach	228	SE	1
Mullett Key	1003	W	1
Anna Maria	24	NNE	1
Palmetto	0	0	1
Boca Grande	21	NNW	1

were recaptured (.94%) even though the tagged specimens were released in well populated areas where the chances of recapture should have been much greater, as has been the case in other parts of North America during the migrating period (Urquhart, 1960).

Presence of Larvae

Brower (1961) recorded breeding populations of the monarch butterfly in the area marked BR (Fig. 1). These observations were made at: Highland Hammock State Park; east side of Lake Childs; Old Venus; and 22 mi. SW of Clewiston, given as the junction of highways 846 and 833. The observations were made during the months of March (25–31), April (2–30), June (15–30), July (7–31), and August (1–4). Brower also reported a breeding populatioin in the same area in January.

During the years 1958–1973 inclusive, larvae were collected in the field and reared outdoors, the resulting imagoes alar tagged and released. The number of larvae collected each day was recorded and summated for a particular month. The number of larvae recorded varied for a particular month from one year to another. This was due to the variable activity of the field assistants, the size of the population in any one year and the restricted oviposition of a particular female or females with respect to the number of milkweed plants present. Thus, although a total of 116 larvae were collected in June of 1969, fewer were collected in June of 1970 and 1971. Hence, the data presented in Table 2 and the summation with imagoes in the histogram (Fig. 4) only indicate trends and not accurate field population densities for each year.

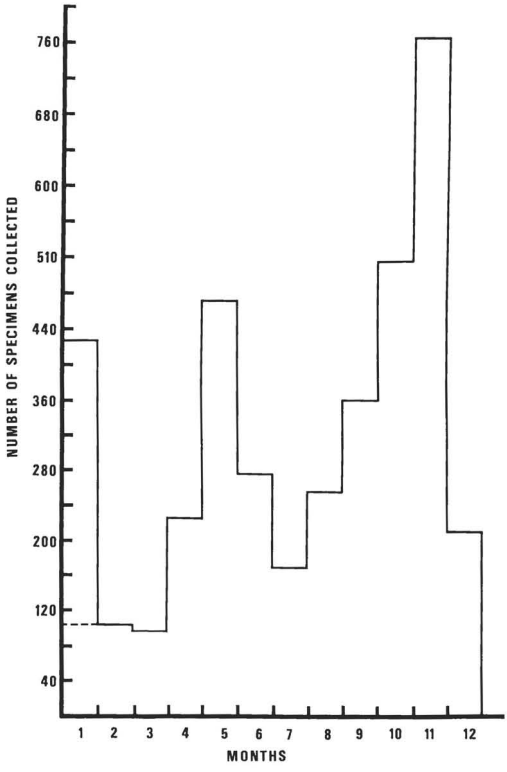

Fig. 4. Number of specimens collected during the entire research period for each month. Broken line in January indicating what was possibly the true population figure as explained in the text. Two peaks of abundance are noted.

Foodplant

The presence of a breeding population of monarch butterflies depends upon the presence of various species of the genus *Asclepias*, upon which the larvae feed.

Of the 21 species of *Asclepias* listed for Florida (Woodson, 1954), 15 occur in Peninsular Florida, the remainder being reported for the north-

TABLE 2. Number of specimens (larvae and imagoes) collected per month for all years (1968–1973).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	220	16	17	48	202	122	58	169	198	158	59	92
	(208)	(88)	(78)	(177)	(269)	(155)	(112)	(87)	(142)	(358)	(706)	(118)
Total	428	104	95	225	471	277	170	256	340	516	765	210

ern portion of Florida here referred to as the Panhandle area. Brower (1961) recorded larvae feeding upon 4 species of *Asclepias*, namely: *tuberosa rolfsii*, *humistrata*, *tomentosa* and *curtisii*. Of these the most abundant were *tuberosa rolfsii* and *tomentosa*, the others recorded as uncommon. In addition to Brower's records, *verticillata*, which occurs in rather dry, wooded areas, and *lanceolata*, found in wet, marshy areas, are of common occurrence throughout Peninsular Florida. The remaining species occur as widely scattered plants and are recorded from only a few localities.

Unlike some species of *Asclepias*, such as *A. syriaca*, which occurs in dense growths, the plants of species found in Peninsular Florida tend to be widely separated from one another. There are some species, such as *humistrata* and *tuberosa*, found as flowering plants in home gardens, and much of the data recorded in this paper are based on larvae collected from such plants.

Whether or not the larvae of the monarch butterfly will feed on the foliage of all species of *Asclepias* is not known. Brower (1961) has recorded 4 species upon which larvae were found feeding. Urquhart (1960) has recorded 10 species of which 4 are found in Peninsular Florida (*incarnata*, *tuberosa*, *tomentosa*, *curassavica*), as well as 3 species of related genera.

From the above records one may assume, subject to further study, that the larvae of the monarch butterfly will feed on all species of *Asclepias*. Hence, breeding populations may occur in many areas of Peninsular Florida in addition to those recorded here, so long as temperature permits the survival of both the host plant and the larvae.

DISCUSSION

Areas of Concentration and Flight Directions

It has been well documented that the autumnal migrants follow a northeast to southwest flight direction (Urquhart, 1960). It has also been shown that although small breeding populations may occur south of Lat. 35°N, by far the greatest concentration of summer population build up takes place between Lat. 45°N and Lat. 35°N and east of Long. 100°. This is specifically correlated with the distribution of *Asclepias syriaca*, a species which, by the nature of its rhizomatous root system, grows in dense clusters often covering many acres of marginal land as well as appearing in considerable abundance along gravel roadways and railway lines (Fig. 5). Other species occur in this area of *syriaca* abundance, such as *amplexicaulis*, *exaltata*, *tuberosa* and *verticellata*, thus adding to the great abundance of host plants throughout the area indicated.

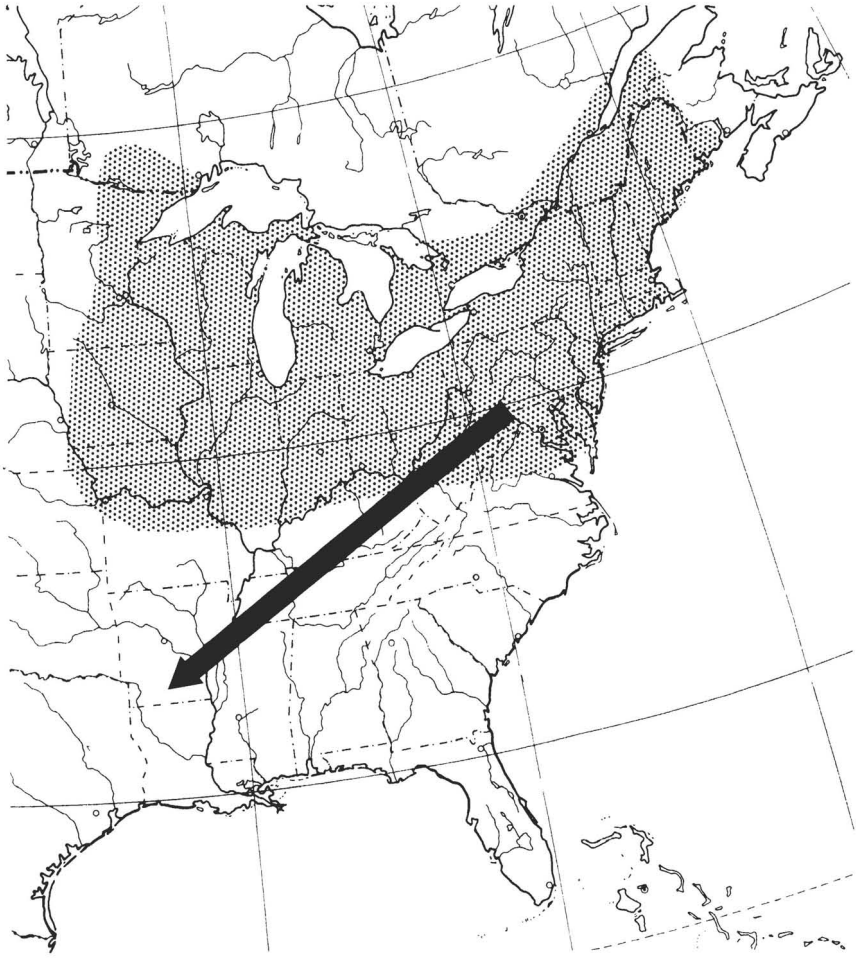

Fig. 5. Area of *Asclepias* abundance (stipled) and direction of monarch migration from this area to the southwest (solid arrow) accounting for the relatively meager migration through Peninsular Florida.

Since the line of autumnal migration is from northeast to southwest, as indicated by the arrow in Fig. 5, the majority of the autumnal migrants will tend to by-pass Peninsular Florida. Observations made on a number of field trips to northern Florida, as well as the eastern section of the United States (east of and including the Appalachian Highlands) have definitely indicated this trend. Therefore, relatively few autumnal migrants from the area of most abundant host plants travel down Peninsular Florida. There will be a certain small number of migrants emanating

from those areas where species of *Asclepias* occur in smaller numbers in the south and southeast parts of the continent; together, this constitutes a minority of the autumnal migrants.

If the above concept is correct, namely that Peninsular Florida is bypassed, then one would expect to find large numbers of migrants along the Florida Panhandle Gulf coast. This has been found to be the case (Urquhart, 1966). During the autumnal migration countless numbers of monarchs move west along the Gulf coast with great concentrations in the Apalachee Bay area at a time when relatively few specimens can be observed in the Gulf coast area of Peninsular Florida. Of those that do enter Peninsular Florida, field observations together with alar tag returns indicate that the movement is south and for the most part along the coast of the Gulf of Mexico.

If the Peninsular Florida populations move southward one would expect to find migrants in some of the islands of the Gulf of Mexico and, perhaps, in parts of southern Mexico and Central America. As a result of field expeditions to the Yucatan Peninsula of Mexico and Guatemala, both larvae and imagoes of the monarch butterfly were collected in the autumnal migration period (Fig. 6). Of the latter, many were definitely migrants as indicated by the colour change and scale loss (Urquhart, 1960). The situation in these areas is similar in all respects to that found in Florida.

It would therefore appear that the small, migrating population of monarch butterflies moving down Peninsular Florida, together with generations resulting from ovipositing migrants, travel via the offshore islands of Florida in the Gulf of Mexico and along the Florida Keys, eventually reaching Cuba. From Cuba, the flight continues from the area of Pinard el Rio to Yucatan, and from there to various parts of southern Mexico and Central America in which migrants in ovarian dormancy, gravid migrants, and generations of larvae and imagoes resulting from the latter occur (Fig. 6).

No large over-wintering concentrations of migrants in dormancy, as reported for California and observed in at least one area of Mexico (ms. in preparation), were located. It is assumed, however, that individuals from Yucatan and Guatemala, as well as other adjacent areas, will, during the vernal migration, travel northeastward, entering Cuba and eventually Florida in the spring and early summer, thus increasing the population of Peninsular Florida during this period.

Correlation Between Larval Population and Migrants

As pointed out in this paper and previously documented (Urquhart, 1960, 1966), migrant females may be in a physiological state which is

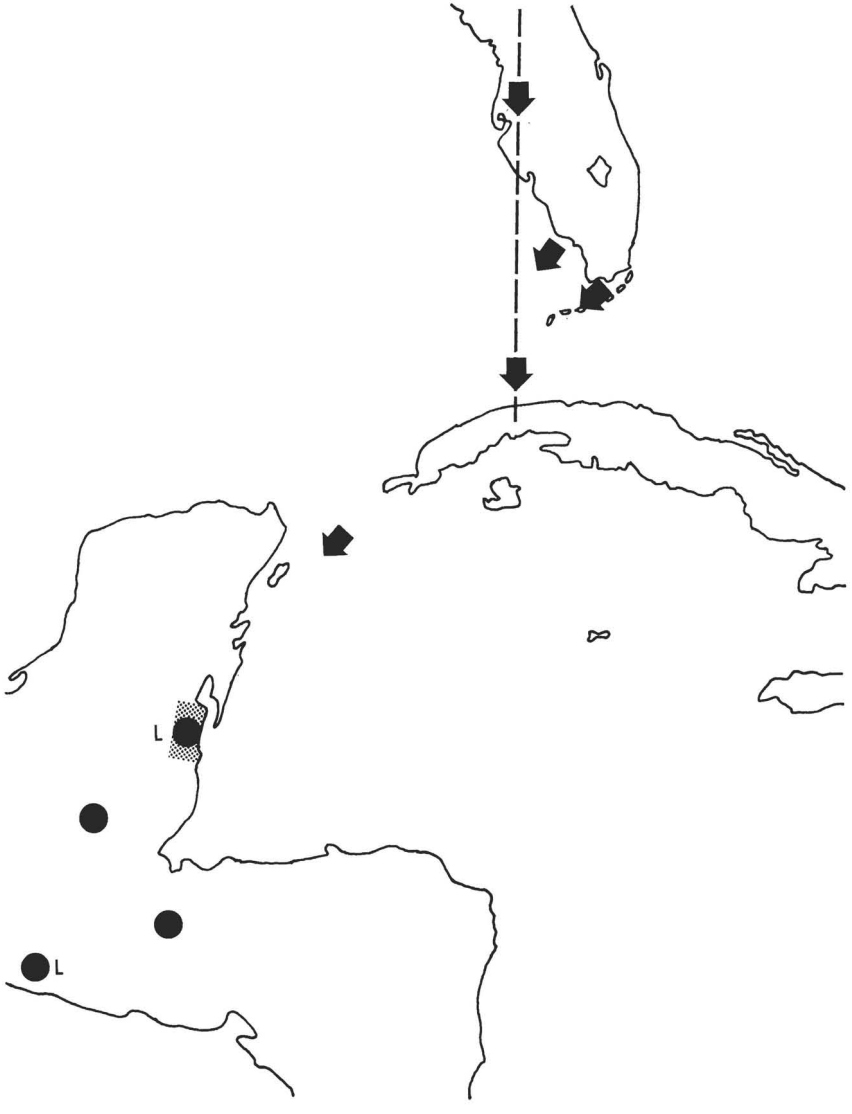

Fig. 6. Migration route from Peninsular Florida to Cuba and Yucatan. Migrant monarchs and larvae found at Chetumal, Flores, Morales and Guatemala as indicated. In addition to localities indicated in the figure, migrants and larvae were found at Villahermosa, Palenque, Zinacantan, Tuxtla and Oaxaca in the isthmus area of southern Mexico.

referred to as ovarian dormancy; or they may be capable of ovipositing wherever species of milkweed occur along the southward migratory route. Hence, larvae will occur from late summer (August) to late fall (November) along the migratory route so long as freezing temperatures do not occur, limiting the growth of milkweed (Urquhart, 1960). Ovipositing migrants reaching Peninsular Florida will oviposit on various species of milkweed and, so long as the temperature is suitable for larval growth and the host plant available, larvae and imagoes may be found throughout the year (Urquhart & Stegner, 1966).

Two peaks of monarch abundance (Fig. 4) occur throughout the year, a small peak in April–June and a larger one in August–November. The first peak is correlated with the advent of ovipositing vernal migrants, as discussed previously, and the second and larger peak with the advent of a much larger population of ovipositing autumnal migrants. Correlated with the occurrence of migrants, and hence a larger population of imagoes, is the presence of more abundant food plants as compared to conditions during the winter period. Decreased populations occur in January–March and July–August as the result of the decrease in the number of migrants. The meager population is, however, maintained as a result of the lingering presence of a few migrant stragglers as well as first and second generations resulting from gravid female migrants.

The rate of growth of the larvae during the winter period is reduced due in part to the lack of available host plants and partly to the effect of low temperatures lowering the growth rate. Concerning the latter, observations on various field expeditions during periods of low temperatures showed that larvae will drop from the host plant and remain on the ground in an inactive state until the return of higher temperatures.

Factors Limiting a Large Population in Peninsular Florida

Larval response in seeking host plants. Urquhart (1960) indicated, by movement tracings of larvae with respect to the ability of the larvae to locate the host plant when in close proximity to it, that they were unable to locate the host plant except by random movement. Experiments carried out in the field indicated that many larvae, when once dislodged from the host plant, were unable to locate the same plant or a substitute one when the plants were widely separated. As a result of numerous observations on various field trips through Peninsular Florida it is concluded that the various species of milkweed plants are widely separated in any growth area. Hence, many larvae would not complete the life cycle in most parts of Florida.

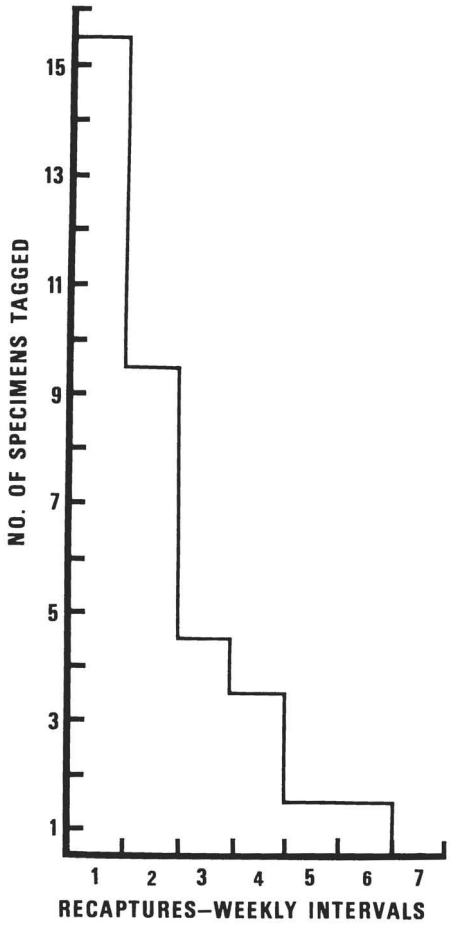

Fig. 7. Showing the rapid decrease in recapture of tagged specimens due to emigration from the area of release.

Insufficient food supply and competition with other species. Although there are a number of species of milkweed found in Peninsular Florida, there are not sufficient numbers of any one species, or of all species, to support a large population such as occurs in northeastern United States. Also, with the advent of low temperatures, particularly in areas north of the frost line (Lat. 28°N), many species of milkweed will drop their leaves and not resume growth until the following spring; in addition, many species die off during the winter period and resume growth the following spring (Woodson, 1954).

Brower (1962) has hypothesized competition for host plants with *Danaus gilippus berenice* (Cramer). However, in our six years of intensive field studies, during which time many hundreds of monarch larvae were collected and reared for migratory purposes, that were carried out through the entire calendar year in many localities throughout Florida (both Peninsular and Panhandle), there was no evidence of such competition. Throughout most of Florida, the larvae of *D. g. berenice* were scarce, only a few specimens being collected by our field assistants and ourselves, while monarch larvae, in many areas, were quite abundant. It is suggested that the observations of Brower were for a limited area and during a short period of the year during which place and time, *D. g. berenice* larvae were locally abundant.

Imago migration. It has been shown in this paper that relatively few alar tagged specimens were recaptured, even though all were liberated in areas of high human population, as compared to returns for other parts of the continent (Urquhart, 1960); further, that the majority of recaptures were made during the first two weeks following release with a marked drop in recaptures in the third and fourth weeks and none after six weeks (Fig. 7). From this it is concluded that the imago population does not remain in a given area but like the true migrants move away from the area to the south in the fall and winter and north in spring and early summer.

SUMMARY

1. Owing to the southwest pattern of the autumnal migration and the relationship of larvae to the presence of the abundant supply of milkweed plants in eastern North America, relatively few migrants pass through Peninsular Florida.

2. Female migrants that are in ovarian dormancy together with migrant males move southward or southwestward to Cuba and thence to the Yucatan Peninsula.

3. Gravid migrant females deposit eggs on species of milkweed along the migratory route.

4. Generations resulting from eggs deposited by gravid females move southward and southwestward, as in 2 above; the females in gravid state.

5. As a result of the paucity and scattered nature of the milkweed plants, limiting survival of larvae, together with the advent of low temperatures which prolongs larval growth period and reduces available food plants, and the movement southward of the imagoes, the monarch population in Peninsular Florida remains relatively low throughout the year.

6. A definite correlation exists between the number of larvae and imagoes and the autumnal and vernal migrations.

ACKNOWLEDGMENTS

The present investigation is part of a larger research program dealing with the migrations and ecology of the monarch butterfly and sponsored by research grants from the National Research Council of Canada, the National Geographic Society, and the Insect Migration Research Association.

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