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Systematics and Acoustic Behavior of United States Crickets of the Genus *Orocharis* (Orthoptera: Gryllidae)[1]

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ABSTRACT

Six species of *Orocharis* (Gryllidae: Entopterinae) occur in the United States. *O. saltator* Uhler and ***luteolira,*** n. sp., are widespread in the southeastern States, while *gryllodes* (Pallas), ***tricornis,*** n. sp., ***diplastes,*** n. sp., and ***nigrifrons,*** n. sp., are limited to coastal peninsular Florida. The distinctive calling songs of all species are described from analyses of field and laboratory tape recordings. The high wing-stroke rate of *gryllodes* (150–280/sec) suggests asynchronous, fibrillar muscles. *O. saltator* and *luteolira* cannot be distinguished morphologically. They have different seasonal life histories and distinctive calling songs but overlap in geographic distribution and habitat.

Crickets of the genus *Orocharis* are widespread and abundant in broad-leaved forests of the warmer, moister parts of the New World. However, they are arboreal and nocturnal, and their ubiquity is better attested by the calls of the males than the specimens in museum collections. Published studies of *Orocharis* have dealt mostly with the nomenclature and external features of a few dozen specimens in European museums (e.g. Saussure 1874, 1878, 1897). Except for Riley's (1881: 62) report on oviposition of *saltator* and Alexander and Otte's (1967) report on mating behavior, the published information on biology of *Orocharis* pertains only to collecting sites and calling songs. For instance, feeding habits have not been studied, but I have observed nymphs and adults feeding on tender leaves. In captivity nymphs can be reared on pieces of apple or on dry dog food and water.

Orocharis is 1 of 27 genera of eneopterine crickets known from the New World (Chopard 1956: 276–7, key). Some 31 species names have been used in combination with *Orocharis,* and 25 of these names have been neither synonymized nor placed in another genus. Of these 25 nominal species, only 2 (*saltator* and *gryllodes*) have been reported from the United States. The other 23 are restricted to the New World tropics.

I have found 4 additional species of *Orocharis* in the United States. The initial discovery of each was a result of hearing an unfamiliar calling song. Once a series of each of the 4 new species had been collected, all but 1 (*luteolira*) proved easy to separate from other U.S. species by morphological features. However, all 4 resemble *saltator* closely enough to have passed undetected in museum collections.

METHODS

Methods were similar to those used in studies of oecanthine crickets (Walker 1962a; 303–5). The calling songs were taped at 15 in./sec with a Magnemite 610E or a Nagra III recorder in the field and with a Magnecorder PT6 or an Ampex 351 recorder in the

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laboratory. Recorded sounds were analyzed with a Kay Sonograph. The tapes are a part of the tape library of the Department of Entomology, University of Florida, Gainesville.

The following abbreviations are used here: ANSF (Academy of Natural Sciences of Philadelphia), FSCA (Florida State Collection of Arthropods), HFS (H. F. Strohecker), JDS (J. D. Spooner), REL (R. E. Love), TJW (T. J. Walker), UFT (University of Florida, Department of Entomology, Tape), UMMZ (University of Michigan Museum of Zoology), USNM (U.S. National Museum).

Holotypes and allotypes of new species have been deposited in USNM, and paratypes have been sent to UMMZ, ANSP, HFS, and Lyman Entomological Museum, Macdonald College, Quebec, Canada.

NOMENCLATURE

Three of the species described here are known only from south peninsular Florida in habitats similar to those of many coastal areas elsewhere in the Caribbean. The possible occurrence of these species outside the United States complicated their naming. Before I assigned new names, I had to consider 23 names that apply to *Orocharis* not known to occur in the United States. All but 2 (*terebrans* Saussure and *meridionalis* Saussure) were eliminated on the basis of published descriptions, keys, and synonymies. By comparing Saussure's type of *terebrans* with drawings, Dr. H. Gisin concluded that it was unlike any of the U.S. species (personal communication). The name *meridionalis* was used by Saussure (1897) for a variety of *O. saltator* from Mexico and Guatamala. The type is missing, and the description is inadequate to place the species; therefore, it is a nomen dubium.

Orocharis gryllodes (Pallas)
Big-eyed bush cricket
(Fig. 1, 2, 10, 12, 13)

Gryllus gryllodes Pallas, 1772: 16, pl. 1, fig. 10. Type-locality: Jamaica. Type: ♂, lost or destroyed.
Platydactylus saulcyi Guerin, 1844: 330. Type-locality: Martinique. Type: ♀ (synonymy by Hebard 1915).

Hebard (1915) is responsible for use of the name *gryllodes* for the present species. The evidence he cited is far from conclusive, but since the type-specimen is missing, one can assume Hebard was correct and continue to use *gryllodes*.

Orocharis saltator Uhler
Jumping bush cricket
(Fig. 1, 3, 8, 12, 14)

Orocharis saltator Uhler, 1864: 245. Type-locality: near Baltimore, Md. Type: ♂ (lectotype here designated from 1 ♂ and 2 ♀ syntypes), 6 Oct., Museum of Comparative Zoology, Cambridge, Mass.
Orocharis saltatrix Saussure 1874: 494 (unjustified emendation).
Orocharis gryllodes, Saussure 1878, 1897 (in part) (misidentification).
Apithes mcneilli Blatchley, 1892: 27. Type-locality: Vigo County, Indiana. Type: ♀, 21 Oct. 1891, Entomology Research Collection, Department of Entomology, Purdue University, Lafayette, Indiana. (synonymy confirmed by TJW).

Orocharis luteolira, n. sp.
False jumping bush cricket
(Fig. 1, 4, 9, 12, 15)

R. D. Alexander (personal communication) was first to suspect that this species was distinct from *saltator.* It cannot be separated from *saltator* by morphological characters, but its specific distinctness is evidenced by sympatry with *saltator* with maintenance of dichotomies in calling songs and seasonal life histories. Most previous records of *saltator* from Florida and the southern Atlantic coastal plain refer to *luteolira* (e.g., Walker 1962b).

Holotype.—♂, University of Florida campus, Gainesville, 31 May 1961, TJW and JDS. UFT 681–17 (a–f) (see Fig. 3, Walker 1962b). Background color light brown. Frons with medial inverted-V-shaped dark area. Dorsum of head as in Fig. 15 (the name *luteolira* refers to the thin yellowish ridge connecting the lateral ocelli). Anterior margin of terminal segment of maxillary palp very slightly concave. Stridulatory file 2.25 mm, with 76 teeth.

Allotype.—♀, Gainesville, Fla., 23 May 1961, JDS. Similar to holotype. Frons with additional dark marks extending along antennal sutures to eyes and from there downward toward anterior tentorial pits.

Measurements of Holotype and Allotype (in mm).—Length of body ♂ 14, ♀ 16; pronotum (length × caudal width) ♂ 2.4×4.0, ♀ 2.7×4.0; length of tegmen ♂ 15.1, ♀ 15.9; length of hind femur ♂ 8.8, ♀ 10.1; length of hind tibia ♂ 8.0, ♀ 9.6; length of ovipositor 13.8; terminal segment of maxillary palp (greatest length × terminal width) ♂ 0.94 × 0.46, ♀ 1.15×0.40.

Paratypes.—FSCA. Taped specimens (12 ♂): FLORIDA, Alachua Co. (UFT 681-14, 15, 16, 64), Clay Co. (UFT 681-65), Highlands Co. (UFT 681-4, 29), Liberty Co. (UFT 681-3, 20), Putnam Co. (UFT 681-1, 2). NORTH CAROLINA, Hoke Co. (UFT 681-66, 67). Other paratypes (50 ♂, 37 ♀, 1 juv.): FLORIDA, 19 counties (49 ♂, 35 ♀, 1 juv.). GEORGIA, Charlton Co., 17 June 1965 (1 ♂ collected as juv.). NORTH CAROLINA, Hoke Co., 26 Aug. 1965 (1 ♀, collected as juv.). ANSP. FLORIDA, Dade Co., Miami, 28 Feb. 1916 (1 ♀, collected under sign on pine tree).

Variations among Paratypes.—Eleven (4 ♂, 7 ♀) of the 100 (62 ♂, 38 ♂) adult paratypes are generally darker and have more dark markings than the holotype and allotype. The males have dark spots on the tegmina, and both sexes have dark occiputs, postocular stripes, and median and lateral pronotal stripes. The color variation appears dimorphic though a few individuals are difficult to classify. A similar color dimorphism occurs in *saltator,* where 11 (10 ♂, 1 ♀) of the 23 (18 ♂, 5 ♀) specimens at hand are dark. Color dimorphism is common among the tettigoniids but the only other case among crickets known to me is in *Oecanthus californicus* Saussure, a species that lives in shrubs and trees as do *Orocharis* spp. (Walker 1962b).

Variation in size is considerable. Measurements of the largest and smallest ♂ and ♀ paratypes are: (♂, Liberty Co., Fla., 12 June 1962, and Highlands Co., Fla., 1 Sep. 1958; ♀, Liberty Co., Fla., 13 June 1962, and Alachua Co., Fla., 9 Sept. 1960) length of body ♂ 17.8, 13.7, ♀ 19.4, 12.8; pronotum (length × caudal width) ♂ 2.6×4.0, 1.8×2.8, ♀ 2.9×4.5, 2.0×2.9; length of tegmen ♂ 16.1, 10.7, ♀ 15.9, 11.1; length of hind femur ♂ 9.8, 6.5, ♀ 11.7, 7.6; length of hind tibia ♂ 9.2, 6.0, ♀ 10.8, 7.3; length of ovipositor 14.0, 10.0.

Peripheral records (Fig. 1) are Torreya State Park, Liberty Co., Fla., (UFT 681-3; FSCA); Tifton, Ga. (UFT 681-55, 56); Cheraw, S. C. (UFT 681-71, 72); Chesterfield Co., Va. (Alexander 1956[2]); Northampton Co., Va. (UFT 681-68, 69, 70); Florida City and Miami, Fla. (UFT 681-61, 62; ANSP); Fla. 94, 5.3 miles S of western junction with U.S. 41, Monroe Co., Fla. (UFT 681-63). J. D. Spooner (personal communication) recently collected and taped *luteolira* from Auburn, Barrow Co., Ga.

Orocharis tricornis, n. sp.
Three-horned bush cricket
(Fig. 1, 5, 9, 16)

The name *tricornis* is used for this species because it is the only *Orocharis* known to have pointed projections above the ocelli (Fig. 16). In general appearance it resembles the dark forms of *saltator* and *luteolira*.

Holotype.—♂, Flamingo, Monroe Co., Fla., 26 Apr. 1963, TJW and JDS. UFT 685-6. Coloration similar to the dark forms of *saltator* and *luteolira*. Frons black except for ventrolateral portions, narrow median stripe, and 2 small subantennal spots. Genae light, each with central black spot. Clypeus with a pair of dorsal black spots. Lateral black stripe extending posteriorly from each eye and fading in lateral field of tegmen. Dorsal field of tegmina with many dark brown spots along major veins. Dorsum of head as in Fig. 16. Anterior margin of maxillary palp slightly concave. Stridulatory file 2.20 mm, with 118 teeth.

Allotype.—♀, Flamingo, Monroe Co., Fla., 21 June 1964, TJW and REL. Similar to holotype. Light markings on frons less clearly defined. Anterior margin of maxillary palp less concave.

Measurements of Holotype and Allotype.—Length of body ♂ 17, ♀ 14; pronotum (length × caudal width) ♂ 2.2×3.5, ♀ 2.4×3.5; length of tegmen ♂ 14.7, ♀ 15.0; length of hind femur ♂ 8.3, ♀ 8.6; length of hind tibia ♂ 7.5, ♀ 8.3; length of ovipositor 11.4; terminal segment of maxillary palp (greatest length × terminal width) ♂ 0.88×0.39, ♀ 0.95×0.30.

Paratypes.—7 ♂ (including 2 taped specimens), 8 ♀, 1 juv. FLORIDA, Dade Co.: 1 ♀, 1 Mar. 1952, HFS (HFS); 1 ♀, Miami, 3 Mar. 1915, Hebard; 1 juv. ♀, Miami, 4 Mar. 1915, Hebard (ANSP). Monroe Co.: 1 ♀, Little Torch Key, 7 May 1961, H. V. Weems, Jr.; 1 ♂ (UFT 685-5), Flamingo, 26 Apr. 1963, TJW, JDS; 4 ♂ (including UFT 485-8), 1 ♀, Flamingo, 21 June 1964, TJW, REL, K. Stone; 2 ♂, 4 ♀, Flamingo, 25 Dec. 1965, JDS (FSCA).

Additional Localities.—UFT 685-1, 3 miles N Flamingo, 17 Aug. 1960; UFT 685-7, Sugarloaf Key, 24 June 1964; heard on Cudjoe Key, 24 June 1964, TJW.

Variation among Paratypes.—All paratypes are similar in size and coloration to the holotype and allotype. Light markings within the dark portion of the frons are variable. *O. tricornis* apparently lacks the color dimorphism of *saltator* and *luteolira*. All *tricornis* are dark though none has the median pronotal stripe found in some dark *saltator* and *luteolira*.

Orocharis diplastes, n. sp.
Keys bush cricket
(Fig. 1, 6, 11, 12, 17)

O. diplastes has the most limited range of any U.S. *Orocharis*. It is known only from the Florida Keys and 24 of the 27 specimens in the type-series are from a single site.

The name *diplastes* (Gr. *diplo*, double; *astes*, singer) refers to the calling song, which contains 2 pulse rates rather than the usual 1.

Holotype.—♂, sec. 32, T66S-R30E, Spanish Harbor Key, Monroe Co., Fla., 16 Aug. 1960, TJW. General coloration similar to light form of *saltator*. Frons dark brown without light areas except for ventrolateral portions. Dark spot on each gena thinly connected to dark portion of frons. Postocular stripes faint. No median pronotal stripe. No spots on dorsal field of tegmina. Dorsum of head as in Fig. 17. Anterior margin of terminal segment of maxillary palp slightly concave. Stridulatory file 1.98 mm, with 140 teeth.

Allotype.—♀, same data as holotype, and similar. Pronotum with dark median stripe and each tegmen with row of elongate dark spots on vein at edge of dorsal field.

Measurements of Holotype and Allotype.—Length of body ♂ 15, ♀ 15; pronotum (length × caudal width) ♂ 2.0×3.3, ♀ 2.2×3.3; length of tegmen ♂ 12.7, ♀ 13.3; length of hind femur ♂ 7.6, ♀ 8.7; length of hind tibia ♂ 6.8, ♀ 7.6; length of ovipositor 10.4; terminal segment of maxillary palp (greatest length × terminal width) ♂ 0.80×0.45, ♀ 0.96×0.36.

Paratypes.—21 ♂ (including 3 taped specimens), 4 ♀ FLORIDA KEYS, 19 ♂ (including UFT 683-4, 5, 6), 3 ♀, same data as holotype. 1 ♂, 1 ♀, Tavernier, S Key Largo, 4 July 1965, REL (FSCA). 1 ♂, Key Largo, 9 Aug. 1930, R. H. Beamer (ANSP).

Additional Localities.—UFT 683-10, Missouri Key, 14 June 1968, J. J. Whitesell.

Variation among Paratypes.—The paratypes can be

[2] R. D. Alexander. 1956. A comparative study of sound production in insects, with special reference to the singing Orthoptera and Cicadidae of the Eastern United States. Ph.D. dissertation, The Ohio State University. 529 p.

separated into dark and light forms by the presence or absence of a dark median pronotal stripe and spots on the dorsal field of the tegmina. The dark forms predominate: 3 of 4 ♀ and 17 of 21 ♂ are dark. One of the males classed as dark lacks the pronotal stripe, and another lacks the spots on the tegmina. The paratypes are nearly uniform in size.

Orocharis nigrifrons, n. sp.
Black-faced bush cricket
(Fig. 1, 7, 11, 18)

O. nigrifrons owes its name to its piceous frons. Since the genae are largely ivory, this species is the most boldly marked of U.S. *Orocharis*.

Holotype.—♂, Marco Island, Collier Co., Fla., 28 Apr. 1963, TJW, JDS. UFT 684-3. General coloration similar to dark form of *saltator*. Frons piceous except for ventral corners. Genae ivory, without spots. Strong postocular stripe extending onto lateral field of tegmen. Median pronotal stripe. Dark spots along major veins of tegmina; membranous areas infuscated. Dorsum of head as in Fig. 18. Anterior margin of terminal segment of maxillary palp concave. Stridulatory file 1.94 mm, with 103 teeth.

Allotype.—♀, same data as holotype, and similar. Small dark spot on each gena. Occiput and disk of pronotum darker than in holotype. Anterior margin of terminal segment of maxillary palp less concave.

Measurements of Holotype and Allotype.—Length of body ♂ 14, ♀ 13; pronotum (length × caudal width) ♂ 2.1×3.0, ♀ 2.2×3.4; length of tegmen ♂ 12.8, ♀ 13.3; length of hind femur ♂ 7.2, ♀ 7.7; length of hind tibia ♂ 6.3, ♀ 6.9; length of ovipositor 10.6; terminal segment of maxillary palp (greatest length × terminal width) ♂ 0.86×0.49, ♀ 0.97×0.35.

Paratypes.—15 ♂ (including 8 taped specimens), 3 ♀ FLORIDA, Collier Co.: 2 ♂ (UFT 684-1, 2), Marco Island, 24 Aug. 1958, TJW; 4 ♂ (including UFT 684-4), 2 ♀, Marco Island, 28 Apr. 1963, TJW, JDS. Dade Co.: 1 ♂ (UFT 684-10), Jewfish Creek nr. Lake Surprise, 4 July 1965, REL. Manatee Co.: 6 ♂ (including UFT 684-7, 8), 1 ♀, U.S. 19 nr. Sunshine Skyway, 16 May 1965, REL. Monroe Co.: 1 ♂ (684-6), northern Key Largo, 22 June 1964, TJW, REL, K. Stone; 1 ♂ (684-5), Saddle Bunch Keys, 24 June 1964, TJW, REL, K. Stone (all FSCA).

Additional Localities.—UFT 684-11, 5.6 miles NE of Tavernier, southern Key Largo, 4 July 1965, REL.

Variation among Paratypes.—No color dimorphism is evident. All specimens are as dark as the dark form of *saltator*. Variation in size is slight. Eight of the paratypes have immaculate genae. The remainder have a central dark dot or spot on 1 or both genae.

GEOGRAPHICAL DISTRIBUTION

Fig. 1 details the geographical distribution of U.S. *Orocharis*. *O. saltator* is the only species of *Orocharis* in much of eastern United States. It is apparently limited westward by prairie and northward by duration of frost-free period. Its failure to occur farther southeastward may be a matter of interaction with *luteolira*. Such interaction is suggested by the apparent failure of the 2 species to occur together in western Florida. However, they do occur together in portions of Virginia and North and South Carolina. Peripheral records of *saltator* are 1 mile W of Cottondale, Jackson Co., Fla. (UFT 686-52, 53); S. F. Austin State Park, Tex. (UFT 686-21, 22); Cherokee Co., Kans. (ANSP); St. Louis, Mo. (Hebard 1931); Indianapolis, Indiana. (Blatchley 1920); Mifflin Twp., Franklin Co., Ohio (Alexander 1956[2]); Marietta, Ohio (TJW); Cornwells, Pa. (ANSP); Orangeburg, S. C. (UFT 686-15, 16); Macon, Ga. (TJW).

O. luteolira may be limited westward by interaction with *saltator* and northward by too short a frost-free period for completing a 2nd generation. Its southern limits correspond to the limits of suitable habitat and the occurrence of other species of *Orocharis*.

The remaining species (*gryllodes, tricornis, diplastes,* and *nigrifrons*) probably have no freeze-hardy stage. Only *gryllodes* is predictable in its occurrence; it occurs northward along the coasts as far as climate and habitat are suitable. The other 3 species are often lacking in places and at times that are apparently suitable. Consequently, no attempt has been made to indicate their general distribution (Fig. 1).

Peripheral records of *gryllodes* in Florida (Fig. 1) are Cedar Key (FSCA); Mosquito Lagoon, T18S-R35E (UFT 682-14, 15); Loggerhead Key, Dry Tortugas (FSCA). *O. gryllodes* is the only U.S. species known to occur outside the areas mapped. West Indian records are Cuba (Saussure 1874), Martinique (Guerin 1844), Jamaica (type-locality; UFT 1966-14-I, K), and Haiti (UFT 682-13).

HABITAT RELATIONSHIPS

All U.S. species of *Orocharis* are most easily collected by shining a bright light on appropriate foliage at night but individuals may be taken during the daylight hours by beating or by peeling away loose bark.

O. saltator and *luteolira* are usually found in broad-leaved trees and occasionally in herbaceous undergrowth, in shrubs, and in pine trees. Where *saltator* and *luteolira* were observed together in localities in Virginia and North and South Carolina, *saltator* was more common in mesic or hydric woodland, while *luteolira* was more common in well-drained, more open woodland (e.g., sandhill vegetation). In Cheraw, S. C., only *luteolira* was heard on the uplands and only *saltator* was heard in the Pee Dee River bottoms. On the other hand, at Little Pee Dee State Park, S. C., and at Alberta, Va., the 2 species were heard on some sites in adjacent trees. In Hoke Co., N. C., *saltator* was taped from some vine-overgrown roadside saplings. When reared, the late-instar nymphs taken from the same vines proved to be *luteolira*. In eastern and peninsular Florida, where *luteolira* occurs and *saltator* does not, *luteolira* is abundant in wet and mesic broad-leaved woodland as well as in dry. It is not known from mangrove or from the subtropical hammocks of south Florida and the Florida Keys. Its southernmost records are from

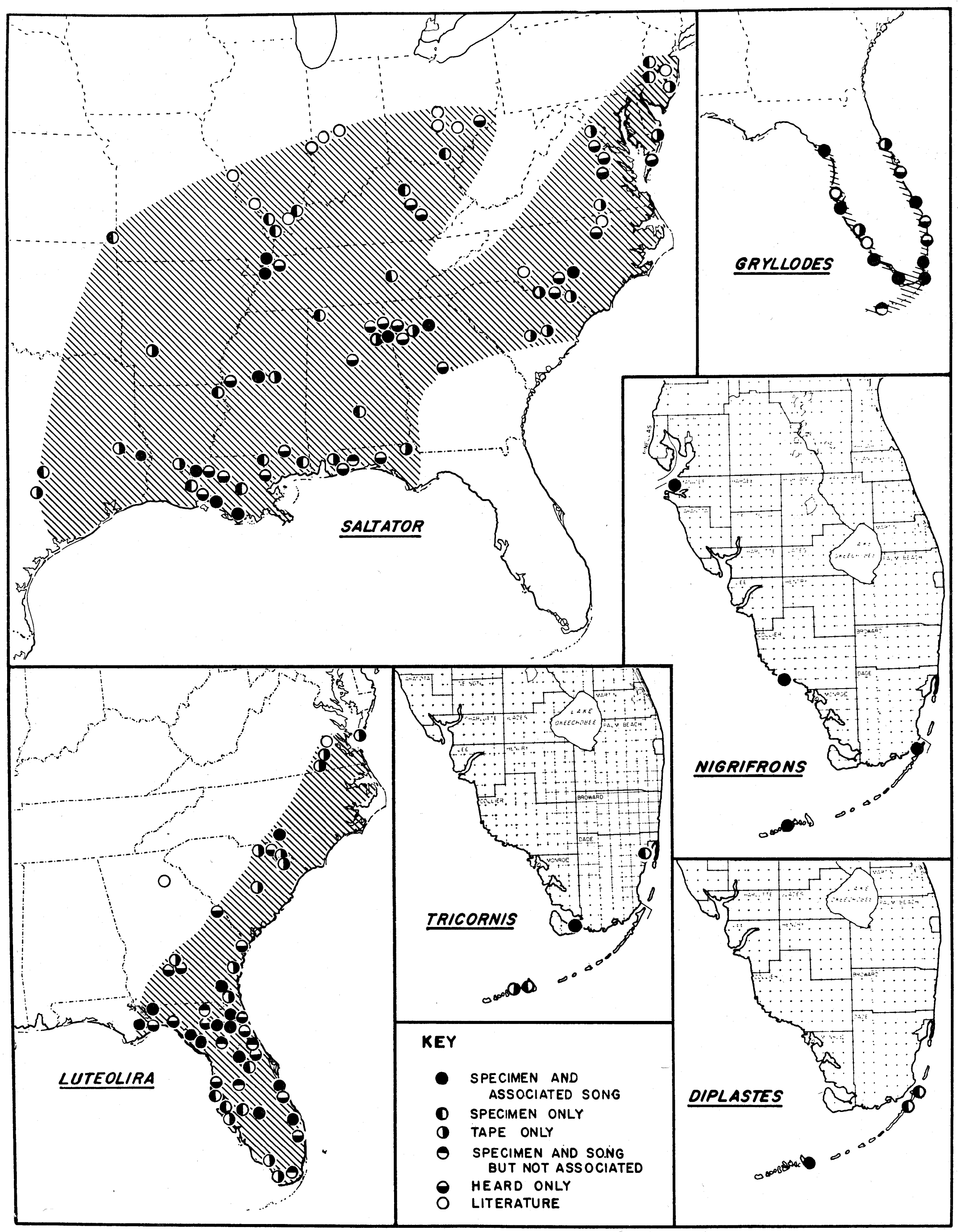

FIG. 1.—Distribution of *Orocharis* in the United States. Peripheral records are substantiated in the text. For *saltator, luteolira,* and *gryllodes,* the predicted distribution is shaded, and the points show county records except that the Upper and Lower Florida Keys are plotted independently from continental Monroe County, Fla. For *tricornis, diplastes,* and *nigrifrons,* all locality records are plotted except for records within a few miles of a plotted record.

shrubby undergrowth and broad-leaved trees in communities dominated by pine and cypress.

O. gryllodes occurs in the trees and on the undergrowth of the subtropical hammocks of south Florida. It is abundant in the coastal mangrove forests there and farther north. North of Dade and Monroe Counties, *gryllodes* is known only from mangrove. The freeze of December 1962 killed back the mangrove and eliminated the population of *gryllodes* at Cedar Key. The mangrove gradually grew back, and *gryllodes* returned in 1968.

O. tricornis occurs with *gryllodes* in south Florida mangrove and subtropical hammocks. The northernmost record is from Brickell's Hammock, Miami (ANSP). Other specific habitat records include buttonwood, *Conocarpus erectus* L.; live oak, *Quercus virginianus* Mill.; and mature mangrove hammock.

O. diplastes and *nigrifrons* are known only from mangrove. Most of the specimens of *diplastes* came from an isolated, 8-ft-high white mangrove, *Laguncularia racemosa* (L.), on Spanish Harbor Key. It was found on black mangrove, *Avicennia nitida* Jacq., at the same site. The only other host record is white mangrove, on southern Key Largo.

O. nigrifrons is known almost exclusively from black mangrove. However, it was found on red mangrove, *Rhizophora mangle* L., as well as black, on the Saddle Bunch Keys (TJW), and in Manatee Co., it was collected on white mangrove (REL). The 1 time that *diplastes* and *nigrifrons* were found in neighboring areas (southern Key Largo, 4 July 1965, REL), *diplastes* was on white mangrove and *nigrifrons* was on black.

SEASONAL LIFE HISTORIES

O. saltator overwinters in the egg stage and has a single generation each year. In the northern part of its range adults are not present until late summer and fall. Even in the South, *saltator* matures late. The earliest record of an adult is 16 July (Washington Par., La., M. Tidwell), and I have collected juveniles in late August in Alabama, Louisiana, and eastern Texas.

In the northern part of its range *O. luteolira* apparently overwinters in the egg stage and has 2 generations per year. It may breed continuously in peninsular Florida. The evidence for 2 generations in Georgia and northward is that I have noted abundant adults in early summer and in fall but none in early August. However, my records are few, and more systematic observations are needed.

Somewhere between mid-Georgia and Gainesville, Fla., *luteolira* changes from 2 clearly defined generations per year with midsummer and winter hiatuses in singing to an ambiguous situation with adults singing on any warm night of the year, but with reductions in singing in late July and January–February.

Records of juveniles in Gainesville are inadequate to indicate whether egg hatching is continuous. The abundance of singing adults suggests 2 principal generations per year with these generations being more protracted than farther north. Blatchley (1920) collected nymphs at Dunedin, Fla., during the winter and spring. This record suggests continuous generations at this latitude.

Where *luteolira* and *saltator* occur together, an early-summer generation of *luteolira* is apparently followed by the maturing of *saltator* and, soon after that, by the 2nd generation of *luteolira* adults. From late August until frost, *luteolira* and *saltator* are both calling, sometimes within hearing of one another.

O. gryllodes evidently breeds continuously. I have records of adults for every month, and late-instar juveniles have been collected at all times of intensive collecting; as early as 18 Mar. and as late as 20 Aug.

Records of *tricornis, diplastes,* and *nigrifrons* are too few to indicate seasonal life histories. Adults of *tricornis* occurred 25 Dec., 3 Mar., April, May, June, and 17 Aug. The only juvenile was collected 4 Mar. in Miami. Adults of *diplastes* have been taken or heard on 14 June, 4 July, and 9 and 16 Aug. The only juveniles observed were last instars on 16 Aug. Adults of *nigrifrons* have been collected 28 Apr., 16 May, 22 and 24 June, 4 July, and 24 Aug. The only juveniles collected were last instars on 16 May.

CALLING SONG

Each U.S. species of *Orocharis* has a distinctive calling song (Fig. 2–12). Four of the species produce brief chirps (½ sec or less, Fig. 2–5) at irregular intervals. The chirps of *gryllodes* sound buzzy and consist of 10–14 pulses (corresponding to wing closures). They are usually produced in groups of 2 or 3 (Fig. 2), and at 25°C 3–6 groups are produced per 10 sec. The other 3 chirping species produce melodious chirps singly at a rate of 3–7 (*saltator* and *luteolira*) or 5–20 (*tricornis*) chirps/10 sec at 25°C.

The rate of wing movement in *gryllodes* (Fig. 10) exceeds 100/sec, the highest rate known for synchronous flight muscles in insects. This rate suggests that the stridulating muscles are asynchronous and fibrillar, a type of muscle not known in Orthoptera (Pringle 1965).[3]

The 3 species of melodious chirpers differ in wing-stroke rate (Fig. 8, 9) and number of pulses per chirp. *O. saltator* has 10–18 pulses/chirp; *luteolira* has 4–9; and *tricornis* has 2–3. The differences between *saltator* and *luteolira* in wing-stroke rate and in pulses per chirp combine to give *saltator* substantially longer chirps than *luteolira*. The only geographic variation detected in the songs of *Orocharis* is that *luteolira* in south Florida usually has 5–6 pulses/chirp whereas *luteolira* from farther north most often has 6–7. The song of neither *saltator* nor *luteolira* changes where the 2 species occur together, suggesting that the typical songs are different enough to eliminate confusion on the part of females.

Two tapes made in Jackson Co., Fla., at 14.5°C were tentatively identified as *saltator* on the basis of pulse number (12–15/chirp) even though the pulse rates were high enough to be *luteolira* (Fig. 8). The crickets may have been in a warmer microclimate

[3] R. K. Josephson and H. Y. Elder (1968: Biol. Bull. 135: 409) report that singing muscles of the katydid *Neoconocephalus robustus* are synchronous and contract at rates as high as 200/sec.

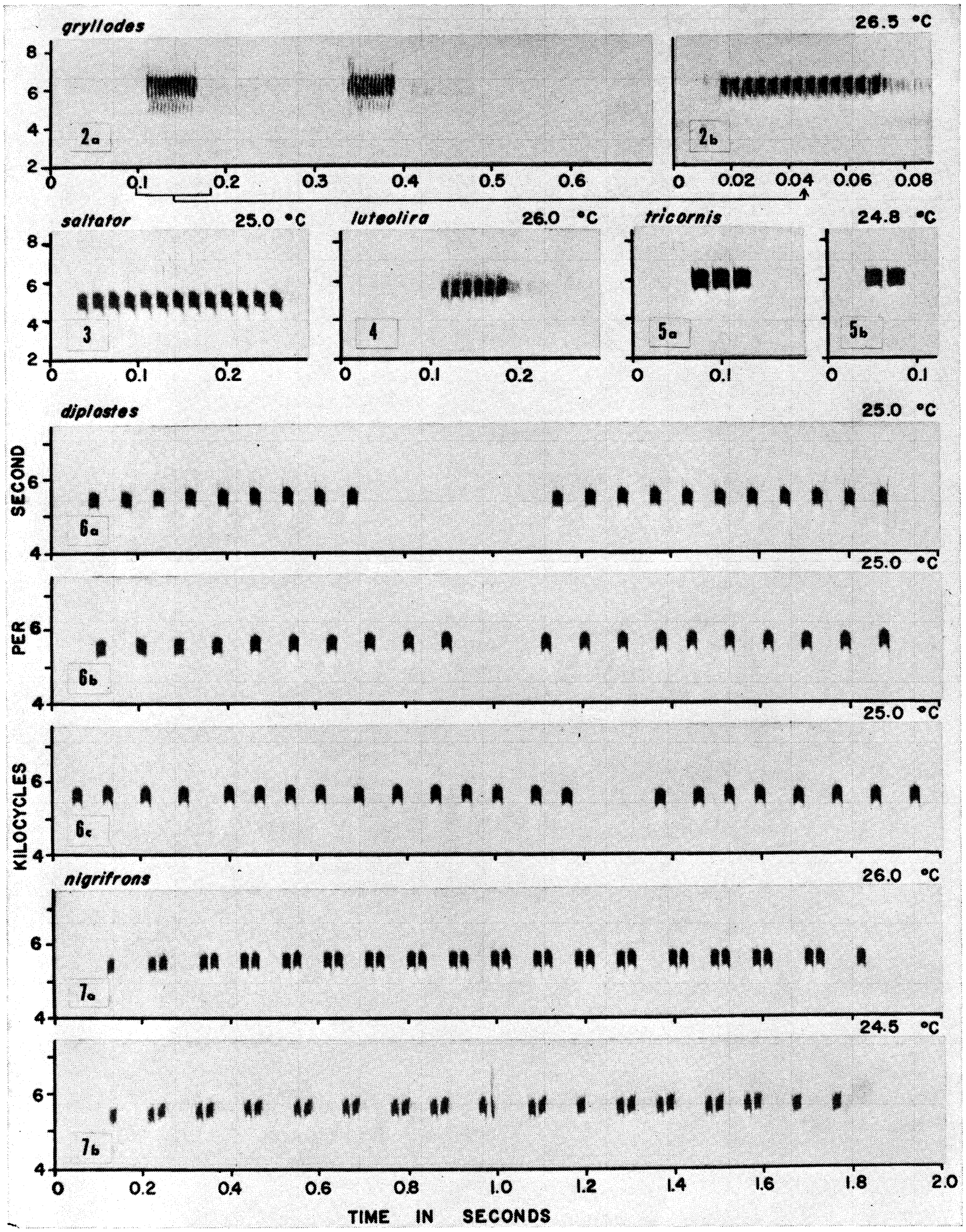

FIG. 2–7.—Audiospectrograms of calling songs of U. S. *Orocharis.* 2a, Chirp group of *gryllodes;* 2b, 3, 4, 5a, 5b, single chirps of *gryllodes, saltator, luteolira,* and *tricornis;* 6a, *O. diplastes,* fast wing-stroke rate; 6b, same, mostly slow wing-stroke rate; 6c, same, frequent changes between fast and slow rates; 7a, *O. nigrifrons,* sequence of pairs showing long and short interpair intervals; 7b, same, sequence of pairs interrupted by a pair with an abortive 2nd pulse and by a single pulse.

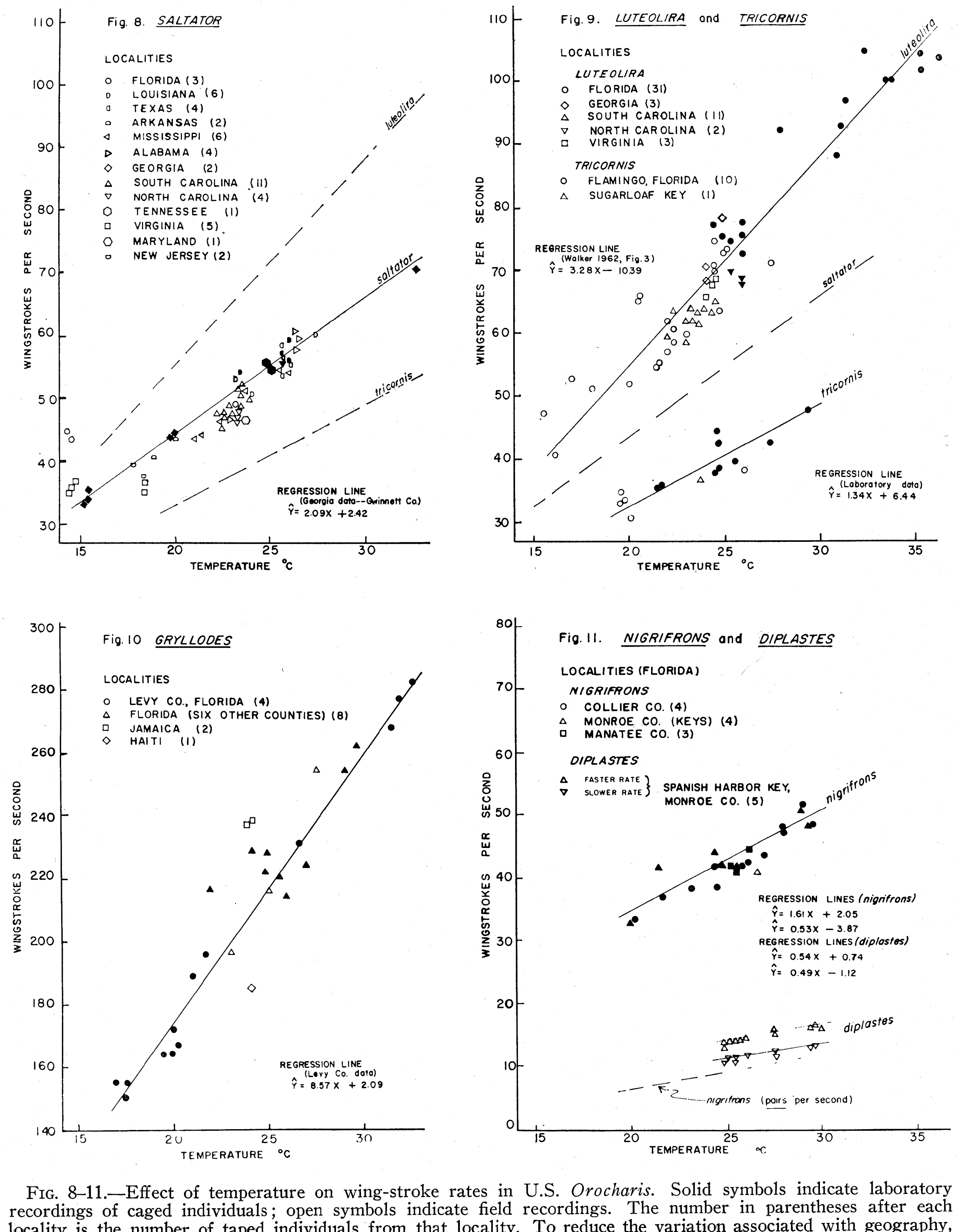

FIG. 8–11.—Effect of temperature on wing-stroke rates in U.S. *Orocharis*. Solid symbols indicate laboratory recordings of caged individuals; open symbols indicate field recordings. The number in parentheses after each locality is the number of taped individuals from that locality. To reduce the variation associated with geography, nonrepresentative samples, and inaccurate fields temperatures, some of the regression lines are calculated from only laboratory recordings of individuals from a single locality.

than the thermometer, but more data are needed before geographical variation or hybridization of *luteolira* and *saltator* can be excluded.

Unlike the other 4 species, *diplastes* and *nigrifrons* do not chirp. Their songs sound much alike yet are produced by very different wing-stroke rhythms.

Each consists of sequences of slowly delivered (5–20/sec), brief (less than 50 msec) melodious sounds. The difference is that in *diplastes* the brief sounds result from single wing strokes (Fig. 6) and in *nigrifrons* from paired wing strokes (Fig. 7). At a given temperature the pair rate of *nigrifrons* is only slightly slower than the pulse rate of *diplastes* (Fig. 11), and the songs are difficult to distinguish by ear. The sequences in *diplastes* tend to be shorter than in *nigrifrons* (0.5–2.0 sec vs. 1–3 sec at 25°C) and are often separated by briefer intervals (0.2–1.0 sec vs. 0.5–1.5 sec).

The calling song of *diplastes* is noteworthy in having *two* characteristic wing-stroke rates that may be irregularly alternated (Fig. 6a–c, 11). Other *Orocharis* (Fig. 8–11), and crickets in general (Walker 1962b), have a single characteristic wing-stroke rate. The dual wing-stroke rates of *diplastes* are not understood with respect to neurophysiology, evolutionary origin, or function.

One hypothesis as to evolutionary origin takes into account what is known of the neurophysiology: Crickets often produce pulse groups (chirps) at varying rates while their wing-stroke rates are generally unvarying (at a given temperature). Huber (1963) gives evidence that in *Gryllus campestris* L. the wing-stroke rate is determined in the mesothoracic ganglion and the timing of groups of wing strokes (chirps) is determined in the brain. A similar situation seems likely in chirping *Orocharis*. In *diplastes* there are no chirps, and the pulse rates seem more likely controlled by the brain than by the mesothoracic ganglion. This hypothesis is supported by features of the song of *nigrifrons*. In *nigrifrons*, sequences of pairs often begin and end with unpaired pulses (Fig. 7a, b). Unpaired pulses occasionally occur within sequences of pairs (Fig. 7b). In *nigrifrons* the rate of wing movement during pair production probably is controlled in a way homologous to the rate of wing movement during chirps in other *Orocharis* (e.g., *tricornis*, Fig. 5b); most likely by the mesothoracic ganglion. The pair rate is likely under brain control, and in Fig. 7a it is apparent that the pair rate is less uniform than the intrapair wing-stroke rate. Indeed, 2 pair intervals are evident (note longer interval after pair no. 1, 12, and 15), and these 2 intervals may be homologous to the 2 pulse intervals of *diplastes*. In short, the single pulses of *diplastes* may be homologous to the pairs of *nigrifrons* or the chirps of *saltator*.

The carrier frequencies of the calling songs of U.S. *Orocharis* vary from 2.9 to 6.9 kc/sec. In each species the frequency increases with increasing temperature and pulse rate. At any 1 temperature, the frequencies of all U.S. species are closely similar (Fig. 2–7), and the intraspecific variation is great. In choruses of *saltator* or *luteolira*, for instance, individuals often have frequencies differing by 0.2–0.4 kc/sec. Data on intraspecific variation in frequency in the song of *luteolira* have been published elsewhere (Fig. 13, Walker 1962b). The other U.S. species of *Orocharis* have similar variation. Fig. 12 summarizes the correlations between pulse rate (or temperature) and frequencies for the 6 species.

MORPHOLOGY

The U.S. species of *Orocharis*, except for *gryllodes*, are confusingly similar. Most males may be identified by characteristics of the stridulatory file (Table 1); only *saltator* and *luteolira* cannot be distinguished by this means.

No morphological feature examined will always distinguish *saltator* and *luteolira*. Most *luteolira* have a thin yellowish ridge connecting the lateral ocelli, and many *saltator* do not (Fig. 14, 15).

The frontal pattern is of some value in identifying species. In *saltator* and *luteolira* the frons either has no pattern or else a broad median light area extending to the clypeus. The frons is entirely dark medially in all *nigrifrons*, most *diplastes*, and some *tricornis*. When a median light area occurs in *diplastes*, it is shaped like an inverted V, and the median portion of the frons, just above the light band along the frontoclypeal suture, is dark. *O. tricornis* most frequently has a light median stripe that always stops short of the frontoclypeal suture.

Only *tricornis* has prominent ocellar horns, but smaller and blunter ocellar processes occur in *nigrifrons* (Fig. 18). *O. luteolira* sometimes has a small median ocellar horn. *O. nigrifrons* is the only species that has no bristles longer than 100 μ on the head behind the ocelli.

R. E. Love (personal communication) examined the male genitalia of the 6 U.S. species of *Orocharis* and discovered no features useful in species identification.

KEY TO *Orocharis* OF THE UNITED STATES

Orocharis may be distinguished from other U.S. eneopterine genera by the tegmina being longer than the abdomen and by having tympanal openings on

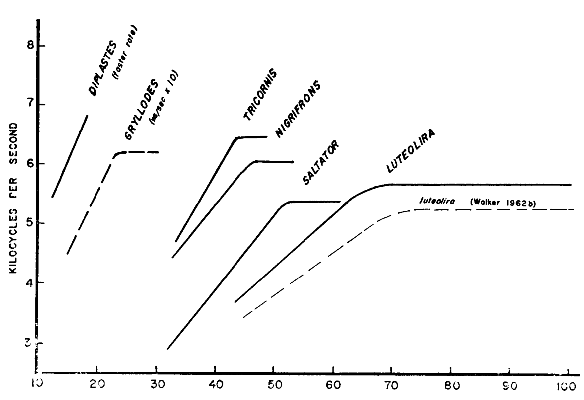

FIG. 12.—Relationship between wing-stroke rate and frequency in calling songs of U.S. *Orocharis*. The data are from the same tapes as used for Fig. 8–11. The curves were fitted by eye to the plotted data. For each curve, more than ⅔ of the points were within 0.5 kc/sec, and all points were within 1.2 kc/sec. The dotted line for *luteolira* is from previously published data from laboratory tapes of 3 individuals from Alachua Co., Fla. (Fig. 13, Walker 1962b).

Table 1.—Characteristics of the stridulatory file of the U.S. species of *Orocharis*.

Species	Localities	Sample size	No. teeth Mean±SD	No. teeth Range	Length (mm) Mean±SD	Length (mm) Range	Teeth/mm Mean±SD	Teeth/mm Range
gryllodes	4 Fla. counties	6	27±2	25–30	0.82±0.06	0.71–0.87	33.0±2.6	29.9–36.6
saltator	6 States	10	77±5	70–85	2.08± .18	1.79–2.43	37.5±1.9	34.0–40.5
luteolira	5 Fla. counties and Hoke Co., N. C.	13	75±4	66–80	1.97± .19	1.75–2.25	38.1±2.6	33.8–42.9
tricornis	Monroe Co., Fla.	6	120±4	113–123	2.16± .06	2.07–2.25	55.4±1.5	53.6–57.2
diplastes	"	7	135±5	126–140	1.96± .07	1.83–2.02	68.8±1.8	65.3–70.7
nigrifrons	3 Fla. counties	7	104±3	100–109	1.95± .06	1.87–2.04	53.2±2.2	49.0–55.6

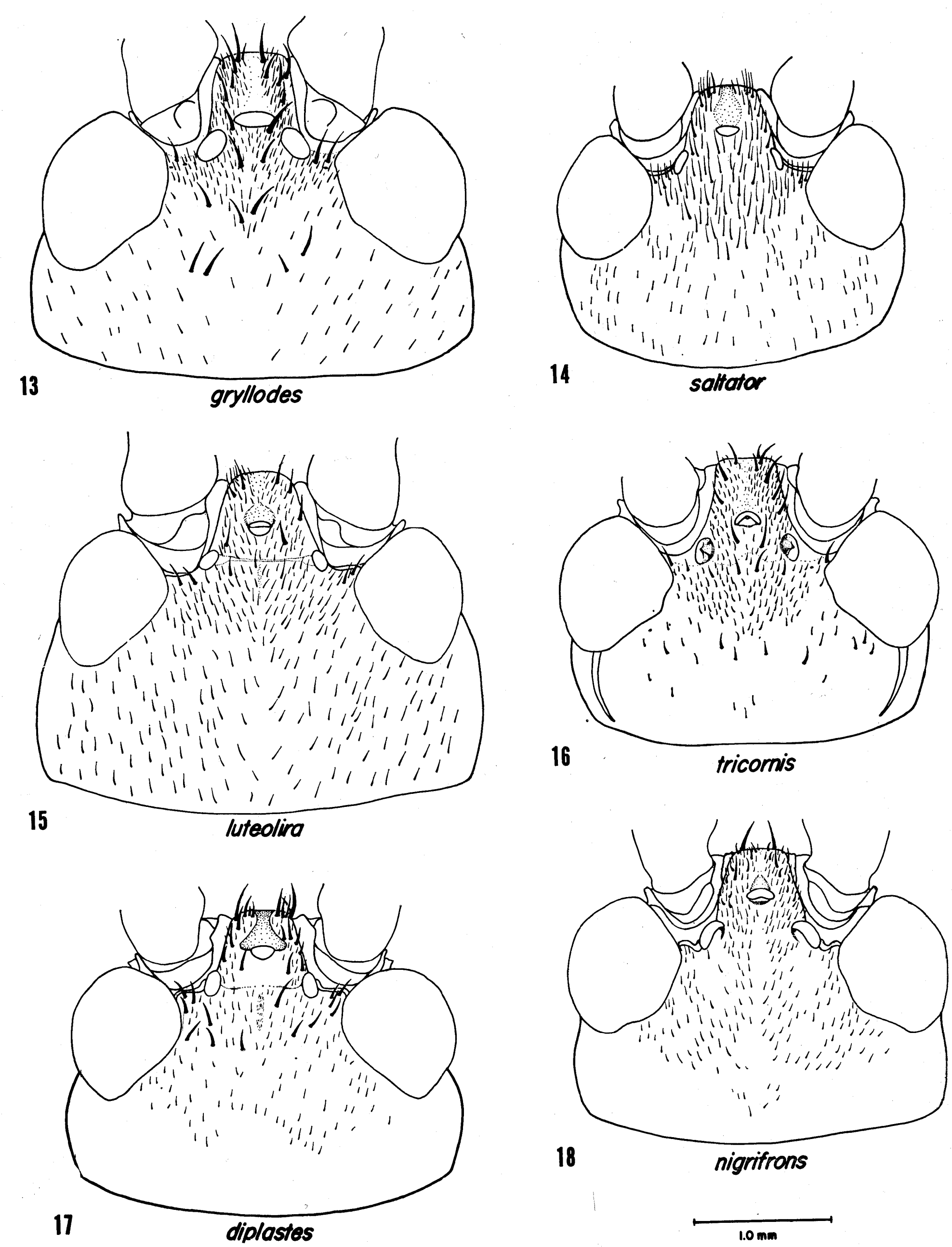

FIG. 13–18.—Dorsal view of the heads of U.S. *Orocharis*. Scale under Fig. 18. 13, Dade Co., Fla.; 14, lectotype; 15–18, holotypes. (Drawings by R. E. Love.)

both anterior and posterior faces of the tibiae. The following key will separate the U.S. species of *Orocharis*. Data on calling song or seasonal life history are required only for *saltator* and *luteolira* from their area of sympatry.

1 Locality north of peninsular Florida............ 2
1′ Locality peninsular Florida.................... 3
2(1) Chirps of calling song with 9 or fewer pulses (Fig. 4); pulse rate approximately 71/sec at 25°C (Fig. 9); distribution as in Fig. 1, lower left; season of adult not restricted to late summer and fall (more than 1 generation/year) ....***luteolira*** (in part)
2′ Chirps of calling song with 10 or more pulses (Fig. 3); pulse rate approximately 55/sec at 25°C (Fig. 8); distribution as in Fig. 1, upper left; season of adult restricted to late summer and fall (a single generation per year)..***saltator***
3(1′) Ocellar diameter less than distance from lateral ocellus to medium ocellus (Fig. 14–18); number of teeth in stridulatory file more than 60.. 4
3′ Ocellar diameter greater than distance from lateral ocellus to median ocellus (Fig. 13); number of teeth in stridulatory file fewer than 35 ....***gryllodes***
4(3) Frons without median light area reaching midpoint of frontoclypeal suture; number of teeth in stridulatory file more than 95............. 5
4′ Frons with median light area reaching midpoint of frontoclypeal suture; number of teeth in stridulatory file fewer than 90.***luteolira*** (in part)
5(4) Area behind lateral ocelli with bristles or setae longer than 100 μ; number of teeth in stridulatory file more than 111; song not a sequence of paired pulses 6
5′ Area behind lateral ocelli with bristles or setae shorter than 100 μ; number of teeth in stridulatory file fewer than 111; song a sequence of paired pulses ....***nigrifrons***
6(5) Conical projection at each ocellus (Fig. 16); number of teeth in stridulatory file fewer than 125; song a brief chirp repeated about once per second ....***tricornis***
6′ Conical projection absent at each ocellus (Fig. 17); number of teeth in stridulatory file more than 125; song a series of slow-pulsed trills ....***diplastes***

PHYLOGENY AND ZOOGEOGRAPHY

Too little is known of *Orocharis* outside the United States to permit a well-grounded reconstruction of the origin of the 6 U.S. species. *O. gryllodes* is evidently from the West Indies and is phylogenetically distant from the other 5 species which are morphologically similar and without known close relatives elsewhere. *O. saltator* and *luteolira,* the 2 most similar species, have present distributions and relationships that strongly suggest speciation within the geographical limits of this study. *O. tricornis* resembles *saltator* and *luteolira* closely enough in song and habitat to make a similar local origin tenable. *O. diplastes* and *nigrifrons* have probably been long separated from *saltator-luteolira-tricornis,* and their present distribution and habitat indicate a West Indian origin.

Present information suggests that *diplastes* and *nigrifrons* occur in the West Indies. If *tricornis* or near relatives should occur in the West Indies, the proposed U.S. origin of the species becomes implausible. Neither *saltator* nor *luteolira* should be expected outside the United States, except perhaps in southern Mexico, where the fauna and flora include a surprising number of eastern U.S. species. Among crickets, for example, 2 species of tree crickets formerly thought restricted to eastern United States are now known from the area (*Neoxabea bipunctata* (De Geer) and *Oecanthus exclamationis* Davis) (Walker 1967).

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