EYEWORMS AND FACE FLIES

in California

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EYEWORM INFECTIONS are of economic importance in parts of Europe, Asia, and Africa, where about a dozen species of nematodes of the genus *Thelazia* inhabit and irritate the eyes of a variety of large mammals, including such domestic animals as cattle, horses, buffalo, camels, dogs, etc. The half-inch long worms live on the surfaces of the eye membranes, under the eyelids, or with some species, in the tear ducts or nasolachrymal canal. Ocular disturbances range from mild inflammation, commonly manifested by excessive tearing and photophobia, to occasional severe dysfunction, even blindness, of affected eyes.

Life cycle

Female worms shed eggs which accumulate in eye and nasal secretions where they are picked up by flies that feed on these secretions. But the parasite will develop only in certain kinds of flies, the relationship generally being highly specific and involving intracellular development of the parasite within the fly. After molting and growing 10- to 20-fold over a month or so, the now infective parasite is capable of pushing its way out of the mouthparts as the fly feeds on the eye secretions of another warm-blooded host. Once transmitted, the still barely-visible eyeworms grow to maturity in another month, mate, and soon begin laying eggs to complete the cycle.

The only native species of mammalian eyeworm in North America is *Thelazia californiensis*, which is largely restricted to California and adjacent parts of neighboring states. Various mammals have been recorded as occasional hosts for this parasite, including dogs, cats, sheep, horses, even man (8 recorded cases), but it occurs mainly in wild animals such as deer, jackrabbits, and coyotes in the foothill and mountainous areas of the state. In the late 1950s a group of investigators at Loma Linda University in Southern California reported the discovery of developing stages of this parasite in the canyon fly, *Fannia benjamini*, and since then, this fly has been widely listed in textbooks as the vector of *T. californiensis*, although the report had not been substantiated.

In the early 1960s it became apparent that the westward movement of the introduced face fly, *Musca autumnalis*, would soon involve California as it spanned the continent from its point of entry into Nova Scotia from Europe in 1950. This notorious livestock pest is a known vector of at least two species of eyeworm, and there was concern about its vector potential when it arrived in the area inhabited by *T. californiensis*. But before this question could be answered, it was necessary to learn something about how the native eyeworm was transmitted in nature.

The main study area was the University of California Field Station at Hopland, some 100 miles north of San Francisco, where eyeworms were known to occur commonly in deer. Subsequent surveys revealed consistently high levels of transmission from 1964 to 1968, with about 60% of the deer and 30% of the jackrabbits infected on this 4,700 acre area. Occasional infections were also detected in grey foxes, raccoons, and hunting dogs. Eyeworm prevalence then began a steady decline at the station for unknown reasons, and is much reduced at present.

Early transmission studies were focused on the canyon fly. Many hundreds of these elusive flies were caught at the station during peak transmission periods and dissected without finding eyeworm larvae. At the same time repeated attempts were made by a variety of means to infect wild-caught and laboratory-reared *F. benjamini*, but results were almost always negative. Yet, in an occasional fly, there would be some *Thelazia* development.

Three possibilities were considered: (1) *F. benjamini* was the vector but conditions were not right for infection; (2) the vector was an unrecognized species or variety that occasionally was present among the flies called *F. benjamini;* (3) other kinds of vectors were involved. While the first possibility seemed probable, intensive efforts to improve infectivity were fruitless. The second possibility seemed least likely, considering the high transmission rate and the large numbers of flies examined from the area. Representative specimens from this material examined independently by two experts on fly identification were refer-

Thelazia californiensis in the eyes of a rabbit (photo by R. W. Merritt).

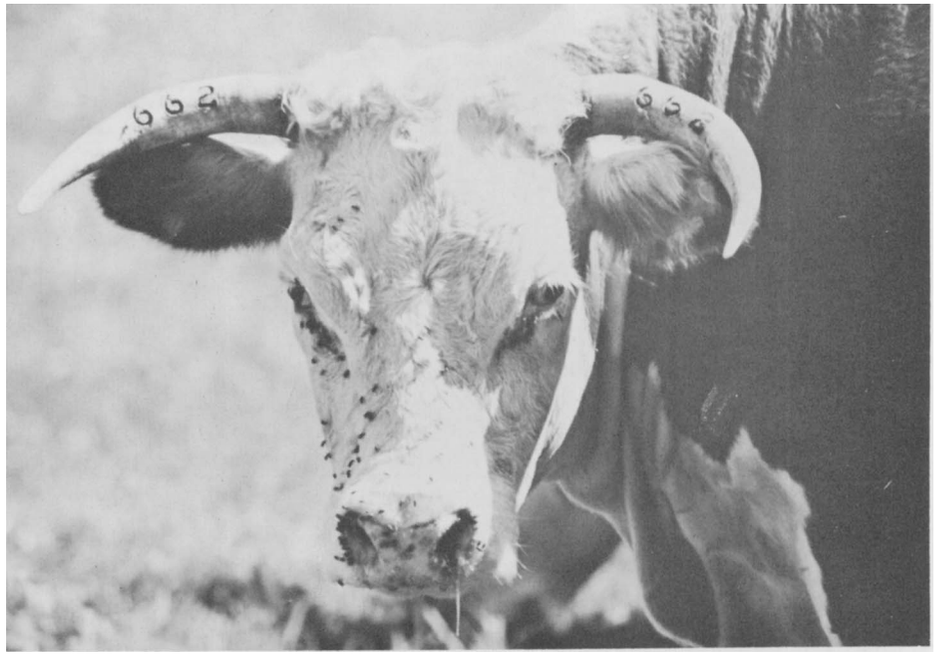
able only to *F. benjamini*. So other possible vectors were investigated. The focus on flies was supported by finding several sentinel jackrabbits infected with eyeworms after living in cages that essentially excluded all but flying insects.

The arthropods regularly associated with these animals and with naturally infected captive deer (some 70 species or so) were examined for eyeworm larvae at all seasons of the year. All were eventually ruled out as potential vectors, on one basis or another, except the canyon fly, which by process of elimination had to be the vector. During this effort many of the flies associated with deer, sheep, and cattle droppings (maggots as well as adult flies) were experimentally fed *Thelazia* eggs without significant parasite development. This was also the case with two shipments of face flies obtained from the Midwest before this fly's invasion of California. But these results meant little if the infectivity of test parasites could not be demonstrated. Obviously there was more to learn about the biology of *F. benjamini*.

Laboratory colonies

Occasionally in the laboratory colony of *F. benjamini*, "strange" male flies were seen. Initially these proved to be male *F. canniculars*, the lesser house fly, and at times a common pest fly about the laboratory premises and an occasional contaminant of the colonies. It had been extensively tested as a host for *Thelazia*, and found to support little or no parasite development. But "strange males" continued to be noticed even after added precautions against outside contamination had been taken. When examined these males proved to be an unknown species of *Fannia*, tentatively identified as close to *F. conspicua*.

The fact that the *F. benjamini* colony was actually a mixture of species was made much more apparent during a concurrent study on the egg-laying behavior of these flies. It was found that three distinctly different kinds of eggs were laid by females that could not otherwise be distinguished from one another. With this discovery, separate colonization was possible, followed by tests for eyeworm susceptibility. Flies from the now pure *F. benjamini* colony failed to support any significant eyeworm development, as was the case with flies from the colony tentatively designated "near *conspicua*." But in the third colony, both male and female flies could readily be infected with eyeworms using the same pool of eggs and procedures that yielded negative results with the other flies. Early parasite growth was intracellular, within the fly's fat-body cells. The parasites developed to the infective stage in about a month and grew into adult eyeworms when transferred to the eyes of laboratory rabbits. This then had to be the vector of *T. californiensis*. Subsequent experiments with this undescribed species of *Fannia* reaffirmed these observations and provided a clue as to why only a few of the thousands of *benjamini-complex* flies caught at Hopland contained developing stages of *Thelazia*. Some dexterity with a net is needed to catch any of these flies (baits and traps have not been useful) but the vector species seems to be particularly elusive, judging from its behavior in the laboratory. It probably was therefore grossly underrepresented in the field collections.



Hereford with face flies, **Musca autumnalis** (photo by L. Dunning).

With the discovery of the native vector and its establishment in the laboratory, it was again possible to turn to the question of compatibility between the face fly and *T. californiensis*. By now, this fly was established in California, indeed even in the study area. Several experiments involving exposure of local face flies to the same pools of eyeworm eggs that were consistently infective for the vector species yielded no evidence of development in *Musca autumnalis*, leading us to conclude that the face fly is unlikely to serve as a vector for our native eyeworm.

However, the presence of face flies in the state does create a potential for infection with foreign eyeworms introduced in imported animals. Such newly introduced parasites could then be transmitted to domesticated livestock. Indications of this potential problem have come to light in the last few years. *Thelazia lacrymalis*, an eyeworm of horses and donkeys in Europe and the Middle East, has been found in native horses in Ontario and Maryland, where face flies abound and are thought to carry this parasite. Larval stages of *Thelazia* have recently been reported from face flies collected in Massachusetts. In 1971, *T. gulosa* was reported occurring in the eyes of a recently arrived giraffe at the Los Angeles Zoo. This eyeworm commonly infects cattle in Europe and Asia, and is known to be transmitted by the face fly. Importers of livestock or wild animals should be alert to the possibility of such introductions, so that the necessary precautions may be taken.

In summary, it might be asked whether the entry of the face fly into California has changed the potential for eyeworm infections of domestic animals. The answer is apparently "no" with regard to the native eyeworm, but "yes" with respect to foreign eyeworms.

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