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The behavior of the homozygous and heterozygous sub-types of rats which are genetically-selected for diabetes insipidus: A comparison with Long Evans and Wistar stocks

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Abstract. Several aspects of spontaneous and conditioned behavior (food and water intake, locomotion and emotionality, passive and active avoidance acquisition and retention) of standard (albino and pigmented) rats, and rats heterozygous (HEDI) and homozygous (HODI) for diabetes insipidus, are reviewed. As would be expected, HODI rats have been repeatedly found to consume far more fluid than either HEDI or control rats. Pigmented rats appear to be more active than albinos. HODI rats exhibit less marked emotional responses than do control rats, among which the pigmented ones exhibit the highest emotionality. Light aversion is more evident in albino than in pigmented rats. No differences are found among HEDI, HODI and normal Long Evans rats. It is quite difficult to provide a clear-cut statement concerning inter-strain differences in passive avoidance behavior, possibly because of the variety of techniques employed. In any case, HODI rats do not perform worse than normal controls do. In one-way active avoidance paradigms, pigmented rats perform better than albinos, and the performance of HODI rats does not differ from that of controls. In two-way avoidance paradigms, albinos appear to outperform pigmented rats. Once again, there are no obvious differences between HODI and control animals.

In addition to indicating that HODI rats may actually be less emotional than the other groups of rats reviewed here, the studies described once again fail to confirm the previously alleged functions of vasopressin in memory consolidation.

Key words. Homozygous and heterozygous for diabetes insipidus rats behaviors; emotionality; feeding and drinking; locomotion and exploration; passive and active avoidance; Brattleboro rats.

Introduction

Most behavioral research is currently being carried out on inbred or outbred rats obtained from commercial or institutional sources. Broadly speaking, these animals can be divided into albino and pigmented rats, and this chromatic classification already entails important behavioral differences. Indeed, it is widely accepted that the albino locus has quite a number of effects on spontaneous and conditioned behavior. It may be possible that these differences are not exclusively related to the visual system[72,78] but to other biological features as well. These may include the activity and induction of hepatic microsomal enzymes[41,42], footshock-induced analgesia[69], sympatho-medullary activity during footshock stress[48], hormonal responses (prolactin, growth hormone, corticosterone) to morphine or stressors[43], kainic acid neurotoxicity[63], brain 5-hydroxytriptamine metabolism[59], ethanol preference[44], and drug and sleep sensitive behavior[37], to mention but a few. On the other hand, there are also significant differences between groups of albino rats, such as differences in the taste reactivity to NaCl shown by Fischer 344 and Wistar rats[33], in parental behavior in virgin female Wistar and Sprague-Dawley rats[40], as well as intra-strain differences in amphetamine-induced rotational behavior of Sprague-Dawley rats from different sources[32].

At present, those engaged in behavioral research are becoming more and more aware of the differences that exist between the several strains of *Rattus norvegicus*, and various strains and stocks are being increasingly selected and bred for specific characteristics. In fact, the genetic background of rats can be manipulated to such an extent that it fits specific research needs[28,54]. For example, much interest has been aroused by the inter-strain differences which exist between normal Long Evans and homozygous diabetes insipidus rats (HODI) of the Brattleboro strain. The latter is genetically defective, producing little or no vasopressin, and has been used to attempt to assess the importance of endogenous vasopressin in modulating learning and memory.

After the development of the HODI Brattleboro strain, there was a steady flow of papers, largely from one source, indicating a positive role for vasopressin, especially on the retention of learned behaviors. Eventually this body of evidence was criticized on methodological grounds, and reports from other workers failed to substantiate most of the claimed mnemonic effects and influences of vasopressin. Recently, although some still maintain that it would be very nice if it could be proven that vasopressin enhances memory (for a review, see Strupp and Levitsky[67]), there have been mostly negative reports on the role of vasopressin on memory. Irrespective of the final assessment of this role, however, much interest in several other behavioral topics has been generated by all of these reports.

In fact, rats heterozygous for diabetes insipidus (HEDI), and HODI rats have been found to differ in quite a number of aspects, from one another and from Long Evans and/or Wistar controls. Some of these characteristics have not been intensively investigated – for example, cold-water swim and morphine analgesia[12], taste aversion[30], behavioral arousal [23], and reinforced lever pressing[61]. The purpose of this short review is to cover some other aspects of behavior which have been more extensively studied, such as food and water intake, locomotion and emotionality, and several types of avoidance behavior.

Food and water intake (tables 1 and 2)

Much information is available on food and water intake, as well as on the distribution of these activities between the light and dark periods of the 24-h cycle, in different strains[65, 73].

Several of these findings have been reviewed[3, 5], and the previously reported differences in feeding and drinking behavior exhibited by albino (mostly Wistar) and pigmented (mostly Long Evans) rats have been confirmed. Generally speaking, Long Evans rats exhibit a lower overall consumption of food than do albino rats, and the feeding behavior of pigmented rats appears to be less restricted to the dark periods. In addition, drinking differences have been found between wild rats and Long Evans rats, the former drinking three times as much[15].

The daily urine output of HODI Brattleboro rats has been reported to be several times that of control rats. However, HEDI rats, despite a partial vasopressin deficit, produce a volume of urine which is only one and a half to two times greater than that of control rats, with no apparent differences in serum osmolarity. HODI rats generally drink about 4–8 times more water than do HEDI, Wistar or Long Evans rats, a finding which has been repeatedly confirmed[14, 16–19, 26, 27, 31, 35, 45, 56, 64]. In another study, no differences in water consumption were found among HODI rats from different sources[38], and it is well-known that water consumption can be brought down to normal in HODI rats by vasopressin infusion[31]. In the HODI strain, polydipsia and hyperdiuresis are necessary correlates of the absence of vasopressin. It must be emphasized, however, that despite a lack of vasopressin, and notwithstanding their very large increase in drinking activity, HODI rats show constant daily drinking rhythms[2].

Table 1. Food intake in Wistar (W), Long Evans (LE), HEDI and HODI rats

Age	Sex	Strain differences	References
70 days	Male	HODI > LE	2
70 days	Male	W > LE	3

Locomotion and emotionality (tables 3 and 4)

Without going into a detailed comparison of 'exploration' vs 'locomotor behavior' as they may, or may not, pertain to emotionality (which will be done by Gentsch et al. in this issue), it should, nevertheless, be briefly mentioned that differences in these behaviors have been found within both albino strains and stocks[39, 58, 77] and within pigmented strains and stocks[29, 77].

Differences have also been found among albino (Wistar) and pigmented (Long Evans and HODI) rats in wheel running. Wistar rats exhibited the lowest wheel-running activity, especially during the dark periods, and HODI rats were much less active than Long Evans rats, both during light and dark periods[2–4]. A study of circadian activity rhythms of wheel-running in HEDI and HODI rats has shown that HEDI rats exhibit much more locomotor activity than HODI rats, irrespective of the light-

Table 2. Water intake in Wistar (W), Long Evans (LE), HEDI and HODI rats

Age or weight	Sex	Strain differences	References
Various weights and ages	Male	HODI > HEDI	14, 26, 27, 45
Various weights and ages	Male	HODI > LE	2, 14, 16–19, 27, 31, 38, 64
Various weights and ages	Male	HODI > W > HEDI	23, 26
90 days	Male	HEDI > LE	27
350–370 g	Male	HEDI > LE	45

Table 3. Locomotion in Wistar (W), Long Evans (LE), HEDI and HODI rats

	Age or weight	Sex	Strain differences	References
a) Open field activity	60–90 days	Male, female	LE > W	7
	90 days	Male	LE > HODI, HEDI	9
	Various weights and ages	Female	HODI > LE	74–76
	110–130 g	Male	HODI = HEDI = W	14
	90 days	Female	HEDI = HODI	9
b) Wheel running	70 days	Male	LE > HODI	2
	110–130 g	Female	HEDI > HODI	35
	70 days	Male	LE > W	2,3
c) Rearing	60–90 days	Male, female	LE = W	7
	90–93 days	Male	HODI = HEDI = LE	9
	90–93 days	Female	HODI,LE > HEDI	9
	90–120 days	Female	LE > HODI	75
	Various weights and ages	Female	LE = HODI	74
	110–130 g	Male	HODI,HEDI > W	14
d) Latency measurements	70 days	Male	LE > W	3
	Various weights and ages	Male	LE > HODI	18, 19, 38

ing conditions (LD, LL Dim, LL Bright)[2]. Circadian rhythms remained consistent in both HODI and HEDI rats, although the periods of free-running rhythms were longer for HODI rats[35].

In a two-box apparatus, significant differences in step-through latency in going from a solid white into a black and white striped chamber were found between pigmented (Long Evans) and albino (Wistar) rats, with the latter exhibiting higher latencies[3].

Initial freezing in the light chamber of a light-dark box apparatus after receiving footshocks in the dark chamber was measured by us in albino (Wistar) and pigmented (Long Evans) rats (table 4,c). Freezing was defined as motor inhibition resulting in immobility, ending when voluntary movements were performed. Wistar rats exhibited shorter freezing durations than Long Evans rats, but only for footshocks of more than 0.6 mA[4]. Freezing, defined as above, was also measured in Long Evans, HEDI and HODI rats. HEDI rats exhibited the longest freezing duration, followed by HODI and then Long Evans rats[1,6].

No significant differences were found between albino (Wistar) and HODI or HEDI rats in open-field performance[14], although Long Evans rats have been reported as being more active than Wistar rats[7]. This lack of difference between HODI and HEDI rats was confirmed in another study, but it was found that male and female HEDI and HODI rats made significantly fewer crossings than did male and female Long Evans rats[9]. Indeed, it appears that these differences between HODI and control Long Evans rats may have been over-emphasized, e.g. when it was stated that the 'time to emerge'performance of HODI rats was so poor, when compared to that of Long Evans rats, that it was impossible to determine activity levels for HODI rats[18,19]. On the contrary, according to other reports, HODI rats displayed an initial higher frequency of crossings than did Long Evans rats in the open-field test[74–76]. Exposure to an acoustic stressor resulted in decreased activity in both groups of animals, but it had a lesser effect on HODI rats. The differences between HODI and normal rats were diminished by handling prior to experimentation[74]. Recently, it has been reported that HODI rats from different sources do not differ in terms of open-field emergence. The same holds true for Long Evans rats from different sources. However, these exhibited lower emergence rates than HODI rats did[38].

When rearing behavior has been measured, also in a circular open-field, only very slight differences have been found between pigmented Long Evans and albino Wistar rats. Albino Sprague-Dawley rats actually showed the highest level of rearing. No differences were found between male and female subjects in any of the three strains[7]. As with the above-mentioned albinos, differences in rearing have been also found between pigmented stocks of rats[57].

Table 4. Emotionality in Wistar (W), Long Evans (LE), HEDI and HODI rats

	Age or weight	Sex	Strain differences	References
a) Emotional reactivity in general	280–350 g	Male	LE > W	11
b) Stress defecation	60–90 days	Male	LE = W	7
	60–90 days	Female	W > LE	7
	120–130 g	Male	W > HODI,HEDI	14
	Various weights and ages	Male	LE > HODI	76
c) Freezing behavior (post footshock)	90–150 days	Female	LE > HODI	76
	60–70 days	Male, female	LE > W	3, 4, 53
	70 days	Male	HODI > LE	1
	70–80 days	Male	HEDI > HODI	6

Emotionality has mostly been studied in open-field paradigms. It must be underlined that there has been a considerable variation in the dimensions and sizes of the apparatus employed, and that defecation counts have mostly been used as the main measurement. Differences in defecation rates have been found within both albino strains and stocks[7,11,58] and pigmented strains and stocks[29,57] on several occasions.

In a circular open-field, it was found that the defecation counts of albino (Wistar) rats were much higher than those of both HODI and HEDI rats, while the two latter strains showed no differences[14]. In HODI and Long Evans age- and weight-matched rats, the former exhibited slightly lower defecation counts in open-field trials[76]. The differences in rearing often seen between albino and pigmented rats in the open-field[49,68] were also maintained even when HEDI and HODI rats were compared with Wistar ones. Wistar rats exhibited less grooming and rearing than the other two strains did[14]. On the other hand, no marked differences in rearing were later reported between Long Evans rats and either HODI[9,74,75], or HEDI[9] rats. Concerning locomotion, albino rats are the least active, with HODI rats exhibiting less locomotor activity than either HEDI or normal Long Evans rats. Even at low activity levels, no alterations of circadian rhythms have been described for HODI rats.

Although one must be very careful in making references to emotionality, considering the scarcity of hormonal data in HODI and HEDI rats, it may be stated that HODI rats appear to display less marked emotional behaviors than do either pigmented or albino control rats.

Light-aversion and pain thresholds

Before covering the theme of passive and active avoidance it may be advantageous to discuss briefly comparative light sensitivity and shock thresholds.

The fact that albino rats prefer the dark (i.e., have an aversion to bright illumination) has been repeatedly confirmed[8,47]. This reaction was termed 'spontaneous passive avoidance reaction', in order to describe the preference for a small, dark space[66]. With regard to pigmented rats, no differences in dark chamber activity (photoactivity) were reported between HODI and Long Evans rats[74,75]. That pigmented rats can see better than albinos has been well documented[24,25,34,55,60] on the basis of both behavioral and physiological evidence.

There are contrasting reports on the pain sensitivity of vasopressin-deficient rats. Initially, it was stated that HODI rats exhibited the highest threshold to electric footshocks, when compared to HEDI and Wistar rats[14]. Later, in the flick-jump test, HODI rats were reported as exhibiting small and significantly lower jump thresholds, when compared to Long Evans rats[13,20]. Finally, no significant differences were found between Long Evans and HODI rats in the tail-flick test[1]. Likewise, no significant differences were reported between HODI, HEDI, and Long Evans rats with regard to electric footshock thresholds[27].

It therefore appears that vasopressin deficiency affects neither the visual abilities of HODI rats, nor their pain sensitivity thresholds.

Passive avoidance (table 5, a)

In a passive avoidance test in which the rats had to suppress the active behavior necessary to obtain a food reward, no strain differences were found between intact albino (Wistar) and pigmented (Long Evans) rats. Septal lesions did not modify these results[11]. Strain differences between male Wistar and Long Evans rats in passive avoidance have also been studied by means of a light-dark two-chamber apparatus. The rats received electric footshocks in the larger, lighted chamber. Whereas Long Evans rats acquired the avoidance response more slowly than Wistar rats, no differences were found between Wistar and Long Evans rats in the extinction of the passive avoidance response[66]. The study of inhibitory learning and passive avoidance in pigmented (Long Evans) and albino (Wistar) rats was extended to cover their early stages of life, from day 1 to day 10/11. The results, besides proving than an inhibitory response can be learned by the neonatal altricial rat and that learning capacity improves with age, also showed only small strain differences[51].

In our laboratory, on the other hand, differences have been reported between albino (Wistar) and pigmented (Long Evans) rats for passive avoidance response acquisition and retention in the light-dark box paradigm, with the Long Evans rats being superior in both criteria[3].

HEDI rats have been reported to exhibit better acquisition and retention of a passive avoidance response than HODI rats (two-box apparatus; passive avoidance was tested after 1.3 min or after 24 h), with particular stress being put on the better resistance to extinction exhibited by HEDI rats[14,71].

On the other hand, the performance of Long Evans rats has been reported to be worse than that of both HEDI and HODI rats (HEDI > HODI > Long Evans) regardless of sex[9], and the deficit in passive avoidance retention exhibited by HODI rats was not so severe and absolute as claimed by other researchers, according to whom it was impossible to demonstrate passive avoidance response in HODI rats 24 h or more after the training trial[26]. For example, in the Punished Motivation Inhibition Test (in which the animals had to suppress an acquired food-motivated locomotory behavior in order to avoid footshocks), HODI rats showed better retention of the punishment effect than normal Long Evans rats[18].

More recently, the passive avoidance of HODI rats was again compared to that of control, age-matched Long Evans or HEDI rats by means of the light-dark box test. No significant differences in the acquisition or in the

Table 5. Avoidance performance in Wistar (W), Long Evans (LE), HEDI and HODI rats

	Age or weight	Sex	Strain differences	References
a) Passive	Various weights and ages	Male, female	HEDI > HODI	9°, 14°, 27°, 71°, 14*, 27*, 70*, 71*
	Various weights and ages	Male	HEDI = HODI	6°, 9°, 6*, 70*
	120 days	Male	HODI > HEDI	70*
	Various weights and ages	Male	HODI > LE	9°, 18*, 19*, 20*
	Various weights and ages	Male, female	HODI = LE	1°, 16°, 38°, 74°, 1*
	140 days	Male	LE > HODI	27°, 27*
	180–230 g	Male	HEDI > LE	9°
	140 g	Male	HEDI = LE	27°, 27*
	70 days	Male	LE > W	3°, 3*
	Various weights and ages	Male, female	LE = W	11°, 51°, 66*
	140 days	Male	W > LE	66°
b) Active (one-way)	70–80 days	Male	HODI > HEDI	6°, 6*
	110–140 g	Male	HODI = HEDI	14°, 27°
	140 g	Male	LE = HEDI	27°, 27*
	Various weights and ages	Male	LE > HODI	1°, 1*, 27*
	140–240 g	Male	LE = HODI	16°, 20°, 27°
	110–120 g	Male	W > HODI,HEDI	14°, 14*
	Various weights and ages	Male	LE > W	3°, 36°, 3*, 36*, 66*
	Various weights and ages	Male	LE = W	11°, 66°
	110–140 g	Male	HEDI > HODI	14*, 27*
c) Active (two-way)	100–150 days	Male, female	HODI > HEDI	22*, 50*
	Various weights and ages	Male, female	LE > HODI	22°, 271°, 50°
	Various weights and ages	Male, female	HODI > LE	20°, 22*, 50*
	Various weights and ages	Male, female	LE > HEDI	27°, 50°
	80–150 days	Male, female	LE = HEDI	22°, 22*, 50*
	Various weights and ages	Male, female	HEDI > HODI	9°, 14,°, 22°, 27°, 50°, 14*
	Various weights and ages	Male, female	HEDI = HODI	9*
	28–85 days	Male, female	W > LE	52°, 53°, 62°, 52*
	280–350 g	Male	W = LE	11°
	120–130 g	Male	W > HODI	14°, 14*
	79–95 days	Male	LE > W	62°

°in acquisition, *in extinction.

retention of the conditioned passive avoidance response were found either between Long Evans and HODI rats, or between HEDI and HODI rats[1,6].

According to some authors, the contradictory results obtained for HODI rats in passive avoidance tests could be due to differences in the age of the rats employed. In fact, HODI rats, when compared with HEDI rats, re-entered the shock compartment sooner when 35 days old, exhibited the same latency when 60 days old, and re-entered later when 120 days old. That is to say, the percentage of HODI rats which re-entered the shock chamber on the post-shock trail decreased with age[70].

Thus, the available data on passive avoidance learning do not unequivocally support the hypothesis that vasopressin plays a necessary role in memory processes. Indeed, other consequences of diabetes insipidus may provide an explanation for the relatively poor passive avoidance performance of HODI rats. Quite recently, in fact[1,6], it was not possible to confirm the alleged deficits in memory acquisition and retention previously described in vasopressin-deficient rats[16,19,20,38,74].

Active avoidance (table 5, b,c)

In a one-way avoidance test (jumping on a bench to escape footshocks from a grid floor) no acquisition differences were found between albino (Wistar) and pigmented (Long Evans) rats, but the extinction of the acquired response was slower in Long Evans than in Wistar rats[66]. Again, there were no differences between Wistar and Long Evans animals during acquisition in runway testing[11]. In a more recent one-way jumping test, however, Long Evans rats learned the response and retained it better than Wistar rats; the rats from both strains were between 3 and 13 weeks old[36]. This better performance (acquisition and retention) by Long Evans rats was confirmed by a study of one-way active avoidance in the light-dark box apparatus[3].

The performance of albino (Wistar) and pigmented (HEDI and HODI) rats was also studied in a pole-jumping paradigm. Wistar rats were reported as exhibiting the best performance both in acquisition and extinction. During extinction, HODI performance was worse than that of HEDI rats[14]. On the other hand, no differences were found in terms of exit latency or the number of responses between HODI and Long Evans control rats in another one-way avoidance test (refusal to enter the dark chamber of a two-box apparatus after the deliverance of footshocks)[20]. This finding was confirmed by two other reports, according to which a) HODI rats remembered an exposure to electric shocks to the same extent as Long Evans rats did in a one-way avoidance test in the light-dark box[16] and b) acquisition performance was the same in Long Evans, HEDI, and HODI subjects, but retention performance was poorest for the HODI rats[27].

The acquisition and retention of a one-way active avoidance response, in the light-dark box test, was also studied by us in Long Evans, HEDI and HODI rats. The active avoidance performance of HODI rats was significantly poorer than that of their Long Evans counterparts both during acquisition and during extinction. HODI subjects acquired and retained the active avoidance response better than HEDI subjects, however, for the lowest footshock intensity. For the highest footshock intensity, the active avoidance response was acquired equally by both HODI and HEDI rats, being retained significantly better by the former[1,6].

Significant differences in two-way, active avoidance have been reported among Long Evans rats obtained from different sources, as well as among albino strains[10,21,39,46,52,77].

In other studies, Wistar rats have performed consistently better in the shuttle-box test than Long Evans rats, with no differences being observed between male and female subjects[53,54]. Also in the shuttle-box, however, sex-linked, opposite differences have been found between Long Evans and Wistar rats (male Long Evans performing better than Wistar ones, Wistar females better than Long Evans females[62]), and other investigators have reported *no* differences between Wistar and Long Evans rats in shuttle-box avoidance[11].

The shuttle-box has also been employed to test vasopressin-deficient rats against control animals. For example, the acquisition and extinction of the conditioned response were studied in Wistar, HEDI and HODI rats. The best performance, both in acquisition and retention, was by Wistar rats, with the poorest performance being seen in HODI rats[14]. Using the same paradigm, the performance of Long Evans, HEDI and HODI rats has also been compared. It was reported that HODI rats were slowest in acquiring the conditioned response but, nonetheless, they exhibited a very marked resistance to extinction[22]. These findings were confirmed, particularly regarding the resistance to extinction in HODI rats[50].

Up until 1979, the available evidence showed HODI rats acquiring shuttle-box avoidance more slowly than either HEDI or control rats. The reason for the poorer performance of HODI rats may have been that it deteriorated, or did not continue to improve, or became quite variable after 10 or 11 days. The drop in performance may indicate that the less robust and weaker HODI rats could not withstand the physical demands imposed by daily active avoidance testing over a relatively long period of time. On the other hand, concerning extinction, most of the published findings indicated that HODI rats did not extinguish significantly faster than Long Evans rats[9].

Of late there have been more conflicting reports on this topic. It has been reported on the one hand that in a shuttle-box avoidance task HODI rats made significantly more avoidance responses than did Long Evans rats[20] and, on the other hand, that the performance of Long Evans rats was found to be better in the same apparatus, followed by that of HEDI and HODI rats[27].

According to some reports the 'freezing reaction', (i.e., the failure of rats in this case to go from one to the other compartment of a shuttle-box), is indicative of increased emotionality[28]. This behavior has been reported to be present in about 10% of pigmented (Long Evans) rats while albino (Wistar) rats were exempt from it[53]. In another study, freezing latency (time period following an acoustic stressor during which no rearing or crossing of an open field were observed) was much shorter for HODI rats than for either age- or weight-matched Long Evans rats[76].

The available data, therefore, in addition to indicating that HODI rats may actually be less emotional than the other groups of rats reviewed here, once again fail to confirm the previously assigned functions of vasopressin in memory consolidation.

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Sexual maturation in female rats: Hereditary, developmental and environmental aspects

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Abstract. Two physiological components of sexual maturation, vaginal opening and first estrus, apparently evolve similarly in Wistar and Sprague-Dawley rats. However, a bimodal distribution in the frequency of the days of vaginal opening is observed within a given strain, which is less related to heredity than to the timing and type of experiment. In addition, when the modulators of sexual maturation are reviewed, it can be observed that sensitivity to external stimuli can vary even within a strain. For a defined set of breeding conditions, one group of rats can be more susceptible to changes in the lighting regimen and not be affected by controlled stressors, while another group responds more to stress and less to light. The reason for susceptibility to one rather than another environmental factor under similar breeding conditions is not understood. In that context, it is difficult to evaluate the role of heredity when we cannot understand the full impact of the environment, not to mention maternal influence in fetal and early life. Using two lines of psychogenetically selected rats, it was possible to show that they had differences in sexual maturation, which strongly suggested a genetic predisposition. Nevertheless, the question arises as to whether the genetic locus directly affects organs implicated in sexual maturation or whether it acts on some unknown factor which only secondarily modifies sexual maturation. In summary, there is more need to understand the role of the environment, including that of the mother early in fetal and neonatal life. It is suggested that the mechanisms underlying organ growth are set for a given species, while developmental and environmental factors fix the timing of vaginal opening and first ovulation. In the rat, there appear to be two times which are preferred for vaginal opening, given the laboratory conditions that have been used in the last 20 or so years: an early period, at 31–35 days, and a late period, at 36–40 days. An explanation for this dichotomy would be that a combination of parameters (not necessarily always the same) is needed for vaginal opening. These parameters oscillate during sexual maturation with different frequencies, which can achieve resonance to lead to vaginal opening and ovulation only during given periods.

Key words. Development; heredity; lighting environment; melatonin; puberty; rat; Roman Low Avoidance; Roman High Avoidance; stress.

I. Position of the problem concerning heredity and reproduction

The wide use of the albino rat necessitated the installation of many colonies throughout the world. In each of these colonies, selection of breeders and differences in breeding facilities led to the development of specific hereditary traits, which can be selected to give specific substrains[82]. To evaluate the hereditary component in the differences observed between rats, it is necessary to assess the amount of variation which results from ontogenic development. In the first summary of this kind concerning vaginal opening, it was observed that huge variations occurred not between strains, but within the same strain used in different laboratories: mean days for vaginal opening in different colonies of Long-Evans rats were 38, 43, 53 and 77 days; similar variations were also described for Wistar rats, with colony means at 42, 47 and 49 days[56].

Given the importance of Wistar (WI) and Sprague-Dawley (SD) rats, we centered our study on these rats, evaluating the timing of sexual maturation through assessment of vaginal opening and first estrus. Different environmental conditions were used in studies which