OCCURRENCE AND WINTER ACTIVITY OF BLACK CUTWORM[1] MOTHS ALONG THE TEXAS GULF COAST, 1987-1991.[2]

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ABSTRACT

Recent evidence strongly supports the hypothesis that adults of the black cutworm, *Agrotis ipsilon* (Hufnagel), undergo both a spring and autumn migration in the United States. This migration activity involves the Corn Belt and southern regions, including the Texas Gulf Coast. Because of the importance of coastal influences on migration and because Texas is a probable source of moths migrating into the Midwest in April and May, the Texas coastline was chosen as a study area likely to produce winter-time data on black cutworm moth activity. In 1987-91, wing-style pheromone traps were used for short-term trapping of black cutworm moths along the Texas coastal region in an attempt to observe black cutworm moth premigratory activity from January to mid- to late-February. Texas-style cone traps monitored at locations on and near the Texas coast provided longer-term data on black cutworm moth activity. Data from moth captures along the coastal areas indicated some possible trends. Black cutworm moths were active throughout the winter months; however, greatest captures of moths tended to occur within a rather narrow time window in February. Black cutworm moths begin their well-documented northward transport approximately one month after major mid-winter coastal capture periods. If, as the weather patterns suggest, the source for moths captured in mid-winter in coastal areas is interior south-central and southeastern Texas, a study of the coastal populations during this behavior transition period may provide better prediction

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capabilities for the onset of the spring transport of black cutworm moths northward to the Corn Belt.

INTRODUCTION

Found worldwide, the black cutworm, *Agrotis ipsilon* (Hufnagel), damages crops in the United States, Canada, Central and South America, Europe, Asia, Africa and Australia (Commonwealth Institute of Entomology 1974, Hill 1975, Carter 1984). The sudden appearances of *A. ipsilon*, often in large numbers, and its seasonal disappearances (especially in India, the Celebes, Egypt and the Middle East) have long caused this pest to be recognized as a migrant (Odiyo 1975). In many parts of the world, migration has been suggested as the source for black cutworm moth populations ovipositing on early spring crops (Johnson 1969, Meszaros and Nagy 1968, Odiyo 1975, Rivnay 1964, Sugimoto and Kobayashi 1978). Research in the United States has also supported a spring migration as the probable source of black cutworm moths infesting northern latitudes (Carey and Beegle 1975, Clement et al. 1985, Domino et al. 1983, Hutchins et al. 1988, Kaster and Showers 1982, Showers et al. 1989a, 1989b). Domino et al. (1983) developed a system to analyze meteorological influences on long-distance and local black cutworm flight. Data from their study indicated that the early-spring Iowa and northern Missouri black cutworm moth populations are composed only of introduced individuals. These authors hypothesized that black cutworm moths may be carried several hundred kilometers from the south-central United States to Iowa in one to three nights by strong southerly winds, and that northern Missouri seems more subject to black cutworm invasion than Iowa because of more numerous southerly wind events. This hypothesis was substantiated after marked moths released in Louisiana and Texas were recaptured three or four nights later in the central Corn Belt (Showers et al. 1989a, 1989b), and feral moths marked with exotic pollens from Mexico were captured in Missouri and Iowa (Hendrix and Showers 1992).

The predictability of the annual spring transport of black cutworm moths into the Corn Belt has been tested with a meteorological forecast model described by McCorcle and Fast (1989). The model has been validated with several years of capture data and has successfully predicted regions of high infestation based on atmospheric circulation.

In addition to spring northward migration, fall southward migration, combined with delayed reproduction, has been suggested (Clement et al. 1985, Kaster and Showers 1982, Showers et al. 1993, Story and Keaster 1982, Williams 1926, Williams et al. 1942).

Plant pollen recovered from insect bodies can also provide evidence of long-distance movement of migratory insects. Hendrix and Showers (1992) found pollen of *Pithecellobium* (Leguminosae) on the probosci of black cutworm moths captured in Missouri and Iowa. *Pithecellobium* is an exotic plant found along the neotropic Gulf Coast and only as far north as southern Texas (Isley 1972)).

The relationship of coastal areas to overall weather patterns may be an important facet in understanding insect migration. Coastal air currents that can contribute to long-range transport of insects are characterized by four interrelated processes: differential heating of land and sea (sea and land breezes), thermal convection (wind shear and density currents), meso-scale circulations (fronts), and low-level jets (Drake and Farrow 1988). These four processes occur within the planetary boundary layer, the lowest 1-2 km of the troposphere (the bottom 10-15 km of the earth's atmosphere). Migrating insects are strongly influenced by the structure and internal motions of the planetary boundary layer (Drake and Farrow 1988).

Small scale circulations of airflow along coastlines result in convergence and convection (Hastenrath 1985) and are important for concentrating night-flying insects. At night, when thermal convection and convergence ceases, the planetary boundary layer becomes shallow, and a wind shear develops at an altitude of 100-300 m (Farrow 1986). From these altitudes to 1500 m, very high airflow speeds develop as a low-level jet maxima. These low-level jets are extremely effective for long-range transportation of biological entities along the coastline and, when associated with surface synoptic systems, to the interior of the mainland (McCorcle and Fast 1989). Scott and Achtemeier (1987) and Showers et al. (1989b) noted that an atmospheric pattern of a high pressure ridge centered along eastern North America, a low pressure system centered over central North America, and a cold front trailing south from the low pressure system favor a warm southerly flow of air from the Gulf states to the north central regions of the U.S. This synoptic system provides a mechanism for the long-range migration of black cutworm moths and other insects into the north-central U.S.

The Texas coastline was chosen as a study area likely to produce early season data on a possible source of black cutworm moths for long-distance spring transport into the Midwest. There is strong evidence that black cutworm moths undergo both a spring and autumn migration involving the Corn Belt and Gulf of Mexico coastal regions. However, the sources for these migrating moths are not known.

MATERIALS AND METHODS

Traps Used to Monitor Black Cutworm Moth Activity. In 1987-91, wing-style traps (26 x 20 x 11 cm [Scentry Inc., Buckeye, Arizona; and Pherocon®1C, Trécé Inc., Salinas, California]) were used for short-term trapping of black cutworm moths along the Texas coastal region in an attempt to observe black cutworm moth activity from late January to mid- to late-February. This time frame was chosen because data from wing traps placed along the Texas coastal route during January 1984-1986 indicated the presence of an active resident black cutworm moth population or an influx of moths from outside the trapping area (Keaster and Showers, unpublished). Although it would have been desirable to monitor the wing traps on the coast for an extended period, budgetary and time constraints prevented longer monitoring of these traps in the coastal areas. Therefore, in addition to our short-term monitoring with wing traps on the coast, cooperators were enlisted to monitor Texas 70-50-cm cone traps (Hartstack et al. 1979) for most of the year during 1990-91 at Beaumont (Jefferson County), Aransas National Wildlife Refuge (Aransas County), and Corpus Christi (1991) (Neuces

County). Although captures of black cutworm moths in cone traps cannot be quantitatively compared with captures in wing traps, cone trap data may nevertheless be useful in indicating trends in black cutworm moth activity.

Wing traps were baited with a rubber septum (Scentry Inc.) impregnated with black cutworm sex pheromone (3:1 ratio of Z-7-dodecenyl acetate and Z-9-tetradecenyl acetate). The lure was suspended at the end of a paper clip attached to the inside top of wing traps and from the cross bar on cone traps.

Trapping Along Coastal Regions - Wing Traps. During the five years of the study, wing-style traps were placed at coastal locations including all or portions of a route (Fig. 1) leading from Sabine Pass (Jefferson County) southwest to a point 40 km north of Harlingen (Willacy County). Traps were placed as near as possible to intervals of 32 km and were suspended on tree or shrub branches at an approximate height of 1.8 m. However, because of the scarcity of suitable trees or shrubs along coastal regions, it was sometimes necessary to hang traps at reduced heights and at distances less or greater than 32 km.

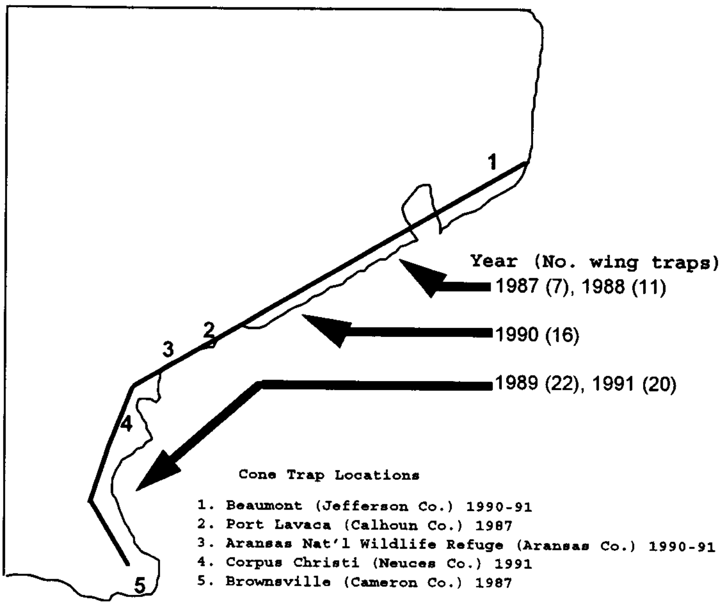

FIG. 1. Extent of trapping routes for 1987-91 and cone trap locations along the Texas Gulf Coast.

For portrayal of data, the coastal route was divided into three general regions. Because of the east-west configuration of the Texas coast, the northernmost region (including Jefferson and Galveston counties) was designated as the eastern region.

This eastern route covered approximately 80 km. The central region included the counties of Brazoria, Matagorda, Calhoun, Refugio and Aransas; this route covered approximately 240 km. The western (southernmost) region included the counties of Nueces, Kleberg, Kenedy, Willacy and Cameron; this route covered approximately 200 km.

In 1987, wing traps were placed along the eastern (northernmost) portion of the coastal route from a beginning point at Sabine Pass to approximately 5 km southwest of Galveston on 11 February. This route included three traps in Jefferson County and four in Galveston County. Traps were monitored from 12-24 February.

The trapping route used in 1988 was extended to 32 km southwest of Galveston, or approximately 19 km southwest of the most western coastal trap in 1987. This route was established on 15 February and monitored from 16-23 February. There were four traps in Jefferson County and seven in Galveston County.

In 1989, traps were placed along the entire coastal route (Jefferson to Willacy counties) on 25-26 January. The 22 traps on this route were monitored from 11-16 February.

During 1990, the trap line along the coast extended to approximately 40 km northeast of Rockport and included Jefferson, Galveston, Brazoria, Matagorda and Aransas Counties. The 16 traps on this route were placed 2-3 February and monitored 3-15 February.

In 1991, traps were again placed along the entire coastal route, with the exception of three sites eastward from High Island to Sabine Pass, which were not used because of impassable roads. This route was similar to that monitored in 1989, except for the deletion of Jefferson County and the addition of Refugio and Cameron Counties. The 20 traps on this route were set in place 1-6 January, with the exception of four traps which were placed 19 January. Traps were monitored at various times from 18 January through 17 February.

Observations for all years were continued daily or at 2 to 3 day intervals (as travel allowed). Captured moths were removed from the traps at each monitoring date. Lures in the wing traps were not changed during the trapping period. However, trap bottoms soiled by high moth catch or damaged by water (rain or Gulf spray) were replaced.

Monitoring with Texas 70-50-cm Cone Traps - 1990-91. In 1990-91, cone traps were monitored at three sites (Fig. 1), providing data on black cutworm moth activity for most of the year. One cone trap was monitored at the Aransas National Wildlife Refuge (Aransas County) beginning in February of 1990 and continuing through 1991. One trap at the Beaumont Research and Extension Center (Jefferson County) was also monitored during 1990-91. A trap was monitored beginning in 1991 at the Texas Agricultural Research and Extension Center near Corpus Christi (Nueces County).

Meteorological Events and Trap Captures. In 1987, a comparison was made of gulf coast weather events in February and simultaneous black cutworm moth captures in four coastal Texas counties. The black cutworm moth capture from one cone trap in Port Lavaca (Calhoun County), one cone trap at Beaumont (Jefferson County), and the mean capture from five cone traps in Brownsville (Cameron County) (Fig. 1) and two wing traps in Corpus Christi (Neuces County) were used for comparisons.

In 1987 and 1990, the daily temperature and northerly component of surface winds at Corpus Christi were compared with black cutworm moth captures from wing traps in the eastern, central, and western coastal regions. Daily temperature and northerly wind component were compared with daily captures of black cutworm moths during January and February 1991 in the cone trap at the Aransas National Wildlife Refuge (Aransas County).

RESULTS AND DISCUSSION

Black cutworm moth captures in wing traps placed along the Texas coastal region indicate some possible trends. In 1987, black cutworm moths were not captured on 12 or 13 February, and only two moths were captured (in Galveston County) on 15 February. However, on 18 February, 16 moths were captured in Jefferson County, and 13 moths were captured in Galveston County (a moth capture of 10 or more moths in one wing trap over a 2-day period is considered an intense capture [Troester et al. 1983]). On 20 February, there were 11 and 3 moths captured in Jefferson and Galveston Counties, respectively; and on 22 February there were 34 and 9 moths captured in the two counties, respectively. A decline in moth catch to 8 and 2, in the two respective counties, occurred two days later on the last monitoring date (24 February). The capture data in Fig. 2 are averages of seven traps in Jefferson and Galveston Counties (eastern region).

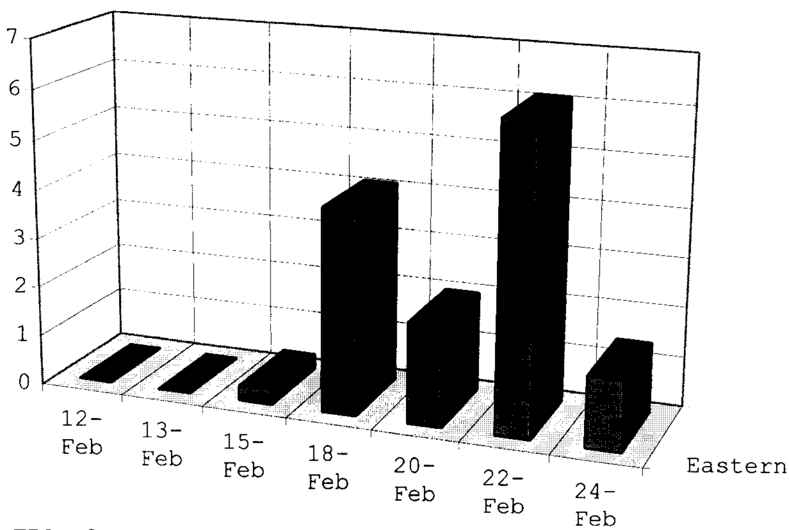

FIG. 2. Averages of black cutworm moth captures in seven wing traps in Jefferson and Galveston Counties, 12-24 February, 1987.

In 1988, there were 24 moths captured in the eastern region (Jefferson and Galveston counties) on 16 February, the first date on which traps were monitored. On 17 February, 3 moths were captured in the four Jefferson County traps and 6 in the seven Galveston County traps. However, major activity was noted on 19 February, when 51 and 69 moths were captured in the two counties, respectively. This flight was followed by another relatively high capture of 18 and 55 moths on 21 February. These captures were followed by a decline in captures similar to that noted in 1987. The capture data in Fig. 3 are averages of the 11 traps in Jefferson and Galveston Counties.

In 1989, moth captures from traps placed southward along the coast in Jefferson, Galveston, Brazoria, Matagorda, Calhoun, Aransas, Nueces, Kleberg, Kenedy and Willacy Counties showed a more marked trend of major catch and subsequent decrease than was seen in 1987 and 1988. Because of the length of this trapping route, two days were required to check the entire route.

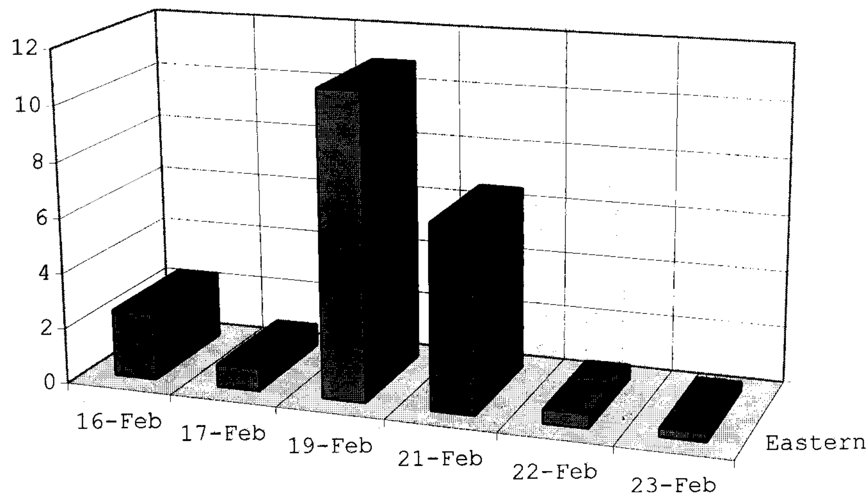

FIG. 3. Averages of black cutworm moth captures in eleven wing traps in Jefferson and Galveston Counties, 16-23 February, 1988.

All traps were checked on 11-12 February, and this two-day capture was recorded for 12 February. The major captures recorded for 12 February were followed by an absence of moths in the traps on 13-15 February and a minimal capture on 16 February. Capture data for 1989 are presented as averages (Fig. 4). The eastern region was comprised of Jefferson and Galveston Counties; Brazoria, Matagorda, Calhoun, and Aransas Counties were included in the central region; Nueces, Kleberg, Kenedy, and Willacy Counties were included in the western region. In 1989, there were six traps in the eastern region, eight in the central, and eight in the western.

Traps in 1990 were set out on 2-3 February, and monitoring began on 3 February and ended on 15 February. These monitoring dates were slightly earlier than the major captures noted in

1987 and 1988, but this trapping period included the dates of the major capture recorded from 1989. The greatest moth capture during this monitoring period occurred on 7 February when 29 moths were captured in six traps in Galveston County, 13 moths in three traps in Brazoria County, 8 moths in two traps in Matagorda County, and 7 in one trap in Aransas County. Moth captures decreased after 7 February, and there were no moth captures recorded for 14-15 February. Capture data for 1990 in Fig. 5 are averages. There were 10 traps in the eastern region

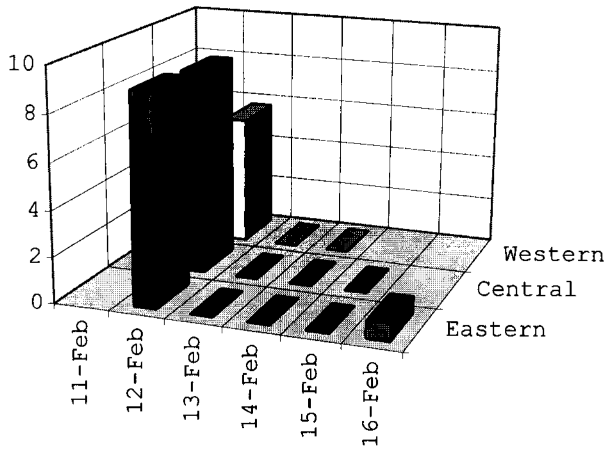

FIG. 4. Averages of black cutworm moth captures in wing traps in the Eastern, Central, and Western Regions of the Texas Gulf Coast, 11-16 February, 1989.

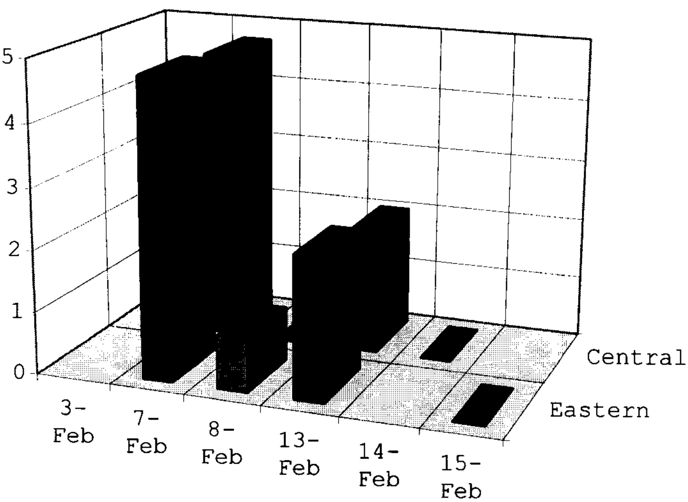

FIG. 5. Averages of black cutworm moth captures in wing traps in the Eastern and Central Regions of the Texas Gulf Coast, 3-15 February, 1990.

(Jefferson and Galveston Counties) and 6 in the central region (Brazoria, Matagorda, and Aransas Counties). Data from the Texas 70-50-cm cone trap in Aransas County in 1990 indicated that the greatest moth capture (5 moths) occurred at the beginning of March and that moths were present in this area when monitoring began on 16 February (Fig. 6). Moths were not

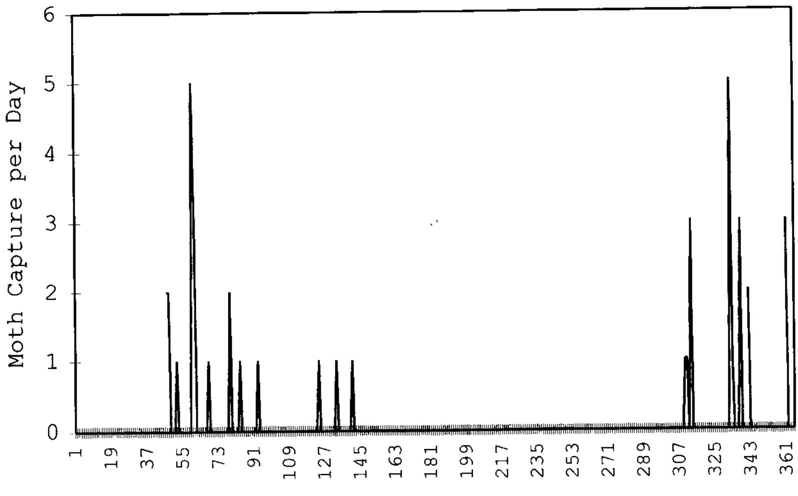

FIG. 6. Daily black cutworm moth capture in Texas-style cone trap at the Aransas National Wildlife Refuge, 1990.

captured in the cone trap in Aransas County from 21 May to 22 October (day 141 to 295) in 1990. The cone trap at Beaumont recorded a major capture in mid-March, but moth numbers were very low in this area from early May until late summer (days 130 to 235, Fig. 7).

A longer period of observation was possible in 1991 when wing traps were placed along the coast 4-6 January (except for four traps placed on 19 January) and observed during three time periods through 17 February. Portions of the trap line were monitored on 19 January, 4 and 5 February, and 14, 15, 16 and 17 February. Capture data for 1991 are trap averages (Fig. 8). There were five traps in the eastern region (Galveston County), nine traps in the central region (Brazoria, Matagorda, Calhoun, Refugio, and Aransas Counties), and five traps in the western region (Nueces, Kleberg, Kenedy, Willacy, and Cameron Counties). A clear trend of appearance and disappearance of moths was not seen during the monitoring period in 1991. However, major catches recorded in 1991 from the cone trap at the Aransas National Wildlife Refuge generally correspond to high moth captures in wing traps along the coast during the January and February monitoring periods, with a marked decline in moth captures in the Aransas cone trap occurring after the end of February (Fig. 9). The cone trap at Corpus Christi recorded a major catch about 20 February, followed by a sharp decline in captures and then an absence of moths until fall (Fig. 10). The

cone trap at Beaumont did not register a peak capture of moths **during the** spring. Low numbers of moths were caught throughout **the summer**, but moth captures increased with the approach of **fall** (Fig. 11).

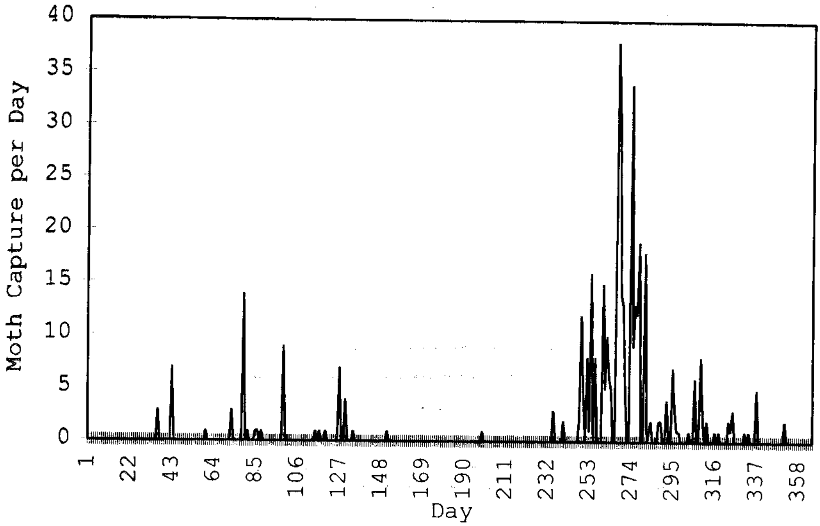

FIG. 7. Daily black cutworm moth captures in Texas-style cone trap at the Beaumont Research and Extension Center, 1990.

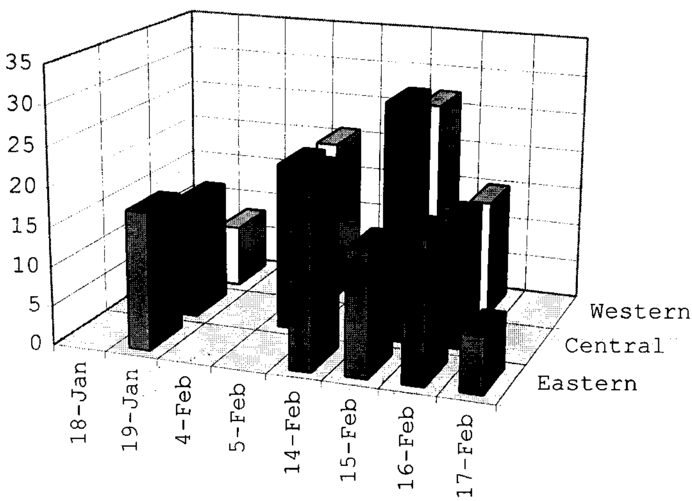

FIG. 8. Averages of black cutworm trap captures in wing traps along the Texas Gulf Coast, 8 January - 17 February, 1991.

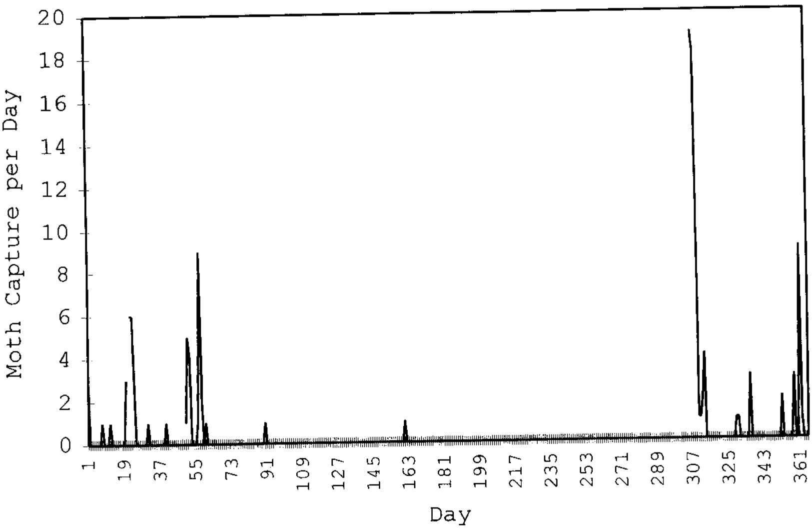

FIG. 9. Daily black cutworm moth captures in Texas-style cone trap at the Aransas National Wildlife Refuge, 1991.

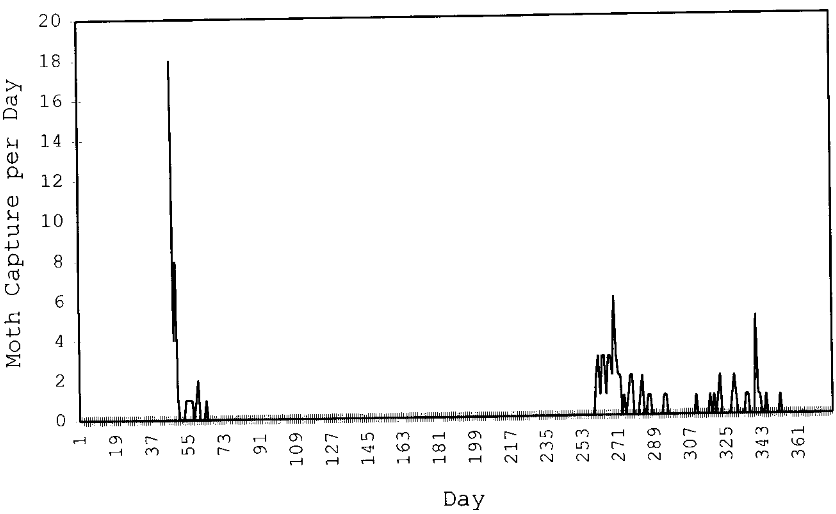

FIG. 10. Daily black cutworm moth captures in Texas-style cone trap at the Texas Agricultural Research and Extension Center, Corpus Christi, 1991.

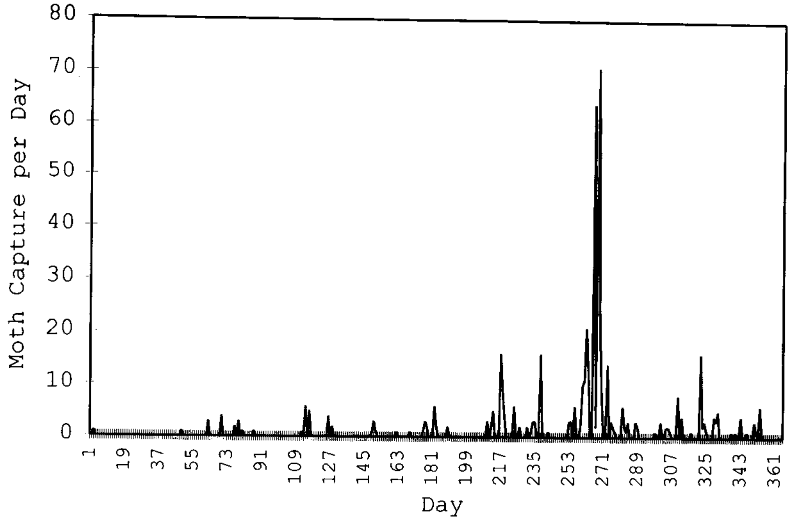

FIG. 11. Daily black cutworm moth captures in Texas-style cone trap at the Beaumont Research and Extension Center, 1991.

Meteorological Discussion. The long-distance movements of black cutworm moths in North America have been linked to particular atmospheric circulation patterns. Using trap capture data, Showers et al. (1989a, 1989b) showed that the annual spring northward transport of black cutworm moths from Texas to the Corn Belt takes place during periods of strong southerly (from the south) low-level winds. During these periods, strong low-level winds or jets enable moths to move from the Gulf Coast to Missouri in only two nights. It has been suggested that similar movements of black cutworm moths from the Corn Belt southward to the Texas Gulf Coast region occur in the autumn on the flanks of the first significant cold fronts that bring north winds across the central United States (Findley 1990, Showers et al. 1993). Because these transports do not have the aid of low-level jets, this autumnal movement of moths may take longer (Showers et al. 1993).

It is a reasonable hypothesis that winds associated with existing weather patterns play a dominant role in the transport and movement of black cutworm moths along the Texas Gulf Coast. Because little is known about the origin of these incoming moth populations, it is unclear whether the movement to the coast resembles the spring behavior of following strong, warm southerly breezes, or the autumn behavior of following closely behind cold fronts on northerly breezes.

Only the months of January and February are generally considered winter in Texas. These months are the season of "northers," cold fronts that sweep rapidly through the state, bringing sudden drops in temperatures. Then within a day or two, warming trends tend to occur.

The wing-trap capture data summarized in Figs. 2, 3, 4, 5 and 8 show that coastal black cutworm moth populations exhibit high variability and may tend to peak during a rather narrow time window in mid-winter, whereas captures in cone traps a short distance inland near Beaumont, Texas, indicate that moth populations are present all year (Figs. 7 and 11). Surface wind data during these periods of coastal transport of black cutworm moths suggests that atmospheric conditions may play a major role. Nearly every coastal moth capture episode represented in the 1987-91 trap data was immediately preceded by northerly winds which accompanied the passage of a north-to-south moving cold front. A strong cold front passed through the area on 18 and 19 February and shifted the winds from southerly to strong northerly (Fig. 12). Between 19 and 25 February, a marked increase in captures was observed all along the coast (Fig. 13). The northerly component of surface winds, observed daily at 0600 LST (local standard time) at Corpus Christi, are compared with captures of moths in wing traps in Jefferson and Galveston

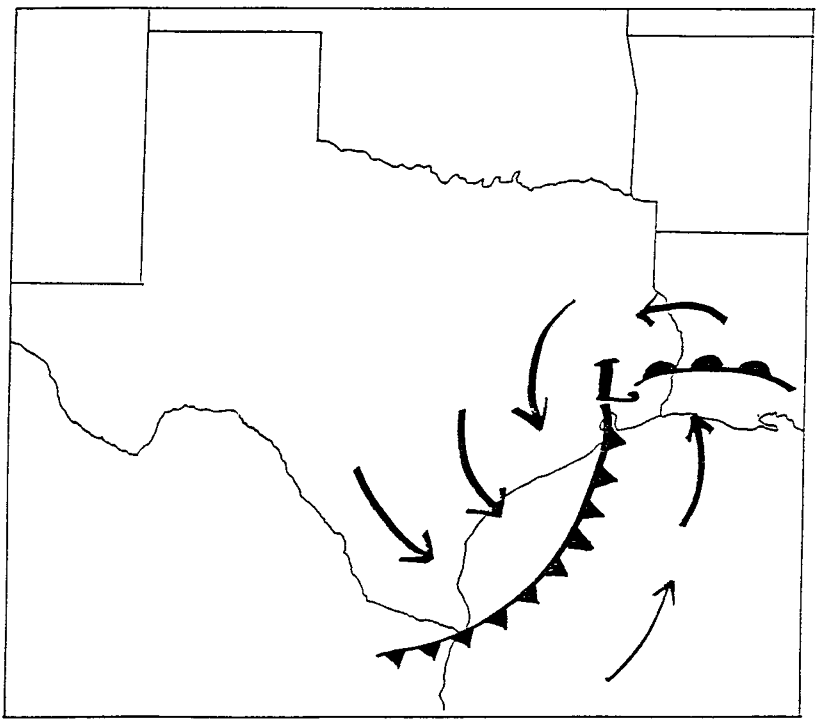

FIG. 12. Typical surface low pressure and frontal position preceding an increase in black cutworm moth captures on the Texas Gulf Coast.

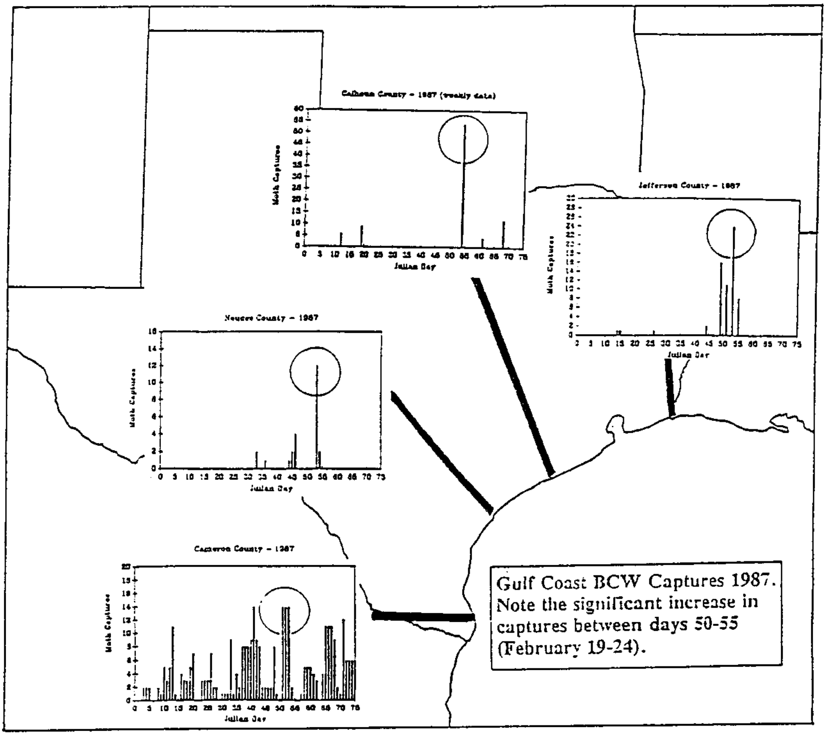

FIG. 13. Black cutworm moth captures in four Texas coastal counties, 1987.

Counties (Fig. 14). A large positive wind value represents a strong wind from the north, and a negative value depicts a southerly wind direction. The strong northerly winds of days 50, 52 and 54 (19, 21 and 23 February) were all followed by moth captures the following day. Earlier, from days 43 to 49 (11-18 February) winds were predominantly from the south, and there were no moths captured on 12-13 February and only two moths captured on 15 February. However, there was a total of 16 and 13 moths captured in Jefferson and Galveston Counties, respectively, on 18 February (day 49). A similar pattern was observed in 1988, when coastal moth captures were again associated with a northerly wind component (Fig. 15).

Wing traps for 1989 were set in place on 25-26 January. Because of other travel commitments, we were unable to check the traps until 12 February. Therefore, the capture recorded for day 43 represents an approximately 2-week moth capture (Fig. 16). However, the northerly wind component (k/h) for the eight days preceding 12 February ranged from 12.0 to 31.5 and was above 16.0 for seven of the eight days.

In 1990, the moth capture on day 38 (7 February) represents a four-day capture in the wing traps (Fig. 17). The northerly wind component (k/h) for the three days preceding 7 February ranged from 4.6 to 11.2. The moth capture for 13 February was for a four-day period and follows four days of temperatures below 10°C and one day (day 41) with a northerly wind component.

Black cutworm captures recorded daily from the cone trap at Aransas Pass were associated with northerly wind components throughout January and February (Figs. 18 and 19). These data support our hypothesis that northerly winds tend to shuttle moths from the more inland areas of Texas toward the shoreline. In every instance before a peak capture of moths, a northerly wind component was recorded. The greatest moth captures occurred on days 22 and 23, day 51, and day 57; the northerly wind components (k/h) during these same periods increased from 11.2, 7.0 and 4.0 to 25.4, 22.5, and 18.4, respectively.

During the winter months of January and February, the movement of storm systems southward usually allows the surface frontal systems to reach extreme southern Texas with the highest frequency of all the seasons. In some winters, these frontal occurrences may be rare or absent. Lack of surface cold fronts may explain the year-to-year fluctuations in the magnitude and frequency of captures of black cutworm moths along the Texas Gulf Coast.

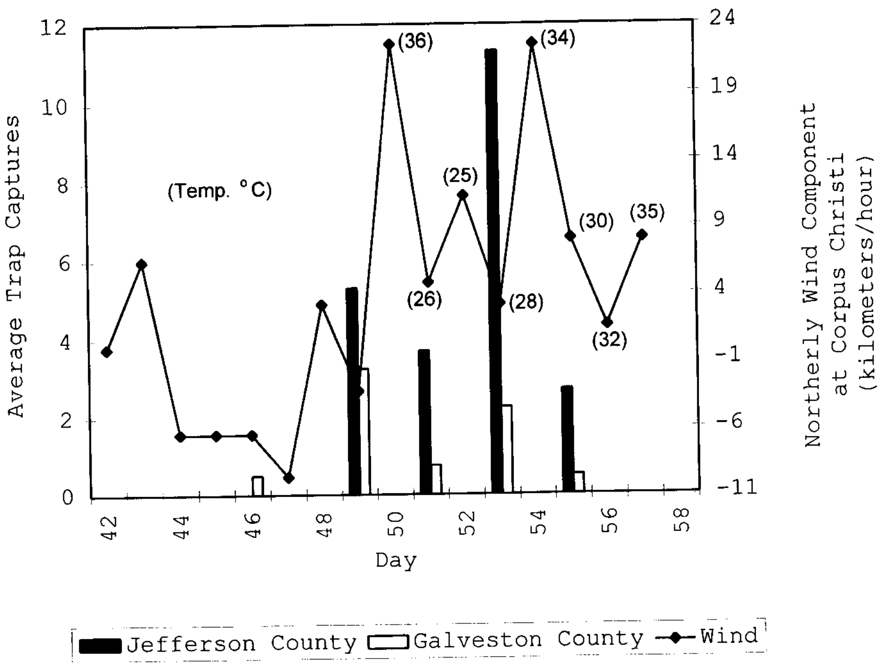

FIG. 14. Northerly component of the surface winds and temperatures recorded daily at 0600 LST at Corpus Christi and black cutworm moth captures in wing traps in Jefferson and Galveston Counties, Texas Gulf Coast, 1987.

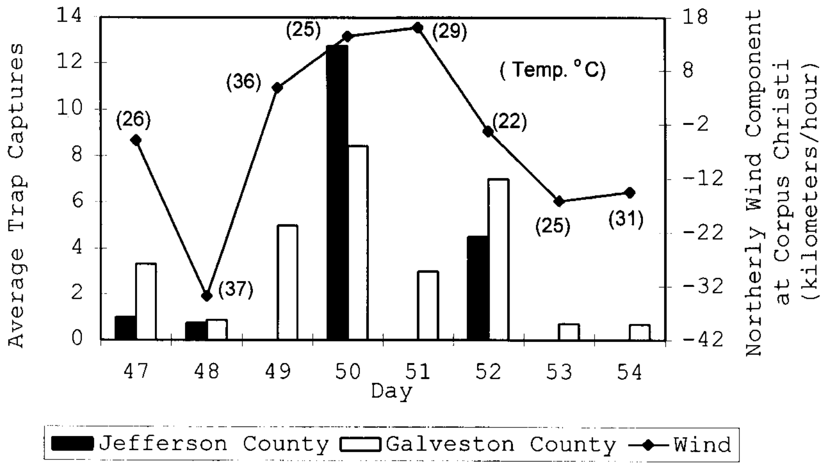

FIG. 15. Northerly component of the surface winds and temperatures recorded daily at 0600 LST at Corpus Christi and black cutworm moth captures in wing traps in Jefferson and Galveston Counties, Texas Gulf Coast, 1988.

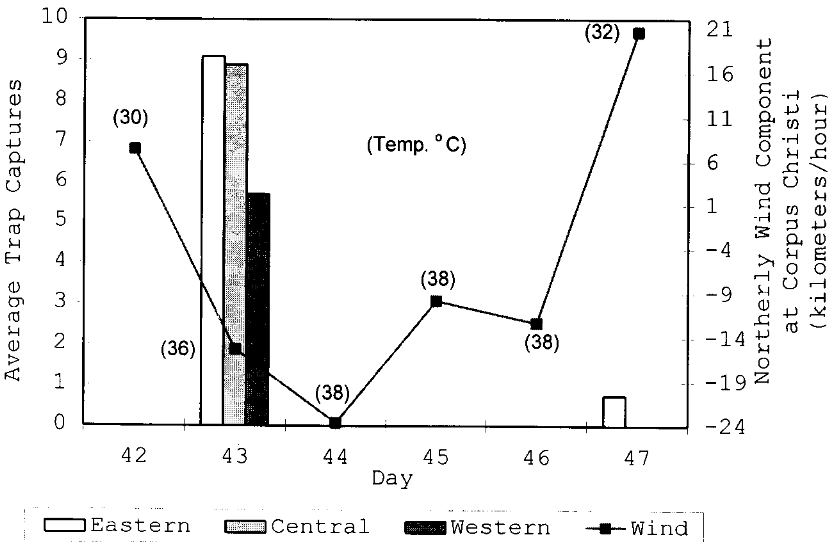

FIG. 16. Northerly component of the surface winds and temperatures recorded daily at 0600 LST at Corpus Christi and black cutworm moth captures in wing trap in Eastern, Central, and Western Regions, Texas Gulf Coast, 1989.

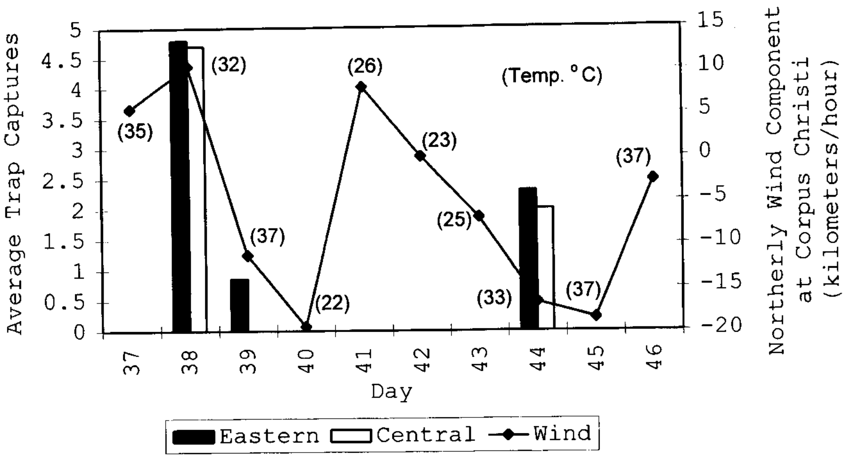

FIG. 17. Northerly component of the surface winds and temperatures at 0600 LST at Corpus Christi and black cutworm moth captures in wing traps Eastern and Central Regions, Texas Gulf Coast, 1990.

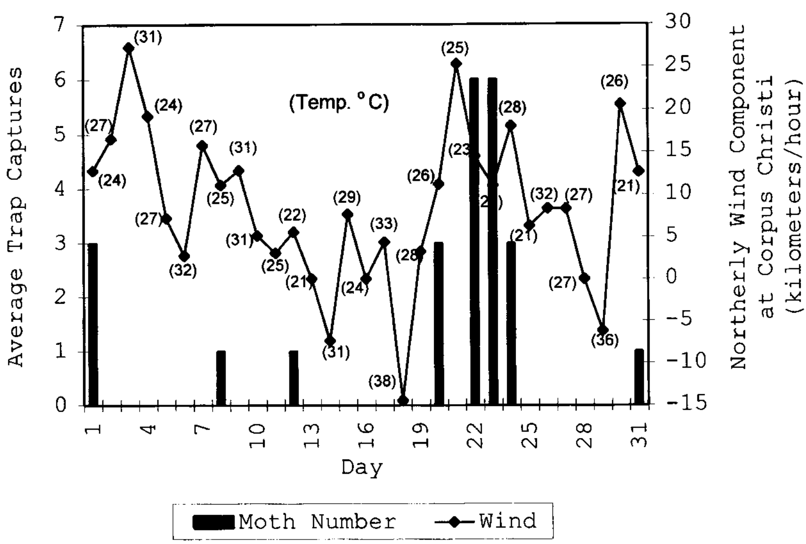

FIG. 18. Northerly component of the surface winds and temperatures recorded daily at 0600 LST at Corpus Christi and daily black cutworm moth captures in a cone trap, Aransas National Wildlife Refuge, 1991.

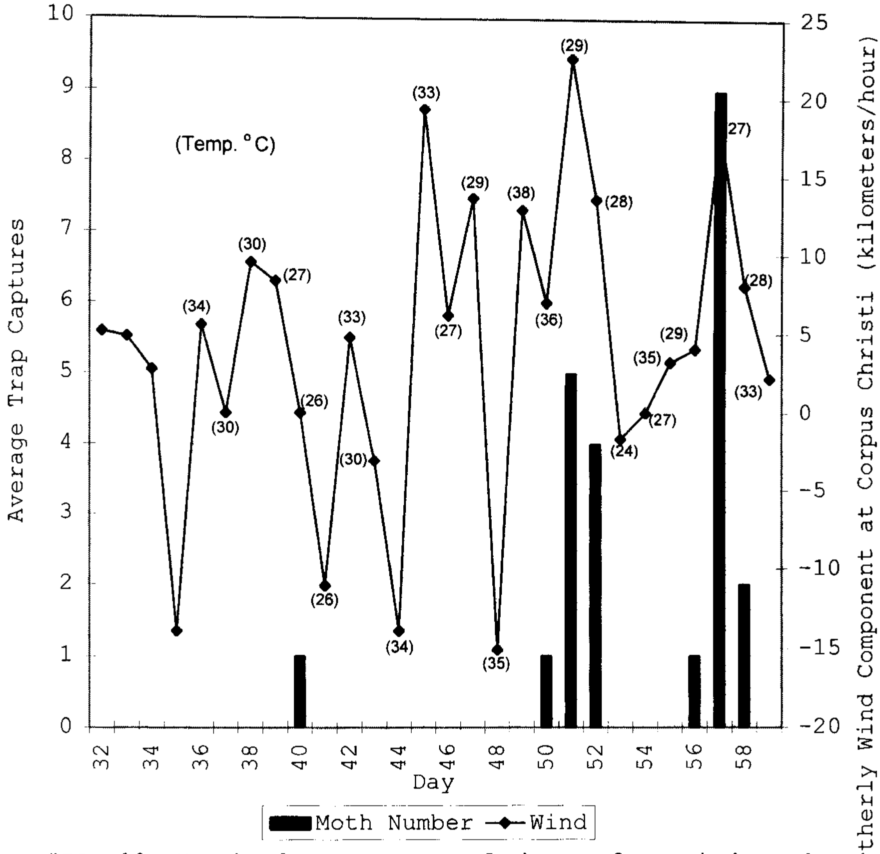

FIG. 19. Northerly component of the surface winds and temperatures recorded daily at 0600 LST at Corpus Christi and daily black cutworm moth captures in a cone trap, Aransas National Wildlife Refuge,1991.

CONCLUSIONS

Black cutworm moths were captured in pheromone-baited wing traps placed along the Texas coast during mid-winter in 1987-1991. Data from cone traps at three sites indicated that black cutworm moths were active throughout the winter months in the coastal area. Our data suggest that black cutworm moths are shuttled toward the Texas coastline following one or more nights of northerly breezes and cool temperatures. It is notable that black cutworm moths begin their well-documented northward transport approximately one month after major winter coastal capture periods. Moths migrating northward in early spring are apparently responding to southerly winds and high temperatures, conditions which are diametrically opposed to the winter coastal transport conditions. The weather patterns suggest that the source for moths captured in mid-winter in coastal areas is interior south-central and southeastern Texas. Therefore, a study of the coastal populations during this behavior transition period may provide better prediction capabilities for the onset of the spring transport of black cutworm moths northward to the Corn Belt.

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