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Normal and Pathogenic Bacteria Isolated From Conditioned, Non-Conditioned and Wild Baboons (Papio Cynocephalus)

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NORMAL AND PATHOGENIC BACTERIA ISOLATED FROM CONDITIONED, NON-CONDITIONED AND WILD BABOONS (PAPIO CYNOCEPHALUS)

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The use of nonhuman primates as a research tool in biomedical research is well established; however, data available as to what constitutes the "normal microbial flora" of these animals is inadequate or non-existent (32). Studies have been made of clinical bacterial infections pertaining to a specific species of nonhuman primate or of a group of nonhuman primates (4, 8, 9, 21, 22, 26, 27, 28, 40, 51, 56, 64). Studies also have been done concerning the aerobic flora (7), the alimentary tract (24) and the fecal material of the chimpanzee (53). Some species of the nonhuman primate, other than the chimpanzee, which have been studied to an extent, bacteriologically, include the marmoset (17, 42), the baboon (10, 11, 63), vervet monkeys (66), and rhesus monkeys (1, 64).

Reasons why extensive bacteriological studies have not been performed on nonhuman primates are many and varied. The expense of maintaining the animals over a period of time is considerable and usually the proper facilities are unavailable. Also, the paucity of nonhuman primates due to their inaccessibility, scarcity of species, or poor

survival rate and reproduction in captivity are other factors to be considered.

In San Antonio, Texas, in 1963, an international symposium was held to determine the potential and practical use of the baboon as a model in biomedical research. The symposium was to bring together all the known information available on the baboon. The advantages of the baboon in uses where nonhuman primates are desired are: (a) baboons are available in large numbers and are considered a pest (48, 63) by many, and therefore no religious, ethical, moral or national political restrictions in regard to their capture and use exist; (b) the baboon is relatively inexpensive, accepts captivity readily, and reproduces in captivity with little difficulty as compared to other species of nonhuman primates (58); and (c) it is rather advanced in the primate order (47).

Studies of biomedical materials gathered in East Africa from the baboon (34) and the collection of biomedical specimens from baboons in Kenya (33) have been reported. Investigators have also reported on the species of parasites found in baboons (37, 45, 46), the clinical parameters of the normal baboon (18, 63), the mycology of the baboon's skin (2), the viral flora found in baboons in captivity (35) and in their native habitat (54). As a partial consequence of these studies and other studies using the baboon as the nonhuman primate of choice, the baboon has become a valuable

tool of biomedical research laboratories. The baboon has been used in such diversified studies as: endotoxin shock (15), drug effects (56), renal functions (43), transplantation (44), polymer tooth implants (30) and atherosclerosis studies (16). However, despite the vast amount of work done in many areas of scientific research using the baboon as the model of choice, there has been no complete bacteriological study to establish the "normal" microbial flora of the baboon. Weber et al. (63) did study 943 baboons in captivity and reported on the pathogenic bacteria of the enteric tract as well as bacterial species found in the oral cavity of the baboon. However, the "normal" bacterial flora of the enteric tract was not established and the oral findings are at variance with preliminary findings at Southwest Foundation for Research and Education (SFRE). Pinkerton et al. (52) did report on the microbiological parameters of the baboon but the number of animals sampled and the duration of sampling time possibly make this data insufficient to use as a guideline.

This study is the summation of the aerobic findings of a five-year longitudinal study designed to catalogue and define the "normal" flora of a conditioned baboon. Also, for comparison and evaluation, the findings of baboons captured and sampled in the "wild" in 1968 or shipped to the SFRE facilities during 1965 or from August of 1968 to December of 1971 are included. The aerobic bacteria had

been selected for study because these organisms are the most frequent isolates of the laboratory and are one of the prime sources of infection or other pathological conditions in nonhuman primates (22, 25, 56).

CHAPTER II

MATERIALS AND METHODS

Animals:

A total of 1496 baboons (Papio cynocephalus) of both sexes and of all ages were studied beginning in January 1964 and terminating in December 1971. The animals are divided into three categories.

1. Conditioned or Baseline Animals. These animals comprise the baseline group of 210 adults or juveniles and 126 infants born to these baboons while in captivity. This colony was maintained in groups of approximately 25 animals the year around in large outdoor community cages containing concrete shelters and rock grottos for protection against adverse weather conditions and to permit the baboons to have a greater degree of mobility. The babies were maintained within the baseline group for six months at which time they were removed from the program. With the exception of a yellow fever vaccination, prior to shipment to SFRE, the animals did not receive medical treatment of any nature, antibiotics or other chemotherapy nor preventive medicine of any type during the study. The animals' diet consisted entirely of a commercially prepared monkey chow (Purina, St.

Louis, Missouri) which has been found sufficient for the nutritional requirements of the baboon (36).

2. Non-Condntioned Animals. These were baboons collected in various regions of Kenya, Africa, and shipped to SFRE by air freight. In addition to the yellow fever vaccination, these animals received treatment for parasite infections prior to being air freighted to the SFRE quarantine facilities. Their diet while en route to SFRE or while in Kenya, Africa, consisted of indigenous fruits, vegetables, etc. All of the animals, 936, were either adults or juveniles of both sexes.

3. "Wild" Animals. Approximately 224 baboons captured during the 1968 field trip near Lake Baringo which is located 270 miles northwest of Nairobi in Kenya, Africa, make up this group. The baboons were trapped and processed as described by Kalter et al. (33).

Sampling:

1. Conditioned Animals. The animals were sampled upon arrival, 30, 60 and 90 days post-arrival and every 90 days thereafter. This schedule remained in effect until the last group of animals to arrive had been sampled for one year. Afterwards, 10 animals from each of the eight groups, approximately 25% of the colony, were sampled every 90 days for the remainder of the program. The infants were sampled immediately, or as soon as possible, after birth, 30 and 60 days post-parturition and prior to being removed from the

program. Due to the necessity to anesthetize the animals before sampling, pregnant animals in this group were not sampled.

2. Non-Conditioned Animals. These baboons, which had been in captivity for a period of 21 days or less were sampled within 72 hours after arrival from Africa. The animals had been collected from all areas of Kenya where they normally reside.

3. "Wild" Animals. This group was sampled as soon as possible after capture. Following sampling the animals were sacrificed by exsanguination at the request of the local authorities.

Primary Culturing Technique:

1. Conditioned and Non-Conditioned Animals. The oral, nose, eye, ear and rectal samples were collected by using SWUBE tubes (Falcon Plastics, Oxnard, Calif.) containing 1 ml of thioglycollate. Initially the rectal swab was streaked onto eosin methylene blue (EMB), MacConkey's, bismuth sulfite (BS), SS and azide blood agar plates. The rectal swab was then inoculated into tetrathionate broth and incubated 18-24 hours at 35° C and from the tetrathionate broth a second BS and SS plate were inoculated. One year later the procedure was modified by elimination of the BS plates and using PEA (phenylethanol agar) plates in conjunction with the azide blood agar plate.

The collected samples (other than the rectal swabs) were streaked onto blood agar plates (BA) within 30 minutes of sampling and incubated at 35° C for a period of 18 to 48 hours. Originally the swabs were also streaked to EMB and PEA plates. However, because of cost, time element and the questionable benefits received from the additional media, it was decided to use BA plates solely. After three years of study the collecting of samples from the eyes, ears and nose of the conditioned baboons was also discontinued.

2. "Wild" Animals. Throat and rectal specimens were taken with sterile cotton swabs, which were inoculated into small screw-cap vials containing 2 ml of Brewer's thioglycollate medium. The oral swabs were then streaked to BA. The thioglycollate cultures were held at ambient temperature until shipped to San Antonio, Texas, for further study. The rectal swabs were streaked to MacConkey agar and SS agar plates and then the swab was transferred to a transport medium, Cary-Blair (14) or C_3D_4 (3). The thioglycollate cultures were treated as those for the oral sample.

The sample cultures were incubated at ambient temperature in a large wooden insulated box. The diurnal temperature range was from 80-105° F. Isolates were taken from the BA plates to brain heart infusion agar (BHI) slants for shipment to SFRE. Rectal isolates were transferred to TSI (Triple Sugar Iron agar) slants for shipment.

All cultures were held at ambient temperature until forwarded to Nairobi by air freight once weekly, and subsequently to SFRE by air freight. Most samples arrived within 3 weeks of the sampling date.

In the SFRE laboratory the samples were processed identically as the procedures described for conditioned and non-conditioned animals.

All isolates from the animals were identified initially by the gram stain; biochemical and serological tests were then completed according to the procedures of Breed et al. (12), Edwards and Ewing (20) and Wilson and Miles (65). Typing sera for E.E.C., Salmonella and Shigella sp. were obtained from Difco (Detroit, Michigan).

CHAPTER III

RESULTS

Rectal Isolates:

While the newly arrived baboons often appeared dehydrated and under-nourished there were no differences between the percentage or type of organisms isolated and those isolated from the healthy-appearing animals. Table 1 is a compilation of the gram negative findings of all of the animals sampled and also the isolates from the transport media. Prior to March 1971, Klebsiella sp. had not been isolated from these two groups of animals, the conditioned or non-conditioned baboons. At that time, three animals newly arrived from Africa were positive for this organism. Seasonal variations, duration of captivity, sex and age of animals are factors which did not alter the gram-negative findings.

The findings of direct sampling in the field and organisms recovered from the transport media are listed separately for comparison.

The isolation of gram-positive organisms was not attempted during the field study due to lack of time, personnel and equipment.

Only S. sonnei or S. flexneri were ever recovered from any of the baboons. As in the two other field studies (33, 34), Shigella sp. was not isolated from "wild" baboons.

Table 2 is a summary of the most common gram-positive aerobes isolated from the conditioned and non-conditioned animals. Since there were significant differences in the percentage of organisms isolated from the babies, these are listed separately.

Oral Isolates:

Unfortunately, the oral samples in Brewer's thioglycollate media were not of any value when received from the 1968 East African field study. Due to transportation difficulties it was nearly three months before these samples were received at SFRE. Table 3 is a summation of oral findings of the three groups of animals. For an additional comparison, the babies born at SFRE to the conditioned animals are listed separately.

Neisseria sp. or beta-hemolytic Streptococcus were not isolated from the conditioned animals until eight months and six months respectively after arrival at SFRE. Whether this was due to the limited number of animals (less than 100) or because of the area in which the animals were captured is not known. The low percentage of Micrococcus sp. recovered in the field study as compared to the other groups of animals is also without explanation.

Eye, Ear and Nose Isolates:

The original investigative proposal was to study these areas in all three groups of animals. However, after a three year study of conditioned animals and their babies, it was determined that the results obtained did not warrant further continuation of this phase of the study. Table 4 is a summary of the eyes, ears and nasal samplings of the conditioned animals and their babies. As Table 4 indicates, there are differences between percentage of isolates from babies under 6 months of age as compared to adults and juveniles. However, as with the isolates from other sampling sites of the baboon, seasonal variations etc., did not alter the bacterial flora noticeably.

CHAPTER IV

DISCUSSION

The information obtained from this study should be of value to investigators either presently using baboons or contemplating the use of nonhuman primates in their research programs.

The baboon (P. cynocephalus) has a normal aerobic oral bacterial flora which compares favorably with that of human primates as described by Rosebury (55) or Jawetz (31). However, our findings do not compare with those found by Weber and his associates (63) in their studies on the baboon (Papio ursinus). Socransky and Manganiella (61) in their studies on the oral microbiota of man found that bacteria established soon after birth tend to remain within the oral cavity throughout the entire lifetime of the individual. Thus, it is most probable that the higher incidence of the Enterics and Staphylococcus aureus haemolyticus isolated in Weber's study (63) is due to local ecological factors such as diet, climate and proximity of other animal species including, possibly, man. These differences between the SFRE oral findings and that of Brede and Murphy (11) or Weber et al. (63) seem to indicate that the baboons tend to

acquire the micro-organisms indigenous to their habitat and to retain these organisms thoughout their lifetime. An example of this is the Neisseria sp. which was not isolated in the oral cavity of the conditioned animals prior to 1968 and now is isolated from these same animals at an incidence of nearly 100%. Beta-hemolytic Streptococcus is another example of an organism which appears to be increasing in both the conditioned and non-conditioned animal isolates. The incidence or genus of organisms isolated during the field study in 1968, or the previous studies by Kalter et al. (33, 34) in the field, generally varied little from that of the conditioned and non-conditioned findings. Perhaps if field conditions, i.e. equipment, time element, transportation, and available media including transport media, were more sophisticated, a more accurate enumeration of incidence and species of organisms might have been possible. However, as the findings indicate, the "wild" and conditioned animals from a general capture area have basically the same oral bacterial flora whether in captivity for a long duration or living in their native habitat.

The cages where the conditioned animals are maintained are washed daily with a chemically treated water. The animal facilities are isolated from other research areas so that the baboons' contact with man is limited to only the personnel necessary to feed the animals and clean the cages. However, rodents, birds, insects, snakes and other

small animals indigenous to Southwest Texas do come into contact with the baboons. Apparently this has not altered the bacterial flora to any discernible extent. Thus, the isolates from the eyes, ears and nose are what one would expect to find when working with animals from clean, well ventilated non-crowded cages.

While dysentery has been a major problem at many primate centers (25, 38, 56, 60), it has not been a problem with either the conditioned or non-conditioned animals at SFRE. Two groups of baboons from Kenya, Africa, were 61.1% and 81.1% positive for Shigella flexneri and Shigella sonnei respectively upon arrival at SFRE. These animals did not exhibit, other than loose stools which is usual in transient nonhuman primates, any clinical signs of illness. With the exception of these two groups of 50 animals, the incidence of Shigella remained at a constant rate of less than 2.0%. The inability to isolate Shigella in the field is not unusual nor without precedent. Earlier studies in the field by Kalter et al. (33, 34), or Carpenter and Cooke (13) in Kenya failed to isolate this organism. Brede and Murphy (10) in a study of animals brought directly from the field in South Africa reported an incidence of S. flexneri of 2.8%. A later study (11) reports an incidence of Shigella sp. of 19.38%, including 2.0% S. schmitz, an organism that has never been isolated from any of the three groups of animals in this study. Thus, it would seem that the "wild"

baboons in South Africa are not only carriers of Shigella sp. but that the incidence is increasing. The inability to isolate Shigella sp. in the field is also not limited to the baboon species of nonhuman primates. Weil et al. (64) found a 67.5% incidence of Shigella species in conditioned rhesus monkeys (Macaca mulatta) while Agarwal and Chakrararti (1) studying rhesus monkeys in the wild in India were unable to isolate either Shigella or Salmonella sp. And, as others have also demonstrated (26, 60), these organisms are always present in large percentages in new rhesus monkey imports. To date, the baboons arriving from Kenya, Africa, still maintain a very low rate, less than 2.0% of Shigella sp. This rate has remained constant in the conditioned animals for a period of eight years without any serious outbreak of dysentery. No one animal is a carrier, rather the Shigella apparently is in transition within the baboon colonies without any adverse effects on the animals. Salmonella sp., too, remain within the baseline colony at a low incidence, less than 1.0%.

Salmonella sp. are also isolated infrequently from the non-conditioned animals. No one serotype has been predominant as has been reported in the South African studies (11, 63). The much greater incidence found in the field bears further study. Perhaps this organism is endemic to particular areas of Africa or even to the baboons themselves in Africa. However, one should expect to find a gradual

increase in the prevalence of isolation from the conditioned and non-conditioned animals. Or, possibly the change of diet, removal of parasites and general improvement in the health of even the recently captured baboons sufficiently alters the lower intestinal tract so that its environment is not conducive for growth of the Salmonella sp. No one particular animal is a carrier of Salmonella sp. in the conditioned animals (baseline). Perhaps these organisms are transients, which the baboons have been infected with by contact with the indigenous wild life or insects of Southwest Texas.

Enteropathogenic E. coli (E.E.C.) is also isolated from both the conditioned and non-conditioned animals at a rate of about 3.0% as compared to 11.0% in the captured "wild" baboons. The baboons from South Africa showed rates of E.E.C. from nearly 20.0% (63) to 30.32% (11). The greater percentage of E.E.C. in animals in the "wild" may be due to the same causes as those responsible for the greater incidence of Salmonella and Shigella in these animals. The role of E.E.C. in clinical disease of nonhuman primates and other laboratory animals has been reported from several laboratories (7, 39, 59). However, E. coli is probably responsible for many of the undiagnosed cases of dysentery in baboons and other human and nonhuman primates. Investigators have demonstrated that "normal" (non-typeable for E.E.C.) E. coli may produce enterotoxins which cause a

diarrhea similar to that of V. cholerae (41, 57). Or, the E. coli may penetrate the cells of the intestinal epithelium and cause a syndrome similar to that of shigellosis (19, 50). In addition, Smith and Halls (62) have demonstrated that the genetic factors responsible for enterotoxin production are transmissible via a plasmid. If a plasmid is found to be responsible for the ability of E. coli to penetrate the intestinal mucosa, then the problems of pathogenic E. coli in laboratory animals may become of even greater significance to researchers. Since there are over 1800 serotypes of Salmonella sp. (23), one may imagine the work that may be involved in the serological typing of pathogenic E. coli. In the baseline colony, there has been no dysentery which can be attributed to the recognized E.E.C. serotypes. However, as Dupont et al. (19) suggests for humans, E. coli should be considered an etiologic agent in patients with acute diarrheal disease from whom a recognized pathogen cannot be isolated. Perhaps this is true for the nonhuman primates as well?

P. morgani, reported as being pathogenic (22, 38), has not been implicated as the causitive agent of diarrhea in either the conditioned or non-conditioned animals.

The finding of this study of large numbers of beta-hemolytic gram positive cocci in the fecal material of young baboons, less than 6 months of age, as compared to that of adults and juveniles is of interest. Weber et al. (63)

reported a high incidence of beta-hemolytic cocci in the oral cavity of the baboon and a much lower incidence of S. aureus in the rectal samples. There are other reports of Micrococci sp. in monkey feces (24, 56) but hemolysis or association with animal age is not mentioned. Haenel (29) found that breast-fed human babies had a different intestinal microflora than bottle-fed babies or adults. Whether baboon milk exhibits these special qualities that have an effect on the microflora of the intestinal tract has not been demonstrated but may be conjectured. This study indicates that the baboon, whether in the wild, conditioned or non-conditioned, has a diverse heterogeneous population of aerobic bacterial species with E. coli predominating in the intestine and the gram positive Micrococci predominating in the oral cavity. The conditioned animals at SFRE, probably due to the excellent conditions under which they are maintained, do not harbor recognized pathogens with the exception of a low incidence of beta-hemolytic Streptococcus in the eyes, ears and nares.

The conditioned and non-conditioned baboon (P. cynocephalus) has as a part of its normal flora a low incidence of Salmonella, Shigella and E.E.C. sp. which does not cause any overt clinical signs of illness to the animal. And, although our "wild" baboon surveys did not isolate Shigella sp., the studies by others (10, 11, 25, 63) seem to indicate these organisms are also present in the wild population.

In summary, the conditioned, non-conditioned and "wild" baboon (P. cynocephalus) from Kenya, Africa, has basically identical aerobic bacterial flora throughout its lifetime. Some species of micro-organisms may become more numerous in frequency of isolation due to changes in the animal's environment, but if proper surveillance, quarantine of new animals and clean environment are maintained, the baboon (P. cynocephalus) has a minimum of bacterial disease problems. It should be cautioned, however, that these animals carry recognized bacterial pathogens without any clinical signs of illness and this fact should be considered when planning the use of these animals in research programs.

TABLE 1

INCIDENCE OF RECTAL BACTERIA IN THE BABOON (*PAPIO CYNOCEPHALUS*)

1496 baboons studied from Jan. 1964-Dec. 1971
224 "wild" baboons studied in Jan.-Feb. 1968

Organism	Cond. & Non-Cond.	Wild	Trans. Media
E. coli	95.3%	81.1%	78.5%
Enterobacter*	37.0	10.1	27.2
P. morgani	13.5	0.4	0.9
P. mirabilis	41.4	1.3	7.1
P. vulgaris	14.2	0.0	4.9
P. rettgeri	2.5	2.6	8.8
Aero. grp.	28.8	10.2	8.1
Citrobacter	1.1	2.6	2.6
Providencia	2.3	0.0	0.0
Alcaligenes	2.4	0.0	0.0
Pseudomonas sp.	8.7	4.9	17.8
Klebsiella sp.	3 isolates**	0.0	0.0
Shigella grp. D	0.5	0.0	0.0
Shigella grp. B	1.4	0.0	0.0
Salmonella sp.***	0.3	5.3	2.6
E.E.C. grp. B	2.0	8.1	0.0
E.E.C. grp. A	1.2	3.4	0.0

* Includes *Serratia* and *Pectobacterium*

** Isolated from new arrivals in March 1971

*** Serotypes A, B, C_1, C_2, E_1, E_4, F, H

TABLE 2

GRAM POSITIVE AEROBES AND PERCENT OF TIME

ISOLATED FROM STOOLS

1496 Baboons Studied Jan. 1964-Dec. 1971

Organism	Cond. & Non-Cond.	SFRE Babies
Alpha hemo *Streptococcus*	82.1%	87.8%
Non hemo *Streptococcus*	3.0	10.0
Beta hemo *Streptococcus*	0.1	6.7
Corynebacterium sp.	73.3	37.8
Non hemo *Micrococcus*	79.7	82.8
Beta hemo *Micrococcus* coagulase neg.	3.0	7.5
Beta hemo *Micrococcus* coagulase pos.	2.0	4.4
Bacillus sp.	4.4	5.5

TABLE 3

PREDOMINANT ORAL BACTERIA (AEROBIC) AND INCIDENCE

1496 baboons studied from Jan. 1964-Dec. 1971
224 "wild" baboons studied in Jan.-Feb. 1968

Organism	Cond.	Non-Cond.	Babies	Wild
Alpha Strep.	72.6%	91.8%	72.6%	92.8%
Beta Strep.	24.6	14.9	18.5	27.3
Gamma Strep.	27.9	19.5	24.1	0.0
Micrococcus	70.5	86.7	78.2	11.6
Neisseria sp.	46.3	85.9	46.2	37.2
Bacillus sp.	19.4	22.9	12.3	21.5
Corynebacterium	10.4	7.3	14.8	5.8
Enterics*	19.4	31.1	18.8	30.2
Staph. aureus	2.3	7.6	6.2	9.8
Beta hemo Micro.	1.7	4.4	7.0	0.0

*As described by Dr. Wm. N. Ewing. Pseudomonas sp. also included. Salmonella or Shigella sp. never isolated from oral cavity.

BIBLIOGRAPHY

1. Agarwal, K. C. and R. N. Chakravarti: Preliminary observations on the intestinal bacterial flora of wild rhesus monkeys with special reference to shigellosis, salmonellosis and vibriosis. J. of the Assoc. of Phys. of India 17:409-412, 1969.
2. Al-Doory, Y.: The mycoflora of the subhuman primates. III. The flora of the skin of the baboon, vervet and gelada in captivity. Folia Primat. 7:292-298, 1967.
3. Bangxang, E. and C. P. Eliot: Amer. J. Hyg. 31:16 (Sect B), 1940.
4. Barnes, L. A., R. C. Durant and W. H. Mackey: Laboratory studies of monkeys with and without Shigella infections. Res. Rep. Naval Med. Res. Inst. 13:467-480, 1955.
5. Bermond, F. and J. Bert: The effect of psilocybin on the behavior of the Cercopithecinae Papio papio. Psychopharmacologia 15:109-115, 1969.
6. Bert, B., H. Ayats and F. Bermond: The effect of psilocybin upon the visual pathways of baboons. In Vagtborg, H. (ed). Use of Nonhuman Primates in Drug Evaluation, p. 442-448. Austin, Univ. of Texas Press, 1968.

7. Boncyk, L. H. and S. S. Kalter: Aerobic bacterial flora of chimpanzees: A four year study. J. Med. Primat. 1:333-343, 1972.

8. Boncyk, L. H., M. Brack and S. S. Kalter: Hemorrhagic necrotic enteritis in a baboon (Papio cynocephalus) due to Vibrio fetus. Lab. Anim. Sci. 22:734-738, 1972.

9. Brack, M., L. H. Boncyk and S. S. Kalter: Filaroides-cebiparasitism and respiratory infections in Cebus apella. J. Med. Primat. (In press).

10. Brede, H. D. and G. P. Murphy: Bacteriological aspects of renal allo-transplantation research. Suppl. to So. Afr. Med. J. 42:83-87, 1968.

11. Brede, H. D. and G. P. Murphy: Bacteriological and virological considerations in primate transplants. Primates in Medicine 7:18-28, Basel, Karger, 1972.

12. Breed, R. S., E. G. D. Murray and N. R. Smith: Bergey's Manual of Determinative Bacteriology. 7th Ed. Baltimore, The Williams and Wilkins Co., 1964.

13. Carpenter, K. P. and E. R. N. Cooke: An attempt to find Shigellae in wild primates. J. Comp. Path. 75: 201-204, 1965.

14. Cary, S. G., M. H. Fusillo and C. Harkins: Survival of Shigella and Salmonella in a new transport medium. Amer. J. Clin. Path. 43:294-296, 1965.

15. Cavanagh, D. and P. S. Rao: Endotoxin shock in the sub-human primate. I. Hemodynamic and biochemical changes. Archives of Surg. 99:107-112, 1969.

16. Clarkson, T. B.: Atherosclerosis-spontaneous and induced. Advances in Lipid Research 1:211-252, 1963.

17. Deinhardt, F., A. W. Holmes, J. Devine and J. Deinhardt: Marmosets as laboratory animals. IV. The microbiology of laboratory-kept marmosets. Lab. Anim. Care 17:48-70, 1967.

18. de la Pena, A. and J. W. Goldzieher: Clinical parameters of the normal baboon. In Vagtborg, H. (ed). The Baboon in Medical Research, p. 379-389. Austin, Univ. of Texas Press, 1967.

19. DuPont, H. L., S. B. Formal, R. B. Hornick, M. J. Snyder, J. P. Libonati, D. G. Sheahan, E. H. LaBree and J. P. Kalas: Pathogenesis of Escherichia coli diarrhea. New Eng. J. of Med. 285:1-9, 1971.

20. Edwards, P. R. and W. H. Ewing: Identification of Enterobacteriaceae. 2nd ed. Minneapolis, Burgess Publishing Co., 1962.

21. Fear, F. A., M. E. Pinkerton, J. A. Cline, F. Kriewaldt and S. S. Kalter: A leptospirosis outbreak in a baboon (Papio sp.) colony. Lab. Anim. Care 18:22-28, 1968.

22. Fiennes, R.: Zoonoses of Primates. Ithaca, Cornell Univ. Press, 1967.

23. Ford, A. C.: Salmonellosis, simians and man. Experimentation Animale 5:1-11, 1972.

24. Gall, L. S.: Study of the bacterial flora of the alimentary tract of chimpanzees. 6571st Aero. Res. Lab. Aero. Med. Div., A.F. Sys. Command, Holloman AFB, New Mexico. ARL-7DR-64-19. 1964.

25. Geldenhuys, J. J., J. H. Groenewald, J. J. W. van Zyl, H. D. Brede and H. W. Weber: Health problems encountered at the University of Stellenbosch primate colony. J. S. Afr. Vet. Med. Assoc. 42:63-65, 1971.

26. Good, R. C., B. D. May and T. Kawatomari: Enteric pathogens in monkeys. J. Bact. 97:1048-1055, 1969.

27. Good, R. C. and B. D. May: Respiratory pathogens in monkeys. Infection and Immunity 3:87-93, 1971.

28. Greenberg, B. and M. Sanati: Enteropathogenic types of E. coli from primates and cockroaches in a zoo. J. Med. Entomology 7:744, 1970.

29. Haenel, H.: Human normal and abnormal gastrointestinal flora. Amer. J. Clin. Nutrition 23:1433-1439, 1970.

30. Hodash, M., M. Povar and G. Shklar: The dental polymer implant concept. J. Prosth. Dent. 22:371-380, 1969.

31. Jawetz, E., L. Melnick and E. A. Adelberg: Review of Medical Microbiology. Los Altos, Calif., Lange Medical Publications, 1962.

32. Kalter, S. S. Virological study in nonhuman primates. In Defining the Laboratory Animal, p. 481-527. Washington, D. C., Nat. Acad of Sci., 1971.

33. Kalter, S. S., R. E. Kuntz, B. J. Myers, A. K. Eugster, A. R. Rodriguez, M. Benke and G. V. Kalter: The collection of biomedical specimens from baboons (Papio sp.) Kenya, 1966. Primates 9:123-139, 1968.

34. Kalter, S. S., R. E. Kuntz, Y. Al-Doory and A. A. Katzberg: Collection of biomedical study materials from baboons in East Africa, preliminary report. Lab. Anim. Care 16:161-177, 1966.

35. Kalter, S. S. and A. R. Rodriguez: Viral infections of the Kenya baboon (Papio cynocephalus) in captivity. In print.

36. Koehn, C. J.: The feeding of baboons (Papio doguera). Lab. Anim. Care 16:178-185, 1966.

37. Kuntz, R. E. and B. J. Myers: Parasites of the Kenya baboon: Arthopods, blood protozoa and helminths (Kenya, 1966). Primates 8:75-82, 1967.

38. Lapin, B. A. and L. A. Yakovleva: Comparative pathology in monkeys, 1st ed. Springfield, Ill., Charles C. Thomas, 1963.

39. McClure, H. M., L. M. Strozier and M. E. Keeling: Enteropathogenic E. coli infection in anthropoid apes. J. Amer. Vet. Med. Assoc. 161:687-689, 1972.

40. Minette, H. P.: Leptospirosis in primates other than man. Amer. J. Trop. Med. Hyg. 15:190-198, 1966.

41. Moon, H. W., S. C. Whipp and A. L. Aaety: Comparative effects of enterotoxins from E. coli and V. cholerae on rabbit and swine small intestine. Lab. Invest. 25:133-140, 1970.

42. Murphy, B. L., J. E. Maynard, D. H. Krushak and K. R. Berquist: Microbial flora of imported marmosets: Viruses and enteric bacteria. Lab. Anim. Sci. 22: 339-343, 1972.

43. Murphy, G. P., J. H. Groenwald, R. Schoonees, J. J. W. Van Zyl, C. P. Retief and J. N. DeKlerk: Renal function in baboon kidneys during hypotensive, isolated, bloodless perfusion with oxygen or helium gas. Invest. Urology 6:348-355, 1969.

44. Murphy, G. P., E. A. Mirand and G. M. Kenny: Erythropoietin alterations during renal transplantation. Med. Times 97:101-110, 1969.

45. Myers, B. J. and R. E. Kuntz: Parasites of baboons taken by the Cambridge Mwanza Expedition (Tanzania, 1965). East Afr. Med. J. 44:322-324, 1967.

46. Myers, B. J. and R. E. Kuntz: A checklist of parasites reported for the baboon. Primates 6:137-194, 1965.

47. Napier, J. R. and P. H. Napier: A Handbook of Living Primates. New York and London, Academic Press, 1967.

48. Neurater, L. J.: The availability of primates. In Vagtborg, H. (ed). Use of Nonhuman Primates in Drug Evaluation, p. 544-548. Austin, Univ. of Texas Press, 1968.

49. Nouvel, J. and J. Prot-Lassalle: Shigella dysentery 2 in captive chimpanzees (Pan troglodytes Blum). Bull. de l'Academie Veterinarire de France 36:373-379, 1963.

50. Ogawa, H.: Experimental approach in studies on pathogenesis of bacillary dysentery-with special references to the invasion of bacilli into intestinal mucosa. Acta. Path. Jap. 20:261-277, 1970.

51. Pinkerton, M. E.: Shigellosis in the baboon (Papio sp.) Lab. Anim. Care 18:11-21, 1968.

52. Pinkerton, M. E., L. H. Boncyk and J. A. Cline: Microbiological parameters of the baboon (Papio sp.): Bacteriology. In Vagtborg, H. (ed). The Baboon in Medical Research, Vol. II, pp. 717-731. Austin and London, Univ. of Texas Press, 1967.

53. Riley, P. E.: Study of the fecal bacterial population of chimpanzees. 6571st Aero. Res. Lab. Aero. Med. Div. AF Sys. Command, Holloman AFB, New Mexico. ARL-TR-66-13, May 1966.

54. Rodriguez, A. R., S. S. Kalter, R. J. Helmke and R. L. Heberling: Viral infections of the Kenya baboon (Papio cynocephalus) in its natural habitat. Primates 13:141-148, 1972.

55. Rosebury, T.: Micro-organisms indigenous to man. New York, The Blakiston Division, McGraw-Hill Book Co., Inc., 1962.

56. Ruch, T. C.: Diseases of Laboratory Primates. Philadelphia, W. B. Saunders Co., 1959.

57. Sack, B. R., S. L. Gorbach, J. G. Banwell, B. Jacobs, B. D. Chatterjee and R. C. Mitra: Enterotoxingenic E. coli isolated from patients with severe cholera-like disease. J. Infect. Dis. 123:378-385, 1971.

58. Vagtborg, H. (ed): The Baboon in Medical Research. Vol. I. Austin, Univ. of Texas Press, 1965.

59. Schiff, L. J., P. W. Barbera, C. D. Port, H. M. Yamashiroya, A. M. Shefner and S. M. Poiley: Enteropathogenic E. coli infections: Increasing awareness of a problem in laboratory animals. Lab. Anim. Sci. 5:705-708, 1972.

60. Schneider, N. J., E. C. Prather, A. L. Lewis, J. E. Scatterday and A. V. Hardy: Enteric bacteriological studies in a large colony of primates. Ann. N. Y. Acad. Sci. 85:935-941, 1960.

61. Socransky, S. S. and S. D. Manganiello: The oral microbiota of man from birth to senility. J. Periodent. 42:485-496, 1971.

62. Smith, H. W. and S. Halls: The transmissible nature of the genetic factor in E. coli that controls enterotoxin production. J. Gen. Micro. 52:319-334, 1968.

63. Weber, H. W., H. D. Brede, C. P. Retief, F. P. Fetief and E. C. Melby, Jr.: The baboon in medical research: Baseline studies in fourteen hundred baboons and pathological observations. In Defining the Laboratory Animal, p. 528-549. Washington, D. C., Nat. Acad. of Sci., 1971.

64. Weil, J. D., M. K. Ward and R. O. Spertzel: Incidence of Shigella in conditioned rhesus monkeys (Macaca mulatta). Lab. Anim. Sci. 21:434-437, 1971.

65. Wilson, G. S. and A. A. Miles: Topley and Wilson's Principles of Bacteriology and Immunity. 5th ed. Baltimore, The Williams and Wilkins Co., 1965.

66. Yamashiroya, H. M., J. M. Reed, W. H. Blair and M. D. Schneider: Some clinical and microbiological findings in vervet monkeys (Cercopithecus aethiops pygerythrus) Lab. Anim. Sci.: 21:873-883, 1971.