Potential Helminth Infections in Humans From Pet or Laboratory Mice and Hamsters

WARD B. STONE, M.S., and REGINALD D. MANWELL, Sc.D.

IT HAS LONG BEEN recognized that wild rodents are hosts to internal and external parasites which are dangerous to human health. In the United States continuing abatement programs usually control wild rats and mice in and around human habitations. However, little attention has been given to the possibility of acquiring parasitic infections from rodents obtained from commercial sources. It appears that many people who fear proximity to wild mice or rats feel safe with pet mice or hamsters.

The number of people exposed to these animals is tremendous. For example, in 1961 approximately 25 million mice (*Mus musculus*) were used in laboratories in the United States. The number of this species being kept as pets is unknown (*1*). However, they are readily available in pet shops and department stores, and the sales clerks said they sold "quite a few." In each year of the 1960's an average of 6 million golden hamsters (*Mesocricetus auratus*) were sold in the United States, and approximately 36 million are in laboratories and homes throughout the world (*2*).

Hymenolepis nana (dwarf tapeworm) and *Hymenolepis diminuta* (rat tapeworm) are significant when found in laboratory and pet rodents because both infect man. In 1947 Stoll listed *H. nana* as infecting 100,000 persons in North America and 20 million in the world (*3*). *H. nana*, the smallest tapeworm found in man, ranges from 7 to 100 mm. long. As many as 7,360 *H. nana* have been found in a single child (*4*). There may be no symptoms in those lightly parasitized, but in heavier infections, headaches, abdominal distress, diarrhea, nervousness, anal itching, anorexia, and even epileptiform convulsions can occur (*5*, *6*). In contrast to *H. nana*, *H. diminuta* is a rare parasite of man, and its eggs are infective only to arthropods which must be ingested by the definitive host.

In addition, two rodent pinworms have been recovered from man. *Syphacia obvelata* worms and eggs were found in the stool of a child who was a member of a family of five in which all were infected with *H. nana* (*7*). *Syphacia muris* eggs were found in the feces of two children and two rhesus monkeys, according to a personal letter from Dr. E. C. Faust of Tulane University, dated January 6, 1965. These cases may have been spurious parasitism, but there is no proof.

Methods

Albino mice were bought from 12 commercial suppliers of laboratory animals, and hamsters were purchased from 4—the majority of which are well-known companies. In addition, mice were bought from 14 pet shops and department stores and hamsters from 6. Mice and hamsters from the Syracuse University zoology animal room which had been born or kept for an extended period at the university for use in research were also studied. A total of 260 mice and 85 hamsters were examined.

To prevent their acquiring infection from Syracuse University animals, all hamsters and mice purchased for this study were killed in an ether chamber immediately after arrival. The intestine was removed in one piece and opened its entire length. The whole intestine of each mouse was placed in a single petri dish contain-

Mr. Stone is a graduate student, department of zoology, Syracuse University, Syracuse, N.Y., and Dr. Manwell is professor emeritus of zoology and research associate, department of zoology, Syracuse University, Syracuse, N.Y.

ing 8 ml. of 0.9 percent sodium chloride solution. The small intestine, cecum, and large intestine of hamsters were separated and placed in individual petri dishes containing 8 ml. of 0.9 percent sodium chloride solution. Fecal material was scraped from the intestine and broken up to release the parasites. To detect protozoan parasites, samples of media from the petri dishes were placed on slides and examined under a compound microscope. The petri dishes then remained at room temperature for 2 hours to permit the tapeworms to separate from the intestine. The worms were counted under a dissecting microscope and manipulated with a watchmaker's forceps.

Results

Observations during the survey of helminths in mice and hamsters are summarized in tables 1 and 2. Seven of 12 purveyors of laboratory

Table 1. Intestinal helminths in mice obtained October 6, 1963–November 30, 1964

Source and location	Number in sample	*Hymenolepis nana*				*Syphacia obvelata*				*Aspiculuris tetraptera*			
		Number infected	Percent infected	Range	Average worm load	Number infected	Percent infected	Range	Average worm load	Number infected	Percent infected	Range	Average worm load
Commercial dealers:													
Baltimore, Md.	15	3	20	1–2	----	15	100	3–104	44	0	0	----	----
Wayne, N.J.	15	0	0	----	----	15	100	1–76	23	0	0	----	----
Altamont, N.Y.	15	0	0	----	----	13	87	1–64	11	0	0	----	----
Germantown, N.Y.	15	0	0	----	----	0	0	----	----	15	100	2–98	28
Millerton, N.Y.	15	2	13	1–6	----	15	100	5–72	33	0	0	----	----
Syracuse, N.Y., A	15	14	93	1–14	6	14	93	1–26	9	0	0	----	----
Syracuse, N.Y., B	15	0	0	----	----	9	60	9–86	26	0	0	----	----
Oshkosh, Wis.	15	3	20	2–46	19	15	100	20–127	62	14	93	2–34	16
Southampton, Mass.	15	7	47	1–17	6	10	67	1–8	5	5	33	1–6	3
Chicago, Ill.	15	1	7	6	6	15	100	4–156	42	13	87	6–47	18
Burlington, S.C.	15	8	53	1–92	20	15	100	7–98	38	0	0	----	----
Bar Harbor, Maine	15	0	0	----	----	9	60	4–21	11	0	0	----	----
Syracuse University animal room	22	5	23	3–22	12	7	32	3–9	10	14	64	2–257	64
Total	202	43	([1])	----	----	152	([1])	----	----	61	([1])	----	----
Pet shops:													
Syracuse, N.Y., A	6	3	50	3–106	38	0	0	----	----	6	100	7–22	14
Syracuse, N.Y., B	3	3	100	7–15	11	3	100	31–66	47	0	0	----	----
Syracuse, N.Y., C	5	5	100	7–696	154	0	0	----	----	5	100	35–145	87
White Plains, N.Y.	4	3	75	7–27	18	2	50	6–8	7	4	100	19–86	59
New York, N.Y.	5	3	60	12–187	93	0	0	----	----	5	100	54–297	210
Hartsdale, N.Y.	5	1	20	3	3	0	0	----	----	4	80	27–216	132
Springfield, Mass.	2	0	0	----	----	2	100	64–87	76	2	100	27–52	40
Madison, N.J.	2	1	50	2	2	2	100	4–6	5	0	0	----	----
Summit, N.J.	2	2	100	2–12	7	2	100	39–54	47	0	0	----	----
Department stores:													
Syracuse, N.Y., A1	7	7	100	2–267	60	7	100	11–47	23	7	100	12–118	37
Syracuse, N.Y., A2	5	0	0	----	----	5	100	6–34	17	0	0	----	----
Syracuse, N.Y., B	2	2	100	2–7	5	0	0	----	----	0	0	----	----
Syracuse, N.Y., A3	3	3	100	37–1,304	467	3	100	62–123	90	3	100	18–68	44
Springfield, Mass.	2	0	0	----	----	2	100	18–32	25	0	0	----	----
Grade school classroom	2	2	100	3–7	5	0	0	----	----	0	0	----	----
New York State Exposition	3	3	100	8–22	16	3	100	35–64	45	0	0	----	----
Total	58	38	([2])	----	----	31	([2])	----	----	36	([2])	----	----

[1] Total percent of mice from commercial dealers and Syracuse University animal room infected with *Hymenolepis nana*, 21; *Syphacia obvelata*, 72; *Aspiculuris tetraptera*, 30.

[2] Total percent of mice from pet shops, department stores, classroom, and exposition infected with *Hymenolepis nana*, 66; *Syphacia obvelata*, 53; *Aspiculuris tetraptera*, 62.

Table 2. Intestinal helminths in hamsters obtained September 22, 1964–June 18, 1965

Source and location	Number in sample	*Hymenolepis nana*				*Syphacia obvelata*			
		Number infected	Percent infected	Range	Average worm load	Number infected	Percent infected	Range	Average worm load
Commercial dealers:									
Oshkosh, Wis	12	0	0			4	33	3–8	5
Chicago, Ill	12	5	42	2–82	38	12	100	6–64	18
Newark, Del	12	0	0			9	67	2–74	25
Gloucester, Mass	12	0	0			11	92	3–84	21
Syracuse University animal room	10	0	0			0	0		
Total	58	5	(1)			36	(1)		
Pet shops:									
Olean, N.Y	2	0	0			2	100	18–64	41
Syracuse, N.Y., A	5	4	80	1–27	10	5	100	92–261	146
Syracuse, N.Y., B	5	0	0			1	20	9	9
Syracuse, N.Y., C	5	0	0			5	100	5–18	10
Department stores:									
Syracuse, N.Y., A	5	5	100	44–833	387	5	100	22–89	53
Syracuse, N.Y., B	5	3	60	6–34	17	3	60	5–9	7
Total	27	12	(2)			21	(2)		

[1] Total percent of hamsters from commercial dealers and Syracuse University animal room infected with *Hymenolepis nana*, 9; *Syphacia obvelata*, 62.
[2] Total percent of hamsters from pet shops and department stores infected with *Hymenolepis nana*, 44; *Syphacia obvelata*, 78.

mice shipped animals with *H. nana* (fig. 1), and these mice plus those from the Syracuse University animal room had an overall infection rate of 21 percent. Twelve of 14 vendors of pets were selling mice with *H. nana*, and these animals had an infection rate of 66 percent. Forty-four percent of the hamsters sold for pets and 9 percent of those from wholesalers and from the animal room were parasitized with *H. nana*.

S. obvelata infected 75 percent of the mice and 60 percent of the hamsters sold for research. It also parasitized 53 percent of the mice and 78 percent of the hamsters sold for pets. This was expected because the life cycle of *S. obvelata* (fig. 1) is like that of *Enterobius vermicularis* (fig. 1), the human pinworm, which makes it extremely difficult to eliminate.

Hamsters in pet shops usually were displayed in cages close to mice. Consequently, eggs from *H. nana*, *S. obvelata*, and other infectious agents might be spread easily by an attendant, arthropods, or dust particles.

Another mouse pinworm, *Aspiculuris tetraptera* (fig. 1), was much more common in mice sold for pets and more numerous in the animals it parasitized. Although *A. tetraptera* is not known to infect man, its presence is a gauge of the hygienic conditions under which the animals were raised. This is so, since to be infective, eggs of *A. tetraptera* (fig. 1) require several days development outside the host, and those incubated for 7 days at 27° C. reach maximum infectivity (*8*, *9*). Good environmental sanitation, including frequent cleaning of cages, would limit *A. tetraptera* infections. A parasitization rate of 62 percent of pet shop and department store mice reflects the overcrowded, dirty cages—frequently with open water and food containers—observed in most establishments.

A. tetraptera was not found in hamsters in this study, and apparently is not infective to this species. In other research using *A. tetraptera* eggs, we failed to infect 20 hamsters although the mice serving as controls became heavily infested.

None of the mice or hamsters in this study had *H. diminuta* (fig. 1) or *S. muris* (fig. 1). However, *H. diminuta* has been found in hamsters from a commercial source in the Los Angeles area (*10*). *S. muris*, the common pinworm of laboratory rats, has been observed in 100 percent of 14 rats from the Syracuse University animal room. Occasionally mice are infected (*11*). The eggs of *S. muris* are so similar to those of *E. vermicularis* that it is possible that *S. muris* in people have been erroneously called *E. vermicularis*.

Protozoan parasites in the intestines of hamsters and mice were very common. For example, *Trichomonas muris* was found in 73 percent, *Hexamita muris* in 83 percent, and *Giardia muris* in 58 percent of the 202 mice from commercial dealers and the Syracuse University animal room. The hamsters showed similar parasitization rates with the same organisms. Although none of these flagellates is known to infect man, they indicate the conditions under which laboratory rodents are raised because these parasites are transmitted by coprophagy.

Discussion

Although *H. nana* found in rodents and in man appear morphologically identical, some investigators think they may be physiologically distinct. However, Grassi infected one child from a group of four adults and two children fed eggs derived from a rodent (*12*). In two other investigations several children fed eggs from worms parasitizing rats were infected with *H. nana*. (*13, 14*).

Saeki infected a child, rats, mice, and a monkey by feeding them *H. nana* eggs from a human source but failed to infect himself (*15*). Uchimura infected rats with eggs from human and rodent sources and concluded worms from rodents and those from people were identical (*16*). Woodland infected 7 of 30 adult mice with *H. nana* eggs from a child's stool (*17*). Tsuchiya and Rohlfing infected 2 of 6 healthy rats with *H. nana* eggs from children, and then infected 5 of 10 rats with eggs taken from the 2 infected rats (*18*).

Knowing the unhygienic habits of rats, mice, hamsters, and some people, particularly children, it is easy to understand how rodent-to-man and man-to-rodent transmission of parasites can occur. Because mice and hamsters are pets in many homes, there is probable opportunity for cross-infections—particularly with children.

Epidemiologic studies provide indirect evidence of the importance of rodents in the transmission of *H. nana*. In 1910 Schloss found 14 of 230 New York City children parasitized by *H. nana*. The homes of the infected children were infested with rats and mice, and a rat from the home of one was found infected. In India, Chandler observed an inverse correlation between the incidence of *H. nana* infections and those of *Trichuris* and *Ascaris* which depend on human fecal contamination for transmission (*20*). The areas with the highest infection rates of *H. nana* were also the regions where *H. diminuta* and the plague—both definitely rodent-borne—were most prevalent. Neghme and Silva believed the high incidence of *H. nana* in Chile was caused by poor sanitation, overcrowding, and heavy infestations of rats (*21*).

Although the eggs of *H. nana* are directly infective to both man and rodents, the parasite can be transmitted through a number of intermediate hosts. These hosts include a variety of fleas, and flour beetles (Tenebrionidae). When the infection of the definitive host originates from eggs, the hexacanth larvae invade the villi of the upper small intestine and form cysticercoids. In 4 to 5 days young worms leave the villi and pass farther down the small intestine where they attach by their scolices. The cysticercoids' development in the villi is highly immunogenic, and later challenging doses of eggs are almost completely rejected. However, cysticercoids from flour beetles are not immunogenic in mice without autoreinfection because the initial larval development in the villi is bypassed. One cysticercoid fed to a nonimmune mouse can engender 1,500 to 2,000 adult worms. Heavy *H. nana* infections in man are thought to be caused by the ingestion of infected flour beetles followed by autoreinfection (*22, 23*).

The tenebrionids become infected by feeding on foods such as dried fruits, flour, or cereals that have been contaminated with rodent feces. A member of one of the smaller species of flour beetles (fig. 2) could pass unnoticed in a bowl of cereal, and these insects are frequent invaders of pantries. Read easily infected himself with cysticercoids from mice (*24*).

A pet mouse or hamster enjoying the freedom of a home—at its master's choice or not—could defecate in a place inhabited by an intermediate host of *H. nana*. We have seen pet hamsters and mice kept on kitchen tables, and on one oc-

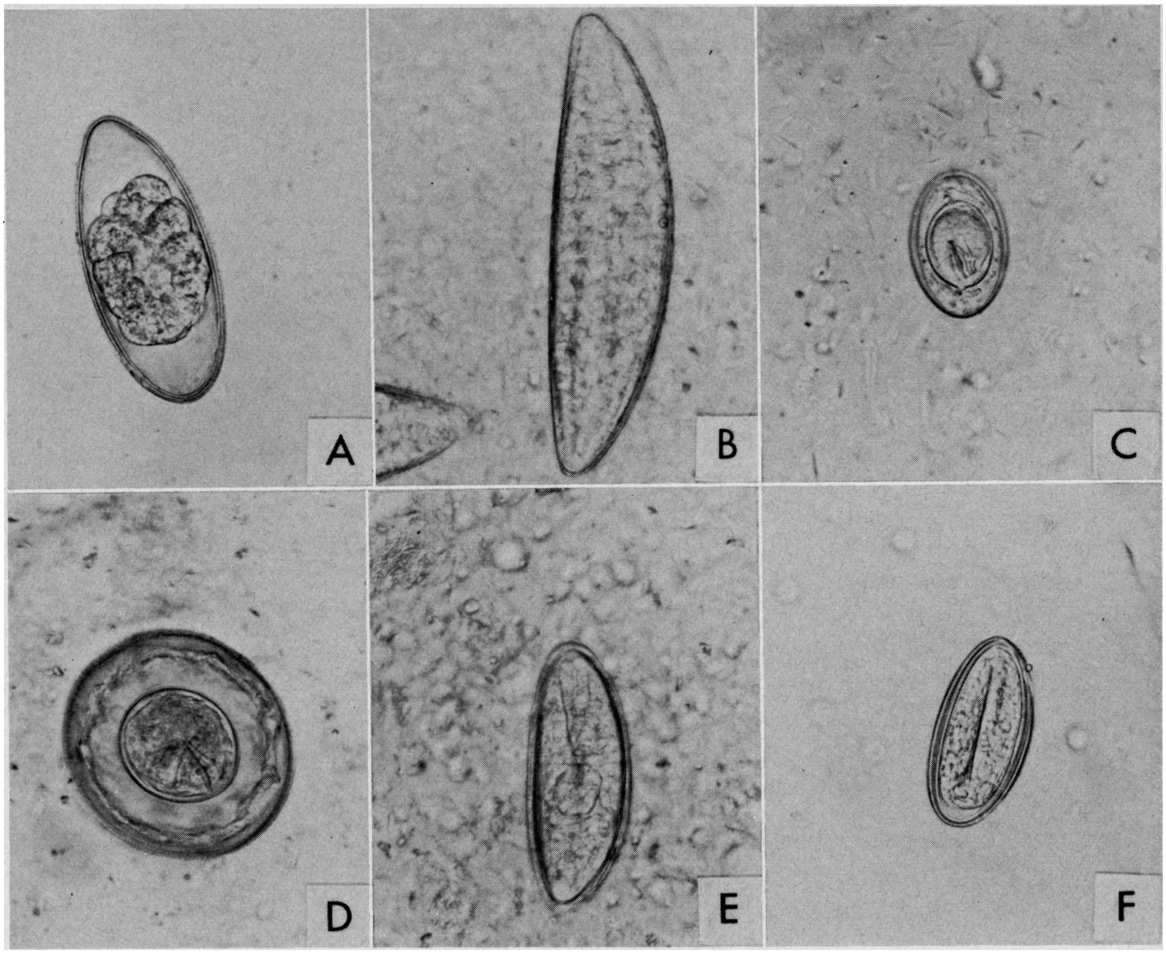

Figure 1. Eggs of helminths, 415x

A. *Aspiculuris tetraptera* B. *Syphacia obvelata* C. *Hymenolepis nana* D. *Hymenolepis diminuta* E. *Syphacia muris* F. *Enterobius vermicularis*

casion we observed more than 50 mice caged in a kitchen. Under such circumstances contamination of food with eggs and the availability of rodent feces for intermediate hosts seems almost inevitable.

Mice approximately 2½ months old are most susceptible to experimental infections with *H. nana;* those over 5 months of age have greater resistance (*25*, *26*). Children are more frequently parasitized by *H. nana*, perhaps because of poorer hygiene, immunological incompetence, or a more suitable intestinal environment than adults (*27*). The seemingly greater susceptibility of children as hosts for *H. nana* is especially important because they own most pet rodents, and mice and hamsters are frequently kept in classrooms. By handling these pets many school children might easily be exposed to *H. nana*.

The general public probably is unaware of any threat of helminth infections from pet rodents. Inexpensive booklets on pet mouse and hamster care, recently bought in places where these animals are sold, did not mention this possibility (*2*, *28*, *29*). One booklet (*30*) even states "No one need worry about catching disease from hamsters, as they have none of their own!" It is little wonder that some people may be careless about handling pet rodents and where they keep these animals. A physician hardly would suspect a rodent-derived helminth infection in a patient living under seemingly healthful conditions—even if he knew the home had pet hamsters or mice.

The high rate of parasitization of laboratory rodents is important to researchers because the helminths may act as variables, usually unsuspected, in experiments. This study shows the improbability of getting worm-free mice or hamsters for research, and the variation in numbers and species of helminths that may be present in animals from a single supplier.

Summary and Conclusions

Mice and hamsters available for pet and laboratory animals were found heavily infected with intestinal helminths and protozoa. The most important is *Hymenolepis nana*, which sometimes infects man. *H. nana* parasitized 21 percent of 202 mice obtained from commercial laboratory dealers and the Syracuse University zoology department animal room and 66 percent of 58 mice sold as pets. Also infected with *H. nana* were 9 percent of 58 hamsters obtained from vendors to laboratories and 44 percent of 27 hamsters sold for pets. This parasite should not be ignored because its customary hosts are ubiquitous and many people are exposed to it.

The heavy parasitization of mice and hamsters from retail stores was consistent with the unsanitary conditions under which many of them were kept. It is obvious that sanitary precautions in such places which would result in the reduction of some of these parasites should be put into practice. Vigilance should be exercised in the relationship of pet rodents and children, and further information sought as to the importance to human health of *H. nana* infections in pet rodents.

Investigators may use parasitization rates as a measure of the sanitary conditions under which their animals were raised. In addition, the heavy parasitization of laboratory mice and hamsters is important to researchers because the parasites may act as variables, usually unsuspected, in experiments.

Figure 2. *Tribolium confusum* (confused flour beetle); the arrow designates the larval stage

REFERENCES

(*1*) U.S. Senate Government Operations Committee: Veterinary medical science and human health. U.S. Government Printing Office, Washington, D.C., 1961, p. 166.

(*2*) Richards, H.: The playful hamster. T F H Publications, Jersey City, N.J., 1962.

(*3*) Stoll, N. R.: This wormy world. J Parasit 33: 1–18 (1947).

(*4*) Bacigalupo, J.: Algunas consideraciones sobre taeniasis per *Hymenolepis nana*. Arch Argent Enferm Apar Dig 8: 359–364 (1932).

(*5*) Donckaster, R., and Habibe, O.: Contribucion al estudio de la infeccion por *Hymenolepis nana*. Bol Chile Parasit 13: 9–11 (1958).

(*6*) Gordadze, G. N., and Gegetashville, M. S.: Epileptoid fits provoked by *Hymenolepis nana*. Med Parazit (Moscow) 28: 430–434 (1959).

(*7*) Riley, W. A.: A mouse oxyurid *Syphacia obvelata*, as a parasite of man. J Parasit 6: 89–93 (1919).

(*8*) Philpot, F.: Notes on the eggs and early development of some species of Oxyuridea. J Helminth 2: 239–252 (1924).

(*9*) Wells, H. S.: Studies of the effect of antibiotics on infections with the mouse pinworm, *Aspiculuris tetraptera*. J Infect Dis 89: 190–192 (1951).

(*10*) Read, C. P.: *Hymenolepis diminuta* in the Syrian hamster. J Parasit 37: 324 (1951).

(*11*) Hussey, K. L.: *Syphacia muris* vs. *S. obvelata* in laboratory rats and mice. J Parasit 43: 555–559 (1957).

(*12*) Grassi, B.: Entwicklungscyclus der *Taenia nana*. Zbl Bakt Parasitenkunde 2: 305–312 (1887).

(*13*) Kiribayashi, S.: Studies on the growth of *Hymenolepis nana*, with special reference to the possibility of differentiation of *H. nana* var *fraterna*. Taiwan Igakkai Zasshi 32: 1175–1190 (1933).

(14) Ogura, K.: Studies on the *Hymenolepis nana* in Korea. J Chosen Med Assoc 26: 649–668 (1936) Abstract: Helminth Abstracts 5: 85 (1936).

(15) Saeki, Y.: Experimental studies on the development of *Hymenolepis nana.* Jikwa Zasshi 238: 203–244 (1920).

(16) Uchimura, R.: On the development of *Hymenolepis nana* and *Hymenolepis murina.* Jikwa Zasshi 240: 268 (1922).

(17) Woodland, W. N. F.: *Hymenolepis nana* and *Hymenolepis fraterna.* Lancet 1: 922–923 (1924).

(18) Tsuchiya, H., and Rohlfing, E. H.: *Hymenolepis nana.* Amer J Dis Child 43: 865–872 (1932).

(19) Schloss, O. M.: The dwarf tapeworm (*Hymenolepis nana*) as an intestinal parasite of children, with a report of fourteen cases. Arch Pediat 27: 100–118 (1910).

(20) Chandler, A. C.: The distribution of *Hymenolepis* infections in India with a discussion of its epidemiological significance. Indian J Med Res 14: 973–994 (1927).

(21) Neghme, A., and Silva, R.: Algunas observaciones epidemiologicas sobre *Hymenolepis nana* in Chile. Bol Lab Clin "Luis Razetti" 16: 615–620 (1955).

(22) Heyneman, D.: Studies on helminth immunity, III. Experimental verification of autoinfection from cysticercoids of *Hymenolepis nana* in the white mouse. J Infect Dis 109: 10–18 (1961).

(23) Heyneman, D.: Host-parasite resistance patterns—some implications from experimental studies with helminths. Ann NY Acad Sci 113: 114–129 (1963).

(24) Chandler, A. C., and Read, C. P.: Introduction to parasitology. Ed. 10. John Wiley & Sons, Inc., New York, 1962.

(25) Hunninen, A. V.: Studies on the life history and host-parasite relations of *Hymenolepis fraterna* (*H. nana* var *fraterna* Stiles) in white mice. Amer J Hyg 36: 187–194 (1935).

(26) Larsh, J. E.: The relation between splenectomy and the resistance of old mice to infection with *Hymenolepis nana* var *fraterna.* Amer J Hyg 39: 187–194 (1944).

(27) Faust, E. C., and Russell, P. F.: Craig and Faust's clinical parasitology. Ed. 7. Lea & Febiger, Philadelphia, 1964.

(28) Roberts, M. F.: Mice as pets. T F H Publications, Jersey City, N.J., 1956.

(29) Schultz, A. V., editor: Hamsters. T F H Publications, Jersey City, N.J., 1955.

(30) Hamsters as pets: a guide to selection, care and breeding of hamsters. T F H Publications, Jersey City, N.J., 1955.

PUBLICATION ANNOUNCEMENTS

Address inquiries to publisher or sponsoring agency.

Occupational Health of Agricultural Workers in California. 1965; 34 pages. Bureau of Health Education, California State Department of Public Health, 2151 Berkeley Way, Berkeley 94704.

Venereal Disease Education. A teaching guide. 1966; 40 pages. Minnesota Department of Health, Public Health Education Section, University Campus, Minneapolis 55440.

Health and Progress in the Americas. By Dr. Abraham Horwitz. PAHO Miscellaneous Publication No. 80. March 1966; 45 pages. Pan American Sanitary Bureau, 525 Twenty-third St., NW., Washington, D.C. 20037.

Man and his Environment. Biomedical knowledge and social action. PAHO Scientific Publication No. 131. March 1966; 18 pages. By René Dubos. Pan American Sanitary Bureau, 525 Twenty-third St., NW., Washington, D.C. 20037.

World Health Organization

WHO publications may be obtained from Columbia University Press, International Documents Service, 2960 Broadway, New York, N.Y. 10027.

Water Pollution Control. Report of a WHO Expert Committee. WHO Technical Report Series No. 318. 1966; 32 pages; 60 cents; Geneva.

Executive Board, Thirty-Seventh Session. Resolutions annexes. Pt. I. Official Records of the World Health Organization No. 148. 1966; 126 pages; $1.25; Geneva.

Proposed Regular Programme and Budget Estimates for the Financial Year 1 January–31 December 1967, with Proposed Programmes and Estimated Obligations under Other Available Sources of Funds. Official Records of the World Health Organization No. 146. 1965; 568 pages; $4; Geneva.

The Work of WHO 1965. Annual Report of the Director-General to the World Health Assembly and to the United Nations. Official Records of the World Health Organization No. 147. 1966; 244 pages; $2; Geneva.

Executive Board, Thirty-Seventh Session. Report on the proposed programme and budget estimates for 1967. Pt. II. Official Records of the World Health Organization No. 149. 1966; 140 pages; $1.25; Geneva.