tosis. The accessibility of the test and the possibility of rapid and objective evaluation make its introduction into scientific research and practical medicine well worth while.

LITERATURE CITED

1. M. E. Viksman and A. N. Mayanskii, Kazan. Med. Zh., No. 5, 99 (1977).
2. A. N. Mayanskii, M. E. Viksman, L. G. Popova, et al., Byull. Éksp. Biol. Med., No. 2, 187 (1978).
3. G. Mowat, in: Information, Immunity, and Hypersensitivity [Russian translation], Moscow (1975), pp. 9-128.
4. R. L. Baehner and D. G. Nathan, New Engl. J. Med., 278, 971 (1968).
5. I. M. Goldstein, H. B. Kaplan, A. Radin, et al., J. Immunol., 117, 1282 (1976).
6. P. M. Henson, Immunol. Commun., 5, 757 (1976).
7. J. Menzel, H. Jungfer and D. Gemsa, Infect. Immun., 19, 659 (1978).
8. I. Miler, Faktory Prirozene Rezistence Organismu, Prague (1976).
9. D. G. Nathan, R. L. Baehner, and D. K. Weaver, J. Clin. Invest., 48, 1885 (1969).
10. G. Nathenson, M. E. Miller, K. A. Myers, et al., Clin. Immunol. Immunopath., 9, 269 (1978).
11. T. M. Saba, in: Immune System and Infectious Diseases, Basel (1975), pp. 489-504.
12. J. Sedlak and H. Rische, (Editors), Enterobacteriaceae – Infektionen, Leipzig (1968).
13. P. C. Wilkinson, Clin. Exp. Immunol., 25, 355 (1976).
14. M. Yamamura and H. Valdimarsson, Immunology, 34, 689 (1978).

SEASONAL VARIATIONS IN THE CATECHOLAMINE CONCENTRATION IN THE ALBINO RAT BRAIN

M. Ya. Otter and L. B. Nurmand

UDC 612.82:612.452.018"32"

Seasonal changes in the concentrations of dopamine (DA), noradrenalin (NA), and homovanillic acid (HVA) in the forebrain and diencaphalon were studied in 258 Wistar albino rats. Experiments were carried out monthly for six years. The concentrations of DA, NA, and HVA in the brain changed significantly in the course of the year, and in both parts of the brain the changes were in the same direction. The DA concentration in the winter and spring months was higher than the average for the year, whereas in summer it was lower. The NA concentration was much higher in spring (by one-third in the diencephalon) than the mean values. In the summer months (June-August) the average NA concentration corresponded to more rapid metabolism of DA (a decrease in DA and an increase in HVA).

KEY WORDS: catecholamines; seasonal variation; rat brain.

Experiments to study the concentrations of indolamines and catecholamines in the tissues and fluids of laboratory animals were carried out previously (during 1972-1976). The experimental animals were kept under standard conditions of temperature and lighting, and the conditions of their food and fluid intake were identical. Material for investigation was always taken at the same time of day (at 10 a.m.) and the monoamines were determined by the same method. Despite this fact, the results varied appreciably in the course of the year. Seasonal variations were particularly marked in the concentration of serotonin and its metabolites [5]. The serotonin concentration, in turn, is known to be connected with catecholamine metabolism. The decisive role in the changes in indole metabolism is played by activity of the serotonin coenzyme A, N-acetyltransferase, whose activity is regulated by noradrenalin through β-adrenoreceptors [8, 9, 14]. The diurnal rhythm of the serotonin concentration in the rat brain also depends on fluctuations in the activity of serotonin decarboxylase, which is under the control of the competitive effect of catecholamines and serotonin on the enzyme [8]. In

Laboratory of Psychopharmacology and Department of Pharmacology, Tartu University. (Presented by Academician of the Academy of Medical Sciences of the USSR M. D. Mashkovskii.)

Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 89, No. 2, pp. 215-217, February, 1980. Original article submitted December 4, 1978.

0007-4888/80/8902-0203$07.50

TABLE 1. Seasonal Changes in NA, DA, and HVA Concentrations in the Forebrain and Diencephalon of Rats in 1972-1978

Month	Forebrain				Diencephalon			
	NA	DA	HVA	HVA/DA	NA	DA	HVA	HVA/DA
	mean annual concentration, μg/g							
	1972—1978							
	0,33±0,04	1,58±0,19	0,28±0,04	0,18	0,68±0,07	0,56±0,06	0,35±0,07	0,63
	1977—1978							
	0,36±0,03	1,58±0,15	0,30±0,05	0,19	0,69±0,06	0,56±0,06	0,32±0,06	0,57
	Percent of mean for the year							
I—III	0,29±0,03 (87,0)	1,80±0,15 (114,0)	0,20±0,03 (68,9)	0,60	0,58±0,07 (85,3)	0,63±0,07 (115,5)	0,18±0,04 (51,4)	0,45
IV—VI	0,39±0,04 (118,0)	1,74±0,16 (110,1)	0,28±0,05 (100,0)	0,90	0,94±0,07 (138,2)	0,60±0,06 (107,5)	0,43±0,09 (122,9)	1,14
VII—IX	0,33±0,03 (99,0)	1,22±0,13 (77,2)	0,35±0,04 (125,0)	1,60	0,62±0,08 (91,2)	0,50±0,06 (89,6)	0,67±0,08 (100,0)	1,79
X—XII	0,32±0,03 (97,0)	1,55±0,17 (98,1)	0,29±0,03 (103,6)	1,06	0,55±0,05 (80,9)	0,47±0,05 (83,9)	0,23±0,05 (65,7)	0,78

Legend. Percentages given in parentheses.

connection with seasonal fluctuations in the serotonin concentration, a more fundamental study of seasonal fluctuations in the catecholamine concentration was thus required.

EXPERIMENTAL METHOD

The data obtained previously (1972-1976) were supplemented by systematic experiments over a period of 18 months (February, 1977 through July, 1978) on male Wistar albino rats weighing 200-250 g. Altogether more than 250 animals were studied. The concentrations of noradrenalin (NA), dopamine (DA), and homovanillic acid (HVA) in the brain were determined. The animals were decapitated and the brain was quickly removed, frozen, and divided into forebrain and diencephalon. After weighing, the parts for testing were homogenized and the substances determined by a spectrophotofluorometric method [12, 13] in the writers' modification [1]. Concentrations of NA, DA, and HVA were calculated in μg/g wet weight of brain tissue.

EXPERIMENTAL RESULTS AND DISCUSSION

The mean annual concentrations of NA, DA, and HVA in the forebrain and diencephalon of the rat in the experimental period and during previous years were virtually identical (Table 1). In the course of the year, however, the concentrations of catecholamines fluctuated considerably, and their changes were always in the same direction in both parts of the brain. The DA concentration in winter and spring (from January through May) was higher than the mean for the year. An increase in the NA concentration was observed in spring (from April through June), and in HVA in summer (from July through September). Metabolism of DA into HVA took place more rapidly in the summer also, as shown by exhaustion of the DA reserves (its concentration fell to a minimum), the comparatively stable NA concentration, and the highest level of HVA: these changes were particularly marked in the diencephalon. Further evidence of this increased rate of DA metabolism was shown by the HVA/DA ratio, which reflects the relative rate of catecholamine catabolism along the pathway leading to HVA formation.

Many workers [3, 8, 15] have found a diurnal rhythm in the concentrations of catecholamines, especially NA, in the brain, maximal concentrations being reached at 3-4 a.m. As regards a seasonal rhythm, much less information is available. The reason for this may be the fact that seasonal changes demand investigations over at least 5 years [14, 15]. The results of shorter investigations are heterogeneous and contradictory: in the brain of mice and rats of both sexes, for instance, a tendency is observed for the NA level to rise in summer and the fall (0.19 ± 0.02 μg in winter, 0.20 ± 0.02 μg/liter in spring, 0.26 ± 0.02 μg/g in summer, and 0.36 ± 0.06 μg/g in the fall) [2]. According to other data, on the other hand, the highest NA concentration in the whole rat brain in observed in December (0.30 μg/g) and the lowest in April (0.13 μg/g) [6]. These differences can be explained, besides by other factors, by the use of animals of different genetic lines [6], or different climatic conditions [3], of differences in the conditions of maintenance of the animals, and also differences in the substrate examined (the whole brain or its individual parts.

Our own data are in good agreement with the well-known fact of activation of metabolic processes in general [10] and, in particular, in rodents in the spring [3].

A certain parallel also can be drawn with seasonal changes in activity of functions connected with the monoaminergic systems of the brain. For example, the mental excitability of the brain is raised in spring and early summer, and lowered in the fall and in winter; the same pattern also is observed as regards the photosensitivity of the human eyes, activity of the gonads of experimental animals, and so on [3]. A parallel also is observed between these changes and seasonal fluctuations in the activity of adrenal cortical extract [7], the effectiveness of action of sedatives [4], cardiovascular functions [11], and so on.

It can be tentatively suggested that seasonal changes in the activity of the catecholaminergic systems of the brain lie at the basis of the phenomena described above. This suggestion is supported by the observation that the most marked seasonal fluctuations in concentrations and rate of metabolism of catecholamines are manifested in the diencephalon, which is more closely connected with autonomic reactions of the body.

LITERATURE CITED

1. L. Kh. Allikmets and A. M. Zharkovskii, Byull. Éksp. Biol. Med., No. 2, 134 (1976).
2. S. V. Andreev and I. D. Kobkova, The Role of Catecholamines in the Healthy and Sick Organism [in Russian], Moscow (1970), p. 44.
3. A. P. Golikov and P. P. Golikov, Seasonal Biorhythms in Physiology and Pathology [in Russian], Moscow (1973).
4. L. B. Nurmand, Byull. Éksp. Biol. Med., No. 3, 73 (1973).
5. M. Ya. Otter, Isv. Akad. Nauk Est. SSR, Biol., 27, No. 2, 125 (1978).
6. M. Beauvallet, M. Solier, and J. Bernard, J. Physiol. (Paris), 60, 344 (1968).
7. O. Fanelli, J. Appl. Physiol., 33, 600 (1972).
8. D. C. Klein and J. L. Weller, Science, 169, 1093 (1970).
9. D. C. Klein, J. L. Weller, and R. Y. Moore, Proc. Natl. Acad. Sci. USA, 68, 3107 (1971).
10. T. Sasaki and L. D. Carlson, Proc. Soc. Exp. Biol. (New York), 116, 332 (1964).
11. R. A. Schneider and J. P. Costiloe, Arch. Environ. Health, 24, 10 (1972).
12. M. K. Schellenberger and J. H. Gordon, Anal. Biochem., 39, 356 (1971).
13. P. F. Spano and N. H. Neff, Anal. Biochem., 42, 113 (1971).
14. M. Stupfel, Biomedicine, 22, 105 (1975).
15. A. Walker, Chronobiologia, 1, 205 (1974).