was increased and the portal vessels of the liver were dilated. In response to stimulation of the ventromedial nucleus, a defensive reaction usually arises, with excitation of the sympathetic nervous system, an increase in the cardiac output and muscular blood flow, and constriction of the abdominal vessels [9, 15] (according to our own data, constriction of the arterial and portal vessels of the liver takes place).

Certain hypothalamic structures may therefore participate in integrative control of the hepatic circulation, by exerting well-marked, differential and, to some extent, specific influences on the hepatic vessels.

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ADRENAL FUNCTION IN *Papio hamadryas* DEPENDING ON HIERARCHICAL RANK IN AN ISOLATED GROUP

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Many research workers have devoted great attention to relations between the endocrine system and the hierarchical rank of the individual in social groups of primates. The results of such investigations, conducted on monkeys of different species, have proved fairly contradictory, evidently because different approaches to the problem were used. In polyandrous groups of primates, for example, correlation can often be traced between the rank of dominance, aggressiveness, and the level of adaptive adrenocortical hormones [3, 7]. In *Macaca rhesus*, for example, correlation can be clearly established between gregarious behavior and adrenal function. The response of the adrenals is regarded as an index of individual adaptation to the conditions of keeping in the cage [8]. On the other hand, in other investigations [5] on monkeys of the same species, the plasma cortisol concentration did not

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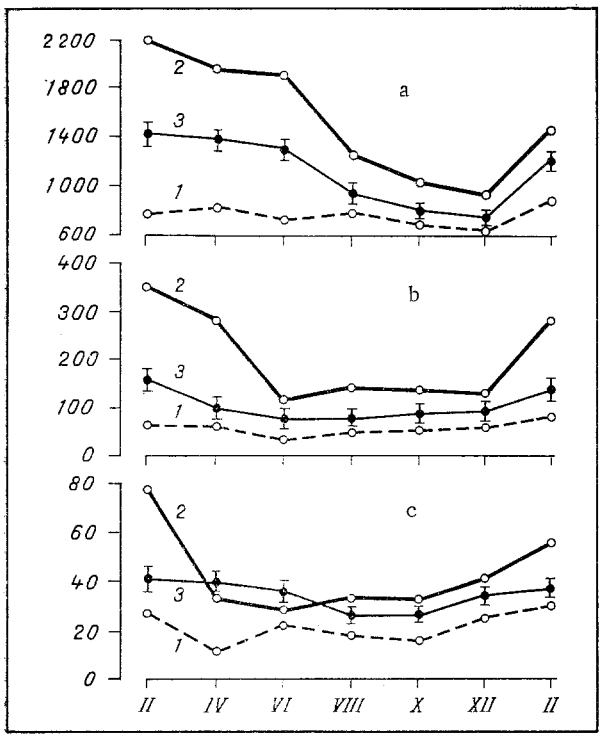

Fig. 1. Annual fluctuations in concentrations of cortisol (a), corticosterone (b), and 11-deoxycortisol (c) in peripheral blood of male baboons depending on hierarchical rank. Abscissa, months of year; ordinate, concentration of corticosteroids (in nM). 1) Dominant male, 2) subordinate male, 3) arithmetic mean value for 16 monkeys (M ± m).

correlate with the character of the animals' behavior in the group. These workers reject the view that the cortisol concentration can be used as a sensitive indicator of the character of the monkeys' behavior. However, the study of correlation between dominance and the level of function of the pituitary-adrenal system in squirrel monkeys has shown that dominant males had a higher cortisol level and exhibited a weaker hormonal stress reaction than subordinate males [2].

To discover any possible correlation between adrenal function and the hierarchical rank occupied by an animal in an isolated group, the social behavior of adult male baboons (*Papio hamadryas*), kept in cages, was studied for 1 year, and plasma levels of corticosterone, cortisol, and its immediate precursor 11-deoxycortisol, were determined in the monkeys.

EXPERIMENTAL METHOD

Experiments were carried out on 16 clinically healthy mature male baboons aged 7-14 years, weighing 17-32 kg. Before the beginning of the experiment the animals were adapted for 5 months in a large cage (150 m^3). For 1 year visual observations were made regularly on the animals' behavior: their mutual agonistic relations, the order of taking food, grooming, aggressiveness, stability or lability of social units, and linear dominance were recorded. Blood was taken from the cubital vein of the animals, in February, April, June, August, October, and December, and collected in tubes containing heparin. Plasma was obtained by centrifuging the blood for 15 min at 3000 rpm and was kept at −20°C until steroid hormone assay. Cortisol was determined by competitive binding with protein [6], corticosterone and 11-deoxycortisol by direct radioimmunoassay, by a method developed in the Laboratory of Experimental Endocrinology, Research Institute of Experimental Pathology and Therapy, Academy of Medical Sciences of the USSR, based on the method in [4], and using highly specific antisera for the purpose.

EXPERIMENTAL RESULTS

Data on the blood cortisol concentrations of the monkeys throughout the year, depending on the rank occupied by the individual in the group, are given in Fig. 1a. The hormone concentration reached a maximum in February and fell to a minimum in the fall ($P < 0.05$). In

the individual who was the leader of the group, the cortisol concentration was minimal with virtually no annual rhythm, and its mean value for the year was 810 ± 30 nM. Conversely, in an animal occupying a lower rank in the group, and with no social partner, i.e., a single male, the cortisol level was highest, and varied within wide limits. The mean annual concentration was 1640 ± 100 nM.

The blood corticosterone concentration showed similar changes, depending both on the time of year and on the hierarchical status (Fig. 1b). Unlike cortisol, the corticosterone concentration fell to a minimum during the summer and remained low until December. The minimal level of the hormone differed statistically significantly from the maximal values, which occurred in February ($P < 0.05$). The mean annual corticosterone concentration in the leading male was 56.3 ± 8.2 nM, and in an animal with a lower hierarchical rank it was 186.7 ± 35.6 nM.

The time course of the blood 11-deoxycortisol level of the monkeys was similar to that of cortisol, with a maximum in February and a minimum in August. The difference between the maximal and minimal concentrations was statistically significant ($P < 0.05$). An annual rhythm likewise was absent in the dominant animal, but in an individual occupying a subordinate position, it was well defined. The mean annual concentration of the steroid was 20.2 ± 2.0 nM in the dominant male and 41.8 ± 7.1 nM in the subordinate male.

These experiments demonstrate that adrenal function reflects the hierarchical rank of an individual in the group. In the case of males occupying a subordinate position, there is a distinct annual rhythm of the corticosteroid concentrations with an acrophase in winter in the summer or the fall. The blood hormone concentrations of the dominant male are low, and remain virtually unchanged throughout the year. Statistical analysis of the results reveals a significant fall in adrenal activity in male baboons in the summer and fall, in agreement with observations made by other workers [1].

Keeping the monkeys in activity in a comparatively restricted space leaves a definite imprint on the social relations between individuals. The inability of the subordinate male to keep at a respectful distance from the dominant male, the rigid feeding hierarchy, due to keeping the animals in a cage, and other unfavorable environmental factors have an activating effect on adrenal function of the monkeys occupying a lower rank. This is manifested as a two-threefold increase in the blood concentrations of adaptive hormones.

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