Factors Affecting the Distribution of Bot Flies (Diptera: Oestridae) on Islands in Lake Barkley Kentucky and Tennessee[1]

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J. Entomol. Sci. 30(4): 513-518 (October 1995)

ABSTRACT The present study analyzes the effect of six abiotic and eight biotic variables on the presence of *Cuterebra* on islands in Lake Barkley in Kentucky and Tennessee. Abiotic factors were: area, length, distance to mainland, distance to nearest island, elevation, and last inundation. Biotic factors were: tree species diversity (sd), shrub sd, vine sd, and herbaceous sd, percent herbaceous cover, percent tree cover, mammal species, and small mammal sd. A *Cuterebra*, presumably *C. fontinella fontinella* (Clark), infested white-footed mice on two islands and house mice on one island. Six other small mammal species were not infested. There was no significant difference between prevalence and sex of host. No correlation between the presence of *Cuterebra* and biotic or abiotic factors was found ($P > 0.05$). The presence of house mice did not determine the presence of *Cuterebra* on islands. Factors associated with island biogeography did not appear to play a role in determining the presence of *Cuterebra*.Only the presence of white-footed mice was related functionally to the presence of *Cuterebra* on islands ($R^2 = 0.85$; $P < 0.05$). Although other small mammals may be found on islands, the occurrence and prevalence of *C. fontinella* on islands was primarily limited by the presence of white-footed mice regardless of other abiotic or biotic factors.

KEY WORDS *Cuterebra, Peromyscus,* biogeography, bot flies

Rodent and rabbit bot flies (Diptera: Oestridae: Cutebribrinae: *Cuterebra* spp.) produce myiasis in their hosts (Payne and Cosgrove 1966). Prevalence of infestation, often mistakenly termed incidence (Margolis et al. 1982), and differences between sex and age groups of hosts has been investigated, often with contradicting results (Dalmat 1943, Dunaway et al. 1967, Hunter et al. 1972, Xia and Millar 1990, Boggs et al. 1991). Studies on the habitat use of cuterebrids has been focused mainly on the aggregation sites of adult flies (Catts 1967, 1994, Meyer and Bock 1980, Hunter and Webster 1983, Schiffer 1983). Few studies have discussed the effect of habitat upon prevalence of cuterebrid larvae in host populations (Layne 1963, Boggs et al. 1991).

[1] Accepted for publication 13 July 1995.

The study of species richness and diversity on islands has been of interest to scientists since Darwin (1859). Island biogeographic theory (MacArthur and Wilson 1967) and its implication for species interactions has been applied, not only on islands but to mountain tops, habitat patches, and conservation practices (Christiansen and Fenchel 1977, Harper and Reveal 1978). The goal of this study was to test functional relationships between cuterebrid infestation of mammals and abiotic and biotic factors affecting their prevalence on islands. Islands may provide an opportunity to test host, parasite, habitat interactions of *Cuterebra* spp.

Materials and Methods

Trapping of islands was conducted from 15 July through 5 August 1988. This collection period was chosen because well-developed larvae are present in late July (Kreeger et al. 1990) and highest bot fly infestations of rodents in Tennessee occur in July (Dunaway et al. 1967). The five islands are located in Lake Barkley, Tennessee and Kentucky, adjacent to the Land Between the Lakes National Demonstration area (LBL). These five islands were originally ridges until the area was flooded during the completion of the Barkley Reservoir Project in 1964 (Wallace 1988). Islands were numbered 1-5 (i.e., I-1) and maps were used to estimate area, lengths, and distances to the nearest embankment and nearest island. Elevation of the island equaled the lake level plus the perpendicular distance to the highest point on the island provided by the U. S. Army Corps of Engineers, Nashville, TN.

Trapping was conducted in each of the major habitat types (based on vegetation structure): open field, early successional stage, and woodland. Each island was trapped with at least one trap array. Islands 4 and 5 were trapped with two trap arrays because of their large size. Each trap array consisted of twenty trap stations spaced 10 m apart. Each trap station consisted of one Museum Special snap trap, one Sherman live trap, and a pitfall trap. Every third trap station also contained a rat snap trap. Bot fly maggots were collected from mammals and preserved in 70% isopropyl alcohol.

Indices of diversity were used to describe small mammal diversity and vegetative diversity. The Shannon-Weiner index of diversity was used to express small-mammal diversity (Poole 1974). Methods recommended by Phillips (1959) were used to describe the island habitats. The pole/intercept method was used to sample tree species; canopy cover was estimated to 5% using a cylinder. Shrub species were recorded using a 4-m^2 grid, placed every 10 m along a transect. Herbaceous vegetation was recorded and percentage cover estimated by using a 1-m^2 grid at every station. Shannon-Weiner index of diversity was used to determine the diversity of trees and shrubs. Shannon-Weiner index of diversity was modified to obtain herbaceous diversity and vine diversity. The Pi (proportion of individuals in the ith species) was determined by dividing the number of grids in which the species was found by the total number of species. The index of diversity for herbaceous species and vine species was determined by summing log Pi. Chi-square analysis and Fisher's exact test were used to determine differences in prevalence of parasitism between mammal species and sex. Multiple regression was used to determine the relationship between abiotic and biotic variables and prevalence of cuterebrid parasitism and mammals.

Results and Discussion

The abiotic and biotic variables recorded on each island are shown in Table 1. Eight species of small mammals (n = 82) were captured on the islands. I-1 had *Peromyscus leucopus* (Rafinesque) (n = 11) and *Blarina brevicauda* (Say) (n = 1). *Microtus ochrogaster* (Wagner) (n = 3) and *B. brevicauda* (n = 8) occurred on I-2. I=3 had *Cryptotis parva* (Say) (n = 1) and *Oryzomys palustris* (Harlan) (n = 9). Seven species were captured on I-4, *B. brevicauda* (n = 1), *C. parva* (n = 2), *P. leucopus* (n = 15), *M. ochrogaster* (n = 9), *M. pinetorum* (Le Conte) (n = 4), *Mus musculus* (L.) (n = 17) and *Reithodontomys humulis* (Audubon and Bachman) (n = 1). No mammals were captured on I-5 despite its large size and the use of two trap arrays.

Table 1. Variables recorded on five islands (I) in Lake Barkley.

Variable	I-1	I-2	I-3	I-4	I-5
Latitude N	36°40'45"	36°41'00"	36°40'00"	36°40'50"	36°41'10"
Longitude W	87°54'55"	87°55'15"	87°55'15"	87°55'50"	87°56'15"
Area(ha)	3.63	5.95	3.97	25.11	43.94
Length(m)	2360	1360	520	4640	4160
*Distmain(m)	880	840	1520	5	80
Elevation(m)	110.1	109.8	109.9	110.1	110.0
**Linun	48.3	26.2	26.2	48.3	48.3
†Vegswid	2.14	2.77	2.94	3.26	2.11
Herbswid	0.82	0.97	1.02	1.19	0.92
Treeswid	0.51	0.78	0.56	0.66	0.60
Shrubswid	0.21	0.34	0.75	0.79	0.59
Vineswid	0.60	0.69	0.62	0.61	0.00
‡Herbcov%	37	48	54	88	47
$Treecov%	92	81	86	17	89
§Mamspnum	2	2	2	7	0
/Mamswid	0.13	0.26	0.14	0.67	0.00

* Distmain - distance to mainland
** Linun - last inundation in months
† Vegswid - plant species Shannon - Weiner index of diversity (swid)
‡ Herbcov% - percentage herbaceous cover
$ Treecov% - percentage canopy cover
§ Mamspnum - number of mammal species
/ Mamswid - mammal swid

Twenty-seven *Cuterebra*, presumably *C. f. fontinella* (Clark) based upon geographic and host ranges (Sabrosky 1986), infested *P. leucopus* on I-1 and I-4, and *M. musculus* on I-4. The six other small mammal species were not infested. On I-1, 9 of 11 *P. leucopus* were infected, a prevalence of 82%. On I-4, 10 of 15 *P. leucopus* were parasitized, a prevalence of 67%. A prevalence of 18% (3 of 17) *M. musculus* were parasitized by cuterebrids. No significant differences occurred between the prevalence of cuterebrid infection between sexes of *P. leucopus* or *M. musculus* on either island ($P > 0.05$). There were no significant differences of prevalence of *Cuterebra* between island populations of *P. leucopus* ($P > 0.05$), but a significantly higher number of *P. leucopus* was parasitized than *M. musculus* on I-4 ($P < 0.05$). The presence of house mice was not related to the presence of *Cuterebra* on islands (R^2 - 0.73, $P > 0.05$). Only the presence of white-footed mice was functionally related to the presence of *Cuterebra* on islands ($R^2 = 0.85$, $P < 0.05$). The percentage of *P. leucopus* infested was 72%, this is higher than the 36% found for *C. angustifrons* (= *C. fontinella*-Catts 1982, Sabrosky 1986) in July in eastern Tennessee (Dunaway et al. 1967).

The abiotic factors were: area, length, distance to mainland, distance to nearest island, elevation, and last inundation. Biotic factors were: tree species diversity (sd), shrub sd, vine sd, and herbaceous sd, percent herbaceous cover, percent tree cover, number of mammal species and small mammal sd. No functional relatedness between the presence of *Cuterebra* and these biotic or abiotic factors was found ($P > 0.05$).

The aggregation sites of adult *Cuterebra* appear to differ depending on cuterebrid species. Hilltops are preferred sites for *C. latifrons* (Catts 1967) and streams are preferred sites of *C. fontinella* (Schiffer 1983). Boggs et al. (1991) stated that infestations of *Cuterebra* spp. might be limited more by the availability of aggregation sites than the density, sex, or age of hosts, and these latter factors only intermittently influenced prevalence. The present study, conducted on islands, appears to have been conducted in prime habitat for *C. fontinella,* and is similar to that of Schiffer (1983). The trees on these islands and the broad expanse of open area provided by the lake, possibly would provide excellent aggregation sites for adults. However, the female must then find a suitable habitat or host on the islands. It has been suggested that habitat may influence the prevalence of larvae infesting hosts. Miller and Getz (1969) found that the wet substrate or greater forbe and shrub strata in a swamp was associated with a lower prevalence of *Cuterebra* sp. in *P. leucopus*, but Layne (1963) indicated that *Cuterebra* sp. were found in moist situations. In the present study, there were no significant differences between prevalence of cuterebrid infestations and vegetative structure, elevation, or time of last inundation of islands. There were also no significant differences of cuterebrid prevalence between host sexes. It appears that although other small mammals may be found on islands, the occurrence and prevalence of *C. fontinella* on islands is primarily limited by the presence of *P. leucopus* regardless of other abiotic or biotic factors.

Further research is needed to determine if aggregation of adult cuterebrids is occurring on these and other islands in Lake Barkley as Schiffer (1983) found that streams serve as aggregation sites for *C. fontinella*. Testing of the importance of abiotic and biotic variables affecting prevalence of cuterbrid parasitism on other islands also should be conducted. Using islands may afford a way to

investigate if female bot flies actively seek habitats containing suitable hosts or if they simply deposit eggs in habitats that normally would have these hosts.

Acknowledgments

I thank D.Snyder, F. Scott, and E. Chester (Austin Peay State University, Clarksville, TN) for their help in data collection. Traps were provided by Austin Peay State University, Clarksville, TN.

References Cited

Boggs, J. F., R. L. Lochmiller, S. T. McMurry, D. M. Leslie, Jr. and D. M. Engle. 1991. *Cuterebra* infestations in small-mammal communities as influenced by herbicides and fire. J. Mammal. 72: 322-327.

Catts, E. P. 1967. Biology of a California rodent bot fly, *Cuterebra latifrons* Coquillet. J. Med. Entomol. 4:87-101.

1994. Sex and the bachelor bot (Diptera: Oestridae). Am. Entomol. 40: 153-160.

Christiansen, F. and T. Fenchel. 1977. Theories of populations in biological communities: ecological studies, vol. 10. Springer Verlag, Berlin-Heidelberg, 1977. 266 p.

Dalmat, H. T. 1943. A contribution to the knowledge of the rodent warble flies (Cuterebridae). J. Parasit. 29: 311-318.

Darwin, C. 1859. The origin of species. John Murray, New York: The New American Library of World Literature Inc. Reprint, 1958, 479 p.

Dunaway, P. B., J. A. Payne, L. L. Lewis and J. O. Storey. 1967. Incidence and effects of *Cuterebra* in *Peromyscus.* J. Mammal. 48: 38-51.

Harper, K. and J. C. Reveal. (editors). 1978. Intermountain biogeography: a symposium. Great Basin Natural Memoirs: no. 2. Brigham Young University Press, Provo. 350 p.

Hunter, D. M., R. M. F. S. Sadler and J. M. Webster. 1972. Studies on ecology of cuterbrid parasitism in deer mice. Can. J. Zool. 50: 25-29.

Hunter, D. M. and Webster. 1983. Aggregation behavior of adult *Cuterebra grisea* and *C. tenebroa* (Diptera: Cuterebridae). Can. Entomol. 105: 1301-1307.

Layne, J. N. 1963. A study of the parasites of the Florida mouse, *Peromyscus floridanus,* in relation to host and environmental factors. Tulane Studies Zool. 11: 1-27.

MacArthur, R. and E. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton. 203 p.

Margolis, L., G. W. Esch, J. C. Holmes, A. M. Kuris and G. A. Schad. 1982. The use of ecological terms in parasitology (Report of an ad hoc committee of the American Society of Parasitologists). J. Parasit. 68: 131-133.

Meyer, R. P. and M. E. Bock. 1980. Aggregation and territoriality of *Cuterebra lepivora* (Diptera; Cuterebridae). J. Med. Entomol. 17: 489-493.

Miller, D. H. and L. L. Getz. 1969. Botfly infections in a population of *Peromyscus leucopus.* J. Mammal. 50: 277-283.

Payne, J. A. and G. E. Cosgrove. 1966. Tissue changes following *Cuterebra* infestation in rodents. Am. Midl. Nat. 75: 205-213.

Phillips, E. 1959. Methods of vegetation study. Henry Holt and Company, NY. 458 p.

Poole, R. 1974. An introduction to quantitative ecology. McGraw-Hill Inc., NY. 458 p.

Schiffer, C. N. 1983. Aggregation behavior of adult *Cuterebra fontinella* (Diptera: Cuterebridae) in Pennsylvania, USA. J. Med. Entomol. 20: 365-370.

Sobrosky, C. W. 1986. North American species of *Cuterebra,* the rabbit and rodent bot flies (Diptera: Cuterebridae). Thomas Say vol. 11, Entomol. Soc. Am., College Park, MD. 240 p.

Wallace, B. 1988. History of Land Between the Lakes, Pp 84-144. *In* D. Snyder (ed.), Proceedings of the first annual symposium on the natural history of lower Tennessee and Cumberland River Valleys. Tennessee: The Center for Field Biology of Land Between the Lakes, Austin Peay State University, Clarksville, 328 p.

Xia, X. and J. S. Millar. 1990. Infestations of wild *Peromyscus leucopus* by bot fly larvae. J. Mammal. 71: 255-258.