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ON THE USE OF THE SQUIRREL MONKEY IN BEHAVIORAL AND PHARMACOLOGICAL EXPERIMENTS

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We have found the squirrel monkey to be a useful experimental subject for behavioral and pharmacological experiments. This note presents techniques used for housing, feeding, handling, and administering drugs to these small primates.

The squirrel monkey (*Saimiri sciurea*) is a small, South American primate. MacLean (1959) and Carmichael and MacLean (1961) have reported on the use of squirrel monkeys in neurophysiological experiments.[2] Over the past three years we have used male squirrel monkeys in chronic studies of behavior and behavioral pharmacology. The present paper reports some observations which may be useful to other investigators who use or want to use squirrel monkeys.

Although the squirrel monkey is a primate, its small size makes it a convenient experimental subject. Biometric norms have not been established for the squirrel monkey as yet. Carmichael and MacLean (1961) report that the mean weight of 76 squirrel monkeys was 717 gm., with a standard deviation of 170.4 gm. Of the 41 squirrel monkeys used in our experiments for at least four months, the mean free-feeding weight was 746 gm., with a standard deviation of 122.7 gm. and a range of 525 to 1100 gm.

Squirrel monkeys that are handled regularly become tame and tractable. Even an untamed squirrel monkey can be safely handled with heavy gloves. A small, rounded dog collar[3] and leash on each squirrel monkey permits convenient moving with a handling pole. The pole, constructed of $\frac{5}{8}$ in. diameter aluminum stock, has a 30 in. shaft. At one end of the shaft is a ring, constructed of $\frac{1}{4}$ in. diameter aluminum stock, with a 1 in. inside diameter (see Fig. 2). The handler can draw the monkey's leash through the loop and hold it against the pole. The monkey will grasp the pole while being carried, and can easily be moved with one hand.

Our squirrel monkeys were individually housed in 12 × 24 × 18 in. cages with solid walls and 1 in. mesh doors. Although there were no indications that these small cages adversely affected the health of the monkeys, the animals appeared slightly cramped, and were recently moved to 18 × 18 × 24 in. cages of 1 in. mesh. Squirrel monkeys can be housed in groups without difficulty. The temperature in our animal room is maintained at 78° F., with a relative humidity of 40 to 50%.

Squirrel monkeys can be maintained on standard monkey biscuits (*cf.* Carmichael and MacLean, 1961) but seem healthier and more vigorous when maintained on a high-protein diet supplemented with vitamins. Ulmer (1954, 1960) has noted that squirrel monkeys are highly insectivorous in their natural environment, and he recommends a high-protein diet for all captive monkeys. Dietary requirements are especially important when the squirrel monkey is chronically maintained on food-deprivation. We use a synthetic diet previously described by Herndon, Greenberg, Van Loon, Kelleher, Cook and Davidson (1958); a modification of this diet is commercially available (Ellison and Riddle, 1961). The diet can be prepared as a dough for routine feeding or as a liquid for convenient use as a reinforcer.

Durability of the squirrel monkey as a subject for chronic experiments can be only roughly estimated. Many monkeys appeared small and sickly on arrival at our laboratory and an attempt is now made to avoid this problem by ordering monkeys that weigh more

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[2]MacLean (1959) is preparing an atlas of the squirrel monkey brain.

[3]Flat collars tend to rub the animals' shoulders causing skin lesions.

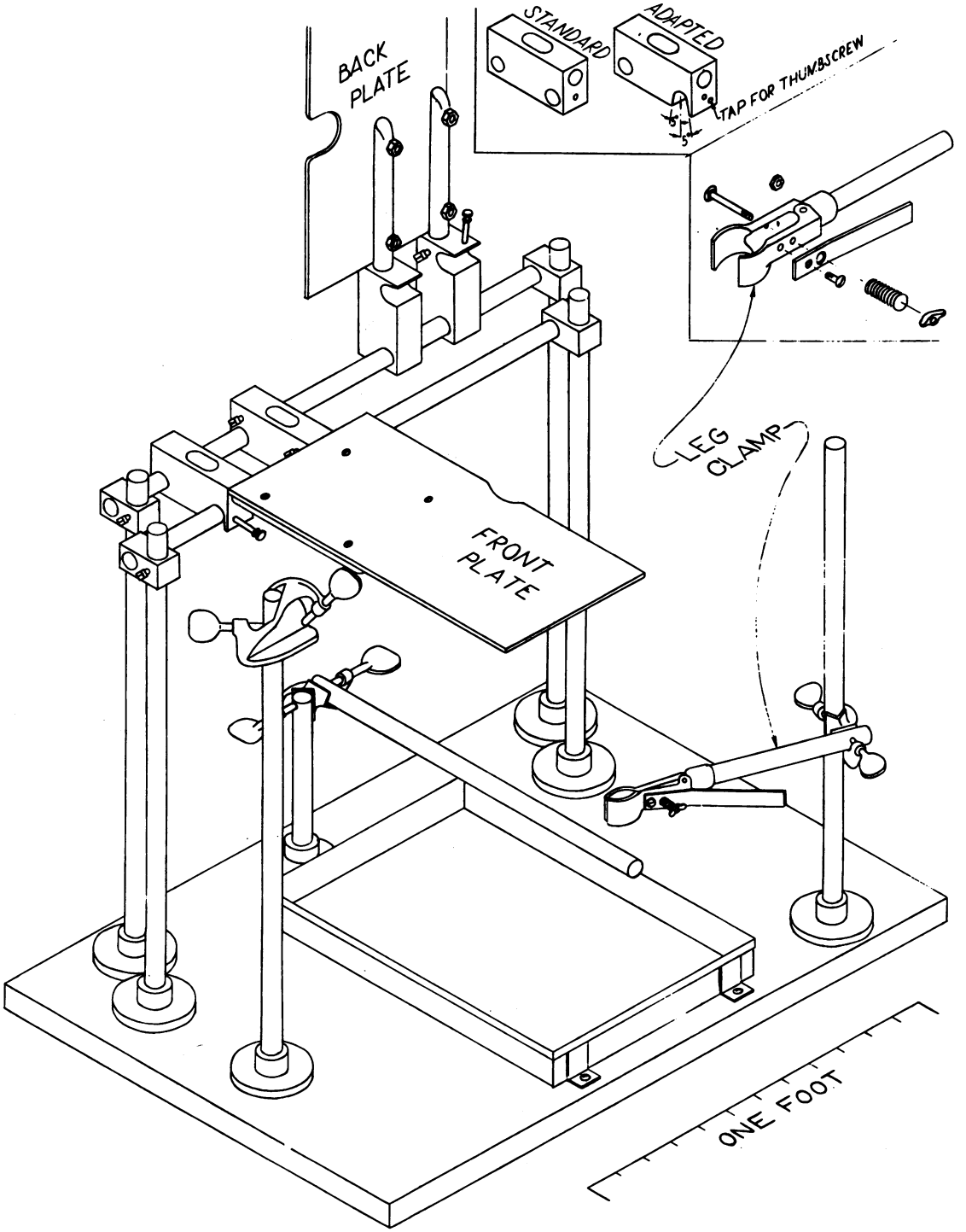

Fig. 1. Diagram of apparatus used to restrain squirrel monkey for administration of drugs.

than 700 gm. Intestinal parasites (especially strongyloides) and blood parasites are common in the squirrel monkey. Some heavily parasitized monkeys appear to be healthy (*cf.* Graham, 1960 and Ruch, 1959), and such animals have been successfully used in experiments lasting longer than 20 months. It is likely, however, that chronic food deprivation and experimental stresses, such as frequent electric shocks or high drug dosages, render the monkey more susceptible to illness (*cf.* Sauer and Fegley, 1960). On several occasions, food-deprived animals stopped drinking water, refused food, became prostrate and died. Because the first step in this process of debilitation was dehydration, fluid therapy (Pickering and Kao, 1961) is now instituted whenever these symptoms appear; *i.e.,* 10 cc of water, milk, or glucose solution are administered through a stomach tube. On occasion, prostrate monkeys have been treated with fluid and staged a rapid recovery to a state in which the animal would drink and eat. In our early experiences with squirrel monkeys, many animals were probably lost through this "dehydration shock".

Some behavioral studies of the squirrel monkey have been reported (Kelleher and Cook, 1959; Fry, Kelleher, and Cook, 1960). Because of the monkey's size, a small experimental chamber (*e.g.,* 12 × 12 × 12 in.) is adequate. The squirrel monkey can be readily magazine-trained and shaped to perform various responses. The squirrel monkey, which has a nonprehensile tail, will press panels, pigeon-keys, telephone switches, and rat-levers with its forepaws. In experimental chambers with two levers, the squirrel monkey will respond with both forepaws. Some preliminary evidence indicates that the rates on each lever can be brought under schedule control.

In general, the squirrel monkey seems comparable to the Rhesus monkey in its performance on simple or multiple schedules of positive and negative reinforcement. On a Sidman-avoidance schedule, with shock-shock and response-shock intervals of 20 or 30 sec, the squirrel monkey will characteristically avoid all but one or two shocks in a 3-hr session. Azrin, Holz and Hake (1962) found that the squirrel monkey will respond on a ratio schedule to escape from a conditioned aversive stimulus. Appel (1961) has reported that the squirrel monkey is sensitive to punishment by electric shock. Stimulus control develops rapidly on multiple schedules (for example, multiple FI10 FR20), but we have not studied more complex discriminations.

The effects of some drugs on the behavior of the squirrel monkey have been reported (Cook and Kelleher, 1961, 1962). Because the monkey is small, one can use small quantities of drug; however, intravenous administration is difficult. We have developed a simple apparatus that enables one man to administer drugs to a monkey. This apparatus, constructed mainly of Fisher laboratory hardware, is shown in Fig. 1. The Fisher multi-clutch connectors and the test-tube holder (leg clamp) must be modified as shown. The front and back plates are made from $\frac{1}{8}$ in. aluminum; Fig. 1 shows the back plate in the up position. Figure 2 shows a monkey prepared for oral dosing in the apparatus. The monkey is placed in position against the back plate by means of the handling pole, and the front plate is slid into place and fastened with the thumbscrew. Next a head clamp, constructed of $\frac{1}{16}$ in. aluminum, is placed around the animal's head, and a plastic rod ($\frac{3}{8}$ in. diameter) is inserted through the clamp and between the monkey's upper and lower teeth. The handler now has both hands free to insert a catheter through the hole in the plastic tube and into the animal's stomach. For parenteral injections, the leg clamp is used to prevent gross body movements.

REFERENCES

Appel, J. B. Punishment in the squirrel monkey Saimiri sciurea. *Science*, 1961, **133**, 36.

Azrin, N. H., Holz, W. C. and Hake, D. Intermittent reinforcement by removal of a conditioned aversive stimulus. *Science*, 1962, **136**, 781-782.

Carmichael, M. and MacLean, P. D. Use of squirrel monkey for brain research with description of restraining chair. *EEG*, 1961, **13**, 128-129.

Cook, L. and Kelleher, R. T. The interaction of drugs and behavior. In *Neuro-Psychopharmacology Vol. 2* (E. Rothlin, ed.). Amsterdam: Elsevier, 1961 (pp. 77-92).

Cook, L. and Kelleher, R. T. Drug effects on the behavior of animals. *Ann. N. Y. Acad. Sci.*, 1962, **96**, 315-335.

Ellison, T. and Riddle, W. C. Commercial liquid diet for animals in behavioral studies. *J. exp. Anal. Behav.*, 1961, **4**, 370.

Fry, W., Kelleher, R. T., and Cook, L. A mathematical index of performance on fixed-interval schedules of reinforcement. *J. exp. Anal. Behav.*, 1960, **3**, 193-199.

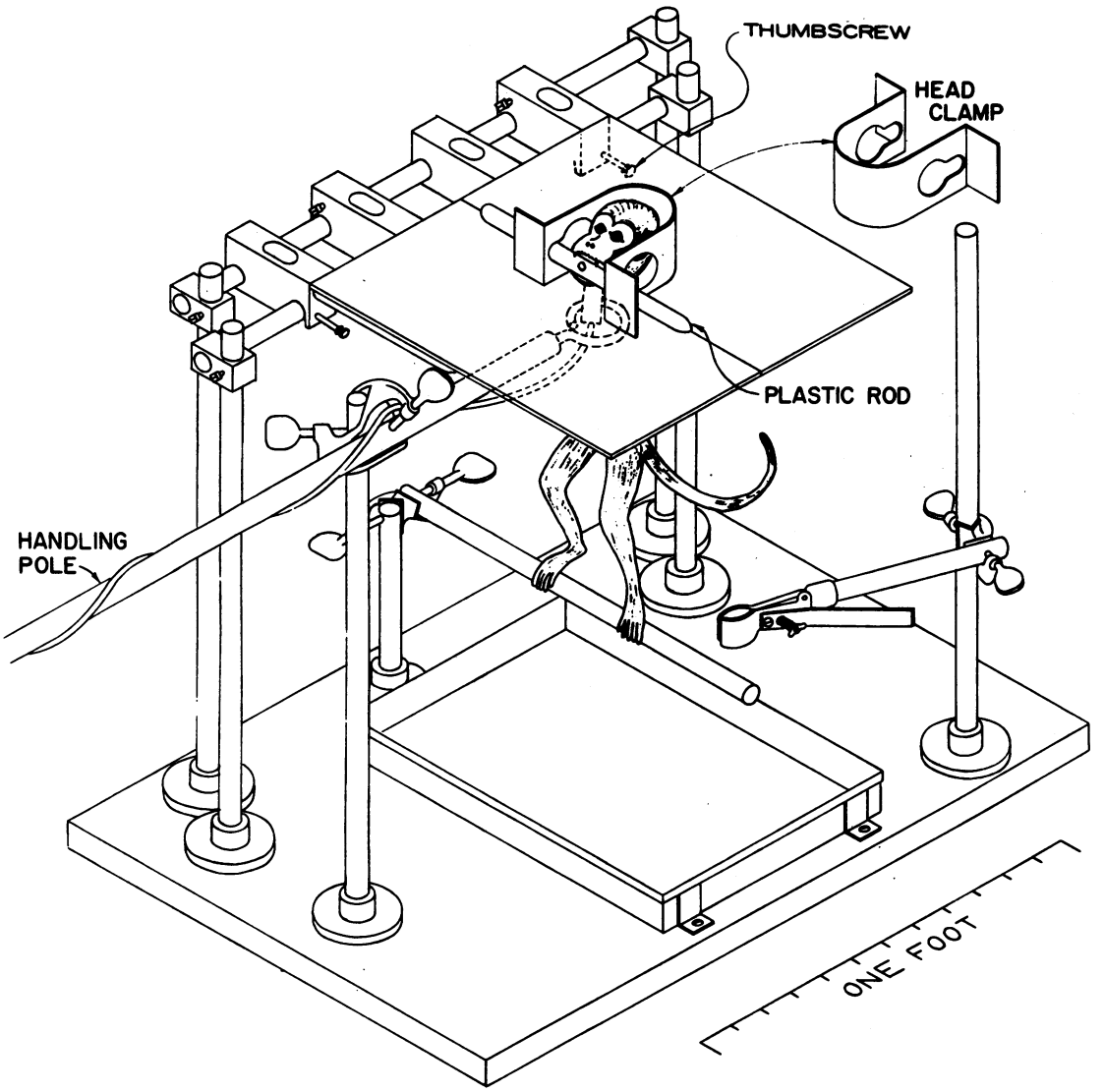

Fig. 2. A monkey in position in the apparatus.

Graham, G. L. Parasitism in monkeys. *Ann. N. Y. Acad. Sci.*, 1960, **85**, 842-860.

Herndon, J. F., Greenberg, S. M., Van Loon, E. J., Kelleher, R. T., Cook, L., and Davidson, A. A liquid diet for animals in behavioral studies. *J. exp. Anal. Behav.*, 1958, **1**, 291-292.

Kelleher, R. T. and Cook, L. An analysis of the behavior of rats and monkeys on concurrent fixed-ratio avoidance schedules. *J. exp. Anal. Behav.*, 1959, **2**, 203-211.

MacLean, P. D. The limbic system with respect to two basic life principles. In *The central nervous system and behavior*. Trans. Second Conf. (M. A. B. Brazier, ed.). New York: Josiah Macy, Jr. Foundation, 1959 (pp. 31-118).

Pickering, D. E. and Kao, T. T. Fluid and electrolyte therapy for monkeys. *J. Am. Vet. Med. Assoc.*, 1961, **138**, 527-531.

Ruch, T. C. *Diseases of laboratory primates*, Philadelphia: Saunders, 1959. Sauer, R. M. and Fegley, H. C. The role of infectious and non-infectious diseases in monkey health. *Ann. N. Y. Acad. Sci.*, 1960, **85**, 855-888.

Ulmer, F. A. Jr. So you'd like a pet monkey? *America's First Zoo*, 1954, **6**, 14-17.

Ulmer, F. A. Jr. The monkey: A comparison of the natural environment with observations in captivity. *Ann. N. Y. Acad. Sci.*, 1960, **85**, 737-746.

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