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ATTRACTION OF SOME ADULT MIDGES (DIPTERA: CHIRONOMIDAE) OF FLORIDA TO ARTIFICIAL LIGHT IN THE FIELD

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ABSTRACT

The attraction of pestiferous species of adult Chironomidae to commercially available lamps of various colors and wattages was studied by employing New Jersey light traps along the shoreline of a central Florida lake. *Glyptotendipes paripes* Edwards, *Goeldichironomus holoprasinus* Goeldi, *Chironomus crassicaudatus* Malloch, and species of Tanypodinae were predominant in the collections. A comparison of 100-W incandescent lamps showed that white was preferred over yellow, and both were preferred over red, orange, green or blue. Analysis of deviance indicated that these differences were due primarily to differences in intensity (lux), although smaller effects of color and differences in response among species were detected. No differences were observed in preference between 60-W white incandescent or fluorescent lamps. These results were consistent with previous laboratory studies, and indicate that manipulating light intensity, rather than color, may be more appropriate in the overall development of an integrated control strategy of nuisance chironomid midges.

RESUMEN

Se estudio la atracción de plagas de especies de Chironomidae por lámparas de varios colores y vatios de tipo New Jersey accesibles comercialmente, a lo largo de la costa de un lago en la parte central de la Florida. *Glypototendipes paripes* Edwards, *Goeldichironomus holoprasinus* Goeldi, *Chironomus crassicaudatus* Malloch, y especies de Tanypodinae predominaron en las colecciones. Una comparación de lámparas incandescentes de 100 vatios indicó que el blanco era preferido sobre el amarillo, y que ambos eran preferidos sobre el rojo, verde, o azul. Análisis de deviación indicó que esas diferencias se debían principalmente a diferencias en intensidad (lux), aunque se detectó pequeño efectos por el color y direrencias en reacción entre las especies. No se observaron diferencias en preferencia entre lámparas blancas de 60 vatios incandescentes o fluorescentes. Estos resultados fueron consistentes con estudios previos de laboratorio, e indican que manipulando la intensidad de luz más que el color, pudiera ser más apropriado enel desarrollo general de una estrategia de control integrado de plagas de chironomids.

Many large lakes in the central region of peninsular Florida support heavy populations of chironomid midge larvae. A number of these lakes are surrounded by homes and business establishments which are severely affected by the dense swarms of adult midges which emerge from adjacent lakes. The nuisance and economic problems in urban areas resulting from the massive accumulations of living and dead adult midges were reported by Ali (1980); the economic loss (including tourist trade) to just one city in central Florida may amount to several million dollars (Anonymous 1977).

Control of midges in small bodies of water (up to 200 ha) by the use of larvicides and insect growth regulators is practiced in some parts of the United States (Ali and Mulla 1977a,b, Polls et al. 1975). The use of these materials, however, is not feasible or economical in the relatively large size midge problem lakes that exist in Florida, each covering thousands of hectares. Moreover, many of these habitats are either part of or feed into river systems. Chemicals added to such systems are subject to displacement and dilution and may be unacceptable from an environmental standpoint. In such situations, development of biological and cultural control strategies against the pest insects are needed.

The manipulation of the attraction behavior of adult midges to artificial light may facilitate midge reductions in the affected areas and thus prove useful in the overall development of an integrated control program for these pestiferous insects. Recently, Ali et al. (1984) investigated the preferences of some Florida pest species of midges to incandescent light of different colors and intensities (wattage) under laboratory conditions. The present studies were conducted beside a lake in central Florida to elucidate the attraction of adult midges to various artificial light sources in the field situation.

Materials and Methods

These studies were conducted during the summer of 1983 and 1984 near Lake Jessup, Seminole County, Florida. Six New Jersey light traps equipped with suction mechanism (Mulhern 1942) were used. Each trap was hung from a wooden pole 3 m above ground level. Six poles were permanently placed at 20 m intervals along the northwest shore of the lake parallel to the waterline. The land area behind the traps was lined with thick and tall vegetation and lacked human dwellings or businesses. Thus, no visible sources of artificial light were noticed in this area during the study periods at night. A portable 3000-W generator (Dayton, Inc., Dayton, OH) and suitable electrical cords were used to illuminate bulbs (lamps) fitted in the traps. In these studies, commonly available incandescent lamps also known as general purpose A-line lamps (Anonymous 1978) were used to conduct three separate tests. In test 1, 100-W lamps of white (WL), yellow (YL), orange (OL), blue (BL), green (GL), and red (RL) were used. Test 2 contained WL, YL, OL, BL, GL, and RL of 25, 40, 40, 100, 100, and 100-W, respectively. In test 3, three 60-W lamps of WL and three 60-W warm white fluorescent (FL) lamps (Circlite(TM) 60) were used. The WL lamps used in these tests were frosted (inside) while the inner lining of all colored lamps was enameled.

The qualitative characteristics (wavelengths) of the lamps used are available

(Anonymous 1978). All of the color lamps emitted broad bands of wavelengths in the visible spectrum. The wavelengths emitted by BL are between 430 and 490 nm, GL between 490 and 550 nm, YL between 550 and 590 nm, OL between 590 and 620 nm, and RL between 620 and 770 nm (Hollingsworth 1961). The radiant energy emitted by WL and FL was in all visible wavelengths of 390 to 770 nm; the FL light peaks at ca. 180-190 nm, which are shorter than the peak wavelenghts of the WL (Ananymous 1978).

To estimate relative brightness (quantity of light) of the lamps, light intensity of each lamp was measured with a LI-COR light meter (Li-Cor, Inc., Lincoln, NB) equipped with a photometric sensor (LI-210SB). The intensity was measured in a photography dark room. Each lamp was fitted in a NJ trap placed at a fixed location 2 m above ground level and illuminated. The intensity reading for each lamp was taken at a 2 m distance from the lamp with the sensor directly facing the light source. Light was measured at the same location and height for each lamp. The measurements of light intensity for 100-W WL, YL, OL, BL, GL, and RL were 37.1, 19.7, 11.1, 1.2, 1.4, and 2.1 lux, respectively, while those of 25-W WL, 60-W WL, 40-W YL, and 40-W OL were 4.9, 17.1, 5.8, and 3.1 lux, respectively. The intensity reading for the FL was 15.9 lux.

To attract adult midges emerging from Lake Jessup, the traps in each test were activated about half an hour before sunset and adult trapping in the field was continued for a period of 2 hours. Tests 1 and 2 were repeated on six different occasions so that each lamp in a test occupied a different pole each time. Test 3 was also conducted on six different occasions and the FL and WL lamps were positioned alternately on each occasion. The adults trapped during each sampling period were identified and counted in the laboratory.

The quantitative (number) differences of adult midges taken in different traps in tests 1 and 2 were analyzed by analysis of variance (ANOVA) and in test 3 by Student's *t*-test. The significance of the qualitative factors, species (S), lamp type (L) and color (C), and the quantitative factor, intensity (I) in attracting the adult midges was elucidated by contingency table analysis using log-linear models with quantitative factors as described in Ali et al. (1984). Since intensity was measured for a lamp type and not each lamp, the data for tests 1 and 2 were combined in the analysis to allow the effects of color to be separated from those of intensity. In this analysis, intensity (I) was fitted first in the hierarchy of increasingly more complex log-linear models, because it was an attribute common to all lamps. Next, terms specifying the influence of lamp color, in addition to its intensity (i.e., C + C x I) were added. Finally, terms defining differences among the species in their response to intensity and color (i.e., S x I + S x C) were entered. The three-way S x C x I interaction could not be included because of aliasing (McCullagh and Nelder 1983) in the experimental design. The analysis for test 3 was designed to separate the effects of lamp type (L) from differences in species preference for a lamp type (i.e., S x L). The effects of intensity in test 3 could not be separated from other aspects of the lamp type. In both tests, the mean residual deviance was significantly greater (chi-square test) than one implying significant heterogeneity. Therefore, the F-test using the mean deviances was employed to determine the significance of the added terms.

Results and Discussion

Glyptotendipes paripes Edwards was the predominant species constituting 76-93% of the total adult midges taken in the three tests. *Goeldichironomus holoprasinus* Goeldi, *Chironomus crassicaudatus* Malloch, and species of Tanypodinae [primarily *Coelotanypus concinnus* (Coquillett), *Coelotanypus scapularis* (Loew), and *Procladius sublettei* (Roback)] constituted 1-20%, <1-3%, and <1-2%, respectively, of the total adults trapped during these studies. Adults of other midge species, *Goeldichironomus carus* (Townes), *Chironomus decorus* Johannsen, *Cryptochironomus fulvus Johannsen, Parachironomus* Sp., *Polypedilum halterale* (Coquillett), *Tribelos* sp., *Rheotanytarsus* spp., *Tanytarsus* spp., and *Cricotopus* spp. collectively constituted 2-3% of the total collections in the three tests.

The number of adult midges attracted to each lamp (color or type) in the combinations of lamps used in tests 1, 2, and 3, is presented in Fig. 1 as a percent of total adults of each species (or group) taken in each test. The value of light intensity of each lamp is also given in the figure. In test 1, WL with the highest intensity (37.1 lux) invariably attracted significantly higher (1% level) numbers of adults of each species (or group) than the YL, OL, BL, GL, or RL. In this test, YL (19.7 lux) was the second best preference of the most predominant midge, *G. paripes*, while the differences between the numbers of all midge species (or groups) attracted to the other four lamps, OL (11.1 lux), BL (1.2 lux), GL (1.4 lux), and RL (2.1 lux) were statistically insignificant.

In test 2, there were no significant differences (1% level) between the total number of adults of each species (or group)attracted to WL (4.9 lux) and YL (5.8 lux). These two lamps attracted >75% of the total *G. paripes* and *C. crassicaudatus* occurring in all the traps used in the test. After WL and YL, *G. paripes* was attracted in significantly higher numbers to the OL (3.1 lux) as compared with the BL (1.2 lux), GL (1.4 lux), or RL (2.1 lux). The differences between the *G. paripes* catch totals by the BL, GL, and RL were statistically insignificant. *Chironomus crassicaudatus* was apparently attracted more to GL than to OL, BL, or RL, but the differences were not signifcant at the 1% level of probability. In contrast to test 1, the attraction behavior of *G. holoprasinus* and species of Tanypodinae differed from that of *G. paripes* and *C. crassicaudatus; G. holoprasinus* and Tanypodinae were attracted the most by BL than the other five lamps in the combination. The statistical comparisons of adult catches of *G. paripes*, *C. crassicaudatus*, *G. holoprasinus*, species of Tanypodinae, and total midges by the incandescent WL and the white FL revealed no signifcant differences except for the category, "other species" which showed a significant difference at the 5% level of probability.

The results of the analysis of deviance for the three tests are presented in Table 1. As shown in previous laboratory study (Ali et al. 1984), the intensity of light was the most imprtant factor which influenced the midge adult catches in tests 1 and 2 as indicated by the value of 88.6% total deviance (% TD) attributed to the light intensity. However, there were significant (95% CL) but relatively small effects of the color (5.7% TD) and also differences in species preference (1% TD) as shown by the different patterns of color preference of *G. paripes* from that of the Tanypodinae (Fig. 1). Considering the magnitude of the % TD associated with the factors studied, it becomes obvious that, in general, lamp color has little impact upon the adult attraction of the species of midges encountered in this study and that the light intensity is the primary factor responsible for their attraction. In test 3, there were no signifcant differences between the WL and FL catches (0.1% TD) and the differences in the species response to the two lamp types were also insignificant (1.1% TD).

Numerous studies on the attraction of adult insects to light have been reported in the literature with most studies conducted on terrestrial insects of economic importance as reviewed by Heinton (1974). A variety of night-flying insects have shown specific attraction responses to a certain range of wavelengths, particularly near the ultraviolet region (300-390 nm) as shown by the cabbage looper [*Trichoplusia ni* (Hubner)], tobacco hornworm [*Manduca sexta* (Johannsen)], pink bollworm [*Pectinophora gossypiella* (Saunders)], corn earworm [*Heliothis zea* Boddie)], and others (Heinton 1974; Menear 1961; Glick and Hollingsworth 1954; Taylor and Deay 1950). The adult boll weevil (*An-*

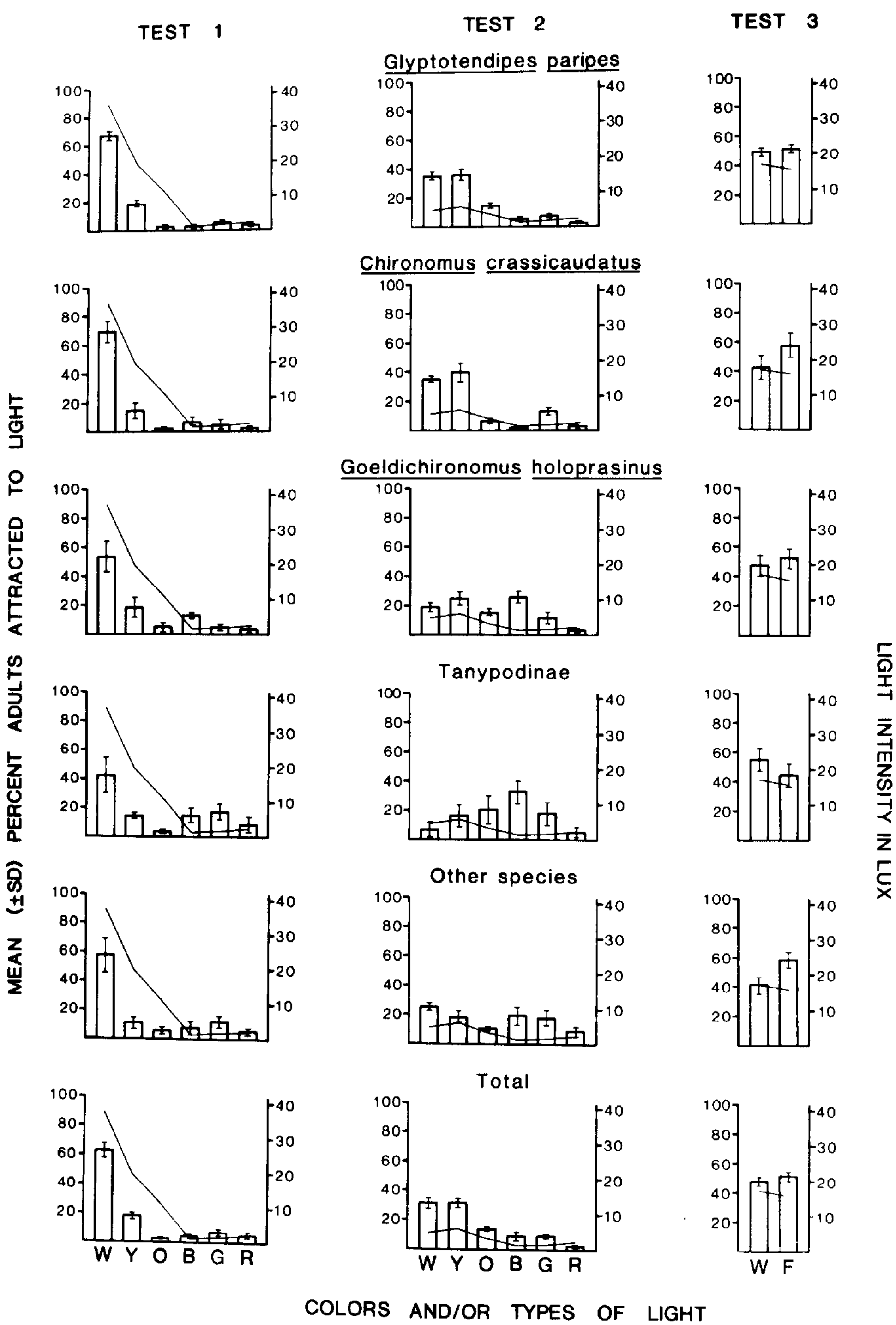

Fig. 1. Attraction of adult chironomid midges in the field to six different color 100-W incandescent lamps (test 1), to six different color incandescent lamps of different wattage (test 2), and to three 60-W white incandescent and three 60-W white fluorescent lamps (test 3). The bars represent the percentage of adults attracted to each lamp while the line graphs indicate the light intensity of each lamp in a test combination. The W, Y, O, B, G, and R indicate white, yellow, orange, blue, green, and red incandescent lamps, respectively, while F indicates white fluorescent lamp. In test 2, the lamps were 25, 40, 40, 100, 100, and 100-W, respectively.

TABLE 1. ANALYSIS OF DEVIANCE FOR FIELD STUDIES ON ADULT CHIRONOMID MIDGE[a] ATTRACTION TO ARTIFICIAL LIGHT.

Lamp color or type combination	Source of variation	df	Change in deviance[b]	% of total deviance[c]
		Tests 1 and 2 (70,809 adults caught)		
WL, YL, OL, BL, GL, RL	I	1	89,946**	88.6
	C + C x I	8	5,816**	5.7
	S x I + S x C	24	998**	1.0
	Residual	262	4,706	4.7
		Test 3 (44,734 adults caught)		
WL, FL	L	1	24	0.1
	S x L	4	339	1.1
	Residual	145	30,878	98.8

[a]Mostly *Glyptotendipes paripes*, *Chironomus crassicaudatus*, *Goeldichironomus holoprasinus*, and Tanypodinae.
[b]Deviance = $-2 \text{Log}_e (L)$, where L is the likelihood function (multinomial) evaluated at its maximum. The change in deviance is approximately asymptotically chi-square distributed under the null hypothesis that the factor(s) does not affect the catch frequencies. **,significant at the 1% level based on the F-test.
[c]Total deviance after replicated and species catch totals were included in the model.

thonomus grandis Boheman) showed maximum attraction to wavelengths in the blue-green region (470-515 nm) of the visible spectrum (Hollingsworth et al. 1964). Among adults of aquatic insects, species of Simuliidae (Williams and Davis 1951) and several other species of Diptera were reported to be attracted to light (Frost 1957). Belton and Pucat (1967) reported that the adult biting midge [*Culicoides sanguisuga* (Coquillett)] showed strong attraction to ultraviolet light. In contrast, the adult mosquito *Aedes aegypti* (L.) showed a preference for the near infrared region (Magnum and Callahan 1968). Thus, adults of different insect species or groups can have a preference for a different band of radiant energy in the electromagnetic specturm.

The attraction of adult chironomid midges to light was previously reported by Frost (1957) and Belton and Pucat (1967). However, the only qualitative and quantitative data on the attraction of adult midges to light are those of Ali et al. (1984) showing that under laboratory conditions, *G. paripes*, *C. crassicaudatus*, and *Polypedilum halterale* (Coquillett) responded more to the quantity (power or intensity) than to the quality (color or wavelength) of light. The field observations made in the present study are in agreement with the laboratory observations of Ali et al. (1984); the most predominant species, *G. paripes* showed maximum attraction to the source of highest light intensity. Other species also showed somewhat similar behavior of attraction although some preferences may have been color or wavelength specific. This study has also revealed that the adult chironomid response to white incandescent and white fluorescent lights of equal wattage was similar.

Observations made in the present study are of practical significance for the development of an integrated control program against pestiferous chironomid midges. Many large lakes in the central Florida area support dense populations of *G. paripes* and *C. crassicaudatus* (Ali and Baggs 1982). By the use of proper lights on and/or around the lakes, adults of these species can be drawn to uninhabited or relatively less urbanized areas for suitable midge control.

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