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[Med. Entomol. Zool. Vol. 52 No. 3 p. 249–252 2001]

Research Note

Effects of blood sources on fertility of a malaria vector, *Anopheles farauti*, in Solomon Islands

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(Received: 4 January 2001; Accepted: 19 July 2001)

Key words: fecundity, fertility, blood sources, *Anopheles farauti*

Abstract: Effects of blood sources on fertility and the ovariole maturation rate (proportion of ovarioles which produced mature eggs to total ovarioles) were studied in a malaria vector, *Anopheles farauti* Laveran, in the Solomon Islands. Blood of different mammals affected fertility and ovariole maturation rate. In the number of eggs and the rate, the difference was significant between females fed on humans and those fed on rats. Wild females of *An. farauti* had a mean of 140.5 eggs when fed on humans, compared to 216.1 with rats. A mean of 57.7% and 91.5% of total ovarioles produced mature eggs in females fed on humans and rats, respectively. The mean number of eggs and the ovariole maturation rate were not significantly different between the females fed on humans and those fed on dogs. Females obtained from a laboratory colony showed the same tendencies as wild females.

INTRODUCTION

Blood of different host animals affects the fertility of mosquitoes (Shelton, 1972; Shroyer and Siverly, 1972; Mather and DeFolrt, 1983). Fertility is the actual number of eggs produced by a female, and is one of the most important bionomical and epidemiological parameters in mosquito species. Blood host-seeking behavior may be evolutionally determined by differences in reproductive rates of females which obtain blood from different hosts. Blood efficacy for egg production has been expressed by the number of eggs produced per mg blood intake. Clements (1992) pointed out that gravimetric measurement of blood intake is prone to underestimation. Fertility is also affected by fecundity, which is the potential number of eggs and closely correlates to the body size of females (Hawley, 1985; Okazawa et al., 1985). Difficulties were, therefore, encountered when comparing fertility of the same species with preceeding studies in which body size data was not given. Ikeshoji (1965) used the rate of the number of eggs laid to the number of ovarioles for assessing the effect of blood meal volume.

In the present study, the effects of human, rat and dog blood on the fertility of *Anopheles farauti* Laveran were assessed. Ovariole maturation rate (=the proportion of ovarioles producing mature eggs to total ovarioles) was used for expression of blood quality. *Anopheles farauti* is the main vector of malaria in the coastal area of the Solomon Islands. Although few studies have been conducted on host preference of this species in the Solomons, domestic animals and several wild vertebrates were reported as the blood source in Papua New Guinea and Australia (Lee et al., 1987).

Materials and Methods

Wild-caught and laboratory-reared females of *An. farauti* were used for measuring fecundity and fertility in the present study. All wild females were collected in 3 hours from 7 : 00 p.m. to 10 : 00 p.m. by a human-biting collection at Giltae, located on the northern coast of Guadalcanal of the Solomon Islands. A laboratory colony was established with about 200 larvae collected at Giltae.

Wild females of *An. farauti* were brought back to the laboratory and divided into 4 groups. Females of Group 1 were killed and dissected without feeding on blood to examine the effects of blood feeding and oviposition on the number of ovarioles. The next evening from 7 : 00 to 10 : 00 p.m., females of Groups 2–4 were allowed to suck blood on humans, rats (*Rattus rattus* Linnaeus) and dogs, respectively, in a dimly-lit room. The females were transferred individually to transparent plastic containers (8 cm in diameter and 12 cm in height) with the upper opening covered with a mesh cloth. The containers were then inverted over non-anesthetized hosts, with the mesh cloth touching the skin. Hairs of the host skin were cut with scissors. The mosquitoes were allowed to suck blood freely without any defensive action. Behavior of the mosquitoes was observed through the wall of the containers. When the females were sated, they spontaneously withdrew the proboscis from the host's skin and ceased probing with the proboscis. The engorged females were transferred individually to small plastic containers (3 cm in diameter and 5 cm in height). The upper openings of these containers were covered with a mesh cloth. Each mosquito was provided with a wet paper towel on the bottom of the container for oviposition, and a small cotton ball soaked with a 5% sugar solution was placed atop the mesh cloth. After the oviposition, the number of eggs laid was counted. The females were then killed and dissected for examination of the numbers of ovarioles and eggs remaining in ovaries. Both the eggs laid and the eggs remaining in the ovary were treated as mature eggs.

The mean number of ovarioles was compared between females fed blood and those unfed to examine whether or not follicular development and oviposition decreased the ovariole number. The mean numbers of ovarioles and mature eggs were then compared among females fed on their respective hosts. The ovariole maturation rates were calculated and compared between Groups 2–4.

The numbers of ovarioles and eggs were also examined in females obtained from a laboratory colony. Larvae were reared with ample food in order to obtain females with full expression of body size and minimum variation. They were allowed to suck blood on humans or rats, and were examined using the same methods as above.

Results

Wild and laboratory females of *An. farauti* fed readily on both humans and rats. Among wild females, blood feeding and oviposition did not affect significantly the number of ovarioles (Table 1). The number of eggs was significantly larger in females fed on rats than in those fed on humans or dogs (t-test, $P<0.01$) (Table 1). The number of eggs in females fed on humans was not significantly different from that of females fed on dogs. In comparison, females fed on rats had 1.5 times and 1.6 times as many eggs as those fed on humans and dogs, respectively. No significant difference was detected in the numbers of ovarioles among the three groups. The ovariole maturation rate was significantly higher in females fed on rats than in those fed on humans or dogs (U-test, $P<0.01$) (Table 2). Median maturation rates were 57.1% for females fed on humans, 64.9% for those fed on dogs and 96.7% for those fed on rats. Mean rates were 57.7%,

Table 1. Number of ovarioles and eggs of *Anopheles farauti* feeding on humans, rats and dogs.

	Source of blood	Wild females				Laboratory females			
		N	Range	Mean±SD	*t*-test	N	Range	Mean±SD	*t*-test
Ovarioles	Humans	36	122–328	240.1±38.8	ns	18	232–327	289.3±24.4	ns
	Rats	24	149–321	235.9±39.1	ns	21	219–339	295.1±36.9	
	Dogs	9	162–290	224.8±34.8	ns				
	non	13	159–302	234.7±43.0					
Eggs	Humans	36	43–246	140.5±43.1	**	18	95–201	148.8±27.7	**
	Rats	24	147–312	216.1±44.8	ns	21	152–330	271.7±45.7	
	Dogs	9	53–220	133.0±52.9	**				

ns Not significant ($P>0.05$) * Significant ($P<0.05$)
** Significant ($P<0.01$)

Table 2. Ovariole maturation rate in *Anopheles farauti* after feeding on humans, rats and dogs.

Source of blood	Wild females					Laboratory females				
	N	Range	Mean±SD	Median	*U*-test	N	Range	Mean±SD	Median	*U*-test
Humans	36	35.2–87.5	57.7±11.9	57.1	**	18	34.3–75.8	51.6±9.2	50.8	*
Rats	24	65.6–100	91.5± 9.9	96.7	ns	21	69.4–100	91.3±9.9	95.6	
Dogs	9	25.5–75.9	58.2±18.2	64.9	**					

ns Not significant ($P>0.05$) * Significant ($P<0.05$)
** Significant ($P<0.01$)

58.2% and 91.5% respectively. The difference in rates between females fed on humans and dogs was not significant (*U*-test, $P=0.411$).

Laboratory females of *An. farauti* showed the same tendencies as those seen in wild females (Table 1). The numbers of ovarioles and eggs in laboratory females were significantly higher than those of wild females (*t*-test, $p<0.01$). Females fed on rats had 1.8 times as many eggs as those fed on humans. The ovariole maturation rate was significantly higher in females fed on rats than in those fed on humans (*U*-test, $p<0.05$).

Discussion

Generally, a mosquito species is attracted to several host species with different preferences under natural conditions. Blood sources obviously affected the fertility of *An. farauti* in the present study. Similar results were reported in *Aedes aegypti* (Linnaeus) (Bennett, 1970), *Ae. triseriatus* (Say) (Mather and DeFoliart, 1983), *Culex pipiens pipiens* Linnaeus (Shroyer and Siverly, 1972), *Cx. quinquefasciatus* Say (McCray and Schoof, 1970) and *Cx. salinarius* Coquillett (Shelton, 1972).

In the present study, the mosquitoes were allowed to suck blood freely and therefore took as large a blood-meal as they wished. The number of ovarioles shows the fecundity, i.e., the maximum potential fertility of each female, and the ovariole maturation rate can be taken as evidence

of blood quality. Since the rates for wild females were comparable to those of laboratory females in the present study, this strongly suggests the reliability of the ovariole maturation rate as a parameter of blood quality. Females fed on rats had 1.5 and 1.8 (wild and laboratory populations, respectively) times as many egg as those fed on humans. Humans are not the best blood host for *An. farauti* as regards egg production. Females of this species attack the host mainly at body parts just above ground level (Lee et al., 1987). These facts suggest that *An. farauti* originally obtained blood from small terrestrial mammals such as murines, and that humans are a relatively new blood host. The relationship between the blood quality for egg production and host preference remains unclear. Strong host preference does not always correlate with high fertility (Ikeshoji, 1993). Some mosquito species show a strong preference for humans, even when ovariole maturation rates are low.

Under field conditions, hosts may be selected by mosquitoes according to blood quality and host availability. The number of eggs produced per unit time has an important role in host selection behavior. In the Solomon Islands mammalian fauna is scarce, and humans are the largest available population in the coastal areas where *An. farauti* prevails. The human blood index for *An. farauti* has been variously reported, with both low and high at New Guinea and Solomon Islands littoral (Lee et al., 1987). Pigs and dogs are common mammals and important hosts for *An. farauti* in the villages in Papua New Guinea. Results of this study suggest that the quality of dog blood was comparable to that of human blood for *An. farauti*. Fertility of *An. farauti* fed on pigs also needs to be studied, since pigs are common domestic animals also in the Solomons.

Acknowledgements

I would like to thank N. Kere, B. Bakotee, the late B. Seijama and J. Villia for their kind cooperation; S. Meek for valuable suggestions. We are also indebted to L. Vaisui and E. Porotaki for their assistance; and M. Sasa for continuous guidance and advice. This study was supported by the Ministry of Health and Medical Services, Solomon Islands and the Japan International Cooperation Agency (JICA).

References

Bennett, G. F. 1970. The influence of blood meal type on the fecundity of *Aedes (Stegomyia) aegypti* L. (Diptera: Culicidae). *Can. J. Zool.*, 48: 539–543.

Clements, A. N. 1992. The Biology of Mosquitoes, Vol. 1, Development, Nutrition and Reproduction. 509 pp. Chapman & Hall, London.

Hawley, W. A. 1985. A high-fecundity aedine: factors affecting egg production of the western treehole mosquito, *Aedes sieffensis* (Diptera: Culicidae). *J. Med. Entomol.*, 22: 220–225.

Ikeshoji, T. 1965. Fecundity of *Culex pipiens fatigans* Wied. fed on various amounts of blood and on different hosts. WHO/VC/133.65.

Ikeshoji, T. 1993. Mosquitoes. 246pp. University of Tokyo Press, Tokyo.

Lee, D. J., Hicks, M. M., Griffiths, M., Debenham, M. L., Bryan, J., Russel, R. C., Geary, M. and Marks, E. N. 1987. The Culicidae of the Australasian Region Vol. 5 (ed. Debenham M. L.), Monograph Series, Entomology Monograph No. 2, 315 pp. Australian Government Publishing Service, Canberra.

Mather, N. T. and DeFoliart, G. R. 1983. Effect of host blood source on the gonotrophic cycles of *Aedes triseriatus*. *Am. J. Trop. Med. Hyg.*, 32: 189–193.

McCray, E. M., Jr. and Schoof, H. F. 1970. Laboratory behavior of *Culex pipiens quinquefasciatus* and the effects of tepa, metepa, and apholate upon its reproduction. *Mosq. News*, 30: 149–155.

Okazawa, T., Horio, M., Mogi, M., Miyagi, I. and Sucharit, S. 1985. Laboratory bionomics of *Tripteroides aranoides*. *J. Am. Mosq. Control Assoc.*, 1: 428–434.

Shelton, R. M. 1972. The effects of blood source and quantity on production of eggs by *Culex salinarius* Coquillett (Diptera: Culicidae). *Mosq. News*, 32: 31–37.

Shroyer, D. A. and Siverly, R. E. 1972. A comparison of egg production of *Culex pipiens pipiens* L. fed on avian and mammalian. *Mosq. News*, 32: 636–637.