Mem. Inst. Oswaldo Cruz, Rio de Janeiro, Vol. *84*, Supl. IV, 491-497 1989

SARCOPROMUSCA PRUNA (DIPTERA: MUSCIDAE) AS AN EGG TRANSPORT HOST OF *DERMATOBIA HOMINIS* (DIPTERA: CUTEREBRIDAE) IN THE CACAU REGION OF BAHIA, BRAZIL

ANTONIO AMANCIO JORGE DA SILVA, DONALD HENRY SMITH & SUELY DE ANDRADE JACQUES DA SILVA BARBOSA*

Departamento de Zoologia, Instituto de Biologia, Universidade Federal da Bahia, Ondina, 40000 Salvador, BA, Brasil * Instituto Biológico da Bahia, Secretaria de Agricultura do Estado da Bahia, Itabuna, Bahia, Brasil

Sarcopromusca pruna *appears to be the predominant transport host for* Dermatobia hominis *eggs among cattle herds in central eastern Bahia, Brazil. In the study area, two seasonal peaks of* S. pruna *abundance coincide with those of* Dermatobia, *from mid July through late September and from mid November until early January, two periods of moderate monthly rainfall between annual extremes. Among more than 26,000 flies examined during the study, 75 (all female* S. pruna*) bore* Dermatobia *eggs.*

Certain aspects of Dermatobia *behavior and ovoposition habits in the field are also discussed.*

Key words: *Sarcopromusca pruna* – *Dermatobia hominis* – Muscidae – Cuterebridae – seasonal distribution – transport host

The geographic distribution of *Dermatobia hominis,* known as "mosca do berne" in Brazil, extends from central Mexico through Central America and the humid tropical regions of north, central and eastern South America to the northern regions of Argentina (Andersen, 1960, 1962; Catts, 1982; Moya Borja, 1982; Guimarães & Papavero, 1983). Catts (1982) emphasized that its economic importance exceeds all other cuterebrids, and it has long been known as the most serious of parasites among bovines in Central and South America (Chandler, 1955). In spite of its great economic importance and occasional concern as a public health nuisance, the natural history of *Dermatobia* is not well known, and studies of its biology have generally been brief and fragmentary (Catts, 1982). Although an extensive bibliograply exists (Guimarães & Papavero, 1966, 1983; Catts, 1982), most recent studies have concerned control methods or aspects of *Dermatobia* biology in the laboratory (Koone & Banegas, 1959; Banegas & Mourier, 1967; Banegas et al., 1967; Moya Borja, 1982; Sanavria, 1987). The objectives of this study, and of others being carried out by the authors, is to expand our knowledge of the natural history of the species and to identify the environmental variables that define its distribution, abundance and behavior on a local scale.

Financial support for this study, and a research scholarship for the junior author in the first year, were provided by CNPq, the Brazilian National Research Council.

MATERIAL AND METHODS

The study area was selected based on the results of a previous survey of the distribution and abundance of *Dermatobia* in the State of Bahia, and as a result of the research infrastructure available at the Veterinary Division of CEPLAC (Executive Commission for the Plan of Cacau Plantation) at Itabuna, Bahia. The cacau region of central eastern Bahia is an area characterized by the Atlantic coastal rain forest, with an annual precipitation of 1330 ± 175 mm, and lacking a distinct dry season. Monthly average rainfall varies from 65 to 277 mm, with a major peak from November to March and a minor peak from July through September. Annual average temperature is 22.7 ± 0.4°C, with the minimum in July (20.3 ± 0.7°C) and the maximum in February (24.4 ± 0.7°C). Relative humidity varies from an average of 81.4% in January to 84.8% in July, with an annual average of 82.9 ± 1.5%. The cattle industry is important in the region, and earlier data showed that the abundance of

Dermatobia there was moderately high for the State, reaching an average of 30 or more larvae per individual in untreated herds. In addition, the extensive, well delineated pastures of the CEPLAC veterinary research facility (14°46' S, 39°13' W) are immediately adjacente to, but isolated from stands of natural tropical forest reserve by barb-wire fences on the north and east boundaries. This permitted the study of distance and direction effects on fly abundance. Finally, the research herd, the technical staff and the laboratory facilities made available by CEPLAC facilitated the manipulation of cattle in the field and the subsequent laboratory studies of the flies captured and of *Dermatobia* biology.

A pilot study to determine the efficiency of malaise and modified Bishop fly traps, in combination with various baits, revealed mechanical collecting methods to be unsatisfactory. Consequently, manual sampling was standardized by using a 40 cm diam. aerial insect net. Two cows were tethered five meters apart and the flanks of the two animals were systematically swept with the net during a one hour period. Initially, sampling was carried out at various hours of the day, from 08:00 to 18:00, and at varying distances from the forest edge, to determine the variation in the abundance of flies that might serve as transport hosts. Once the diurnal peak in fly activity and the area of major fly abundance were determined, sampling was standardized from 09:30 to 10:30 and at a distance of approximately 100 meters from the forest edge. Sampling was repeated at two week intervals from July 1986 until June 1988. All collections were made by the same author (S. S. B.), thus standardizing sampling efficiency as well as method, hour and distance from the forest. In general a sampling period was a single collection, but when fly abundance was low sampling was repeated for three days to confirm that low fly numbers were real, and not a consequence of daily weather variables (rain, wind, etc.). During the majority of the study a hygrothermograph (Belfort Instrument Company, Baltimore, Maryland, U. S. A.) was maintained in the field during the periods of collection. In addition, meteorological data from the CEPLAC weather station, approximately one kilometer north of the study site, served to correlate fly activity with daily and seasonal weather variables.

All insects captured were routinely killed in ethyl acetate vapor and posteriorly fixed in 70% ethanol. Flies were counted in the laboratory soon after each collection, and individuals bearing *Dermatobia* eggs were separated and conserved individually in 70% ethanol + 5% glycerine. Normally, all flies were subsequently sent to the "Fundação Oswaldo Cruz" in Rio de Janeiro for separation and classification of the species captured, but on several occasions material was unidentifiable because of alcohol loss in storage or transport.

Specimens of flies bearing *Dermatobia* eggs were posteriorly examined individually to confirm the identification, to observe and describe the position and number of eggs, and to measure the abdomens of transporting flies in an effort to relate number of eggs deposited to host size. The numbers of flies bearing eggs on the left versus the right side of the abdomen were compared using the binomial test. The position of the egg mass and the primary orientation of the eggs were noted, and statistical summaries were calculated. The number of eggs per host was compared with host abdomen width and length by correlation and regression analysis using log transformed values.

RESULTS

Preliminary studies of the diurnal abundance of dipterans considered to be potential transport hosts for *Dermatobia* eggs revealed that fly activity was limited prior to 08:00, but increased rapidly once the temperature began to rise. The number of flies captured using standardized sweeping methods rose to a peak between 09:30 and 10:30, when the air temperature was between 26 and 29°C and relative humidity was above 70%. As air temperature continued to rise and relative humidity declined later in the morning, fly activity decreased and remained moderately low for the remainder of the day, with a slight rise in activity in the late afternoon. During the two years of the definitive study 76 samples were collected, 43 of which resulted in a variable number of flies captured.

Fly abundance was relatively high when the study was initiated in July 1986. Hourly captures of 2000 or more flies were common and a maximum of 4929 flies was captured on 18 August. Fly abundance at that time was so high that several insecticide treatments were applied to the pastures, severely reducing the number of flies and truncating the seasonal abundance curve in early September. Captures remained low (0 to 25 flies) until mid November, when the second peak of seasonal abundance began. Fly abundance increased from 25 November until 11 December, when a maximum of 1085 flies were captured. Numbers declined again until early January 1987, after which captures remained relatively stable (0 to 12 flies) until the July-September peak of 1987.

The 1987 July-September peak was much reduced in abundance, but more prolonged than that of 1986, reaching a maximum capture of 1341 flies on 26 August and declining gradually until early October. The November-January peak began in mid November, at the same time as in the previous year, but reached a maximum of only 100 flies captured on 26 November and disappeared before the first December collection. Captures remained extremely low (0 to 1 flies) until the study was terminated in June 1988.

In general, rainy or moderately windy weather, or extremely hot, dry periods, suppressed fly activity, and on those occasions sampling was repeated for three days to assure a relatively accurate estimate of fly numbers. On a seasonal basis, the number of flies captured was always negatively correlated with air temperature, especially in the summer ($r = -0.659$, $P < 0.005$). Fly abundance was positively correlated with relative humidity in the winter ($r = +0.610$, $P = 0.023$) but negatively correlated in the summer ($r = -0.548$, $P = 0.033$), when higher humidity was associated with windy, rainy days. During the summer rainy season, which began in November, fly abundance was significantly correlated with the number of hours of sunshine on the day of capture and on the first and second days prior to capture (average $r = +0.662$, $P = 0.027$) and with wind velocity ($r = +0.506$, $P = 0.047$). These correlations were not significant during the winter.

Among the 19,863 flies captured from July to September 1986, 40 (0.20%) bore *Dermatobia* eggs. Of 2756 flies captured during the November 1986 – January 1987 peak, 28 (1.02%) were transporting eggs. During the reduced peaks of fly abundance observed in 1987, 5 (0.15%) of 3436 bore eggs in July-September and 2 (1.80%) of 111 flies bore eggs in November. All 75 of the transport hosts captured during the study were subsequently identified as females of *Sarcopromusca pruna*.

Among the 26,244 flies captured during the study, 23,351 were subsequently classified and/or identified by researchers at the "Fundação Oswaldo Cruz", Rio de Janeiro (Table). Of these, 22,725 (97.32%) were *S. pruna*. The sex ratio among *S. pruna* collected in the field was 1:0.527 in favor of females. A binomial test of the observed host sex in comparison with the general sex ratio of *S. pruna* in the collections yielded a highly significant result ($P < 0.0001$).

TABLE

Classification of Diptera from 36 samples at Itabuna, State of Bahia, Brazil, from July 1986 to June 1988, with observations on transport hosts of *Dermatobia* eggs

Group	Total Number	Percent	Number and Percent of Transporters
Nematocera	13	.06%	0 (0.00%)
Brachycera			
Tabanidae	1	<0.01%	0 (0.00%)
Cyclorrapha			
Acalyptratae	337	1.44%	0 (0.00%)
Calyptratae			
Sarcopromusca pruna	22,725	97.32%	75 (0.33%)
Stomoxys calcitrans	161	0.69%	0 (0.00%)
Musca domestica	24	0.10%	0 (0.00%)
Cochliomyia macellaria	12	0.05%	0 (0.00%)
Chrisomyia putoria	8	0.03%	0 (0.00%)
Morellia nitida	3	<0.01%	0 (0.00%)
Morellia humeralis	1	<0.01%	0 (0.00%)
Biopyrellia bipuncta	1	<0.01%	0 (0.00%)
Sarcophagidae	65	0.28%	0 (0.00%)
TOTAL	23,351	100.00%	75 (0.32%)

Among the *S. pruna* which carried eggs and were conserved in ethanol plus glycerine, a number of egg masses detatched from the host. Of 64 *S. pruna* which were posteriorly examined for position of the egg mass, 32 bore eggs on the right side of the abdomen, 31 on the left side, and 1 on both sides of the abdomen. *Dermatobia* clearly showed no preference for either side. Egg masses were also classified by relative position (dorsal, lateral, ventral, etc.) on the abdomen, using the approximate center of mass as the location indicator. The position and relative frequencies of egg masses were: dorsal 0.00%, dorso-lateral 10.5%, lateral 19.3%, ventro-lateral 66.7% and ventral 3.5%. In general, eggs were directed with the operculated, distal extremity angled downward and posteriorly, in such a way that larvae leaving the eggs are directed toward the body surface of a prospective host. The general orientation of eggs within each mass was classified as follows: approximately 0° (horizontally-posteriorly), 5.3%; approximately 30°, 33.3%; 45°, 47.4%; 60°, 12.3%; and 90° (approximately vertical, downward), 1.8%. The single egg mass with vertical orientation was ventral on an atrophied abdomen.

The number of eggs per mass varied from 10 to 56, with an average of 22.5 and standard deviation of 9.4 (N = 65). A single female bore eggs on both sides of the abdomen; 32 and 10 eggs. The frequency distribution of eggs was significantly and positively skewed. Because of the female with two egg masses and the positive skewness of the frequency distribution, we assumed that counts above the mean plus two standard deviations represented double ovopositions. When the three most extreme cases were removed the mean number of eggs was 21.3 with a standard deviation of 7.7 (N = 62), and did not differ significantly from a normal distribution. The number of eggs per mass was significantly correlated with the size of the fly's abdomen. The highest single correlation was between log (number of eggs) and log (width) of the abdomen ($r = + 0.454$, $P < 0.001$). Multiple regression analysis of log (number of eggs) against log (width), log (length) and log (width x length) yielded the equation:

$$\text{Log (eggs)} = 0.8958 - 399.6882 \text{ Log (width)} - 401.5977 \text{ Log (length)} + 401.6973 \text{ Log (width x length)}$$

The corrected R-square was 0.3474; 34.74% of the variation in number of eggs was related to the size of the fly's abdomen. All three partial correlation coefficients were highly significant ($P < 0.007$).

Six adult *Dermatobia* were observed and/or captured in the field. During preliminary studies in July of 1985 one female was captured in a modified Bishop fly trap. The trap was baited with mascerated liver suspension and hung from a tree limb at approximately 1.5 meters from the ground. The single *Dermatobia* was captured during the daylight hours, together with several hundred calliphorid and muscid flies.

During the standardized collections carried out from July 1986 to June 1988, *Dermatobia* were observed on five occasions, and three females were captured. On all five occasions the adult flies were observed resting or walking on the lower leg of cows, only slightly above the hoof. As with other cuterebrids, they are strong agile, fliers and escaped capture with facility. After fleeing the net, the flies almost always returned to the same lower leg region of the tethered cows.

DISCUSSION

During the preliminary sampling and when the definitive study was begun (July 1986) fly abundance was relatively high. Extended daylight sampling to monitor fly activity revealed a rapid increase in abundance until approximately 10:00, after which fly abundance declined as the air temperature rose above 29 °C and the relative humidity declined below 75%. A slight rise in fly abundance was observed in late afternoon, but the peak of fly activity was definately during the mid morning hours. After experimenting with various locations within the pastures, at varying distances from the forest edge, it was determined that the greatest number of flies were collected within 100 meters of the forest, but far enough away from the dense vegetation to facilitate visual localization of the tethered cattle from all directions.

The seasonal peaks in fly abundance observed during the two years of standardized sampling, from July 1986 to June 1988, corresponded well. A major, winter peak was observed from July through September and a lesser, early summer peak, from November through early January. The 1986 winter peak was truncated in early Sptember by a general application of insecticide in the pastures, but the 1987 peak began during the same period of mid July and continued until late Sptember. The fly abundance in summer 1986-87 was 80% below that of the winter. The summer application of insecticides undoubtedly influenced this decline, but a similar reduction in fly numbers was observed between winter and summer peaks in the following year, without the application of insecticides. The cacau region of Bahia suffered a severe drought, that decimated local crops, in 1987 and this undoubtedly played a major role in fly reduction as well. Fly abundance in the winter of 1987 was only about 25% of that observed in 1986, but still reflected a 50% increase above the previous summer's peak. The summer peak of 1987 began during the same mid November period as in 1986, attained numbers only 10% of the previous year's abundance, and fly activity halted within two weeks. No insecticides were applied in the pastures after September of 1986, so the drastic decline in fly abundance in 1987 was apparently due primarily to the extended drought in the region. General fly abundance and *Dermatobia* infestations in the local cattle continued extremely low until the study was terminated in June 1988, and *Dermatobia* infestations have only begun to reappear (in reduced numbers) recently, in November 1989.

The two seasonal peaks of fly abundance correspond to the initiation of two periods of increased rainfall in the region. A significant increase in precipitation from June (70 mm) to July (130 mm) initiates fly abundance in July that continues until late Sptember. A drastic reduction in rainfall (90 to 25 mm) and a concomitant increase in mean temperature from September (21 ^{o}C) through October (23 ^{o}C) are accompained by a drastic reduction in fly numbers. Similarly, a significant increase in mean precipitation from October (25 mm) to November (140 mm) is associated with the second peak of abundance, beginning in November. In the summer, however, rainfall continues to increase until February, with a mean of 270 mm. Although temperature regimes do not alter significantly until May, rainfall remains extremely high (above 150 mm monthly) until April. Continual high precipitation limits fly activity, and water saturated and/or flooded soils severely limit the larval and pupal survival of muscoid flies, which predominated in the collections.

Fly activity was always negatively correlated with air temperature. In the winter, when mean monthly temperatures varied between 20 and 21 ^{o}C, this correlation was negative but not significant. Mean monthly temperatures in the summer varied from 23 to 24 ^{o}C, and the negative correlation was highly significant ($P < 0.001$). In both cases it should be noted that we deal with monthly mean temperatures. Daily temperature extremes are much more extensive, and it is the daily fluctuations that impact directly on fly activity. The response of flies to relative humidity (RH) is more difficult to interpret. RH was always higher in the early morning hours, but variation among days was primarily a function of cloud cover and precipitation. In the winter, when rains are less intense, and cloud cover more uniform, the correlation between fly abundance and RH was positive and significant ($P = 0.023$), while correlation with cloud cover or sunshine was not. In the summer, when heavy thunder showers are accompanied by wind and more intense frontal movements, the correlation with RH was negative ($P = 0.033$), and flies responded positively to sunshine ($P = 0.027$). Our conclusion is that fly activity was controlled primarily by the intensity of rain and wind, while response to humidity was secondary, thus explaining the reversal of correlations between the two seasons. Mean wind velocity did not differ significantly between winter (0.67 ± 0.28 m/s) and summer (0.71 ± 0.21 m/s), but wind direction changed drastically. In the winter, when winds were predominantly from the south (180.0 ± 83.6^{o}) and swept across the pastures before entering the forest, no significant correlation was noted with fly activity. In the summer, with northeast winds (52.5 ± 83.6^{o}) flowing from the forest edge to the pastures, correlation was relatively high and significant ($r = + 0.506$, $P = 0.047$). Daily weather variables are always difficult to interpret in the cause/effect sense, because all are highly interrelated, thus not independent, and are impossible to control in the field.

The great majority of flies collected during the study were muscids, and a single species, *Sarcopromusca pruna*, represented 97.3% of the total catch. *S. pruna* has, in recent times, become a notable nuisance among Latin American cattle herds, and has previously been reported as a vector of *Dermatobia* eggs under several names: *Sarcopromusca pruna* = *Morellia pruna* = *Sarcopromusca arcuata* (Guimarães & Papavero, 1983) from Costa Rica (Neel et al., 1955) to southern Brazil (Artigas & Serra, 1965).

S. pruna was the only species captured transporting *Dermatobia* eggs during this study, but that does not mean that it is the only vector in the area. Considering the low incidence (0.33%) of transporters among the species, one would expect only one in 333 flies to bear eggs. The second most abundant group of flies captured was the acalypterates, with a total of 337 individuals. With an expected incidence so low, our sampling could easily have missed transporters among this group, and other groups/species were even less abundant. It is apparent, however, that *S. pruna* was by far the prodominant vector in the region. The impressive numbers of *S. pruna* observed among the experimental herd at CEPLAC may be well below the average in the region, since the pastures and cattle there were well groomed and periodically treated with insecticides. Many private ranches, with less infrastructure and lower economic means, probably suffer a higher abundance of *S. pruna* and of *Dermatobia* infestations.

The fact that all 75 vectors captured were female *S. pruna*, when 34.5% of the species was male, is interesting but hard to explain with our current knowledge of the two species concerned. It is difficult to believe that *Dermatobia*, with such a long list of vector host species, would descrimate against the male of a species, or even perceive the difference between the sexes. It is more likely that behavioral differences between the sexes leave male *S. pruna* considerably less susceptible.

The position and orientation of *Dermatobia* eggs on the vectors observed in this study do not warrant much discussion, except to say that they confirm and refine earlier descriptions (e. g. Mourier & Banegas, 1970). The modal position was ventro-lateral (66.7%) and orientation approximately 45^{o} downward and backward from horizontal (47.4%).

An examination of the number of egg masses on the left vs. right side of vector abdomens showed no significant difference in this study; no preference was shown. The rarity of bilateral egg masses (Catts, 1982; one observed among 75 vectors in this study) suggests that *Dermatobia* do not readily divide an ovoposition between the left and right sides of a host. This may be simply because one side is sufficient to "satisfy" the ovipositing female, because of difficulty in manipulating the host, in conjunction with limited ovipositor length, or it may induce a significant disadvantage to vector survival, which would consequently be maladaptive for the *Dermatobia*. Whatever the reason, it seems safe to suppose that bilateral egg masses represent double ovoposition. If female *Dermatobia* do not normally show preference for one side vs. the other, and cannot readily manipulate the vector to select a side, it also seems reasonable to assume that a second ovoposition might just as likely be on top of the first as on the opposite side, and the number of bilateral egg masses observed would represent only half of the double ovopositions. In this study we observed only one bilateral egg mass among 75 vectors. If the true rate were twice this, the three individuals which we later eliminated from our statistical analyses as double ovopositions would be close to the number expected. If, on the other hand, the probability of a *S. pruna* being captured the second time is equal to that of the first capture (0.0033 = 0.33% in this study) the expected frequency of double captures would be 0.0033 squared, or only one in about 91,827 flies, a much lower rate than observed in this study. The fact that flies already bearing eggs would be older and/or disappearing from the population would even further reduce this expectation. Flies already bearing an egg mass may be less agile than non-parasitized individuals, and thus more susceptible to subsequent captures. This would explain a higher rate of double ovopositions, but remains to be proven by experimental studies in the laboratory and not in the field. Double ovopositions may be confirmed if the developmental states of the embryos or larvae in the two groups differ. Unfortunately, embryological development is rapid in comparison with the potential residence time of larvae in the egg, and two groups of larvae may appear equal even though of different ages. This would underestimate the rate of double ovopositions. We were unable to confirm double ovopositions with the method in this study.

The number of eggs deposited on vectors in this study was significantly and positively correlated with host abdomen size ($P < 0.001$). 34.7% of the variation in egg number was associated with variations in the size of the host. This implies that the number of eggs per mass is not a characteristic of *Dermatobia*, but rather varies with the size of the vector species and among individuals of the same species, a question of space available or of the possible survivalship capacity of the host in relation to egg burden. The mean number of eggs per mass thus becomes an interesting statistic for the relative importance of vector species, but perhaps should not be considered a definitive characteristic of *Dermatobia*, except that an upper limit may exist for a single ovoposition (Mourier & Banegas, 1970).

The single capture of a female *Dermatobia* in a Bishop trap appears to be rarity, since no references to this type of capture appear in the literature. We assume that the female was attracted by other flies, possibly by visual and/

or auditory stimuli, and not by the bait. The morning sightings of *Dermatobia* on the lower legs of cattle also appears to be a new observation. Most reports are of individuals on the flanks and/or backs of domestic animals in the heat of the day (e. g. Neiva & Gomes, 1917; Travassos, 1931). The hypothesis of morning "warm-up" behavior seems to be discared by the fact that the flies flew rapidly in response to the net and generally returned to the same resting site afterwards. It is possible that the site is conducive to the capture of sluggish vectors, because of their "warm-up" behavior or because young vectors, recently ecloded from puparia in the soil or in cattle feces, use the site to rest before their initial foraging and/or nuptial flights. The latter would be especially adaptive for *Dermatobia,* since it would tend to maximize the life expectancy of vectors receiving eggs.

ACKNOWLEDGEMENTS

To CEPLAC for providing the laboratory facilities, the meteorological data and their experimental herd for the study, and the biologists at the Entomological Collection of the Oswaldo Cruz Institute, Vinicius Marins Carraro and Luiz Eduardo Pereira do Rego, who under the orientation of Drs Rubens Pinto de Mello and Sebastião José de Oliveira, identified our material. Special thanks are extended to the latter, for the help provided for the conclusion and publication of the present work, and to Dr Hugo de Souza Lopes for the orientation and stimulus given to the project.

REFERENCES

ANDERSEN, E. H., 1960. Biology distribution and control of *Dermatobia hominis. Vet. Med., 55:* 72-78 + figs.

ANDERSEN, E. H., 1962. Control of *Dermatobia hominis* in Central America. *Vet. Rec., 74:* 784-87.

ARTIGAS, P. T., & SERRA, R. G., 1965. Portadores de ovos de *Dermatobia hominis* (L. Jr., 1781). Atualização da lista de foréticos, com a enumeração de novos agentes transmissores de "berne". *Cienc. Cult., S. Paulo 17:* 21-29.

BANEGAS, A. D., & MOURIER, H., 1967. Laboratory observations on the life-history and habits of *Dermatobia hominis* (Diptera: Cuterebridae). I. Mating behavior. *Ann. Ent. Soc. Am., 60:* 878-81.

BANEGAS, A. D., MOURIER, H., & GRAHAM, O. H., 1967. Laboratory colonization of *Dermatobia hominis* (Diptera: Cuterebridae). Ann. Ent. Soc. Am., 60:511-14.

CATTS, E. P., 1982. Biology of the New World bot flies: Cuterebridae. *Ann. Rev. Entomol., 27:* 313-38.

CHANDLER, A. C., 1955. *Introduction to Parasitology,* 9 ed. John Wiley & Sons, New York. 799 p.

GUIMARÃES, J. H., & PAPAVERO, N., 1966. A tentative annotated bibliography of *Dermatobia hominis* (Linnaeus Jr., 1781) (Diptera, Cuterebridae). *Arqos. Zool.,* S. Paulo *14:* 223-294.

GUIMARÃES, J. H.; PAPAVERO, N., & PRADO, A. P., 1983. As miiases na região neotropical. *Revta. Bras. Zool.,* S. Paulo *1:* 239-416.

KOONE, H. D., & BANEGAS, A. D., 1959. Biology and control of *Dermatobia hominis* in Honduras (Diptera: Cuterebridae). *J. Kans. Ent. Soc., 32:* 100-108.

NEEL, W. W., URBINA, O., HAVIS, J. R. & de ALBA, J. 1955. Combate del torsalo *(Dermatobia hominis* L. Jr.) por meio de insecticidas, em Turrialba, Costa Rica. *Turrialba, 5:* 139-46 + figs.

NEIVA, A., & GOMES, J. F., 1917. Biologia do mosca berne *(Dermatobia hominis)* observada em todas as suas phases. *Ann. Paulistas Med., 8:* 197-209.

MOURIER, H., & BANEGAS, A. D., 1970. Observations on the ovoposition and the ecology of eggs of *Dermatobia hominis* (Diptera: Cuterebridae). *Vidensk. Meddr dansl naturh. Foren., 33:* 59-68.

MOYA BORJA, G. E., 1982. O berne: biologia, comportamento e controle. *Agroquimica CIBA-GEIGY, 17:* 19-26.

SANAVRIA, A., 1987. *Bioecologia, patologia e alternativas de controle quimoterápico de* Dermatobia hominis *(Linneaus Junior, 1871) (Diptera: Cuterebridae) no Rio de Janeiro.* Thesis, D. V. M., Univ. Fed. Rural, Rio de Janeiro.

TRAVASSOS, L., 1931. Algumas observações sobre a *Dermatobia hominis* (L. J., 1781) (Diptera: Oestridae). *Bolm. Biol. Clube Zool. Bras., 18:* 35-38 + figs.