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THE RISE AND FALL OF TROPICAL BLUES IN FLORIDA: *CYCLARGUS AMMON* AND *CYCLARGUS THOMASI BETHUNEBAKERI* (LEPIDOPTERA: LYCAENIDAE)

JOHN V. CALHOUN[1,4], JEFFREY R. SLOTTEN[2,4], AND MARK H. SALVATO[3]

[1] 977 Wicks Drive, Palm Harbor, Florida 34684-4656
[2] 5421 NW 69th Lane, Gainesville, Florida 32653-7016
[3] Dept. of Entomology and Nematology, University of Florida, Gainesville, Florida 32611, USA

ABSTRACT.– *Cyclargus ammon* (Lucas) has been established on Big Pine Key, Florida since at least 1997. The species arrived from Cuba, possibly with the assistance of a meteorological event. It inhabits rockland pine forests in Florida and is known to utilize as hostplants *Acacia pinetorum*, *Acacia farnesiana* and *Caesalpinia pauciflora* (Fabaceae). The habitat, abundance, nectar sources and life history are detailed. The decline of endemic *Cyclargus thomasi bethunebakeri* (Comstock & Huntington) is also discussed. Once locally common in South Florida, there were no verified records of this subspecies during the period of March 1992-October 1999. It is now known to occur at a single location in the lower Florida Keys. Loss of habitat through coastal development is the likely cause of this decline, perhaps exacerbated by other factors such as succession, tropical storms, and mosquito control. Surveys are required to determine the current status of *C. t. bethunebakeri* in Florida.

KEY WORDS: *Anaea*, Arecaceae, Asteraceae, Bahamas, biology, Cuba, Cycadaceae, distribution, *Ephyriades*, *Eumaeus*, Euphorbiaceae, Fabaceae, *Hemiargus*, *Hesperia*, Hesperiidae, hostplants, *Leptotes*, life history, Nearctic, Neotropical, *Phoebis*, Pieridae, Pinaceae, *Ministrymon*, Sapindaceae, *Strymon*, West Indies.

Johnson and Bálint (1995) recently replaced *Hemiargus thomasi* (Clench) and the closely related *Hemiargus ammon* (Lucas) into the genus *Cyclargus* as originally proposed by Nabokov (1945). Due to a persistent confusion between these very similar species, *C. ammon* has been reported from Florida since the late nineteenth century (e.g., Scudder, 1876; Slosson, 1895; Holland, 1898; Dyar, 1903; Grossbeck, 1917; Matteson, 1930). Bethune-Baker (1916) was the first to suspect that *C. ammon* was not found in Florida, remarking "this species does not, I believe, occur on the mainland." He further observed that the Florida phenotype "is considerably different from the Cuban insect and is certainly distinct from it." Comstock and Huntington (1943) also recognized this disparity and described the Florida phenotype as *Hemiargus ammon bethune-bakeri*, in honor of Bethune-Baker's earlier observation. They commented that Cuban *C. ammon* probably did not occur in Florida, "except possibly as a casual visitor." Nabokov (1945) finally concluded that the Florida phenotype more appropriately belonged to his newly elevated species, *Cyclargus thomasi*. Although Nabokov's classification was generally accepted, some authors continued to refer to the Florida insect as *C. ammon* (e.g. dos Passos, 1964; Rutkowski, 1971; Brown, 1973; Covell and Rawson, 1973). Based on actual specimen records, we are reasonably certain that all historical Florida reports of *C. ammon* are actually referable to *C. thomasi*.

Until recently, the range of *C. ammon* (Nickerbean Blue) was restricted to Cuba, the Isle of Pines and the Bahamas (Smith *et al.*, 1994). Records from Jamaica and the Cayman Islands are now considered to represent endemic species: *Cyclargus shuturn* Johnson & Bálint and *Cyclargus erembis* Nabokov, respectively (Johnson and Bálint, 1995). The distribution of *C. thomasi* includes 5 recognized subspecies, extending from Florida and the Bahamas, southward to the Turks and Caicos Islands and Hispaniola (Smith *et al.*, 1994). A report of the occurrence of this species in Central America (Johnson & Bálint, 1995) is in error (Bálint, pers. comm.). Records from the vicinity of Puerto Rico and the Lesser Antilles probably represent another species: *Cyclargus woodruffi* W. P. Comstock & Huntington (Johnson and Bálint, 1995). *Cyclargus thomasi* is represented in Florida by the endemic subspecies, *C. t. bethunebakeri* (Comstock & Huntington) (Miami Blue). Due to the occurrence of *C. t. bethunebakeri* in the Bahamas (particularly the Bimini Islands), Calhoun (1997) did not consider this subspecies as endemic to Florida. However, its presence outside Florida is irregular and may represent nothing more than non-breeding strays or temporary colonists (Riley, 1975, Smith, *et al.*, 1994). An insect similar to *C. thomasi* has recently been found on Cuba, but its relationship is not clearly understood (L. R. Hernández, pers. comm.). The ranges of *C. ammon* and *C. thomasi* were previously known to overlap only in the Bahamas (Scott, 1986; Smith *et al.*, 1994).

In 1998, a color photograph of an adult female *C. ammon*, inadvertently misidentified as *C. thomasi*, was included in a popular article on the Florida Keys as well as a pamphlet on Florida butterflies (Salvato, 1998; SCCF, 1998). The photograph was taken by Jane M. Ruffin on Big Pine Key, Monroe County, Florida on 18 March 1998. Adults of *C. ammon* also were encountered on Big Pine Key on 21 March 1998 by Jeffrey R. Slotten and Wayne Miller who properly identified them. Without knowledge of the earlier reports, George O. Krizek photographed two *C. ammon* on Big Pine Key on 31 May 1998 and published this record as the first for the United States (Krizek, 1998, 1999). Glassberg (1999) included more photographs of *C. ammon*, taken by Jane Ruffin and others on Big Pine Key in 1998-99. A thorough review of *Cyclargus* specimens, photographs and observations has shown that *C. ammon* has been present in Florida since at least 1997. Mark Salvato photographed it on Big Pine Key on 12 July 1997, and Linda and Byrum (Buck) Cooper also photographed it on Big Pine Key on 16 October 1997. Robert Beiriger captured a single specimen on 19 July 1997. Since that time, there have been numerous reports from Big Pine Key (JC has cataloged records comprising over 400 observed adults). There is also an unverified report of a single adult, captured in Homestead

4. Research Associate, Florida State Collection of Arthropods, Div. of Plant Industry, Florida Dept. Agric. & Consumer Services, Gainesville, Florida 32614.

(Miami-Dade County) on 10 August 1999 (L. Koehn, pers. comm.), possibly indicating that colonization of the Florida mainland is already in progress.

One earlier fresh specimen of *C. ammon* (sex unknown) was purportedly captured on Big Pine Key by Thomas W. Kral on 5 April 1984 and published as a new United States record (Beck, 1985). The specimen was reportedly donated to the Allyn Museum (Sarasota, Florida) and tentatively determined as *C. ammon* by Lee D. Miller (Beck, 1985, T. W. Kral, pers. comm.). However, L. D. Miller (pers. comm.) has no recollection of this specimen and our efforts to locate it within the collections of the Allyn Museum and Florida State Collection of Arthropods (Gainesville, Florida) have proven unsuccessful. Similar efforts by Minno and Emmel (1993) and George Krizek (pers. comm.) were likewise futile. Although the specimen was reportedly captured in the same general area of Big Pine Key as more recent records (T. Kral, pers. comm.), its disposition and true identity are unknown. The unverified report of two additional Big Pine Key specimens, obtained on 7 May 1988 and 26 October 1989 (L. Koehn, pers. comm.), may lend further credibility to Kral's prior record. If ultimately validated, these records would reveal that the species has been present in Florida for at least 17 years.

HABITAT AND ABUNDANCE

All verified Florida records of *C. ammon* have been from Big Pine Key where it is closely associated with rockland pine forests (known variously in the literature as pine rockland, South Florida rockland, subtropical pine forests, rockland flatwoods, rockland pinewoods, dry pineland and shallow soil flatwoods) (Fig. 1, 2a). Rockland of the lower Florida Keys (including Big Pine Key) is an outcrop of Miami limestone where pine forests occur on locally elevated areas of bedrock (Snyder et. al, 1994). Rainfall is lower than mainland pine rockland, resulting in more xeric conditions. Pineland habitats on Big Pine Key are characterized by a canopy of slash pine (*Pinus elliottii* var. *densa* Little & Dorman) (Pinaceae) and a rather sparse understory comprised largely of grasses with patches of exposed limestone. Florida silver palm (*Coccothrinax argentata* (Jacq.) Bailey) (Arecaceae) and Key thatch palm (*Thrinax morrisii* Wendl.) (Arecaceae) are prevalent subcanopy species. The herbaceous flora is depauperate, supporting fewer than 150 species (Snyder et. al, 1994). These pinelands share many characteristics with those occupied by *C. ammon* in the Bahamas (Clench, 1977, Snyder, et. al, 1994). In Florida, *C. ammon* seems to prefer more open pinelands with a profusion of grassy clearings and trails.

Since it was discovered in 1997, *C. ammon* has become progressively more common on Big Pine Key. Adults have been observed during every month of the year, with a minor peak in abundance from February to May. Adults are active from early morning until dust, flying erratically near the ground and freely visiting nectar sources, including *Bidens alba* var. *radiata* (Schultz Bip.) R. E. Ballard ex Melchert (Asteraceae), *Melanthera nivea* (L.) Small (Asteraceae), *Pluchea carolinensis* (Jacq.) G. Don (Asteraceae), *Croton liniaris* Jacq. (Euphorbiaceae), and *Acacia pinetorum* F. J. Hermann (Fabaceae). In flight, they are extremely similar in appearance to *Hemiargus ceraunus antibubastus* Hübner (Lycaenidae), a ubiquitous butterfly throughout the Keys. Males of *C. ammon* can be seen flying along roads through pinelands and perching on the tips of grass blades and other low plants, often basking with partially outstretched wings. Females (Fig. 2i) frequent clearings that support the hostplants and are less often encountered. Oviposition has been observed in mid-late afternoon. Butterfly species sharing pine rockland habitat with *C. ammon* on Big Pine Key include *Polygonus leo savigny* Latrielle (Hesperiidae), *Ephyriades brunnea floridensis* (Bell & Comstock) (Hesperiidae), *Phoebis agarithe maxima* (Neumoegen) (Pieridae), *H. c. antibubastus*, and *Leptotes cassius theonus* (Lucas) (Lycaenidae). *Strymon acis bartrami* (Comstock & Huntington) (Lycaenidae) and *Anaea troglodyta floridalis* F. Johnson & Comstock (Nympha-lidae) are endemic subspecies restricted to pine rockland of the Keys and

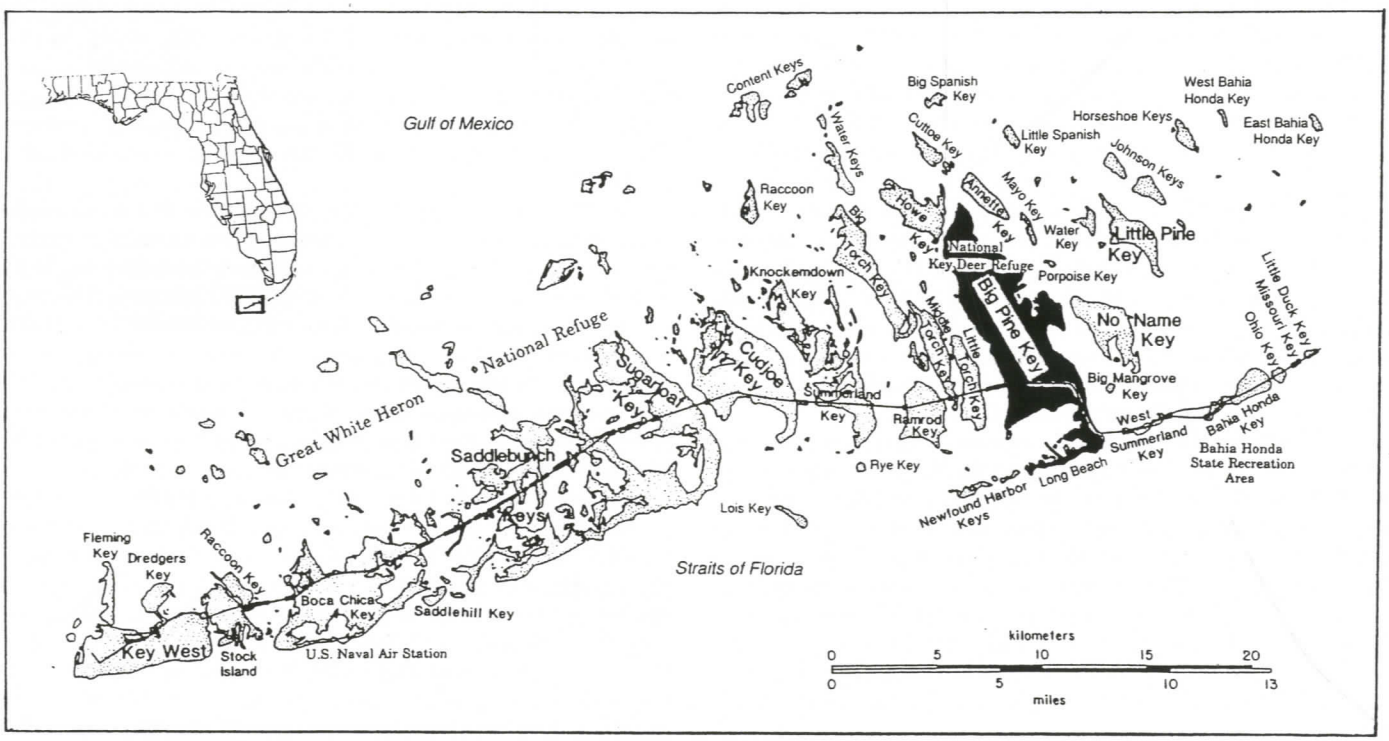

Fig. 1. Map of lower Florida Keys showing location of Big Pine Key.

southern mainland. These taxa were regarded as species of special concern by Baggett (1982) and threatened by Minno and Emmel (1994c, d). An endemic, yet undescribed, Florida Keys subspecies of *Hesperia meskei* (E. H. Edwards) (Hesperiidae) has been recorded only in pine rockland of Big Pine and Sugarloaf Keys. This subspecies was regarded as endangered by Minno and Emmel (1994a) and recently feared extinct. Fortunately, small numbers were encountered on Big Pine Key in 1998 (Salvato, 1999).

There are a number of endemic vertebrates associated with pine rockland of the Florida Keys, including the diminutive Key deer (*Odocoileus virginianus clavium* Barbour and Allen) (Cervidae) which is restricted to Big Pine Key and surrounding islands. This endangered subspecies has prompted the formation of the National Key Deer Refuge that contains extensive tracts of this habitat. *Cyclargus ammon* has been documented at numerous sites on Big Pine Key, including those within the Key Deer Refuge.

LIFE HISTORY

The life history of *C. ammon* was previously unknown. Gundlach (1881) found larvae on a species of *Caesalpinia* (L.) (Fabaceae) in Cuba, but did not provide a description of the early stages. Based on the common name, "Brasilete," used by Gundlach, Alayo and Hernández (1987) limited the species to *Caesalpinia bahamensis* Lam. (L. R. Hernández, pers. comm.). This species of *Caesalpinia* does not occur in Florida, but four other species are found in extreme South Florida and the Keys (Wunderlin and Hanson, 2000). A popular Internet web page on the butterflies of North America (Opler *et al.*, 1995) includes some life history data for *C. ammon*, but obviously duplicated this information from its treatment of *C. t. bethunebakeri.*

On 26-27 February 2000, we (JC and JS) observed females of *C. ammon* ovipositing on pineland acacia, *A. pinetorum*, growing within small pineland clearings on Big Pine Key. *Acacia pinetorum* is endemic to Florida and inhabits shell middens, coastal hammocks and pinelands as far north as Citrus County, but is most common in pine rockland of the southern mainland and Keys (Wunderlin, 1998; R. P. Wunderlin, pers. comm.). Fourth and fifth instar larvae of *C. ammon* were also found on sweet acacia, *Acacia farnesiana* (L.) Willd. (Fabaceae), growing along a pineland road on Big Pine Key. Also found on *A. farnesiana* were larvae of *H. c. antibubastus* and *Ministrymon azia* (Hewitson) (Lycaenidae), representing a new host for both species. Although *A. farnesiana* is found throughout much of Florida in the same habitats as *A. pinetorum*, its distribution has been greatly enhanced by escapes from cultivation (R. P. Wunderlin, pers. comm.). There is some disagreement whether *A. farnesiana* is native to Florida or naturalized (Clarke et. al, 1989; Wunderlin, 1998). Nearly twenty species of *Acacia*, including *A. farnesiana*, occur in Cuba (Leon and Alain, 1951).

Ten adults of *C. ammon* were reared (by JC and JS) from ova and larvae collected from *A. pinetorum* and *A. farnesiana* on Big Pine Key. They were fed hostplant cuttings obtained on Big Pine Key. Additional ova were obtained by confining two *C. ammon* females in a small container with a cutting of *A. pinetorum*. The surviving four larvae were reared to adults on fresh flower heads from a cultivated *Acacia smallii* Isely (Fabaceae) in Gainesville, Florida. Most authors (e.g. Clark et. al, 1989; Wunderlin, 1998) now consider *A. smallii* synonymous with *A. farnesiana*. Ova are deposited singly on developing flower heads and larvae consume the embryonic floral structures. It is also possible that larvae bore into pods and feed on the developing seeds. Larvae tend to concentrate near the tips of hostplant branches where budding flowers are most plentiful.

On 6 May 2000, Leroy Koehn and Robert Beiriger observed females of *C. ammon* ovipositing on the developing leaves of *Caesalpinia pauciflora* (Griseb.) C. Wright (Fabaceae) within the pinelands of Big Pine Key. L. Koehn confined four females with cuttings of the plant, resulting in numerous eggs. Five adults were obtained from the surviving larvae, which fed on the flowers and especially the young leaves of the host. *Caesalpina pauciflora* is a rare Florida native, known only from pinelands and tropical hammocks of the Keys (Wunderlin, 1998). This record confirms the earlier Cuban host report of *Caesalpinia* and suggests that *C. ammon* may feed upon numerous leguminous plants (and possibly related families).

Egg

Eggs are bluish white and elliptical. They have an irregular surface with minute protuberances (Fig. 2b).

Larva

Very similar to *C. t. bethunebakeri*. Young larvae are pale green to nearly yellow (Fig. 2c). Mature larvae are highly variable (Figs. 2d-f), ranging from green with paler green dorsal markings, to brown with beige dorsal markings and red dorsal stripe. All larvae possess lateral stripes of either white, pale green, or greenish yellow, bordered with a narrower stripe of dark green or pink. The head capsule is dark brown. The ant, *Camponotus planatus* Roger (Formicidae), tended the larvae of *C. ammon* and *H. c. antibubastus* found on *A. farnesiana*. Other Polyommatine butterflies tented by ants in Florida include *Celastrina neglecta* (W. H. Edwards) (Lycaenidae) and *Brephidium isophthalma pseudofea* (Morrison) (Lycaenidae) (Harvey and Webb, 1980; Harvey and Longino, 1989). A species of *Camponotus* is also known to tend larvae of *C. t. bethunebakeri* (Minno and Emmel, 1993).

Pupa

The pupae also closely resemble those of *C. t. bethunebakeri* (see figures in Minno and Emmel, 1993), being either green or dark brown (nearly black) (Figs. 2g-h). Pupal duration was from eight to ten days.

Adult

Adults of *C. ammon* are very similar in general appearance to *C. thomasi bethunebakeri*, but considerably smaller (Fig. 2j). In fact, some adult *C. ammon* are nearly comparable in size to *B. i. pseudofea*, considered the smallest butterfly in eastern North America. The average forewing length of Florida *C. ammon* is 9.14mm, compared to 12.31mm for *C. t. bethunebakeri* (base to apex; 10 field-collected males and 10 field-collected females of each species). In males of *C. ammon*, the submarginal black spot in cell Cu_1 of the dorsal hindwing has a pale orange cap, which is usually absent in males of *C. t. bethunebakeri*. In females this dorsal orange cap is enlarged and more triangular in *C. ammon* while it is smaller and crescent-shaped in *C. t. bethunebakeri*. The ventral hindwing of *C. ammon* also exhibits a dark spot in cell Cu_1 with a triangular orange cap that is typically larger than that of *C. t. bethunebakeri*. Ventral white pattern elements are more defined and enlarged in both sexes of *C. ammon*. The area just beyond the discal cell, in cells M_1 and M_2, is white in *C. ammon*, but gray in *C. t. bethunebakeri*. Three black spots are present across the basal hindwing of *C. ammon*, while *C. t. bethunebakeri* has four spots (the spot at the base of cell Cu_2 is often small and indistinct). Wet season females of *C. ammon* tend to have more extensive dark overscaling dorsally.

Plants in the genus *Caesalpinia* are commonly known as "nickers" or "nickerbeans," leading the North American Butterfly Association (NABA) to adopt the common name "Nickerbean Blue" for *C. ammon* (Glassberg, 1999). Although *Caesalpinia* is also fed upon in Florida, we suggest the shorter alternative English name, "Acacia Blue," to emphasize the prevalent host of these populations.

DISCUSSION

Thomas C. Emmel reviewed a photograph of *C. ammon* from Big Pine Key and noted that it resembled "*Hemiargus ammon erem-*


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bis" from the Cayman Islands (Krizek, 1998, 1999) (as discussed above, this taxon is now recognized as a distinct species, *C. erembis*). To more precisely understand the derivation of Florida *C. ammon*, two fresh male specimens were examined by Kurt Johnson who concluded that "the entire range of genitalic characteristics appear quite typical of *C. ammon* in Cuba." This species is a common resident of Cuba where it occurs in various habitats (Alayo & Hernández, 1992; L. R. Hernández, pers. comm.). *Cyclargus ammon* adds to a growing list of exotic, primarily Cuban, butterfly species to successfully colonize Florida (see discussion in Calhoun, 1996). Butterfly surveys of the Florida Keys during the 1980's by Schwartz (1987) and Minno and Emmel (1993) did not document *C. ammon*. Nevertheless, it may have been present for many years prior to 1997, but sustained a low level of density and/or was overlooked due to its similarity to *C. t. bethunebakeri* (the three unverified Florida reports from 1984, 1988 and 1989 support this view). It is now common throughout much of Big Pine Key. During visits on 26-27 February 2000 and 9 April 2000, we observed over 130 adults.

Any discussion of the means by which *C. ammon* arrived in Florida is highly speculative. The dispersal capabilities of butterflies remain poorly understood and conjectural (Brown, 1978; Miller and Miller, 1989). The appearance of *C. ammon* in Florida is probably the result of natural immigration, but begs the obvious question, "why now?" The proximity of Cuba to the Florida Keys (180km) suggests that movement between the islands is not uncommon. However, surprisingly few butterflies of Cuban origin actually manage to become established in Florida.

Insects, particularly small species like *C. ammon*, could be carried aloft in upper level winds and deposited far from the point of origin. Comstock and Huntington (1943) advocated the possibility of hurricane dispersal for butterflies, but Brown (1978) posed a number of problems, including heavy rains and tumultuous winds. Whatever the method of entrance, it is plausible that adults of *C. ammon* have reached Florida in the past, but failed to become established due (at least in part) to a lack of acceptable hostplants at the point of arrival. Big Pine Key, with its abundance of hostplants, may finally have afforded the catalyst for successful colonization. Four species of *Acacia* and four species of *Caesalpinia* occur in extreme southern Florida, including the Keys (Wunderlin, 1998). At least 22 species of *Acacia* have been cultivated in the state of Florida (Burch *et al.*, 1988).

Cyclargus ammon will probably be found in other Florida locations. We have searched for *C. ammon* in the pinelands of No Name Key and Cudjoe Key without success, but these areas do not support an abundance of *Acacia* or *Caesalpinia* hostplants. The continuing success of *C. ammon* on Big Pine Key increases the probability that it will colonize the mainland in the near future (or has already done so). As in Cuba and the Bahamas, *C. ammon* is probably capable of exploiting leguminous hostplants in many habitats, even those in urban and residential situations.

DECLINE OF *CYCLARGUS THOMASI BETHUNEBAKERI*

The arrival of *C. ammon* in Florida is accompanied by the virtual disappearance of *C. t. bethunebakeri*. There is not a cause and effect relationship, however, as the range of *C. t. bethunebakeri* has been retracting southward for many years. This decline prompted the U. S. Fish and Wildlife Service to briefly identify this butterfly as a Category 2 candidate species for listing (a defunct category used to identify species that may require listing as threatened or endangered, but biological information to support such a proposal is inadequate) (USFWS, 1989). Minno and Emmel (1994b) declared it a species of special concern and underscored the need for updated ecological studies. The Florida Natural Areas Inventory (2001), in collaboration with The Association for Biodiversity Information (2001), currently ranks *C. t. bethunebakeri* as globally vulnerable: very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals), found locally in a restricted range, or vulnerable to extinction from other factors.

Cyclargus t. bethunebakeri was originally distributed from Hillsborough and Volusia Counties, southward throughout coastal South Florida and the Keys, including the Dry Tortugas (Forbes, 1941; Kimball, 1965; Calhoun, unpublished). It was most common on the southern mainland and Keys, especially Key Largo and Big Pine Key (Monroe County). It has been recorded on at least ten of the thirty primary islands of the Keys (Minno and Emmel, 1993). Into the 1980s, it maintained outposts on at least three barrier islands along the west coast; Sanibel Island (Lee County), Marco Island, and Chokoloskee (both Collier County) (Brewer, 1982; Calhoun, 1988; Minno and Emmel, 1993). By the 1990s, very few populations of *C. t. bethunebakeri* were known to persist. In 1990, it was reported from Sanibel Island and a barrier island near Miami (Miami-Dade County) (Baggett, 1990, H. Zirlin, pers. comm). It was recorded in 1991 near Homestead (Miami-Dade County) and on Key Largo (Baggett, 1992; R. L. Romeyn, pers. comm.). It was last verified on Big Pine Key in March 1992 (photograph) and seen there again in March 1993 (H. Zirlin, pers. comm.), the latter, however, without any verifiable photographs or specimens.

In the years that followed, there were a few unsupported reports (no available photographs or specimens) of *C. t. bethunebakeri* from Key Largo and Big Pine Key, as well as the southeastern Florida mainland. For example, on 30 October 1996, L. and B. Cooper observed several adults in the area of what is now the Key Largo Hammocks State Botanical Site. Unfortunately, later habitat restoration apparently eradicated the population (L. and B. Cooper, pers. comm.). Other searches in south Florida failed to locate *C. t. bethunebakeri*, fueling fears that this endemic subspecies was extirpated. These worries were allayed on 29 November 1999 when Jane Ruffin discovered and photographed adults of a population in the lower Florida Keys. Approximately 50 individuals were observed during a subsequent visit to the site on 5-6 December (Ruffin and Glassberg, 2000). On 22-23 March 2000, a second site was located nearby and adults were observed ovipositing on *Caesalpinia bonduc* (L.) Roxb. (Fabaceae) (J. Ruffin, pers. comm.) (Fig. 2k). To protect the population, the exact area where these observations occurred was not divulged. We have likewise decided not to provide the location. However, a birding/butterflying tour-group from New Jersey independently discovered the population in January 2000 (Zemaitis, 2000). Four months later, a group of butterfly enthusiasts visited the area and also observed and photographed *C. t. bethunebakeri* (Watts, 2000).

Hope also exists for the continued survival of the butterfly on Key Largo. Richard Gillmore, a seasoned lepidopterist, reported seeing a single *C. t. bethunebakeri* visiting *Bidens* flowers near the Key Largo Hammocks State Botanical Site on 5 May 2001 (R. Gill-

Fig. 2. a, unpaved road through pine rockland habitat of *C. ammon* on Big Pine Key; **b-h**, early stages of *C. ammon*: **b**, egg; **c**, third instar yellow larva; **d**, fifth instar light green larva; **e**, fifth instar brown larva; **f**, fifth instar dark green larva; **g**, green pupa; **h**, green and brown pupae; **i**, perching female *C. ammon*, Big Pine Key, FL (H. Zirlin); **j**, comparison of dorsal male, dorsal female and ventral wing markings of *C. t. bethunebakeri* (top row) to *C. ammon* (bottom row) showing definitive characteristics (discussed in text) (all specimens from Florida); **k**, female *C. t. bethunebakeri* ovipositing on *Caesalpinia bonduc*, FL Keys, March 2000 (J. Ruffin).

more, pers. comm.). Although no photographs were taken, the observation is encouraging, especially since the Coopers reportedly saw adults in the same vicinity in 1996.

Documented hostplants for *C. t. bethunebakeri* include the native tropical trees and shrubs, *C. bonduc*, *Pithecellobium keyense* Britt. ex Britt. & Rose (Fabaceae), and *Pithecellobium unguis-cati* (L.) Benth. (Fabaceae) (Matteson, 1930; Lenczewski, 1980; Brewer, 1982). These trees are primarily restricted to coastal strands and coastal hammocks (Wunderlin, 1998). It has also been reported to feed on *Caesalpinia pulcherrima* (L.) Sw. (Fabaceae), a widely cultivated exotic that has escaped into disturbed sites of South Florida (Matteson, 1930). Rutkowski (1971) observed a female deposit a single egg on *Chiococca alba* (L.) Hitchc. (Rubiaceae), but this may have been an oviposition error and needs confirmation. During the last thirty years, the most frequently reported host is *Cardiospermum halicacabum* L. (Sapindaceae) (e.g. Lenczewski, 1980; Leston, et. al, 1982; Minno and Emmel, 1993). Seeds of this tropical exotic vine are commonly offered by botanical retailers and the plants readily escape cultivation into moist disturbed sites (USDA, 1999). In natural situations, *C. halicacabum* was never very common in Florida and has been recorded in only a portion of the historical range of *C. t. bethunebakeri* (Seminole, Polk, Miami-Dade, and Monroe Counties) (Wunderlin and Hanson, 2000; Wunderlin, pers. comm.).

The initial decline of *C. t. bethunebakeri* probably followed the development of coastal habitats supporting native hosts. Delayed development on some barrier islands may have preserved populations in these areas, at least temporarily. The butterfly probably persisted on the extreme southeastern Florida peninsula and Keys by exploiting the exotic *C. halicacabum*, which was locally abundant at the edges of tropical hammocks. However, *C. halicacabum*, like many other coastal species, has also become less common over the past twenty-five years due to continued development (W. P. Wunderlin, pers. comm.). In 1992, Hurricane Andrew devastated extreme southeastern Florida where many surviving populations of *C. t. bethunebakeri* were found. This storm may have dealt a fatal blow to the majority of these populations by locally eradicating stands of *C. halicacabum* and other potential hosts.

Cardiospermum halicacabum also serves as the local hostplant of the recently established *Chlorostrymon simaethis* (Drury) (Lycaenidae). First recorded in Florida in 1970 (Fisher, 1974, 1975), this butterfly became locally common during the 1980s on the southern mainland and Keys. It is now decidedly rare. The only recent reports of *C. simaethis* in Florida are from within the Key Largo Hammocks State Botanical Site, where it was observed and photographed in October 1996, and in May and June 2001 (L. and B. Cooper, pers. comm.).

Most of the islands that supported populations of *C. t. bethunebakeri*, including Marco Island and Chokoloskee Island, are now suffering from intense developmental pressures and have lost much available habitat. Natural succession undoubtedly also forced *C. t. bethunebakeri* from some of the few remaining sites. Mosquito pesticide application may have placed further stress on struggling populations of *C. t. bethunebakeri* (Emmel and Tucker, 1991; Hennessey and Habeck, 1991; Salvato, 1999). Intriguing evidence suggests that *C. t. bethunebakeri* larvae which feed on *Cardiospermum* seed pods are more susceptible to insecticides than larvae of *C. simaethis* also utilizing the pods. In order to enter pods, the larva of *C. t. bethunebakeri* nibbles a hole in the side of the pod. This hole subsequently allows tending ants access to the larva, but fatally exposes it to the insecticides. Conversely, the larva of *C. simaethis* plugs its entrance hole to deter predaceous ants (this species is not tended), thereby incidentally isolating itself from harmful chemical effects (Emmel, 1991). Because *C. simaethis* has also experienced a decline in Florida, additional research is needed to confirm this relationship and its implications.

A combination of factors probably resulted in an acute fragmentation of *C. t. bethunebakeri,* severely diminishing its ability to repopulate formerly inhabited sites or successfully locate hostplants in new areas. During the last 7 years, several lepidopterists have visited sites on the southeastern mainland and Keys where *C. t. bethunebakeri* was most recently known to occur. Leroy Koehn has personally examined most of these areas, in some cases multiple times. Despite the presence of *C. halicacabum* at a few locations, the butterfly remains elusive. Brief surveys of Marco Island and Chokoloskee by JC in June 2000 also failed to locate *C. t. bethunebakeri.*

The unexpected disappearance of *C. t. bethunebakeri* from Big Pine Key is of particular interest. If the subspecies is still found on the island, it is extremely rare and localized. Unlike elsewhere in its range, habitat loss does not appear to be the primary cause. Until the early 1990s, it most commonly occurred in the same pine rockland habitats where *C. ammon* is now established, but its hostplant was never verified. On Big Pine Key, *C. halicacabum* seems less common than formerly, but prefers the moist edges of tropical hammocks, rather than dry pinelands. *Acacia* is acceptable to *C. ammon* and *H. c. antibubastus*, thus it can reasonably be assumed that these plants were also exploited by *C. t. bethunebakeri.* However, because of the abundance of *Acacia*, we doubt that competition with *C. ammon*, *H. c. antibubastus*, or even *M. azia* played a significant role. *Caesalpinia* hosts also occur within the pinelands of Big Pine Key. Development of pine rockland has slowed during the past decade and the National Key Deer Refuge has actually been expanded to increase key deer habitat. Moreover, no devastating hurricanes have directly affected the region within the last two decades. Regardless of suitable habitat on Big Pine Key, *C. t. bethunebakeri* has possibly been negatively impacted by other human factors, most notably the widespread aerial and ground application of mosquito adulticides. Such a relationship between mosquito adulticides and butterfly population suppression has been observed elsewhere on other Florida Keys, especially in association with *Papilio aristodemus ponceanus* Schaus (Papilionidae) (Eliazar and Emmel, 1991). Although *C. ammon* and *H. c. antibubastus* do not appear adversely affected by current application regimes, tolerance and adaptability to chemical exposure may vary widely between species. Whatever the cause (or causes) of the decline of *C. t. bethunebakeri* on Big Pine Key, the relative isolation of the island and intense fragmentation of the species have apparently prevented its rapid recovery.

The decline of *C. t. bethunebakeri* is nearly identical to that experienced by *Eumaeus atala florida* (Röber) (Lycaenidae). This subspecies was widespread and common in southern Florida, but precipitously declined following the urbanization of habitat and reduction of its native hostplant, *Zamia pumila* (L.) (Cycadaceae). After the last known population disappeared in the early 1970s, *E. a. florida* was believed extirpated in Florida until a single population was located in a park near Miami in 1979. Soon after, new populations were successfully established through captive breeding and translocation of early stages into appropriate habitats in the vicinity of Miami (Emmel and Minno, 1993; Hammer, 1996). Today, *E. a. florida* enjoys local abundance and is sometimes considered a pest of cultivated cycads in the Miami area. At least 12 exotic species of cycads are also acceptable hosts of *E. a. florida* (Hammer, 1996). Several species, including the native *Z. pumila*, are grown in South Florida gardens with the express purpose of attracting this butterfly. It has become a symbol of species resurrec-

tion and pride by gardeners and landscapers who continue to contribute to the success of this butterfly. Cycad hostplants also have become popular choices for xeriscape and city beautification projects throughout central and southern Florida. Although it is often referred to as "threatened," *E. a. florida* has never been regulated on a federal or state level. It remains unlisted (to the delight of those treating cycads for troublesome larvae), and is expanding with the increasing cultivation of cycads.

Closely following the rediscovery of *C. t. bethunebakeri* in Florida, a petition was submitted to the U. S. Fish and Wildlife Service requesting that the subspecies receive emergency listing as federally endangered, pursuant to the Endangered Species Act of 1973 (Glassberg, 2000a,b,c). In May 2001, the USFWS stated that this butterfly will receive emergency listing "if warrented" (DOI, 2001). Regardless of any federal intervention, it may be revealed that the recovery of *C. t. bethunebakeri* could easily be enhanced through captive breeding, translocation and the controlled cultivation of *C. halicacabum*, *Caesalpinia*, and other hosts. Simply increasing public awareness could result in conservation by informed landowners and developers.

Despite the obvious rarity of *C. t. bethunebakeri*, comprehensive surveys are still required to determine its precise status in Florida. Just as Arnold (1983) and New (1993) emphasized the importance of ecological and biological investigations of endangered species of Lycaenidae, a detailed understanding of known populations is necessary before suitable regulation and management can be achieved, or a recovery plan drafted.

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