ATTRACTION OF THE "LOVEBUG", *PLECIA NEARCTICA* (DIPTERA: BIBIONIDAE), TO UV IRRADIATED AUTOMOBILE EXHAUST FUMES[1,2]

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ABSTRACT

The "lovebug", *Plecia nearctica* Hardy, is attracted to automobile exhaust fumes irradiated with 3600 A UV light. However, they are not attracted to UV light or exhaust fumes alone nor to the methane or CO_2 component of exhaust fumes irradiated with 3600 A UV.

The "lovebug", *Plecia nearctica* Hardy, has been present in the Gulf Coast area of the United States for many years. Large populations have been found in Louisiana for over 20 years, and populations have increased gradually in the states to the east, especially along the Gulf Coast. In Florida, the numbers have been increasing since about 1954 from Pensacola to Tampa and in some areas farther south according to reports in the files of the Division of Plant Industry. The adults emerge in May and September and accumulate along highways where they are smashed against windshields, obscuring the vision of motorists. Cars often overheat when radiators become clogged, and the smashed specimens damage car paint if the body fluids are not removed soon after contact.

Hetrick (1970) studied the biology of the lovebug and estimated that the flight of adults occurs over approximately one-fourth the land area of Florida. Airplane pilots have reported the insects at altitudes of 1000 to 1500 ft., and fishermen have reported mating pairs several miles from the coastline over the Gulf of Mexico.

Our observations of the flight patterns of lovebugs indicate that the largest number fly between 10:00 AM and 4:00 PM. However, flights of insects found away from the highways appear to fly in a searching pattern, probably for food and water, while those on or near highways appear to fly aimlessly and without direction. Male and female adults take nectar and pollen during the 1 week, approximately, in which they live. We also observed larger numbers of adults congregating at intersections, particularly near traffic lights, filling stations, or recently parked cars with warm engines. Freshly painted buildings, especially light-colored ones, and heated asphalt roofing are also attractive to the adults.

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[2]Mention of a proprietary product in this paper does not constitute an endorsement of this product by the USDA or FDACS.

Callahan (1972) noted that Bibionidae were the most numerous of the fossil Diptera collected at the Florissant, Colorado digging. He questioned which characteristics of the catastrophic eruption of neighboring volcanoes insured such an abundance of Bibionidae. During the Tertiary period the Florissant, Colorado region of the Rampart Range had the same climate as north central Florida. The marshes and lakes of the Florissant region were buried in hot volcanic ash at some period during the Miocene epoch. Heated volcanic gases have much in common with automobile exhaust fumes. Our observations suggested testing the hypothesis that *P. nearctica* is attracted to the burning hydrocarbon pollutants from automobile exhausts.

Methods and Materials

An olfactometer originally designed by the senior author for testing attractants for noctuid moths was utilized in the experiments. It consisted of a $1 \times 1 \times 10$ ft wooden box with a removable plexiglass top. At one end, a small suction fan was mounted. It could be reversed to remove air or to pull air into the box at slightly less than 1 mph wind speed. At the opposite end, a flexible rubber hose was connected to an automobile exhaust pipe. A 150-W GE photoflood light and a 6-W GE F8T5/BLB UV bulb were used as light sources and were moved from end to end of the box during the experiments. Insects were introduced into the box at the center. Each replication consisted of 20 copulating pairs collected in the field the morning of the tests. The box was aired out for 1 hr between replications. The room was lighted by daylight type fluorescent lights during all treatments.

Measurements of the ultraviolet light incident on the highway in the range from 3000 to 4000 Å were taken with an Ultraviolet Products light meter having a range of 0 to 50 $\mu w/cm^2 \times 100$. Temperature was recorded with a Model 43TD Yellow Springs Tele-thermometer. Readings were taken with a surface thermistor directly on the road surface and with an air probe thermistor 6 ft above the road.

Results

Preliminary experiments indicated that bursts of exhaust fumes lasting more than 5 sec filled the olfactometer with such a high concentration of fumes that the behavior of the insects was affected adversely. Five sec exposure to the exhaust fumes at a low light intensity (60 ft-c) caused considerable random walking movement but no flight or directional movement. When the photoflood was turned on so that the light intensity 1 ft from the bulb end of the box equaled 2240 ft-c, the insects were stimulated to flight, and 3 or 4 pairs out of 20 flew and/or walked toward the photoflood lamp. The temperature in the box ranged from 35°C at the bulb end to 28°C at the opposite end. Reversing the airflow did not affect the slight drift of the insects toward the light.

Lovebugs flew both upwind and downwind to the light. When exhaust was expelled and the box was aired for 1 hr, there was no flight toward the photoflood bulb.

Further preliminary experiments demonstrated that temperatures above 28°C and visible light above 2000 ft-c stimulated flight but not orientation behavior. The insects are diurnal and fly in daylight. Neither of the authors have ever collected *P. nearctica* at a blacklight trap or tungsten light trap. The species has never been reported collected at a point source of light.

Although the threshold for flight stimulation was not determined precisely, these preliminary experiments indicated that it is approximately between 26°C and 32°C and above 2000 ft-c of daylight.

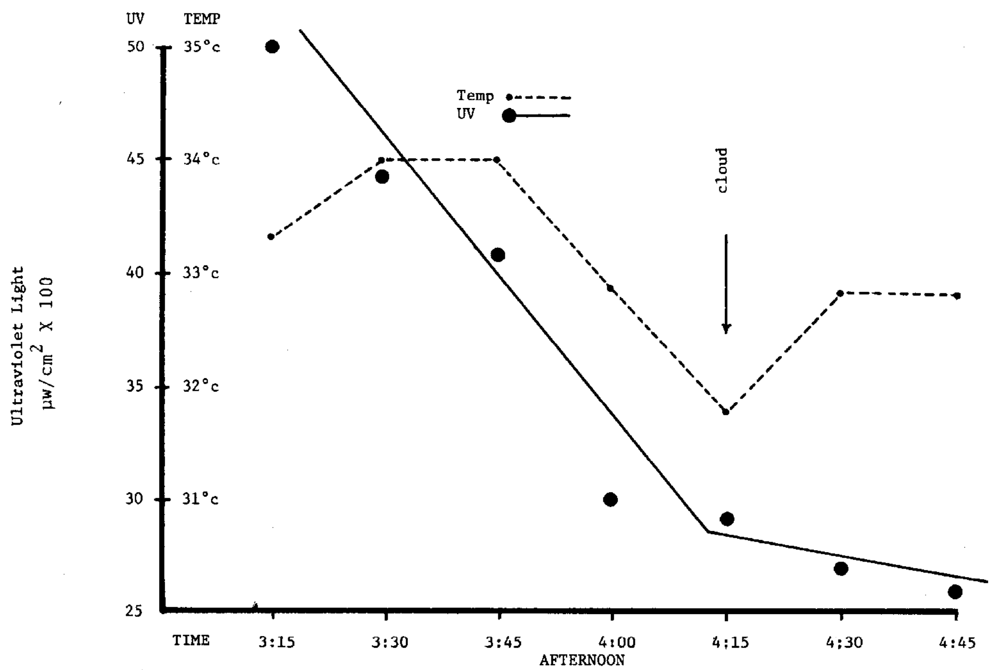

Fig. 1.—Temperature and radiation measured with an ultra-violet meter and a tele-thermometer over the highway the afternoon of 12 October 1972.

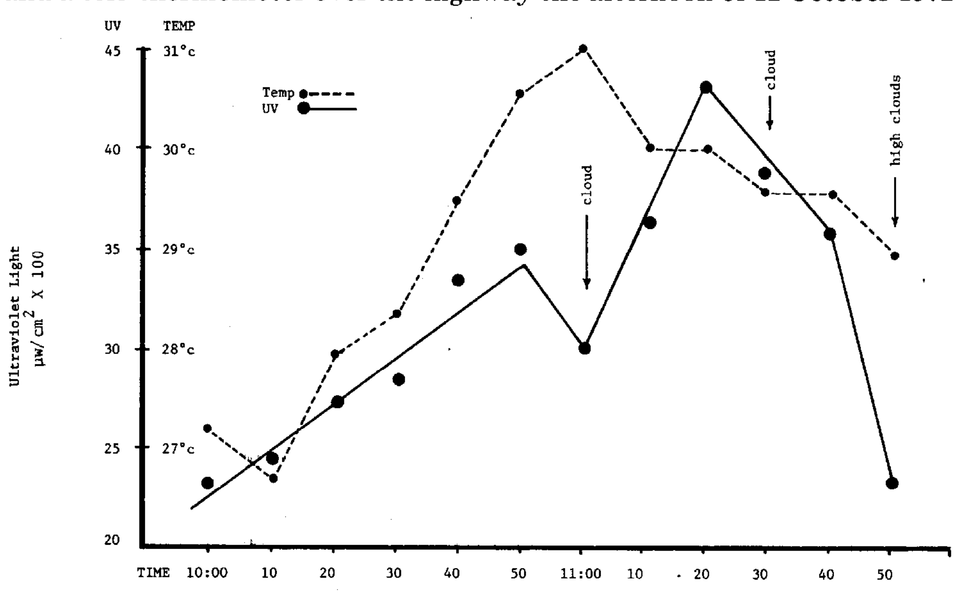

Fig. 2.—Temperature and radiation measured with an ultra-violet meter and a tele-thermometer over the highway the morning of 14 October 1972.

Figures 1 and 2 show the temperature and UV radiation recorded between 1000 to 1150 hr and 1515 to 1645 hr over the road. The UV radiation peaked at approximately 40 to 50 $\mu w/cm^2 \times 100$ between 1100 and 1530 hr, and the daily flight of the lovebug also peaks during this period. The temperature over the roadway is also optimum for flight (Fig. 1 and 2). Cumulus clouds cause a considerably greater drop in the UV radiation than in temperature, but the cooling effect of passing clouds is sporadic and lags the decline of intensity of the UV radiation.

The significant finding of these preliminary experiments is that flight is stimulated when temperature and light thresholds are reached; however, no flight orientation toward the visible light occurred without the presence of exhaust fumes. When the exhaust fumes were blown across the visible light, the response was insignificant.

Callahan (1967) postulated that gaseous insect attractants are stimulated to higher energy output by the interaction of radiation with the attractant chemical. He called it MASER-like action (*molecular amplification by stimulated emission of radiation*). His theories state that the dielectric antennae of insect species might decode such high intensity chemical emissions by resonating to the output frequencies of molecular vibration. Based on this theory a 6-W BLB was substituted for the photoflood lamp. Table 1, Exp. 1, gives the results of 5 sec bursts of exhaust fumes blown or pulled across the BLB UV bulb.

The attraction to the combination blacklight and exhaust was extremely high. The only insects that failed to respond within 1 to 10 sec were either injured or moribund (some may have been dead). There was little or no attraction to the exhaust fumes alone (Table 1, Exp. 2) or to the UV light alone (Table 1, Exp. 3). Methane and CO_2 are components of automobile combustion products, but there was no response to either of these gases alone (Table 1, Exp. 4).

TABLE 1. FOUR ATTRACTION EXPERIMENTS WITH *Plecia nearctica*.

Experiment	No. of replications	No. of mating pairs*	Percent remaining at site	Percent flying to UV plus exhaust fumes	Percent flying away from UV plus exhaust fumes
1	*Attraction of adults to exhaust fumes plus UV light*				
	9	180	7.2	92.8	0
2	*Attraction to adults to exhaust fumes without UV light*				
	4	80	81	10	9
3	*Attraction of adults to UV light without exhaust fumes*				
	4	80	96	4	0
4	*Attraction of adults to technical grade methane and CO_2*				
Methane	1	20	100	0	0
CO_2	1	20	100	0	0

*20 pairs of insects per replication.

When the blacklight source was moved from one end of the test box to the other, the insects moved to the lighted end. They also flew both upwind and downwind to the combination exhaust and blacklight (Table 2).

The insects did not condition to, and continued to respond to, exhaust fumes plus blacklight after an hour-long exposure. When visible light was reduced to low intensity (below 100 ft-c), the insects did not fly but crawled to the attractant. The response to the attractant and the speed of the reaction were the greatest ever witnessed by the authors.

TABLE 2. ATTRACTION OF *Plecia nearctia* TO EXHAUST FUMES WHEN THE UV LIGHT IS MOVED FROM ONE END OF THE BOX TO THE OTHER. ARROW INDICATES DIRECTION OF AIRFLOW.

Replication*	No. moving to left	← No. remaining at site	No. moving to right
1 (light at left)	34	6	0
2 (light at right)	0	6	34
3 (light at left)	26	8	6

*Each replication consisted of the same 40 pairs used again.

DISCUSSION

The attraction of the lovebug to automobile exhaust and UV light demonstrates the complex relationship between insect attractants and radiation. Callahan (1967) pointed out that the high attraction of insects to blacklight traps baited with pheromones is probably related to an interaction between the UV radiation and the molecules of the pheromone. He postulated a free-flowing, maser-like phenomenon, based on the close proximity of the irradiated molecules to the sensilla sensors. Mathematically, such radiation can be treated as coherent (in phase) (Metha and Wolf 1964). Treating the insect sensilla as a dielectric waveguide system allows the utilization of antennae and waveguide theory to an analysis of the insect antenna. Insect physiologists, and biologists in general, have ignored wave principles in favor of a more classical quantal treatment of sensory systems. This is unfortunate, for wave theory has much to offer as a theoretical approach to interpreting sensory systems. This experiment was rationalized on the basis of the waveguide approach.

It occurred to us that photochemical smog was involved in this attraction. The complex photochemistry of automobile emissions was reviewed by Cadle and Allen (1970). The absorption of energy by atoms, molecules, free radicals, or ions can produce excited species, decomposition, or ionization. However, a minimum energy (frequency) is required for each type of reaction.

Solar radiation below 2900 Å does not penetrate the atmosphere, but above 3300 Å, the solar spectral intensity distribution is the same as that at the top of the atmosphere (Cadle and Allen 1970). The blacklight bulb utilized in the experiment duplicated this sky radiation since it peaks at 3600 Å and has a range from 3000 to 4000 Å. Intensity of the radiation from the bulb was 40

$\mu w/cm^2 \times 100$ at 2 cm distance (by the UV meter). This equaled the peak intensity taken over an asphalt roadway at a zenith angle of approximately 10°.

The best explanation of the unusual attractance of lovebugs to UV-irradiated exhaust is that one of the products of the photochemical reactions duplicates the oviposition attractant of the insect. (Since the insects are already mated, pheromone duplication can be ruled out.) For oviposition, lovebugs are known to prefer sites with decaying organic matter such as dead leaves, grass clippings, well-kept lawns, and cow droppings in cutover pasture lands (Schremer 1968). Hydrocarbons and aldehydes reach a peak in automobile exhaust fumes between 0800 and 1500 (Cadle and Allen 1970) which are near the peak flight periods of the lovebug. Such compounds are also generated by decaying organic matter in nature (Bethea and Narayan 1972). Natural oviposition attractants could not compete with a duplicate attractant generated by millions of horsepower from automobiles. Well-traveled highways are saturated with invisible vapor trails that are irradiated by the UV that passes through the atmosphere.

Entomologists generally agree that larger than usual populations of lovebugs have been emerging from certain areas of north Florida. These insects appear to be able to fly great distances. Although they occur in great numbers off the highways, we believe they are attracted to and are held over the highway by the photochemical reaction of automobile exhaust fumes plus UV radiation.

One of the best evidences that the attraction involves the interaction of UV and molecular frequencies or ionization charges is the fact that the insect is not attracted to UV alone.

In photochemical reactions (smog), atomic oxygen reacts with hydrocarbons and other organic compounds to produce a wide variety of organic-free radicals. The energy from free radicals or ions is activated by UV radiation. The attraction may involve frequencies from such reactions.

Many of the unpleasant properties of smog over cities are caused, in part, by compounds produced by photochemical reactions (Cadle and Allen 1970). Photochemical smog originates from automobile exhaust.

Since the automobile exhaust is apparently creating the problem by attracting lovebugs to highways, a possible solution will be to isolate the component(s) of automobile exhaust that serve as the attractants. If this material can be identified and omitted from gasoline, the problem could be solved easily. Tests will be continued when adults emerge again in May 1973.

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BRAZIL ENTOMOLOGY MEETING

The "Sociedade Entomologica do Brasil" will have its first annual meeting at The Federal University of Vicosa at Vicosa, Mina Gerais from July 2-7, 1973.

One of the primary purposes of this new society is to sponsor these annual meetings as a means of stimulating entomological research and to open new channels of communication with the personal contacts.

Representatives from all parts of Brazil will present scientific papers on all phases of entomology. The meeting is open to all.

The first issue of the society's new publication "Anais da Sociedade Entomologica do Brasil" will be ready for shipment very shortly. If you would like to be a member of the society and receive the publication, contact Dr. Williams at the address below.

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