DIET MANIPULATION AFFECTS SOCIAL BEHAVIOR OF CATFISH: Importance of Body Odor

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Abstract—Diet manipulation, an habituation test, and chemical analysis of urinary free amino acids were used to demonstrate that bullhead catfish (Ictalurus nebulosus) naturally detect the body odors of conspecifics and respond to them in a predictable fashion. These signals are used in dominance and territorial relationships and lead to increased aggression toward chemical "strangers." The results support the general notion that nonspecific metabolites, as well as specific pheromones, are important in chemical mediation of social behavior.

Key Words—Pheromones, body odors, catfish, diet, Ictalurus nebulosus, social behavior, amino acids, urine.

INTRODUCTION

Body odor is the sum of all perceivable compounds in excreta and secreta. Pheromones represent a specialized portion of this odor complex and play an important role in the formation and maintenance of many vertebrate social relationships (Müller-Schwarze, 1974; Doty, 1976). They represent the social chemical "sign stimuli" (Tinbergen, 1951; Brown, 1975) which tend to be of discrete chemical composition and are usually associated with stereotyped physiological or behavioral responses (Wilson and Bossert, 1963; Wilson, 1975). These latter responses are generally thought not to be dependent upon learning. Commonly, pheromone synthesis is glandular and release is under voluntary control (Albone, 1984; Liley, 1982). Body odors, on the other hand, are typi-

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cally chemically complex (Müller-Schwarze, 1969; Beruter et al., 1973; Evans et al., 1978; Preti et al., 1977) and consist of general metabolic waste-products rather than specifically synthesized compounds. It has been suggested that at least in mammals, chemical complexity in social stimuli may be common (Beauchamp et al., 1976). In addition, these types of stimuli tend to be used in behavioral contexts which allow or depend upon considerable plasticity or variation in response (Beauchamp et al., 1976).

In fish, a role for social chemical stimuli has been demonstrated primarily in behavior leading to spawning (Liley, 1982). These chemical stimuli function as sex- or species-specific attractants (Keenleyside, 1955; Kendle, 1968; Gandolfi, 1969; Mainardi and Rossi, 1968; Newcombe and Hartman, 1973; Chen and Martinich, 1975; Ingersoll and Lee, 1980; Teeter, 1980) or as indicators of reproductive status (Tavolga, 1956; Partridge et al., 1976; Crow and Liley, 1979; Honda, 1979, 1980a, Ingersoll and Lee, 1980; Crapon de Carpona, 1980). In addition, population-specific odors are implicated in home stream recognition (Selset and Øving, 1980). Equally important and less well studied are those chemical stimuli associated with pair-bonding (MacGintie, 1939) or dominance and territorial behavior (Todd, 1968; Todd et al., 1967). MacGintie (1939) demonstrated that mated blind gobies (Typhlogobius californiensis) chemically perceive gender, evicting nest intruders of the same sex. Similarly, in dominance and territorial behavior, the recognition of traits such as gender, individuality, or physiological or social status may also be mediated by chemical stimuli.

Todd et al. (1967) and Richards (1976), using sensory ablation (cautery) and behavioral conditioning methods, inferred that olfaction is important in the dominance and territorial behavior of several ictalurid catfish species. Their experiments, while demonstrating sensory capabilities, do not demonstrate which stimuli or biological traits the fish actually respond to during normal unconditioned behavior. In addition, sensory ablation can cause confounding effects by affecting aspects of behavior that are not normally mediated by the ablated sense, i.e., general motivation (Alberts, 1974). An attractive alternative to manipulation of the sensory system is to manipulate the stimulus and observe unconditioned responses to it. By altering a portion (chemical, visual, etc.) of a stimulus complex, it is possible to determine if and how that portion contributes to behavior.

We were interested in determining the importance of nonpheromonal metabolites in social behavior. To this end, we examined the chemosensory basis of bullhead catfish social behavior by changing the chemical output of one of a pair of socially interacting fish by diet manipulation. Behavioral observations indicated that changing the diet of one of the fish resulted in altered behavior of the other fish. That the observed change in behavior was due to chemical stimuli was supported by two lines of evidence. First, results from a behavioral bioassay based on habituation comparisons indicated that urine from donor fish,