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BRIEF COMMUNICATION

Voluntary Alcohol Consumption in Vervet Monkeys: Individual, Sex, and Age Differences

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JUAREZ, J., C. GUZMAN-FLORES, F. R. ERVIN AND R. M. PALMOUR. *Voluntary alcohol consumption in vervet monkeys: Individual, sex, and age differences.* PHARMACOL BIOCHEM BEHAV 46(4) 985-988, 1993.—The patterns of voluntary alcohol consumption were studied in 35 vervet monkeys (*Cercopithecus aethiops*), classified into four groups. Each monkey showed a fairly steady rate during the studied period, resulting in individual differences that became more evident as the treatment evolved. Females showed higher alcohol intake frequencies than males. This sexual difference was maintained among adults and juveniles. Age differences were also observed: juveniles showed higher frequencies of intake than adults, both in general and in each sex group. Intake frequency was not related to age in prepubertal subjects, neither in general nor in each particular sex. The origin of these sex and age alcohol consumption differences remains to be studied, but differences in alcohol metabolism and factors related to puberty are possible influences.

Alcohol Vervet monkeys Sex and age differences

ABUSE of alcohol consumption has been related to several factors, and the patterns of consumption (periodicity and quantity) have been implicated in the development of alcoholism (10). Gender seems to influence alcohol intake patterns: men are reported to drink larger amounts of alcohol, and more frequently, than women (2,4,12,14). Furthermore, experimental evidence reveals that the metabolic rate of alcohol (11,13,15,17) and its hepatotoxicity (16) may depend on sexual factors as well. Age has also been cited as a factor that affects alcohol metabolism and its consumption. Studies in humans report that the amount of alcohol consumed decreases with age (18) and the percentage of consumers declines with time (1).

Interaction between sex and age has been reported in rats: the rates of ethanol metabolism and hepatic alcohol dehydrogenase activity are high in prepubertal rats and not different between the two sexes. These rates decline in adult male rats but tend to remain higher in adult females (13). In a population screening of 196 individually tested vervet monkeys, 17% were reported to drink substantial quantities of alcohol. Of these animals, most were juveniles and subadults of both sexes and a few were adult females, but none were sexually mature males (3).

A fair amount of data indicate that sex and age may influence alcohol consumption patterns; unfortunately, longitudinal studies in humans with objective records of intake patterns are difficult to obtain. Therefore, information from animal models may be a useful contribution. In this sense, vervet monkeys show a tendency to drink alcohol voluntarily, in the presence of other beverages and without partial or total food deprivation (3), which is one of the indispensable criteria for an animal model for studies on alcoholism (6-8).

The aim of this investigation was to study individual, sex, and age differences related to alcohol drinking frequency and patterns of voluntary alcohol consumption for a period of time in vervet monkey groups.

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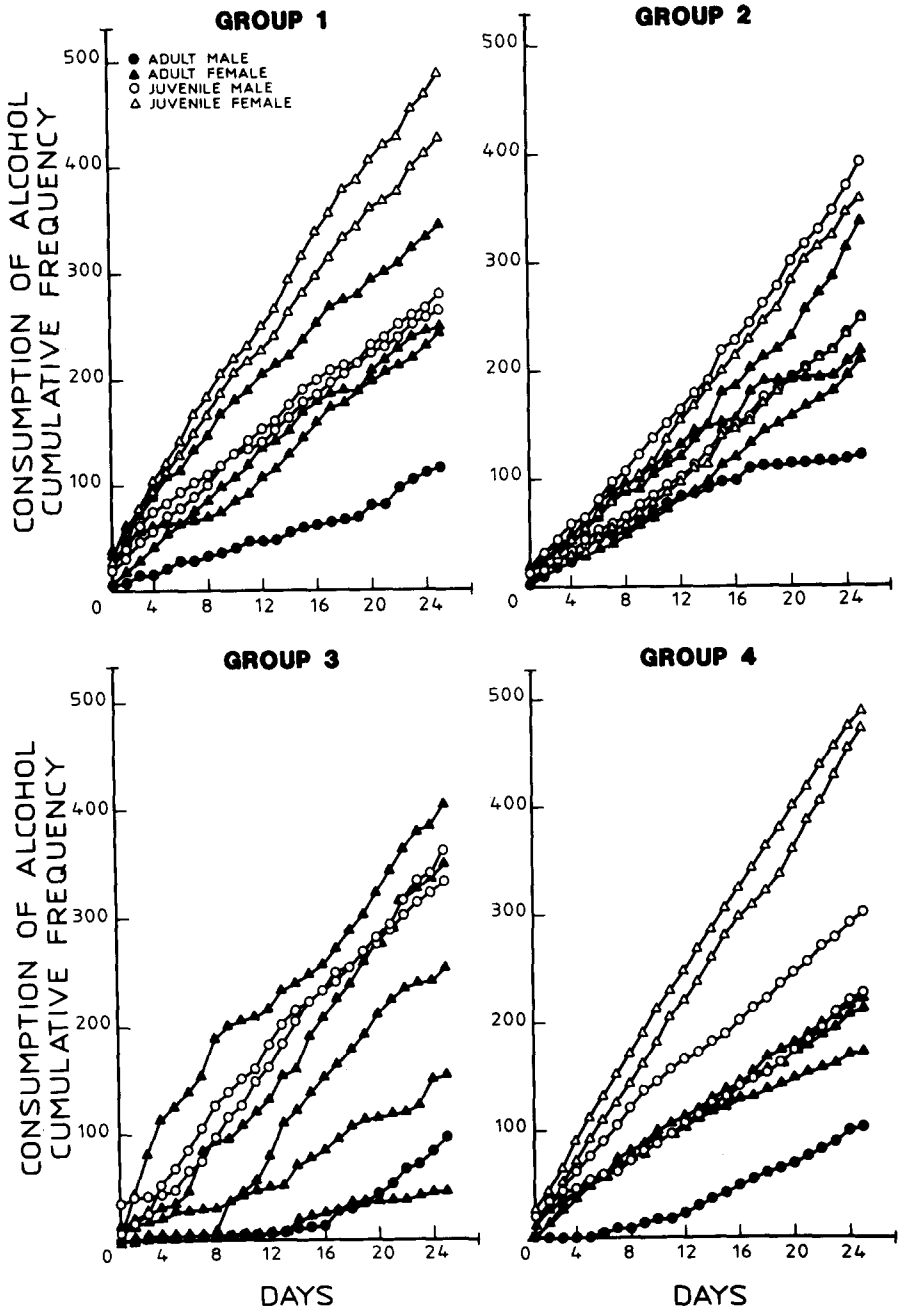

FIG. 1. Cumulative frequency of 6% alcohol consumption for each monkey in its group during 25 days of access to alcohol. The final value on day 25 represents the total frequency for each subject in the studied period.

METHOD

Four groups of experimentally naive vervet monkeys (*Cercopithecus aethiops*) were studied: the composition of groups 1, 2, and 4 was equal; each consisted of three adult females, two juvenile females, one adult male, and two juvenile males. Group 3 was composed of six adult females, one adult male, two juvenile males, and two infant males. The total number of monkeys was 35. Adult subjects, with the exception of two males, originated from St. Kitts (Lesser Antilles) and had spent at least 4 years at the Centro de Primates "San Andres Tototepec," Mexico City. All juveniles were born at this Centro de Primates. Subjects were classified, according to their age, into a) adults, 5 or more years of age and sexually mature, and b) juveniles (prepuberty) from 7 to 36 months of age. The general distribution for analytical purposes was as follows: 14 adult females, six juvenile females, four adult males, and eight juvenile males. Each group was housed in cages of 14 to 18 m^2 surface by 2.20 m height. Diet consisted of fresh fruit, seeds, and water ad lib. All members of each

group participated in the study and monkeys were not selected for their preference to alcohol.

Alcohol exposure occurred at 12:00, 2 h after the daily meal was supplied. Two drinking spouts, placed at 2 m distance from each other, contained a solution of water, sucrose (8 g/100 ml), and 6% (v/v) alcohol (commercial rum, 40° G.L.); water was also available during the ethanol drinking period. The spouts were supplied to each group for 1 h, every other day, 3 days a week, for 8.5 weeks (25 days of access to alcohol). Monkeys were never deprived of food or drinking water.

Alcohol drinking behavior was recorded directly after placing the spouts, which were removed at the end of each session to avoid access to the alcoholic beverage until the next recording. Under these conditions, monkeys drank intermittently; thus, the drinking behavior was visually monitored and recorded with a timer. Each 10-s lapse was considered as one unit of intake frequency. Each partial drinking period (less than 10 s) was accumulated to the next drinking period.

Differences were evaluated by one- or two-way ANOVA, and the level of significance was set at $p < 0.05$.

RESULTS

One adult female and two infants of 2 months of age were not considered in the analysis. The female did not drink alcohol in the studied period and the infants were observed to start drinking alcohol between the fifth and sixth week of age and to drink consistently after the ninth week. These monkeys were still suckling, and their approximations to the drinking spouts largely depended on the degree of possession of their mothers, who frequently recovered their infant when it approached the spouts.

On the first days of access to alcohol, juvenile monkeys lead the initiative of alcohol intake and most subjects tried the drink from the first day of exposure. Ataxia and atypical behavior was observed coincident with the acute effects of alcohol, especially in juvenile monkeys. The drinking frequency varied from one day to the next during the 25 days of access to alcohol. However, subjects were observed to maintain a consistent intake rate during the studied period, with clear individual differences among them. This may be observed in Fig. 1, which shows the cumulative drinking frequency of each subject during the 25 days of access to alcohol. Subjects that started off with low intake rates continued that rate during the 25 days, whereas those that started off with high intake rates showed the highest cumulative frequencies at the end of the studied period. Differences in intake rates were defined from the beginning and became more evident as treatment evolved.

Age and Sex Differences

Two-way ANOVA (sex, age) showed significant differences: regarding the sex factor, females displayed higher alcohol intake frequencies than males, $F(1, 28) = 15.2$, $p < 0.001$, and as to the age factor, juveniles showed higher alcohol intake frequencies than adults, $F(1, 28) = 30.64$, $p < 0.001$. In these differences juveniles duplicated, on average, the adult values of alcohol intake frequency.

As in the ANOVA for main effect, age differences in alcohol consumption were also significant among females, ($F(1, 18) = 12.7$, $p = 0.003$, and among males, $F(1, 10) = 42.78$, $p < 0.001$. In both cases juveniles exhibited higher alcohol intake frequencies than adults (Fig. 2). Females also showed higher alcohol intake values than males among adults, ($F(1, 16) = 7.62$, $p = 0.013$, and among juveniles, $F(1, 12) = 7.96$, $p = 0.015$) (Fig. 2).

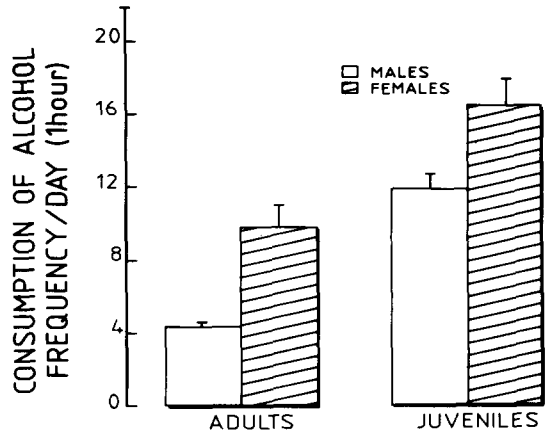

FIG. 2. Mean and SE of alcohol intake frequency per day (1 h of access) for each age and sex group. Age differences in alcohol consumption were significant among females, $F(1, 18) = 12.7$, $p = 0.003$, and among males, $F(1, 10) = 42.78$, $p < 0.001$. Sex differences were significant among adults, $F(1, 16) = 7.62$, $p = 0.013$, and among juveniles, $F(1, 12) = 7.96$, $p = 0.015$.

The age of juveniles was accurately known because all of them were born at the Primate Center. To study if alcohol consumption frequency was in any way related with the stages of development among juveniles, their age within the studied period was calculated and the average age from beginning to end of the treatment was considered. The age of juveniles, in general, varied between 7 and 36 months, in males from 7 to 34, and in females from 9 to 36. Age and average alcohol intake frequency were not found to be related in this range of ages in general, nor in each particular sex.

DISCUSSION

Ervin et al. (3) states that monkeys originating from a Caribbean population (St. Kitts) are naturally exposed to burned and fermented sugar cane, which may favor their disposition towards alcohol. However, the juvenile subjects of this study were born at the Centro de Primates "San Andrés Totoltepec" in México City, out of the sugar cane environment, and they all also drank alcohol without being deprived of food or water. Besides, monkeys of African paternal and maternal origin also consume alcohol voluntarily, which suggests that the disposition to drink alcohol is a feature of this species.

The differences in alcohol intake patterns observed since the first days of exposure tended to remain until treatment was completed among members of each group. Thus, in spite of daily variations, the consumption rate was consistent for each individual during the study. This was so in all groups.

It is characteristic of juveniles to exhibit intense social activity and great curiosity for all new stimuli, which is probably one of the reasons why they were the first to drink during the initial exposures to alcohol. This is consistent with previous reports (3). One significant difference was that the juveniles exhibited higher frequency values of alcohol intake than adults. Social factors could influence these differences, since it is more important to obtain and keep a social position for adults than for infants or juveniles, who are in turn more dependent on the parents' hierarchy or affiliative relationships (9). When juveniles reach adulthood, they become more in-

volved in situations of social hierarchy and consequently are more exposed to stress or social conflict, which may affect their patterns of alcohol intake (5). It is therefore possible that adults drink less because they have to be more alert and perceptive of the social dynamics of the group. Age differences were not found in prepuberty subjects from 7 to 36 months old, which suggests that factors related to maturity after puberty exert an important influence on such differences.

Female vervet monkeys showed significantly higher frequency of alcohol intake than males. It has been reported that females display higher alcohol metabolic rate than males, in humans (11) and rats (13), but no information is available on this matter in the vervet monkey. Nevertheless, if the same relation between sex and metabolic rate holds for this species, it could be a factor influencing the frequency of alcohol intake in females, since, if alcohol elimination is faster, it is necessary to drink more to maintain a given blood alcohol level in time.

The present data do not allow definite conclusions on the factors related to sex and age differences in alcohol consumption. However, published data suggest that factors related to maturity before and after puberty and a possible sex dimorphism in alcohol metabolism may exert some influence on these differences, which remain to be studied in this species.

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REFERENCES

1. Adams, W. L.; Garry, P. J.; Rhyne, R.; Hunt, W. C.; Goodwin, J. S. Alcohol intake in the healthy elderly. Changes with age in a cross-sectional and longitudinal study. J. Am. Geriatr. Soc. 38: 211–216; 1990.
2. Crawford, S.; Ryder, D. A study of sex differences in cognitive impairment in alcoholics using traditional and computer-based tests. Drug Alcohol Depend. 18(4):369–375; 1986.
3. Ervin, F. R.; Palmour, R. M.; Young, S. N.; Guzman-Flores, C.; Juàrez, J. Voluntary consumption of beverage alcohol by vervet monkeys: Population screening, descriptive behavior and biochemical measures. Pharmacol. Biochem. Behav. 36:367–373; 1990.
4. Isralowitz, R. E.; Hong, O. T. Sex differences in drinking patterns and behaviours among college students in Singapore. Psychol. Rep. 64(2):364–366; 1989.
5. Juárez, J.; Guzmán-Flores, C.; García-Castells, E.; Ervin, F. R. Efectos crónicos de la ingestión de alcohol en la conducta social del mono verde. VI Congreso Mexicano de Psicología. Memorias (resumen); 1990:1–34.
6. Keane, B.; Leonard, B. E. Rodent models of alcoholism: A review. Alcohol 24(4):299–309; 1989.
7. Lester, D.; Freed, E. X. Criteria for an animal model of alcoholism. Theoretical review. Pharmacol. Biochem. Behav. 1(1):103–107; 1973.
8. Li, T. K.; Lumeng, L.; McBride, W. J.; Murphy, J. M. Alcoholism: Is it a model for the study of disorders of mood and consummatory behavior? Ann. NY Acad. Sci. 499(3):239–249; 1987.
9. McKenna, J. J. The evolution of primate societies, reproduction, and parenting. In: Fobes, J. L.; King, J. E., eds. Primate behavior. New York: Academic Press, Inc.; 1982:87–133.
10. Mello, N. K. Alcoholism and the behavioral pharmacology of alcohol: 1967–1977. In: Lipton, M. A.; DiMascio, A.; Killam, K. F., eds. Psychopharmacology: A generation of progress. New York: Raven Press; 1978:1619–1637.
11. Mishra, L.; Sharma, S.; Potter, J. J.; Mezey, E. More rapid elimination of alcohol in women as compared to their male siblings. Alcoholism 13(6):752–754; 1989.
12. Mooney, D. K.; Fromme, K.; Kivlahan, D. R.; Marlatt, G. A. Correlates of alcohol consumption: Sex, age, and expectancies relate differentially to quantity and frequency. Addict. Behav. 12(3):235–240; 1987.
13. Rachamin, G.; MacDonald, A.; Wahid, S.; Clapp, J. J.; Khanna, J. M.; Israel Y. Modulation of alcohol dehydrogenase and ethanol metabolism by sex hormones in the spontaneously hypertensive rat. Effect of chronic ethanol administration. Biochem. J. 186:483–490; 1980.
14. Robbins, C. Sex differences in psychosocial consequences of alcohol and drug abuse. J. Health Soc. Behav. 30(1):117–130; 1989.
15. Sutker, P. B.; Goist, K. C., Jr.; Allain, A. N.; Bugg, F. Acute alcohol intoxication: Sex comparisons on pharmacokinetic and mood measures. Alcoholism 11(6):507–512; 1987.
16. Van Thiel, D. H.; Gavaler, J. S. Ethanol metabolism and hepatotoxicity. Does sex make a difference?. Recent Dev. Alcohol. 6(3): 291–304; 1988.
17. Van Thiel, D. H.; Tarter, R. E.; Rosenblum, E.; Gavaler, J. S. Ethanol its metabolism and gonadal effects: Does sex make a difference?. Adv. Alcohol Subst. Abuse 7(3–4):131–169; 1988.
18. Vogel-Sprott, M.; Barrett, P. Age, drinking habits and the effects of alcohol. J. Stud. Alcohol 45:517–521; 1984.