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BRIEF COMMUNICATION

Effects of p-Chlorophenylalanine on the Predatory Behavior of *Onychomys torridus* [1]

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MCCARTY, R. C., G. H. WHITESIDES AND T. K. TOMOSKY. *Effects of p-chlorophenylalanine on the predatory behavior of* Onychomys torridus. PHARMAC. BIOCHEM. BEHAV. 4(2) 217–220, 1976. – Adult male and female grasshopper mice, *Onychomys torridus*, were treated over a 5 day period with p-chlorophenylalanine (50 mg/kg daily), a depletor of brain 5-hydroxytryptamine (5-HT). These mice exhibited a significant decrease over the 5 day test interval in predation time and predation score in encounters with cricket prey. However, the basic pattern and frequency of attacks for drug-treated mice remained similar to saline controls. The relation between the various brain amine systems and predatory behavior is discussed and the utility of the grasshopper mouse as a laboratory model for the study of predatory behavior is emphasized.

Onychomys torridus Grasshopper mouse p-Chlorophenylalanine Predation Aggression
5-Hydroxytryptamine Serotonin

BRAIN 5-hydroxytryptamine (5-HT) has been reported to function as an inhibitor of predatory aggression in laboratory rats [21]. Depletion of brain 5-HT with p-chlorophenylalanine (PCPA), an inhibitor of the rate-limiting enzyme tryptophan hydroxylase [15], results in the conversion of a significant number of nonkilling rats into muricidal rats [8, 13, 17, 22]. Additionally, treatment of muricidal rats with 5-hydroxytryptophan (5-HTP), a precursor of 5-HT, blocks the expression of predatory behavior in encounters with laboratory mouse opponents [4,22].

Predatory aggression has been described as the destruction of a natural item of prey and it is usually associated with food acquisition [18,21]. Although some laboratory rats will consistently attack and kill a variety of prey items, including frogs, mice, turtles, and chicks [3], the suitability of the laboratory rat as a model system for the study of predatory aggression has been questioned [1]. The rat is not considered a predator in its natural environment [25] and a large percentage of laboratory rats will not kill mice, even after a period of food deprivation. Additional inconsistencies have been reported regarding the effects of developmental influences on predation [19,27] and the relationship between the killing and eating of prey items [14,20].

The southern grasshopper mouse, *Onychomys torridus*, represents an excellent model for the laboratory study of predatory aggression. This species is native to the southwestern United States and northern Mexico [10] and is naturally predatory on a wide variety of arthropod and small vertebrate species [2, 7, 12]. Grasshopper mice are easily maintained in the laboratory with low to moderate reproductive success [16] and virtually all animals will attack, kill, and consume a variety of vertebrate and arthropod prey [2, 5, 6, 7, 12, 16].

The present experiment was designed to evaluate the effects of a depletion of brain levels of 5-HT on the predatory behavior of adult *O. torridus* animals in encounters with house crickets.

METHOD

Animals

A breeding colony of southern grasshopper mice was established in this laboratory with 8 bisexual pairs of adult mice trapped in the vicinity of Tucson, Arizona and purchased from the Pet Corral. Animals for the present study were second and third generation laboratory-born offspring housed as male-female pairs in plastic cages (28 × 17 × 12 cm) and provided with free access to water and laboratory chow. The colony room was maintained at 25 ± 3°C with a 12:12 light-dark photoperiod.

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Apparatus

Cricket predation tests were conducted in a clear plastic chamber (44 x 26 x 16 cm) containing a thin layer of bedding material, 5 laboratory chow biscuits, and 5 large crickets. After each predation test, the chamber was cleaned and fresh crickets were added. All testing was conducted from 0900–1500 in a room separate from the colony room.

Procedure

PCPA solutions were prepared by suspending the drug in 0.9% saline that contained 1 drop of Tween 80 per 10 ml of saline. Vehicle solutions contained saline and Tween 80 only. One group of 10 male-female pairs received single daily injections of PCPA (50 mg/kg) intraperitoneally (IP) for 5 consecutive days. A control group of 10 male-female pairs received equivalent amounts of vehicle in daily IP injections over an identical 5 day period. None of the mice used in this experiment had previous experience with arthropod prey.

Predation tests were administered 24 hr after each of the 5 daily injections. Mice were transported to the testing room in their home cage and each member of the pair was individually placed in the test chamber for a 10 min period. During each test, the latency to first attack, total number of attacks, and total time spent attacking and eating (predation time) were recorded. At the end of the test, the animal was immediately removed from the chamber, given its daily injection of either PCPA or vehicle, and returned to its home cage. Crickets in the chamber were then examined and classified as intact, incapacitated, or dead. Crickets were considered incapacitated if they were unable to move in a rapid and coordinated manner when prodded with forceps. Deaths were recorded if at least the head of the cricket was eaten. A predation score combined these 2 measures by scoring 0.5 for each incapacitation and 1.0 for each death, for a maximum possible score for any given bout of 5.0.

Four representative pairs were chosen from each treatment group and sacrificed by cervical dislocation within 3 hr after predation testing. The brain was removed from each animal, rapidly frozen in liquid nitrogen, and stored for later analysis of whole brain 5-HT concentration by a modification of the method of Snyder *et al.* [23].

RESULTS

Mean daily values for each measure of predatory behavior for male and female *O. torridus* are presented in Fig. 1. For purposes of analysis, individual values for each behavioral criterion were averaged over the 5 day test interval and subjected to a nonparametric Kruskal-Wallis H test [28]. A summary of the results expressed as 5 day mean values is included in Table 1.

Treatment of males and females with PCPA had no significant effect on latency to first attack or total number of attacks ($p>0.05$). Both sexes displayed a trend of increased attack latencies and decreased total numbers of attacks over the 5 day period, however. This trend may reflect an habituation to the presence of the crickets under conditions of ad lib access to food in the home cage. PCPA-treated males exhibited a significant decrease in predation score ($p<0.01$), while PCPA-treated females experienced significant declines in predation time ($p<0.05$)

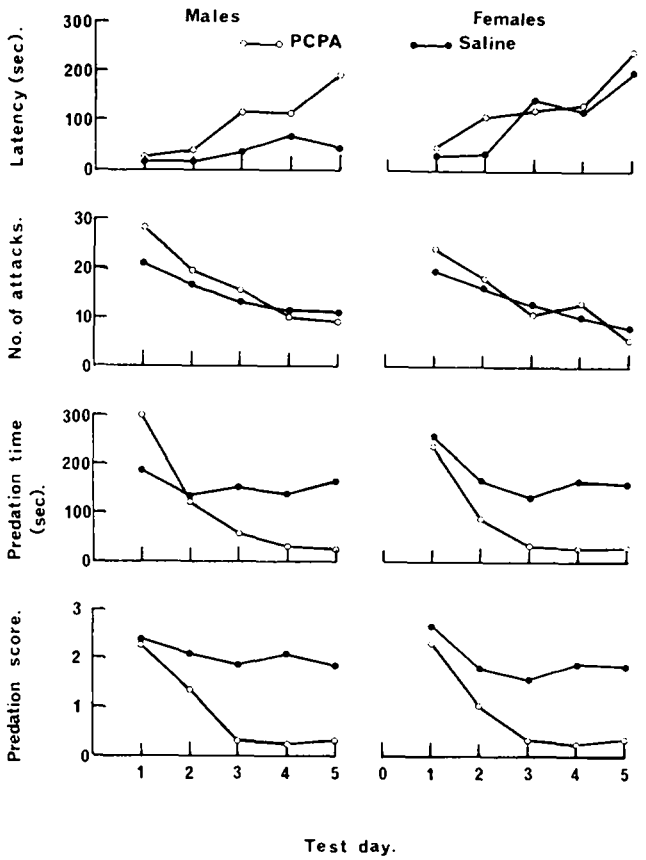

FIG. 1. Mean values for each measure of predatory behavior of male and female mice over a 5 day test period. Treatment groups for each sex consisted of saline-injected controls and PCPA-treated mice. Details of injection schedules and a description of each of the behavioral measures is included in Procedure.

and predation score ($p<0.01$). The unusually high predation time for drug-injected males on Day 1 (see Fig. 1) may reflect an initial facilitation of predatory behavior; however, the mean predation time for PCPA males over the final 3 test days was significantly less than that for vehicle-injected controls ($p<0.01$).

In the course of the 5 day test schedule, all PCPA-treated animals became quite difficult to handle and would actively attempt to avoid capture. Drug-injected animals also differed from controls in their response to cricket prey. Following placement into the test chamber, PCPA-treated animals were easily startled by any sudden escape movements by the crickets and they would typically run rapidly about the test chamber for a variable length of time. Following a successful attack, drug-treated mice would hold the cricket with the forepaws, then quickly release it unharmed. In contrast to this pattern, a majority of the control *Q. torridus* adults efficiently captured, incapacitated, and consumed several crickets in a 10 min test.

Treatment of grasshopper mice with PCPA over a 5 day period resulted in a depletion of whole brain 5-HT concentration to 58% of control levels. Whole brain 5-HT concentrations (± SE) for vehicle and PCPA treatments were 0.36 ± .02 μg/g and 0.21 ± 0.01 μg/g, respectively ($p<0.001$). There was also a significant decrease in the whole brain weight of drug-treated animals (483.8 ± 34.0

TABLE 1

FIVE DAY MEAN VALUES (± SEM) FOR 4 MEASURES OF PREDATORY BEHAVIOR OF *ONYCHOMYS TORRIDUS* ADULT ANIMALS IN ENCOUNTERS WITH HOUSE CRICKETS. DETAILS OF DRUG INJECTION SCHEDULES ARE INCLUDED IN PROCEDURE

Group	N	Latency	No. of Attacks	Predation Time	Predation Score
Males					
Vehicle	10	37.6 ± 12.6	14.9 ± 0.9	155.0 ± 31.0	2.07 ± 0.26
PCPA	10	98.6 ± 33.6	16.7 ± 2.3	109.2 ± 20.1	0.90 ± 0.18†
Females					
Vehicle	10	102.3 ± 29.4	13.7 ± 1.3	179.3 ± 34.9	1.95 ± 0.31
PCPA	10	130.8 ± 42.1	14.7 ± 2.3	83.3 ± 16.4*	0.81 ± 0.16†

*$p<0.05$ †$p<0.01$ Drug treatment group vs vehicle-injected controls according to Kruskal-Wallis H test.

mg) as compared to controls (584.1 ± 20.9 mg) ($p<0.05$). There was no change in the body weights of either treatment group over the 5 day test interval ($p>0.05$).

DISCUSSION

Evidence has accumulated over the past several years suggesting a correlation between the functioning of various brain monoamine systems and the elicitation of various types of aggressive behavior [1, 18, 21]. In particular, a lowering of brain 5-HT with PCPA has been reported to facilitate the muricidal behavior of laboratory rats [8, 13, 17, 22]. Additionally, administration of 5-HTP to consistent mouse-killing rats blocks the muricidal response [4,22].

In the present study with grasshopper mice, PCPA decreased the total predatory time and the destruction of cricket prey without altering the basic pattern or frequency of attacks. Drug-treated mice were also quite reactive to handling and were easily startled by any sudden cricket movements. Correlated with these PCPA-induced behavioral changes were a decrease in total brain weight and a decrease in whole brain 5-HT concentration to 58% of controls.

The interaction of the various neurotransmitter systems of the brain have been stressed by a number of workers [11, 24, 26]. It is therefore difficult to selectively increase or decrease the concentration of a single brain amine without producing associated changes in other amine pools. Although PCPA is reported to be a relatively selective depletor of brain 5-HT [15], more recent evidence has demonstrated its associated effects on brain catecholamines. Welch and Welch [26] have reported significant decreases in brain concentrations of 5-HT, 5-hydroxyindoleacetic acid, dopamine, and norepinephrine in grouped laboratory mice after a single injection of 360 mg/kg PCPA. It was suggested that the behavioral and physiological alterations produced by this drug cannot be attributed solely to its inhibitory effect on tryptophan hydroxylase [26].

Because of the multiple changes induced by a single drug treatment, it is not possible to ascribe the decreases in predatory behavior of grasshopper mice in the present study solely to alterations in levels in brain 5-HT. In particular, the effects of PCPA on whole brain weights of *O. torridus* deserves further investigation. It does appear, however, that 5-HT bears a different relation to predatory aggression than that previously described for the muricidal response of laboratory rats [4, 8, 14, 17, 22].

Several factors favor *Onychomys torridus* as a superior model for the laboratory study of predatory behavior. Evidence from a number of field studies has clearly established the predatory habit of this species in the wild [2, 10, 12, 16]. Virtually all members of this species will attack, kill, and consume a variety of arthropod prey species. In addition, this complex behavioral pattern is not dependent on prior field or laboratory experience with prey and is easily elicited under controlled laboratory conditions [7]. Additional research with this interesting species may provide a clearer understanding of the relationship between brain monoamine systems and various kinds of aggressive and predatory behaviors.

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