Table 1. The distribution of *Syphacia muris* in the intestine of albino rats.

T(day)*	Rats (No.)	Worm burdens		Anal swabs
		Cecum	Colon	
1	2	386	0	−
2	2	367	0	−
3	4	635	7	−
4	4	170	0	−
5	4	620	6	−
5½	4	218	0	−
6	4	760	15	−
7	4	270	25	+
7½	4	130	119	+
8	4	133	11	+
9	4	41	3	+
9½	4	61	0	+
10	4	7	3	+

* Time after exposure to infection.

knowledge of the period of migration of *S. muris* down the rat's intestine would greatly facilitate the recovery of large numbers of gravid "migrators" as a source of infective eggs.

Forty-eight helminth-free albino rats, 3 to 5 weeks old, were placed for 24 hours in contaminated cages containing heavily infected *S. muris* "source" rats. This procedure is a modified version of Chan's (*3*) technique for infecting mice with *S. obvelata*. At periodic intervals thereafter, Scotch tape anal swabs were taken from each rat and examined for the presence of *S. muris* eggs, then two or four rats were killed and their pinworm burdens were determined.

Table 1 summarizes the results of this study. The migratory phase of the *S. muris* life cycle began on the sixth to seventh day after infection, as determined by autopsy findings and the presence of eggs on the perianal regions of the rats. During the seventh and eighth days, maximal numbers of gravid migrators were found in the colon of the rats. Many of the migrating female worms spontaneously shed their eggs on exposure to air or to saline solution. In addition, a small number of gravid nonmigrating female worms, from the cecum, also shed their eggs upon exposure. These spontaneously shed eggs were infective to rats after incubation in saline for periods ranging from 30 minutes at room temperature to 4 hours at 37°C (*4*).

WALTER STAHL

Department of Microbiology, Seton Hall College of Medicine and Dentistry, Jersey City, New Jersey

References and Notes

1. F. Philpot, *J. Helminthol.* **2**, 239 (1924); M. J. R. Prince, *Science* **111**, 66 (1950).
2. K. F. Chan, *Am. J. Hyg.* **56**, 14 (1952).
3. ———, *ibid.* **56**, 22 (1952).
4. This investigation was carried out in the Columbia University School of Public Health and Administrative Medicine, and was supported in part by research grant No. E-461(C) of the National Institutes of Health, U.S. Public Health Service.

9 September 1960

Low Temperature Induced Male Sterility in Male-Fertile Pennisetum clandestinum

Abstract. Controlled environment studies of *Pennisetum clandestinum* showed that at 10°C stamens of the male-fertile strain were not exserted from the floret although stigmas emerged normally. At higher temperatures both stamens and stigmas were exserted. Pollen abortion was high at 10°C and was increased by lengthening photoperiod. Flowering of the male-sterile strain was not changed by any temperature or photoperiod. These responses to temperature may explain the natural sterility during the cool season.

Pennisetum clandestinum, introduced to the United States about 1920, consists of male-sterile and male-fertile strains. The inflorescences of the two strains have been described by Edwards (*1*) and Narayan (*2*). Anthers of the male-sterile strain are retained in the leaf sheath enclosing the flower and contain no viable pollen. Anthers of the male-fertile strain are exserted from the enveloping sheath on long filaments. Stigmas are exserted in both strains throughout the year in the Los Angeles area, but few or no stamens emerge during the winter in the male-fertile strain. I observed approximately 25 percent nonstaining (sterile) pollen during the summer and 50 percent or more in the winter in the fertile strain. No stainable pollen was observed in the sterile strain at any season (*3*).

Anther abortion in wheat by chilling was demonstrated by Suneson (*4*). Nitsch *et al.* (*5*) reported deformed male flowers in Cucurbitaceae as well as a reduction in the proportion of male flowers when temperatures were reduced from 26°C to 20°C. The purpose of this study was to determine if the seasonal changes in sex expression of *P. clandestinum* were caused by changes in temperature or photoperiod.

Plants of *P. clandestinum* were propagated in 5-in. pots from a male-sterile and a male-fertile clone. All plants were kept in a 21°C minimum temperature greenhouse. As the plants developed they were clipped frequently to stimulate flowering (*6*). At full flowering, they were transferred to controlled environment growing chambers under 8- and 16-hour photoperiods at the following temperatures centigrade: 27°, 10°, and 21° minimum for days to 10° for nights. Plants, given the alternating temperature and 16-hour photoperiod, received 8 hours of light at the day temperature and 8 hours at the night temperature. In addition, two lots of plants were given continuous light at 27° and 10°C. Five plants of each clone were placed in each treatment.

Flowering behavior was noted periodically as the treatment progressed. After 4 weeks in the growing chambers, pollen fertility was determined by staining with acetocarmine (*7*). Three inflorescences from each plant were examined.

Observation of the male-fertile strain showed a pronounced reduction in the number of florets with exserted stamens between the second and third week in the 10°C treatments. Table 1 shows that by the fourth week there were no stamens visible on any plants in these treatments, but numerous stigmas were still exserted. All fertile plants in the other treatments continued to flower in a normal manner, producing numerous stamens.

Flowering was not affected by the photoperiods within the temperature treatments. Exsertion of stamens stopped at the same time in the 8-, 10-, and 24-hour light periods at 10°C. In all other temperature-photoperiod treatments, exsertion of new stamens continued during the treatment period of 8 weeks. Normal-appearing stigmas developed on all plants in all treatments throughout the entire period.

Flowering behavior of the male-sterile strain did not appear to be altered in any way by any of the treatments. Stigmas but no stamens emerged under all temperatures and photoperiods.

Plants of both strains receiving continuous light developed shoots with long internodes and few branches; thus the total number of inflorescenses per plant was lower than for plants under the 8- and 16-hour photoperiods.

Pollen sterility was nearly complete in the male-sterile strain regardless of treatment. Anthers were flat, containing only shrunken nonstaining pollen grains. As shown in Table 1, anthers from male-fertile plants grown at 27° and 21°C days to 10°C nights contained high percentages of stainable pollen. These percentages are comparable to those observed in field grown plants during summer.

Anthers on short filaments, removed from plants grown at 10°C, contained a much lower percentage of stainable

Table 1. Appearance of florets, after 4 weeks of treatment, in fertile *P. clandestinum*.

Day length (hr)	Stamens	Fertile pollen (%)
	Temperature 27°C	
8	Exserted	89 ± 16
16	Exserted	65 ± 11
24	Exserted	71 ± 13
	Temperature 10°C	
8	Nonexserted	36 ± 5
16	Nonexserted	21 ± 6
24	Nonexserted	0.4 ± 0.2
Temperature	*21°C (day) to 10°C (night)*	
8	Exserted	72 ± 13
16	Exserted	82 ± 16

pollen than in the other treatments. Thus, there was a decrease in pollen fertility associated with the nonexsertion of anthers in the low temperature treatment.

Photoperiod did not affect the degree of pollen fertility at the warmer temperatures. However, at 10°C, pollen fertility decreased as the photoperiod increased. Under continuous light, sterility was essentially complete.

Seasonal sterility in *P. clandestinum* therefore appears to be influenced primarily by low temperature. The interaction of long photoperiod with low temperature to increase sterility is difficult to relate to the natural seasonal sterility.

VICTOR B. YOUNGNER
Department of Floriculture and Ornamental Horticulture, University of California, Los Angeles

References and Notes

1. D. C. Edwards, *Empire J. Exptl. Agr.* **5**, 371 (1937).
2. K. N. Narayan, *Proc. Indian Acad. Sci.* **41**, 196 (1955).
3. Part of a longer paper submitted for publication in another journal.
4. C. A. Suneson, *J. Am. Soc. Agron.* **29**, 247 (1937).
5. J. P. Nitsch, E. B. Kurtz, J. L. Liverman, F. W. Went, *Am. J. Botany* **39**, 32 (1952).
6. D. J. Carr and Ng. Eng Kok, *Australian J. Agri. Research* **7**, 1 (1956).
7. J. W. Lesley and M. M. Lesley, *J. Agr. Research* **58**, 621 (1939).

20 October 1960

Hemoglobin Types of Macaca irus and Macaca mulatta Monkeys

Abstract. Hemoglobin of 30 *Macaca mulatta* monkeys and of 15 *Macaca irus* monkeys consisted of one electrophoretic component similar to human hemoglobin A. Twenty-one *M. irus* monkeys had two types of hemoglobin. In 20 animals the hemoglobin resembled human hemoglobin AJ, and in one animal it resembled human hemoglobin AI.

While studying the hematological effects of irradiation in animals, we examined the blood and bone marrow of 36 adult monkeys of the species *Macaca irus* (cynomolgus) and 30 of the species *Macaca mulatta* (rhesus). Hemoglobin was analyzed by paper electrophoresis at *p*H 8.6 with veronal buffer, 0.05 ionic strength (*1*), and the percentage of alkali-resistant hemoglobin was measured (*2*). Stained smears of blood and bone marrow were examined, and the packed-cell volume and percentage of reticulocytes were determined.

Hemoglobin of all the *M. mulatta* and 15 of the 36 *M. irus* monkeys resembled human hemoglobin A by electrophoretic analysis (Fig. 1). Hemoglobin of 21 (58 percent) *M. irus*

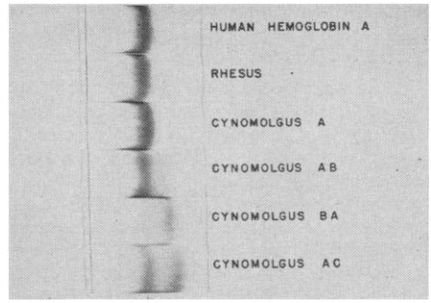

Fig. 1. Relative electrophoretic mobilities of hemoglobins as designated.

monkeys consisted of two components similar to the human hemoglobin combination AJ. The electrophoretically slow component in our monkeys was designated type A, the fast component, type B. The predominant component was type A in some animals (type AB); in others it was type B (type BA), as shown in Fig. 1 and Table 1. The hemoglobin of one animal consisted of type A, and a second component which migrated more rapidly than type B and was designated type C (Fig. 1). The percentage of alkali-resistant hemoglobin ranged from 0.3 to 2.0 with no significant differences among the groups under study, although we did observe significant increments in the alkali-resistant fraction of hemoglobin in *M. mulatta* and *M. irus* animals with types A, AB, and BA hemoglobin after sublethal irradiation (*3*).

We found no evidence that the presence of B or C hemoglobins imposed a hematological handicap upon the carriers (Table 1). An examination of bone marrow aspirates obtained from the anterior iliac crest revealed no abnormality. There were no distinguishing morphological characteristics of erythrocytes in carriers of B or C hemoglobins. The sex of the animals was not correlated with the incidence of hemoglobin type B (Table 1).

The differences in hemoglobin types among different species of monkeys and among members of the same species have been described recently by others (*4–7*). The hemoglobin of six *M. irus* animals studied by Kunkel (*5*) by starch block electrophoresis had two electrophoretic components, one of which resembled human hemoglobin A. A fast component was present in concentrations ranging from 25 to 65 percent of the total hemoglobin. Lie *et al.* (*4*) performed paper electrophoretic analysis of the hemoglobins of a total of 116 *M. irus* animals obtained from different areas of Indonesia. Forty-three percent of monkeys from one area and 73 percent of those from a second area had two types of hemoglobin. The electrophoretic mobility of the hemoglobin from animals with a single component was similar to human hemoglobin A. The second component migrated more rapidly than type A. The predominant fraction of hemoglobin in some cases was the fast component; in others, the slow component predominated. Although different methods of paper electrophoretic analysis were employed, we believe that the hemoglobin types A and B described by Lie and her co-workers (*4*) are, respectively, the same as the types A and B which we have found.

The occurrence of type B hemoglobin in the absence of type A hemoglobin in *M. irus* has not been reported, despite the relatively high incidence of hemoglobin AB in the series of Lie *et al.* (*4*) and in our series. These findings suggest the following possibilities: (i) Synthesis of hemoglobins A and B is controlled by allelic genes and the combination of BB is lethal in the early life of the affected animal. (ii) Prevalence of hemoglobin B results from a state of balanced polymorphism, analogous to the high incidence of hemoglobin AS and the low incidence of hemoglobin SS disease in adults in some areas of Africa (*8*). (iii) Genes responsible for synthesis of hemoglobins A and B are nonallelic, similar to the nonallelism of genes controlling hemoglobins A and G in the human being (*9*).

Hemoglobin type C appears to be quite rare in *M. irus* since it was encountered only once in our series and in none of the animals studied by Lie *et al.* (*4*). The type C variant is similar to the fast component found by Jacob and Tappen (*6*), in a monkey of the species *Cercopithecus mitis*, which

Table 1. Hemoglobin types of *M. irus* and *M. mulatta* monkeys.

Hemoglobin type	Animals (No.)	Sex		Range and mean (%)	
		M	F	Packed cell volume	Reticulocytes
	M. irus				
A	15	9	6	34–47 (40.6)	0.1–4.3 (0.8)
AB	11	7	4	35–45 (40.3)	0.2–1.1 (0.7)
BA	9	4	5	39–45 (42)	0.3–1.3 (0.7)
AC	1	1	0	42	1.0
	M. mulatta				
A	30	19	11	36–47 (40.9)	0.2–2.3 (0.87)