EFFECT OF THE ARTHROPOD COMMUNITY ON SURVIVORSHIP OF IMMATURE *HAEMATOBIA IRRITANS* (DIPTERA: MUSCIDAE) IN NORTH CENTRAL FLORIDA

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Abstract

Field mortality of horn flies caused by the arthropod community was tested by seeding colony-reared horn fly (*Haematobia irritans* L.) eggs underneath artificial cattle pats placed in the field and collecting the emerging flies using cone traps. Mean numbers of horn flies that emerged from pats exposed to the whole arthropod community during the developmental period of the immature stages were significantly lower than those from pats isolated from all members of the community except *Solenopsis invicta* Buren. The community-caused mortalities of horn flies were 75.9% and 66.7% in July and August 1992, respectively, with an overall average of 71.3%. Predation by *S. invicta* raised mortality to at least 93.9%. These results suggest that the other arthropods in cattle dung played an important role in reducing horn fly populations in north-central Florida.

Key Words: Fire ants, insect community, mortality, cattle dung, horn fly

Resumen

Fue evaluada la mortalidad de la mosca *Hematobia irritans* L. causada por artrópodos depredadores en estiércol rociando huevos de *H. irritans* en tortas de estiércol artificial. Las tortas de estiércol fueron luego expuestas a la comunidad de artrópodos o aisladas de forma que los artrópodos, con la excepción de *Solenopsis invicta* Buren, no tuviesen acceso a ellas. Las moscas sobrevivientes de cada una de las tortas fueron capturadas en trampas de embudo. El número promedio de moscas obtenidas en las tortas de estiércol expuestas a toda la comunidad de artrópodos fue significativamente más baja que el de las tortas aisladas de la comunidad de artrópodos. La mortalidad de campo causada por artrópodos fue de 75.9% y 66.7% en Julio y Agosto de 1992, respectivamente, con una mortalidad promedio total de 71.3%. La depredación por *S. invicta* aumentó la mortalidad al nivel del 93.9% por lo menos. Los resultados obtenidos sugieren que otros artrópodos en el estiércol juegan un papel muy importante en el control poblacional de la mosca en la región norte centro de la Florida.

The horn fly, *Haematobia irritans* L., is a widespread, economically important pest of cattle (Morgan & Thomas 1974, 1977). The blood loss and annoyance due to bites of the adult flies cause a reduction of weight gain to cattle. Annual losses to the cattle industry in the United States attributed to this pest have been estimated to reach $870 million (Kunz et al. 1991). In Florida, Butler (cited in Hogsette & Koehler 1986) estimated an annual loss of about $61 million from horn flies. Control of this pest typically has been by using chemical insecticides, but widespread insecticide resistance has occurred throughout the country (Sheppard 1990). In addition, residues from feed-through insecticides used for controlling dung-inhabiting flies adversely affect the abundance of biological control agents in dung (e.g., Scarabaeidae and Staphylinidae) (Fincher 1992, Madsen et al. 1990, Wall & Strong 1987).

Horn fly larvae are coprophagous and develop only in fresh cattle dung (Macqueen & Beirne 1975, Skidmore 1991). The dung arthropod community has been shown to reduce horn fly populations in the USA (Blume et al. 1970, Thomas & Morgan 1972, Kunz et al. 1972, Roth 1989), Canada (Macqueen & Beirne 1975) and Australia (Fay et al. 1986, 1990). In Florida, Escher (1977) and Butler et al. (1981) reported parasitism of horn flies, but there have been no studies on the effect of the whole arthropod community on horn fly survivorship. During a survey of the arthropod community in cattle dung in Florida pastures, more than 220 species of arthropods were collected (Hu 1995). The objective of this study was to estimate the effect of the arthropod community on survivorship of immature horn flies in north central Florida.

Materials and Methods

Laboratory Studies on Horn Fly Survivorship

Survivorship of horn flies was studied in the laboratory before initiating field studies. Horn flies were obtained from the colony maintained by J. F. Butler, Department of Entomology /Nematology, University of Florida. Standard colony rearing methods were developed by Greer (1975) and modified by Okine & Butler (1995). Constituents of the larval medium included cow manure which had been frozen and then allowed to thaw, and pelleted peanut hulls. Adults were fed bovine blood and maintained in an environmental chamber at 27±3°C and 75±5% RH with continuous light.

Manure used for experiments was collected within 30 min after its deposition and frozen until needed. Manure processed this way contained no living insects when held >3 wk at 25°C.

Artificial pats were prepared by following the procedure of Thomas & Morgan (1972). Horn fly eggs <4 hr old were suspended in water and pipetted onto paper towel strips (6 cm long × 2 cm wide; 25 eggs per strip) moistened with water. A metal hoop, 20.3 cm diam and 5.1 cm high, was placed on a grass turf in a large metal pan. The area within the hoop was moistened with water. Four paper towel strips (100 total eggs) were placed on the grass and spaced equally around the perimeter of the hoop. The area within the hoop was covered with manure which had been taken from storage and thawed under room temperature. The hoop was removed, leaving a simulated manure pat approximately 25 cm diam × 5 cm high. The simulated manure pats were held in a rearing room for 7-8 days and then covered with cone traps (see below) to collect emerging horn flies. Six replicates were made. Parameters measured were percent egg hatch after 24 h, and adult survival based on the original number of eggs.

Field Studies on Horn Fly Mortality

Field mortality of the horn fly was evaluated during July and August 1992 in a beef range where an arthropod survey was conducted at the same time. Horn fly eggs from the laboratory colony were used. The manure collection and artificial pat formation techniques used for laboratory survival studies were also used in the field studies. Female horn flies oviposit only on fresh cattle droppings (Bruce 1964, Skidmore 1991), so artificially formed pats had no attraction to horn flies. No horn flies were found to land on artificially formed pats in the fields.

Two trials were conducted, one each in July and August 1992. Twenty simulated manure pats were formed for each trial. They were placed in a line outside the fence surrounding the pastures (3 pastures in total) that contained cattle. Adjacent pats were separated by 10 m. Egg-seeding procedures (100 eggs per pat) followed those for laboratory survival studies. Ten pats (odd numbers) were at first left uncovered to allow other arthropods to come to the dung and then covered by cone traps on the 8th day after egg-seeding; the other 10 (even numbers) were covered immediately after egg-seeding. The arrangement of the pats was a a randomized complete block design, each pair of pats (adjacent to each other) containing a covered (treatment) and an uncovered (control) pat.

The cone traps (Fig. 1) used for covering the seeded cattle pats were constructed of a wire frame and wrapped with a fine Saran® screen of 2 mesh per mm. Traps were 30.5 cm diam (bottom) and 50.8 cm high. A circular hole (5 cm diam) was cut through the screen on the top of the trap, and an 8.9 cm high × 5.1 cm diam vial was screwed on (the lid of the vial was perforated, then glued and riveted to the trap) to collect horn flies that emerged from the pat. The mouth of the vial was fitted with a Saran® screen funnel to prevent insects from escaping back into the trap. The vials were checked daily from the 8th day after egg-seeding until two days after the last horn flies were found. The cone traps excluded insects that flew to the dung pats. Because they were slightly embedded in soil, they excluded insects that walked, but not those that tunneled.

Differences in horn fly emergence between treatments were analyzed by a paired Student's *t*-test (SigmaPlot 1994). Before the *t*-test was conducted, the numbers of horn flies were transformed by log (n+1) to satisfy equal variance and normality required by the *t*-test (Marks 1990).

Results and Discussion

Laboratory Horn Fly Survival

Hatch of horn fly eggs ranged from 78 to 94%, with an average of 85.7±4.1% (SE) when the eggs were distributed on paper towel strips inserted into the artificial pat

Fig. 1. Cone traps used for covering cattle pats to collect horn flies and other flies that emerged from the pats.

for 24 hours. Survival of the eggs to the adult stage ranged from 22-41%, with an average of 29.8±6.15.

Fauna-induced Field Horn Fly Mortality

July 1992 trial. Horn flies emerged from the 9th to 13th day after their eggs were seeded under the artificial pat, with peak emergence occurring on the 10th and 11th day. An average of 2.9±0.95 (SE) horn flies emerged from the pats covered by cone traps (range 0-8); an average of 0.7±0.3 (SE) horn flies emerged from the pats exposed to other arthropods (range 0-3). This difference was significant (t=3.09, df=9, P<0.01; Fig. 2). Horn fly numbers were reduced by an average of 75.86% in the uncovered pats compared with the covered ones.

August 1992 trial. An average of 3.0±0.56 (SE) horn flies emerged from the pats covered by cone traps (range 0-5); an average of 1.0±0.26 (SE) flies emerged from the pats exposed to other arthropods (range 0-2). This difference was also significant (t=5.48, df=9, P<0.01; Fig. 2). Horn fly numbers were reduced by 66.7% in the uncovered pats compared with those in the covered pats. Combined data from July and August 1992 showed that the dung arthropod community caused 71.26% mortality to immature horn flies in artificially formed cattle pats.

The estimates of mortality in the field relied on the contrast between numbers of flies trapped in artificial pats that were (a) covered immediately with cone traps, and (b) left uncovered until just before adult flies began to emerge. Mortality was underestimated to the extent that some predatory or parasitic insects were not excluded by the cone traps. Damaged adult horn flies were observed in the vial at the top of some cone traps in both treatments, giving evidence that *Solenopsis invicta* Buren, red im-

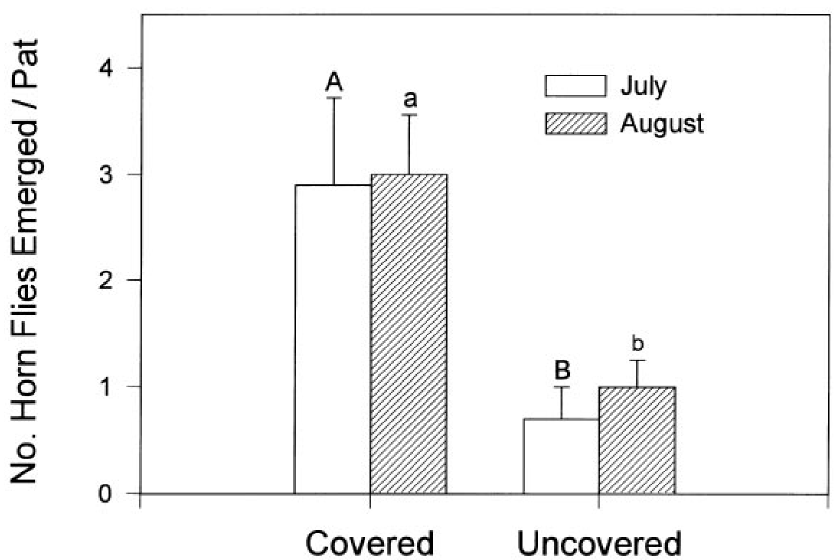

Fig. 2. Horn flies (avg.±SE) emerged from covered and uncovered cattle pats in a north-central Florida pasture in 1992 (n=10 for each treatment). Different letters above bars indicate significant differences within each trial (P<0.05).

ported fire ant (RIFA), succeeded in tunneling underground to reach the cone traps. A study in the same pasture, but using different methods, showed that RIFA caused an average of 78.6% mortality to immature horn fly when it was deliberately allowed access to dung pats (Hu & Frank 1996). Faced with the evidence, we treated the data as if *S. invicta* was not excluded by the cone traps.

Horn fly survivorship in our laboratory was about 29.8% without predators, parasitoids and competitors. Unknown causes of death may have included genetic degradation of the laboratory colony (Barlett 1984), desiccation of eggs, inability of some neonate larvae to enter dung pats, and physiological death (Thomas & Morgan 1972). High daytime temperatures in the field may have further increased mortality. The combined effects of these causes and predation by RIFA reduced horn fly numbers from 100 eggs to an average of 2.95 emerged adults per covered dung pat. In the pats that were left uncovered to allow access by other components of the fauna, the number of adults that emerged per pat was reduced to an average of 0.85, a reduction of 71.3% compared with covered in the field.

Another set of experiments in the same pasture, but not at the same time, used other methods to exclude RIFA (Hu & Frank 1996). The combined effects of mortality due to unknown causes and mortality caused by other components of the fauna reduced horn fly numbers from 100 eggs to an average of 2.42 adults emerged per pat. In the pats to which RIFA was allowed access, the number of adults that emerged per pat was reduced to an average of 0.59, a reduction of 78.6% (Hu & Frank 1996).

Although RIFA reduced numbers of several members of the dung fauna, including some predatory beetles (Hu 1995), its combined effects on horn flies were additional to the effects of other components of the fauna. Even when constrained by the presence of the other mortality components, RIFA exerted 78.6% mortality, and the other natural enemies likewise exerted 71.3%. A minimal estimate of their combined effect is 93.9%, calculated as 100- (100×(1-0.713)×(1-0.786); the actual level of fauna-caused horn fly mortality may have been considerably higher. Contributions of the arthropod community in pastures to horn fly mortality in Texas were reported as 87.9% (Roth 1989) and 90% (Kunz et al. 1972), in Missouri 97.7%(Thomas & Morgan 1972), and in Australia 79-84% (Fay et al. 1990). The mortality of immature horn flies caused by the dung fauna in the present study was within the range of mortalities reported elsewhere.

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References Cited

Barlett, A. C. 1984. Genetic changes during insect domestication, p. 2-8 *in* E. G. King and N. C. Leppla [eds.] Advances and Challenges in Insect Rearing. U.S. Dept. Agric., Agric. Res. Serv.

Blume, R. R. 1970. Insects associated with bovine droppings in Kerr and Bexar Counties, Texas. J. Econ. Entomol. 63: 1023-1024.

Bruce, W. G. 1964. The history and biology of the horn fly, *Haematobia irritans* (Linnaeus); with comments on control. North Carolina Agric. Exp. Tech. Bull. 157: 1-33.

BUTLER, J. F., R. L. ESCHER, AND J. A. HOGSETTE. 1981. Natural parasite levels in house flies, stable flies, and horn flies in Florida, p. 61-79 *in* R. S. Patterson [ed.]: Status of Biological Control of Filth Flies. Proceedings of a Workshop. U.S. Dept. Agric. Sci. Education Administ. Gainesville, Florida.

ESCHER, R. L. 1977. Pupal parasites of the horn fly, *Haematobia irritans* (L.) (Diptera: Muscidae) in north-central Florida. Thesis, Department of Entomology and Nematology, University of Florida, Gainesville, 88 p.

FAY, H. A. C. 1986. Fauna-induced mortality in *Haematobia thirouxi potans* (Bezzi) (Diptera: Muscidae) in buffalo dung in relation to soil and vegetation type, p. 142-149 *in* R. S. Patterson and D. A. Rutz [eds]: Biological Control of Muscoid Flies. Entomol. Soc. America Misc. Publ. 61.

FAY, H. A. C., A. MACQUEEN, AND B. M. DOUBE. 1990. Impact of fauna on mortality and size of *Haematobia* spp. (Diptera: Muscidae) in natural dung pads in Australia and South Africa. Bull. Entomol. Res. 80: 385-392.

FINCHER, G. T. 1992. Injectable ivermectin for cattle: Effects on some dung inhabiting insects. Environ. Entomol. 21: 871-876.

GREER, N. I. 1975. Effect of insect growth regulations on the bionomics and control of the horn fly, *Haematobia irritans* (L.). Ph. D. dissertation, University of Florida, Gainesville, 103 p.

HOGSETTE, J. A., AND P. G. KOEHLER. 1986. Biology and control of horn flies, house flies and stable flies on cattle in Florida. Livestock Production Pointers, University of Florida-IFAS. 18: 1-11.

HU, G. Y. 1995. The arthropod community in pastures and its biocontrol potential for the horn fly, *Haematobia irritans* (L.) in north-central Florida. Ph. D. dissertation, University of Florida, Gainesville, 170 p.

HU, G. Y., AND J. H. FRANK. 1996. Effect of the red imported fire ant (Hymenoptera: Formicidae) on the horn fly and other dung-inhabiting arthropods in north central Florida. Environ. Entomol. (in press).

KUNZ, S. E., K. D. MURRELL, G. LAMBERT, L. F. JAMES, AND C. E. TERRILL. 1991. Estimated losses of livestock to pests, p. 69-98 *in* D. Pimentel [ed.]: CRC Handbook of Pest Management in Agriculture. Vol. 1, CRC, Boca Raton, Florida.

KUNZ, S. E., B. F. HOGAN, R. R. BLUME, AND J.L. ESCHLE. 1972. Some bionomical aspects of horn fly populations in central Texas. Environ. Entomol. 1: 565-568.

MACQUEEN, A., AND B. P. BEIRNE. 1975. Influence of other insects on production of horn fly, *Haematobia irritans* (Diptera: Muscidae), from cattle dung in south central British Columbia. Canadian Entomol. 107: 1255-1264.

MADSEN, M., B. OVERGAARD NIELSEN, P. HOLTER, O. C. PEDERSEN, J. BROCHNER JESPERSEN, K. M. VAGN JENSEN, P. NANSEN, AND J. GRONVOLD. 1990. Treating cattle with ivermectin: Effects on fauna and decomposition of dung pats. J. Appl. Ecol. 27: 1-15.

MARKS, R. G. 1990. Analyzing Research Data. Robert E. Krieger Publ. Co., Malabar, Florida.

MORGAN, C. E., AND G. D. THOMAS. 1974. Annotated bibliography of the horn fly, *Haematobia irritans* (L.), including references on the buffalo fly, *H. exigua* (de Meijere), and other species belonging to the genus *Haematobia*. U.S. Dept. Agric. Misc. Pub. 1278, 134 p.

MORGAN, C. E., AND G. D. THOMAS. 1977. Supplement I: Annotated bibliography of the horn fly, *Haematobia irritans* (L.), including reference in the buffalo fly, *H. exigua* (de Meijere), and other species belonging to the genus *Haematobia*, U.S. Dept. Agric. Misc. Publ. 1278, 38 p.

OKINE, J. S., AND J. F. BUTLER. 1995. Effect of bovine blood plasma and erythrocyte diets on adult horn fly, *Haematobia irritans* (L.) (Diptera: Muscidae) mortality and oogenesis. J. Agric. Entomol. 12: 111-117.

ROTH, J. P. 1989. Field mortality of the horn fly on unimproved central Texas pasture. Environ. Entomol. 18: 98-102.

SHEPPARD, D. C. 1990. Insecticide resistance in horn flies in USA. p. 1216-1222 *in* 16th World Buiatrics Congress Symposium. Brazil. 1263 p.

SIGMAPLOT. 1994. User's Manual: SigmaPlot Scientific Graphing Software for Windows. SPW 2. Jandel Company, San Rafael, California.

SKIDMORE, P. 1991. Insects of the British cow-dung community. Field Studies Council, Shrewsbury, England, Occas. Publ. 21, 166 p.

THOMAS, G. D., AND C. E. MORGAN. 1972. Field-mortality studies of the immature stages of the horn fly in Missouri. Environ. Entomol. 1: 453-459.

WALL, R., AND L. STRONG. 1987. Environmental consequences of treating cattle with the antiparasitic drug ivermectin. Nature 327: 418-421.

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