A REDUCTION IN MILK PRODUCTION CAUSED BY THE FEEDING OF BLACKFLIES (DIPTERA:SIMULIIDAE) ON DAIRY CATTLE IN CALIFORNIA, WITH NOTES ON THE FEEDING ACTIVITY ON OTHER ANIMALS

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Attacks of feeding blackflies have been directly responsible for the deaths of domesticated animals in North America (Bradley, 1935; Cameron, 1918; Millar and Rempel, 1944; Rempel and Arnason, 1947) and indirectly responsible for deaths of poultry by serving as vectors of *Leucocytozoon* spp. (Anderson, Trainer and DeFoliart, 1962; Fallis, Anderson, and Bennett, 1956; Johnson, *et al.*, 1938; O'Roke, 1934; Skidmore, 1932), but reports indicating their economic importance to livestock short of causing death are scarce (Curtis, 1954; Edgar, 1953).

Freeborn, Regan and Folger (1925) in California first showed the relationship between blood-sucking flies (horn and stable flies) and a reduction in milk production. In more recent years several workers have demonstrated a similar effect (especially among dairy herds on pasture) caused by the continued presence of these blood-sucking flies (Bruce and Decker, 1947, 1958; Grannett and Hansens, 1957). Although relationships between reduced milk production and the continued presence of multivoltine blood-sucking flies have been established, there is little substantial evidence that single large outbreaks of hematophagous flies lasting for only relatively short periods of time may likewise cause a marked decline in milk production. This paper reports the effects of such a relationship involving a simuliid outbreak which occurred primarily through May 1962 in Merced County, California.

METHODS. Initially we were informed of the outbreak when several farmers reported huge swarms of "gnats" causing considerable annoyance to man and livestock. Specimens submitted for identification were received on May 7. Subsequent observations and collections were made on May 9–10, 14–15, and 17–18. On these dates we observed flies feeding on various hosts, aspirated hundreds of engorged specimens from the animals, and observed the direct effects of their bites.

Immature stages were collected from the Merced River and several irrigation canals in and adjacent to the affected area. Later visits were made to the area during June and July, but at this time the general population of simuliids was low and only collections of immatures were obtained. Species identifications were made (by J. R. A.) and individual milk production records were obtained from the farmers' 2-day milk receipt totals after the outbreak had subsided.

EXTENT AND DURATION OF THE OUTBREAK. All observations and collections were limited to an area of 3 square miles located approximately 7 miles NNW of the city of Merced in Merced County, California. However, later interviews with several farmers outside the study area indicated that the total area affected may have been at least twice as large. Four large (6–12 feet wide) irrigation canals flow through various sectors of the area and the Merced River flows along the northern edge. Farmers (some of whom collected flies at various times) reported that "substantial numbers" of blackflies

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were intermittently present from about May 1 through June 1. Although the major emergence occurred about May 1, newly emerged, nulliparous flies were being added to the population all through May and immatures of the major pest species involved (*S.* (*P.-P.*) *trivittatum*) were collected on each visit. All of the species present were either bi- or multivoltine, but only the tremendous numbers resulting from overwintering populations were of economic importance. The fly population in May was, therefore, typical of a short-term outbreak of a univoltine species. At dairy "BR" the largest number of feeding flies was present on May 6–7 and May 29–30, on which dates the herd was extremely unmanageable.

Species Present and the Effects on Their Hosts. The immature stages of *Simulium* (*E.*) *aureum*, *S.* (*E.*) *canonicolum*, *S.* (*N.*) *argus* *S.* (*N.*) *vittatum*, *S.* (*P.*) *bivittatum*, *S.* (*P.*) *trivittatum*, and *S.* (*S.*) *tuberosum* were collected from the Merced River and from all the irrigation canals. Only *S. aureum* and *S. tuberosum* were not collected feeding on animals. *S. argus*, *S. bivittatum*, *S. trivittatum*, and *S. vittatum* fed on cattle and horses; *S. canonicolum* on chickens and turkeys; and *S. trivittatum* on man.

A number of young chicken pullets on one farm were left with bloody heads and 11 subsequently died after being fed on by hordes of flies on May 5 and 6. The egg production of older layers also dropped off following these attacks. In addition to actually being bitten by flies, humans were annoyed by the large numbers of males swarming about the buildings and yards. Their effect on man was essentially as reported for *S.* (*S.*) *jenningsi* and *S. vittatum* by Anderson and DeFoliart (1961) in Wisconsin.

Feeding flies were aspirated from cattle and horses on five different occasions. Of the 2565 specimens collected from these animals, 96 percent were *S. trivittatum*. This also was the most predominant species in the immature collections. Except for a few horn flies (5–20 per animal) on the cattle, no other blood-sucking insects were seen.

Although *S. trivittatum* fed on man at times during the outbreak, few flies landed and none fed on us while aspirating blood-seeking flies from cattle and horses. No change in the intensity of fly-feeding activity was noted when collecting from animals.

Like the feeding behavior of other simuliids which feed principally on large mammals (Breev, 1950; Davies, 1957; Fredeen, 1961; Rempel and Arnason, 1947), *S. trivittatum* fed primarily along the exposed ventral regions of the animals. However, a few flies were also present on other areas of the animals' bodies as well (most commonly on the chest, neck, in the ears, or around the eyes). On cattle, most flies feeding on the ventral surface were congregated on the udder and teats and forward along the milk vein to an area just anterior to the navel. Lesser numbers fed on the ventral surface near the front legs. On horses, the feeding flies were more evenly distributed over the entire ventral surface of the body with slightly larger numbers near the inner margins of the fore and hind legs. They fed in greater numbers in the chest and neck region of horses than on cattle.

On May 14–15 and 17–18, it was estimated that various individual cows and horses had from 0 to 10 simuliids on them at any given time from 9:00 a.m. to 3:00 p.m. (P.S.T.), but thereafter the feeding activity of flies increased greatly until dusk. The maximum number of flies present on an individual cow was estimated to be between 500 and 800. Huge swarms of males were intermittently present throughout the daylight hours between buildings in the farm yards and along the peripheral margins and below the canopies of trees. Both sexes were present throughout the day on leaves and branches in the lower canopy area.

When exposed to swarms of blood-seeking flies while on pasture, individual cows exhibited a strong avoidance reaction in which an animal at the peripheral margin of the herd would attempt to avoid the flies by lowering her head and forcing her way into the center of the herd. This reaction resulted in a constant shifting and milling about of the herd and thus disrupted grazing activities and quite possibly rumination as well. On days when flies were most numerous one farmer reported that it took 30 to 40 minutes longer than usual to bring the cows in for milking. In this case, the lead cow (under heavy attack) repeatedly put her head down and moved back among the other cows (presumably seeking protection). This behavior resulted in considerable confoundment among the herd and a notable delay in their appearance at the milk barn. During these attacks it was necessary for a rider on horseback actually to herd the cattle in for milking. At this time the horse also was attacked by numerous flies. As discussed in the following section, on these particular days, both fly activity and the resulting change in the milking schedule probably contributed to the decline in the daily milk production rate.

Feeding flies remained on the cattle as they entered the milk barns. After completing their blood meals many of these flies flew to the windows of the barns from which they could easily be collected. As blackfly bites are usually painful to man, one might assume that cattle attacked by hundreds of feeding flies are under considerable stress. Bite wounds commonly bled freely for a short time before clotting and large, raised wheals, caused by both immediate and delayed hypersensitivity reactions, appeared on the teats, udders, and other bitten areas. A number of individual animals in each herd subsequently contracted secondary infections manifested in large ulcerating sores on the teats and udders.

Effect of the Outbreak on Milk Production. A marked reduction in milk production occurred in at least six dairies within the area investigated. Among the many factors which may influence the daily milk production rates of lactating cattle are a change in diet, a change in the milking schedule or a change in the personnel milking the cattle, and the number of days since the cow began lactating. Fluctuations in the number of pounds appearing on daily milk receipts can also result from unequal daily amounts of milk being removed for the farmer's home use before the milk is collected from individual farm storage tanks. The fact that feed and management practices may have contributed to the decline in milk production on individual farms cannot be ruled out entirely. However, the only common phenomenon occurring on all affected farms during May was the presence of numerous blackflies. To the best of our knowledge (based on personal interviews with the farmers involved) other factors were of negligible importance on the farms for which the data herein are presented.

Although the physical features on each farm differed somewhat, all dairies visited maintained pasture herds (as opposed to feed-lot-managed herds). However, as illustrated in Table 1 and in Figures 1 and 2, all herds attacked showed a simultaneous drop in milk production during the same period, whereas other dairy herds near two of the peripheral margins of the area either showed little change or an actual increase in production during this same period. The data presented for affected herds represent typical reductions in milk production resulting from blackfly attacks on 3 of the 6 dairy herds for which we obtained the greatest amount of information. Except for production on the "BR" dairy (Fig. 2), all production records on the other herds attacked were similar to the one illustrated in Figure 1. Each point on the graphs represents chronological 2-day milk receipt totals.

As all dairy herds in the general area of investigation are put on pasture about April 1, the peak months for milk production are April and May with a gradual decrease thereafter as the average monthly temperature rises. The lowest milk production rates for pastured herds in this

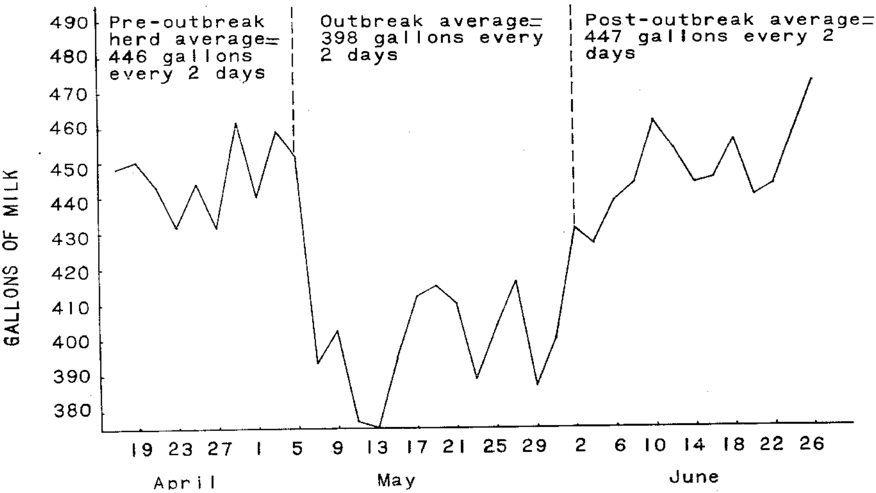

FIG. 1.—Typical decline in milk production occurring on six farms during the period of the simuliid outbreak ("GA" dairy illustrated here).

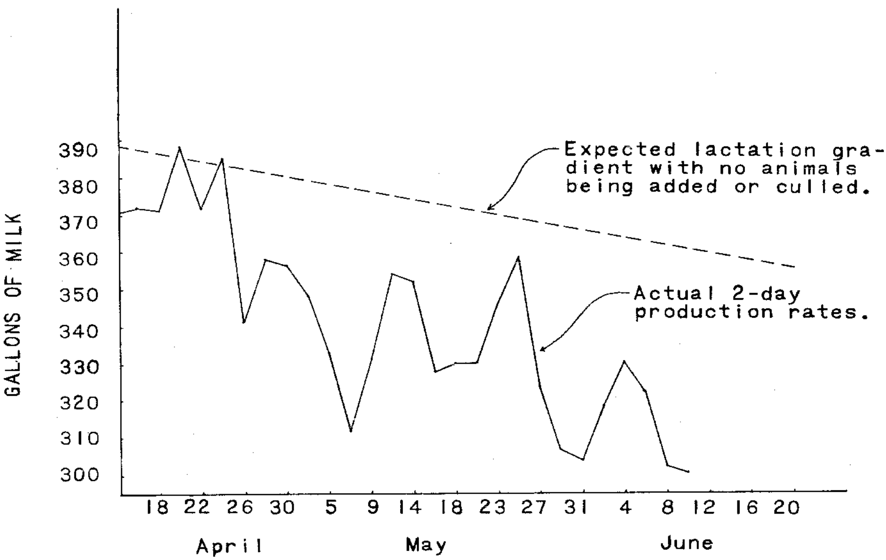

FIG. 2.—Actual vs. expected milk production on the "BR" dairy.

TABLE 1.—Average daily milk production (in gallons) from dairies within and outside of the outbreak area for various periods from April to June, 1962.

Dairy	Pre-outbreak average[a]	Outbreak average	Post-outbreak average[b]	Lbs. lost during outbreak	Monetary loss[c]
		Farms in outbreak area			
"Br"	189	168[d]	..	7516	300.00
"Ga"	223	199[e]	224	5478	219.00
"SW"	184	159[f]	178	7476	299.00
		Farms outside outbreak area			
"So"	263	271[g]	282	none	none
"Le"	250	258	275	"	"
"Pa"	341	338	334	"	"
"Ga"	151	148	147	"	"

[a] Determined from the 20-day average prior to the outbreak.
[b] Determination from the 20–30 day average following the outbreak.
[c] Calculated at a rate of 4.00 per 100 lbs.
[d] April 26–June 2.
[e] May 6–May 31.
[f] April 28–June 4.
[g] Averages on all check farms from May 1–May 31.

area occur during August and September. The blackfly attacks therefore occurred during a period when milk production was expected to be at its highest average daily rate.

All herds in Table 1 except the "BR" herd were maintained on a management program in which fresh animals were intermittently added to the herd and poor producers culled. In theory, this practice tends to maintain the herd milk production rate at a constant level. However, instead of the relatively constant level of milk production expected on such a management program, the data show that on all farms within the outbreak area a marked decline in milk production occurred during the period of the simuliid outbreak.

As the farmer at the "BR" dairy planned to discontinue operations, no fresh cows were added to the herd and no poor producers were removed during the period illustrated in Figure 1. Past county Dairy Herd Improvement Association records showed that the herd average for individual cows on this dairy had been 9,900 pounds of milk produced during a 305-day lactation period. The superimposed lactation gradient illustrated in Figure 2 is based on these data. Because of this herd's stable state, it could be expected that its average daily milk production would decrease much as is illustrated by the superimposed line. Instead, the average daily production rates were quite erratic, with the three major drops in milk production all coinciding with the presence of numerous simuliids feeding on the cattle.

Although it is not possible to compare the actual outbreak production average with a pre- or post-outbreak average for the "BR" dairy because of the lactation gradient in effect in this herd, we were fortunate in having this herd within the study area for comparison with the other herds attacked. Thus, by using charts available for computing the expected lactation gradient of a lactating cow (Kendrick, 1957) it is possible to determine the expected production during a given period and to compare this with the actual production. On this basis it was calculated that the "BR" dairy lost 7516 pounds of milk during the outbreak at an estimated monetary loss of $300.00.

This comparison shows that the average daily milk production of herds managed in two different ways simultaneously and notably declined from the expected production rates with the appearance of huge warms of host-seeking simuliids. This eduction persisted in the "BR" herd even fter the major blackfly outbreak had ubsided, but in those herds in which oor producers were culled out periodically n favor of fresh cows, production rates eturned to pre-outbreak levels shortly fter the outbreak of simuliids had subided.

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