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## Food Imprinting in the Snapping Turtle, Chelydra serpentina


Abstract. *Three groups of hatchling snapping turtles, totaling 20, were fed either meat, fish, or worms. When they were tested for preference after 12 daily feedings, each preferred the diet to which it was accustomed. After 12 more days of eating a different food, each still preferred its original diet. A form of imprinting may be operative in the feeding behavior of this species.*


Imprinting, extensively studied in precocial birds, differs significantly from association learning (*1*). This conclusion derives from work with imprinting to a parental object or with social imprinting. Recent work indicates the existence in birds of two other forms of imprinting: environmental or habitat imprinting, and food imprinting (*1, 2*). The latter form was demonstrated in chicks in which the innate pecking preference for a certain color and shape was modified, through reinforcement of pecks, to another color and shape; such modification could occur only at a specific age.

We investigated the existence of food imprinting in turtles, using a different criterion for imprinting: the primacy of early experience. Imprinting has never been reported in turtles or in any other reptile. Turtles are even more precocial than birds; they are completely independent upon hatching, even of parental care or attention, so that social imprinting is unlikely. Food imprinting, however, could be as adaptive in turtles as in birds. Study of imprinting in a species from which the possibility of classical imprinting is absent may help one to understand the basic mechanisms underlying all imprinting.

Twenty snapping turtles (*Chelydra serpentina*) were hatched in captivity in two clutches (*3*). Turtles 1 to 15 and 20 (Table 1) were from a clutch found in Illinois; their mean weight was 10.8 g. The eggs were incubated, with the dirt and sand mixture in which they were found, in a large jar. Turtles 16 to 19 were from eggs removed from a dead female collected in Texas; they were kept first between sheets of moist paper toweling and then in sand; their mean hatched weight was 13.5 g. The incubation media were kept moist, and the air temperature varied from 27° to 30°C by day to somewhat less by night.

Snapping turtles when hatched have an external yolk sac and will not eat for the first few days, being capable of long fasts before the first meal. Animals 1 to 16 and 18 to 20 were approximately 10 days old when the experiment began; No. 17 was 4 days old.

After hatching, most of the turtles were kept in 3 cm of water in several 16-liter aquariums covered with black cloth. After a week they were transferred to individual all-glass tanks measuring 23 by 14 by 17 cm. The exceptions, turtles 17 to 20, were placed in the individual tanks as soon as they were discovered. Each turtle was visually isolated from its neighbors by cardboard partitions. Throughout the experiment each tank contained 2 cm of aged tapwater. The turtles were washed off and the tanks were cleaned and refilled with aged water after the first six feedings, before the first test, after six feedings on a new food, and before the final test.

The turtles were divided into three groups containing 7, 6, and 7, respectively. Turtles in group 1 were fed daily with lean, finely ground horsemeat rolled into balls about 7 mm in diameter; those in group 2 received daily a female guppy (*Lebistes reticulatus*) about 1.7 cm long; and those in group 3 were fed daily a piece of redworm (*Eisenia foetida*) averaging 1.5 cm in length. The weight of each meal was approximately 75 mg. All food was nonmoving; guppies and worms were prekilled by immersion in water at 55°C.

During feeding, a 15- by 20-cm sheet of aluminum was placed between the turtle and the center of the tank where the food was placed with forceps. Because the metal was wider than the tank, which it split diagonally, the turtle was restrained in one corner. With the food in position, the sheet was removed and the animal was allowed to search for and eat it. Once it began to eat, no turtle ever refused its food. After 12 such feedings each turtle was tested for preference by offering it all three foods.

The test procedure was the same as in the regular feedings except that all three types of food were placed in the center of the tank in a straight line parallel with the diagonal metal sheet hiding the turtle; the foods were placed 2 cm apart and the order of placement was systematically varied from turtle to turtle. Almost invariably the turtle was about equidistant from all three foods when it began to head toward one; it was given 10 minutes to make its first choice and then 10 more minutes to make a second choice.

The results (Table 1) show a general first preference for the original diet, which was chosen by 16 ($p <$ .00003, the binomial test was used for all statistics; $P$, .33). After this test, the turtles received 12 feedings on a different food: group 1, originally fed horsemeat, received worms; group 2 (fish) were given worms; and group 3 (worms) were fed meat. Only 11 feedings were given if the first or second choice in the first test was the food to be given during the second series of feedings. After this second series the choice situation was repeated (Table 1), with each order of presentation different from that used in the first test.

Again there was strong preference for the food originally eaten, which was chosen by 16 ($p < .00003$). Even the results for two of the subgroups are significant, which is surprising because of the smallness of the groups (group 1, $p < .001$; group 3, $p < .05$).

The results seem best interpreted in terms of imprinting since the primacy of the early experience has been clearly shown. Although the limited number of turtles available precluded testing for food preference before any prior feeding, the experimental results and informal observations indicate that chopped horsemeat was the most preferred of the three foods. All subjects originally fed horsemeat preferred it on test 1. Turtles that were not fed horsemeat originally invariably took it in test 1 when the originally fed food was not chosen. And no turtle originally fed horsemeat changed its choice. This preference is probably due

Table 1. Food preference by snapping turtles after 12 days on each of two constant diets. M, horsemeat; F, fish (guppy); W, redworm.

| Turtle (No.) | Original diet | Choice, first test | | Second diet | Choice, second test | |
|---|---|---|---|---|---|---|
| | | First | Second | | First | Second |
| | | | *Group 1* | | | |
| 1 | M | M | | W | M | W |
| 4 | M | M | | W | M | W |
| 7 | M | M | | W | M | W |
| 10 | M | M | W | W | M | W |
| 13 | M | M | W | W | M | F |
| 16 | M | M | W | W | M | W |
| 19 | M | M | | W | M | W |
| | | | *Group 2* | | | |
| 2 | F | M | F | W | F | W |
| 5 | F | M | F | W | F | W |
| 8 | F | M | W | W | W | F |
| 11 | F | F | M | W | F | W |
| 14 | F | F | | W | F | W |
| 17 | F | F | M | W | M | F |
| | | | *Group 3* | | | |
| 3 | W | W | M | M | W | M |
| 6 | W | W | F | M | W | M |
| 9 | W | W | M | M | M | F |
| 12 | W | M | W | M | M | |
| 15 | W | W | M | M | W | M |
| 18 | W | W | M | M | W | M |
| 20 | W | W | M | M | W | M |

to either the type or quantity of chemical stimuli emanating from the meat when it is placed in water. Nevertheless the fact that the group originally fed worms developed a preference for worms, and maintained such preference through an equally long exposure to meat, suggests that food preference in turtles can be modified in a way similar to that shown to obtain in chicks.

One of the original criteria for imprinting was irreversibility (*4*). The status of this concept has not been adequately tested in the laboratory, although indications are that the situation in social imprinting is more complex than was originally assumed (*5*). The study of food imprinting in chicks, however, showed that the results of experience during the critical period strongly resist extinction for at least 10 days. The turtles in our experiment would eat food other than the imprinted one, but, all things being equal, they preferentially selected the imprinted food. Prolongation of the period of original exposure to a particular food may further lower the probability of response to unimprinted foods. This possibility is consistent with observations of hatchling diamondback terrapins (*Malaclemys terrapin*): those reared for an unspecified period on an all-beef diet "consistently refused to accept any other type of food" (*6*).

Our results do not tell us much about involvement of a "critical period" in the imprinting, similar to that demonstrated in chicks (*2*). Since newly hatched turtles can endure long periods without food, it is probable that the first experiences of feeding are important, regardless of their exact times after hatching. Twelve small feedings, or less, suffice to modify food preference, but the amount of food given, the number of consummatory snapping reflexes, or the time interval from the first feeding also are possible factors.

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## Quaternary Stratigraphy

Charles B. Hunt's review of Quaternary geology in the United States, 1 Oct., p. 47, refers to what he calls "an old ailment in Quaternary stratigraphy, the numbers game. Given one glaciation, it must be Wisconsin; given two they must be Wisconsin and Illinoian; given three they must be Wisconsin, Illinoian, and Kansan, and so on."

Certainly, Chamberlin, Leverett, Kay, and others who worked large areas in detail recognized no such premise. That was not the way the Illinoian came to be distinguished from the Kansan. They differentiated drift sheets on the basis of age differences as indicated by weathering and erosion. Field studies have advanced to the point where it can be definitely said that the Pleistocene had at least four continental glaciations separated by interglacials, though it is recognized that a glaciation older than the Nebraskan may yet be found beneath the Nebraskan, as more exposures occur, but it must bear definite record of prolonged weathering before burial.

Mountain glaciation is in another category. The deposits are isolated, subject to different back-wall, side-wall, and axial valley environments. The older deposits of mountain glaciation are usually fragmentary. One who is experienced in the study of the older drifts in the Middle West is aware of the much longer duration of the Yarmouth and Aftonian interglacials than the Sangamon or the Recent, and is better oriented to recognize older mountain glaciation. Although exacting study of field evidence is given first place, the number of deposits of distinctly different age may aid in reaching conclusions. By this discipline we have no "numbers game." Otherwise, our study of glaciation can lay no claim to science.

Correlation of glacial substages of mountain glaciation with those of continental glaciation is more subtle than that of glacial stages. Although the climatic changes that bring about successive substages are believed to be worldwide and may affect continental glaciations fairly consistently, the factors affecting mountain glaciation and deglaciation are so variable that substages may not be distinguishable from interstadials between a succession of retreatal moraines. Moreover, the admissibility of radiocarbon datings must be critically assessed. Reliable analytical practice in chemistry requires duplicate analysis; radiocarbon determinations, which commonly meet with more unknown factors than does chemical analysis, should receive no less than equal care.

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