

## Ethogram of *Sacalia quadriocellata* (Reptilia: Testudines: Geoemydidae) in Captivity

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**ABSTRACT.**—To construct an ethogram of *Sacalia quadriocellata* and introduce coding system into chelonian behavior research for quantitative comparison, 15 captive *S. quadriocellata* (eight females and seven males) were observed for one year using a digital surveillance system, and an ethogram constructed. Fourteen types of states and 84 types of events were recorded. Seventy-five behaviors were defined and described, and these were classified into eight categories of behavior: Feeding, Elimination, Conflict, Alert, Rest, Locomotion, Courtship, and Other. Feeding, Elimination, and Locomotion are frequent behaviors, whereas Conflict and Other behaviors are seldom observed. Mainly, this may be caused by environmental conditions that eliminate these plastic behaviors (e.g., Conflict and Other behaviors) and keep the nonplastic behaviors (e.g., Feeding, Elimination, and Locomotion). Finally, the comparison between *S. quadriocellata* and other chelonian species indicate that the behavioral patterns are similar on the whole, but the Conflict behaviors of *S. quadriocellata* are milder than other species.

Behavior is an essential aspect of a species' natural history. An initial step in behavioral research involves the construction of an ethogram (Immelmann, 1980; Martin and Bateson, 1993; Lehner, 1996). Based on the ethogram, documenting the similarities and differences in species' behavior is possible. Unfortunately, comparison of behaviors among species is often complicated by the use of unique, nonstandardized characters that may or may not be homologous (McFarland, 1987). Accurate, standardized descriptions are essential for comparative behavior.

The Four-Eyed Turtle, *Sacalia quadriocellata*, has received various levels of protection in China. It has been designated as endangered (Zhao, 1998) and subsequently as vulnerable to extinction (Wang and Xie, 2004). The species has been listed in Appendix III of CITES as of 2004 and as threatened by the IUCN in 1996. Not only will behavioral studies on *S. quadriocellata* add to our limited knowledge of freshwater turtle behavior, but also they may help address pressing conservation issues. An understanding of the behaviors of endangered and threatened species has great preservation and protection value. For example, responses of the Desert Tortoise (*Gopherus agassizii*) to relocation (Berry, 1986), to barriers (Boarman et al., 1992), and to captive breeding help in the management of this species (Ruby and Niblick, 1994).

For *S. quadriocellata*, activity cycles in nature (Shi et al., 2002) and habits and diet in captivity (Zhou, 1997; Wang et al., 2005) have been described, but an entire ethogram has not been constructed. Herein, all states, events, and behaviors (Martin and Bateson, 1993; Lehner, 1996) of *S. quadriocellata* are recorded and defined. The behaviors are used to construct an ethogram. All states, events, and behaviors are

described and standardized. Each behavior is coded with a state code and an event code.

### MATERIALS AND METHODS

**Experimental Procedure.**—Fifteen *S. quadriocellata* (seven males and eight females) were captured from Qiongzong County, Hainan Province, China, and kept in captivity for several years prior to this study. The turtles were maintained in three 60 × 80 cm indoor cement pools with a glass front. Males and females were housed separately. Each pool had a water depth of 20–25 cm and contained an inverted basin with a diameter of 25 cm to provide both shelter and a basking platform. Turtles were fed a diet of shrimp, chopped pork, liver, heart, tomato, banana, and vegetables. The photoperiod was the same as outside, and UVB lamps were used during the daytime. Air temperature, water temperature, and air humidity were recorded daily.

From June 2003 through May 2004, turtle behavior was recorded on six randomly selected days per month, with observation periods lasting 24 h. Individual turtles were randomly sorted into groups of either two males and three females or three males and two females, and then returned to the same-sex groups after the observation period. The diet and environmental conditions during observations were the same as above.

Four SUNMOON-820 video cameras were placed in front of the glass to record the turtles' behaviors. The cameras used a 1/3 SONY Super HAD CCD DC12V video card (minimum contrast 0.005 Lux/F1, PAL format) shot at 12.5 frame/s. A "WS" multimedia digital surveillance system (Vansion Electronic Scientific and Technical Corporation, Shenzhen, China) was used to store and play the videos. All-occurrence recording (i.e., recording all behaviors occurring in the observation period) was used to record behaviors,

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tracking the type, duration, and frequency of all behaviors within the given period.

*Description and Quantification.*—Observed behaviors were described, and states and events were numerically coded. To categorize the location of the event type, the body was divided into five regions: mouth, head and neck, eyes and nose, limbs, and tail. All of these states and events were coded with consecutive numbers (for details, see Appendices 1 and 2). A series of states and events were separately recorded and combined to form patterns, and all behavior frequencies were recorded in both males and females.

#### RESULTS

*Ethogram.*—The ethogram for *S. quadriocellata* consists of 75 behaviors, categorized into eight types. "Other" includes behaviors that seldom occur and whose functions are unknown. The codes of states and events in every behavior and the frequency in both males and females are recorded in Table 1. Most of these behaviors are self-explanatory, but some ambiguous behaviors are concisely described in Appendix 3.

The frequency of every behavior in males and females is given in Table 1. Feeding, Evading, Alert, Resting, and some of locomotion were observed in every individual. Elimination, Threatening, Avoiding, Biting, Retreating, Fleeing, Sleeping, and Climbing and Rushing wall were frequently observed but did not occur in every individual. Finally, some behaviors only occurred infrequently (e.g., Alert jumping, Creeping sideways, Drawing with head, Pushing aside with limbs).

There are also some differences in the frequencies of certain behaviors between males and females (see Table 1). The main difference is found in courtship behavior. Each courtship behavior type is only observed in a single sex and is absent in the other sex.

*Comparisons.*—Most chelonians appear to express similar behaviors. Behavioral states listed in Appendix 1 vary slightly among different chelonian species. Table 2 compares main courtship events for six species of chelonians. Because only data on courtship behavior are available from another five species, we restricted our comparison to these taxa. Nearly all courtship events occurred in the six species, except for "vibrate toes and nails," "holding tail with legs," and "open and close shell." Two additional types of behavior also occurred in *S. quadriocellata*, although these did not occur in courtship: "pull" and "rotate palm."

Table 3 compares behavioral attributes of six chelonian species. Because of the limited amount of data, a complete comparison is possible only for *G. agassizii* and *S. quadriocellata*. Locomotion and Feeding behaviors are available for *Trionyx triunguis*, and only courtship behavioral data are available for *Clemmys insculpta*, *Terrapene carolina carolina*, and *Kinostemon subrubrum hippocrepis* (Table 3). Substantial discrepancies between *G. agassizii* and *S. quadriocellata* occur in Locomotion, Feeding, and Thermoregulatory behaviors. Almost all behaviors are shared between *S. quadriocellata* and the other species.

#### DISCUSSION

The ethogram summarizes the most basic behaviors of a particular species. This study evaluates many

behaviors of captive *S. quadriocellata* and marks the beginning of behavioral studies of this species. Because standardized language is used to describe every behavior, the comparisons among different species are now possible and can form a framework for building ethograms for others. The ethogram of *S. quadriocellata* consists of 75 behaviors, made up of 14 state types, and 84 events.

It is possible that the low frequency of some behaviors (Table 1) is an artifact of captivity and that other behaviors observed in nature may have been missed altogether (Jiang et al., 2001). When food and living space are limited, inflexible behaviors are released, but flexible behaviors either may not be released or may be released at such a low frequency that they are not detected. The limited space of the indoor artificial pools may explain why some behaviors (e.g., Feeding behavior, Resting behavior, Locomotion, Conflict, Elimination, and Sleeping) were recorded frequently, whereas other behaviors were less commonly observed. Environmental enrichment can extend activity time and increase behavioral diversity in some captive animals (e.g., Swaisgood et al., 2001). Thus, the lack of environmental diversity may have resulted in decreased behavioral diversity in *S. quadriocellata*. In addition to limited space, stress in captivity from human disruption also can inhibit behavior (Newton, 1982; Isreali and Kimmel, 1996). These factors may have influenced the frequency of observed behaviors in our study.

Table 2 compares main courtship events for *S. quadriocellata* to the data available for five other turtle species. Nearly all courtship events occurred in the six species. However, five courtship events were absent in *S. quadriocellata*: "Vibrate toes and nails," "Rotate palm," "Holding tail with legs," "Open and close shell," and "Pull" (Table 2). The absence of most of these events can be explained based on morphological differences. Two of these events ("Vibrate toes and nails" and "Rotate palm") are unique in the "Titillation" behavior of some species (e.g., *Chrysemys picta bellii*). "Titillation" is facilitated by males having elongated forelimb claws to vibrate and knock on a female's head and eye area to make their head withdraw into shell, which can effectively reduce female's rejection behavior especially Biting behavior in courtship. It is considered to be a specific tactile signal used to calm females (Jackson and Davis, 1972). The event "Holding tail with legs" can only occur in species in which the male has scaly patches on their legs. These patches hold the female's tail during copulation (Mahmoud, 1967). The event "Open and close shell" can only occur in the species with a hinged plastron, which is absent in *S. quadriocellata*. Finally, the unique event "Pull" subdues the female to allow the male to adjust his position for copulation. This event is present in *K. s. hippocrepis* (Mahmoud, 1967) and *T. c. carolina* (Evans, 1953). Although there does not seem to be any morphological difference causing the absence of this event in *S. quadriocellata*, the events "Head-bobbing" and "Adjusting on female's back" seem serve the same function as "Pull" behavior of *K. s. hippocrepis* and *T. c. carolina* in *S. quadriocellata* (Liu et al., 2008).

Data on general turtle behaviors are available for five turtle species, although the data are incomplete.

TABLE 1. Coding system for the behaviors of *S. quadriocellata*. Symbols in state codes and event codes are as follows: “;” = and; “/” = or; “→” = transfer from one state to another.

| Behavior                            | Proportion<br>in males<br>(%) | Proportion<br>in females<br>(%) | Codes       |                                 |
|-------------------------------------|-------------------------------|---------------------------------|-------------|---------------------------------|
|                                     |                               |                                 | State codes | Event codes                     |
| <b>Feeding</b>                      |                               |                                 |             |                                 |
| Searching underwater                | 100.00                        | 100.00                          | 8           | 10,12,37                        |
| Sniffing food                       | 100.00                        | 100.00                          | 9           | 10,12,37                        |
| Sniffing and touching food          | 100.00                        | 100.00                          | 1           | 14,18,16,36                     |
| Feeding while standing              | 100.00                        | 100.00                          | 3           | 1,2,3,5,11,14,15,16,17          |
| Feeding while flattened             | 100.00                        | 100.00                          | 1           | 1,2,3,11,14,16,53,54            |
| Pressing food                       | 100.00                        | 100.00                          | 1           | 61                              |
| Biting and pulling food             | 100.00                        | 100.00                          | 1           | 1,2,3,5,14,16                   |
| Assisted swallowing                 | 100.00                        | 100.00                          | 1           | 62,72                           |
| Swallowing in water                 | 100.00                        | 100.00                          | 1           | 1,3,4,6,14,19                   |
| <b>Elimination</b>                  |                               |                                 |             |                                 |
| Defecating while standing in water  | 28.57                         | 50.00                           | 1           | 14,16,77,82,83                  |
| Defecating while flattened in water | 28.57                         | 50.00                           | 5           | 14,16,20,77,82,83               |
| <b>Conflict</b>                     |                               |                                 |             |                                 |
| Approaching                         | 57.14                         | 37.50                           | 2           | 12,32                           |
| Threatening by staring              | 57.14                         | 50.00                           | 1           | 14,26,32                        |
| Threatening by raising neck         | 57.14                         | 50.00                           | 1           | 8,15,41,44                      |
| Threatening by extending neck       | 57.14                         | 50.00                           | 1           | 8,13                            |
| Threatening by unsuccessful biting  | 57.14                         | 50.00                           | 1           | 1,2,3,11,14,16,53               |
| Threatening by chasing              | 57.14                         | 37.50                           | 6/7         | 26,33                           |
| Threatening by evading              | 57.14                         | 50.00                           | 1           | 14,16,53,54                     |
| Biting                              | 71.43                         | 75.00                           | 1           | 1,2,3,11,14,53                  |
| Evading face-to-face                | 100.00                        | 100.00                          | 4           | 16,22,42,45                     |
| Evading side                        | 100.00                        | 100.00                          | 4           | 16,22/23,47                     |
| Retreating                          | 42.86                         | 62.50                           | 12          | 16,23                           |
| Avoiding and escaping face-to-face  | 57.14                         | 50.00                           | 4           | 16,22,42,45,53                  |
| Avoiding and escaping side          | 57.14                         | 50.00                           | 4           | 16,22/23,47,51,53               |
| Chasing                             | 28.57                         | 50.00                           | 6/7         | 26,32                           |
| Fleeing                             | 42.86                         | 62.50                           | 6/7         | 21                              |
| Pacification                        | 42.86                         | 0.00                            | 1           | 17,16,26                        |
| <b>Alert</b>                        |                               |                                 |             |                                 |
| Looking around                      | 100.00                        | 100.00                          | 1/5         | 8,13,32                         |
| Evading                             | 100.00                        | 100.00                          | 5           | 3,16,22/23,29,35,38,39/40,45,46 |
| Retreating                          | 100.00                        | 100.00                          | 2/12        | 16,26                           |
| <b>Rest</b>                         |                               |                                 |             |                                 |
| Resting and show head               | 100.00                        | 100.00                          | 5           | 26,34,35,78                     |
| Resting and showing snout           | 100.00                        | 100.00                          | 5           | 23,34,35,78                     |
| Resting on the wall                 | 100.00                        | 100.00                          | 3           | 26,34,35,75,78                  |
| Sleeping with extended neck         | 57.14                         | 62.50                           | 5           | 25,34,35,60/68,59/69,79         |
| Sleeping with withdrawn neck        | 57.14                         | 62.50                           | 5           | 23/26,34,35,60/68,59/69,79      |
| <b>Locomotion</b>                   |                               |                                 |             |                                 |
| Creeping slowly                     | 100.00                        | 100.00                          | 2           | 13,23/26                        |
| Running                             | 100.00                        | 100.00                          | 6           | 13,23/26                        |
| Walking while swimming              | 100.00                        | 100.00                          | 6/7         | 13,23/26                        |
| Swimming                            | 100.00                        | 100.00                          | 7           | 13,23/26                        |
| Climbing                            | 100.00                        | 100.00                          | 3           | 14,12,50,41,42,51               |
| Jumping down                        | 28.57                         | 50.00                           | 10          | 8,14,27,31,52,53                |
| Alert jumping                       | 0.00                          | 12.50                           | 1           | 16,23/26,52,53                  |
| Creeping sideways                   | 14.29                         | 25.00                           | 1           | 13/23/26,66,70,67,71            |
| Looking around                      | 100.00                        | 100.00                          | 1/5/13/14   | 13,31,10                        |
| Crowding                            | 100.00                        | 100.00                          | 1           | 23,51,52,53                     |
| Synchronized scratching             | 0.00                          | 12.50                           | 1           | 26,56                           |
| Turning over                        | 100.00                        | 100.00                          | 11→1        | 10,26,18,16                     |
| Turning about                       | 100.00                        | 100.00                          | 1           | 51,53,70,71                     |
| Surfacing                           | 100.00                        | 100.00                          | 3           | 13, 26                          |
| Diving                              | 100.00                        | 100.00                          | 7           | 27,23/26                        |

TABLE 1. Continued.

| Behavior                          | Proportion<br>in males<br>(%) | Proportion<br>in females<br>(%) | Codes       |                               |
|-----------------------------------|-------------------------------|---------------------------------|-------------|-------------------------------|
|                                   |                               |                                 | State codes | Event codes                   |
| <b>Courtship</b>                  |                               |                                 |             |                               |
| Approaching                       | 100.00                        | 0.00                            | 2           | 12,32                         |
| Chasing                           | 100.00                        | 0.00                            | 6/7         | 26,32                         |
| Cloaca sniffing and contacting    | 100.00                        | 0.00                            | 9           | 10,12,37                      |
| Bridge sniffing and contacting    | 100.00                        | 0.00                            | 9           | 10,12,37                      |
| Head sniffing and contacting      | 100.00                        | 0.00                            | 9           | 10,12,37                      |
| Hind limb sniffing and contacting | 100.00                        | 0.00                            | 9           | 10,12,37                      |
| Standing by                       | 100.00                        | 0.00                            | 1/13        | 13,31,10                      |
| Anterior turning movements        | 100.00                        | 0.00                            | 2           | 14/26,32,70,71                |
| Posterior turning movements       | 100.00                        | 0.00                            | 2           | 14/26,32,70,71                |
| Head-bobbing                      | 100.00                        | 0.00                            | 1           | 7,13,14,15,16,17,20,42,44,57  |
| Mounting                          | 100.00                        | 0.00                            | 1           | 10,14,33,74,75,76             |
| Adjusting on female's back        | 100.00                        | 0.00                            | 2           | 14/26,32,70,71                |
| Copulation                        | 100.00                        | 0.00                            | 3           | 10,14,42,74,75,80,81,82,83,84 |
| Alerting                          | 0.00                          | 100.00                          | 1/5         | 8,13,32                       |
| Biting                            | 0.00                          | 100.00                          | 1           | 1,2,3,11,14,53                |
| Fleeing                           | 0.00                          | 100.00                          | 6/7         | 21                            |
| <b>Other</b>                      |                               |                                 |             |                               |
| Climbing wall                     | 42.86                         | 62.50                           | 3           | 14,12,42,64                   |
| Clawing head                      | 100.00                        | 100.00                          | 1           | 26,27,63,48                   |
| Forelimbs paddling                | 28.57                         | 50.00                           | 1           | 26,48,52/56                   |
| Hind legs paddling                | 42.86                         | 25.00                           | 1           | 26,49,57                      |
| Hind legs patting                 | 0.00                          | 12.50                           | 5           | 58                            |
| Drawing with head                 | 0.00                          | 12.50                           | 1           | 17,27,10,9,16,53,54           |
| Forelimbs pushing aside           | 14.29                         | 25.00                           | 1           | 61,48,64                      |
| Hind legs pushing aside           | 14.29                         | 0.00                            | 1           | 61,49,65                      |
| Rushing wall                      | 42.86                         | 62.50                           | 1           | 23,52,53                      |

TABLE 2. Comparisons of main courtship events that occur in six species of freshwater turtles. "—" = not mentioned in the literature; "?" = not mentioned but possibly present.

| Events                    | <i>Chelydra serpentina</i> | <i>K. s. hippocrepis</i> | <i>C. p. bellii</i> | <i>Clemmys insculpta</i>     | <i>T. c. carolina</i> | <i>S. quadriocellata</i>                   |
|---------------------------|----------------------------|--------------------------|---------------------|------------------------------|-----------------------|--|
| References                | Legler, 1955               | Mahmoud, 1967            | Taylor, 1933        | Evans, 1961                  | Evans, 1953           | This report                                |
| Mouth                     |                            |                          |                     |                              |                       |  |
| Bite                      | Males, females             | Males, females           | —                   | Males only                   | Males only            | Females only,<br>both sexes<br>in conflict |
| Head and neck             |                            |                          |                     |                              |                       |  |
| Wave neck                 | Horizontally               | Vertically               | —                   | Horizontally<br>(Carr, 1952) | —                     | Vertically                                 |
| Extend neck               | Yes                        | Yes                      | ?                   | Yes                          | Yes                   | Yes  |
| Limbs                     |                            |                          |                     |                              |                       |  |
| Grasp and relax           | Males only                 | Males only               | Males only          | Males only                   | Males only            | Males only                                 |
| Vibrate toes<br>and nails | No                         | No                       | Yes                 | No                           | No                    | No   |
| Rotate palm               | No                         | No                       | Yes                 | No                           | No                    | Not in<br>courtship                        |
| Holding tail<br>with legs | No                         | Yes                      | No                  | No                           | No                    | No   |
| Open and close<br>shell   | No                         | No                       | No                  | No                           | Yes                   | No   |
| Tail                      |                            |                          |                     |                              |                       |  |
| Wave to search            | Yes                        | Yes                      | Yes                 | ?                            | Yes                   | Yes  |
| Grasp the<br>other's tail | Yes                        | Yes                      | Yes*                | Yes                          | Yes                   | Yes  |

\*Cited from Davis and Jackson (1970)

TABLE 3. Comparisons of main behaviors that occur in six species. “—” = not mentioned in the literature; “?” = not mentioned but possibly present.

| Behaviors               | <i>G. agassizii</i>    | <i>K. s. hippocrepis</i> | <i>Tr. triunguis</i>   | <i>Cl. insculpta</i> | <i>T. c. carolina</i> | <i>S. quadriocellata</i> |
|-------------------------|------------------------|--------------------------|------------------------|----------------------|-----------------------|--------------------------|
| References              | Ruby and Niblick, 1994 | Mahmoud, 1967            | Burghardt et al., 1996 | Evans, 1961          | Evans, 1953           | This report              |
| <b>Locomotion</b>       |                        |                          |                        |                      |                       |                          |
| Swimming                | No                     | Yes                      | Yes                    | Circle               | —                     | Yes                      |
| Surfacing               | No                     | Yes                      | Yes                    | —                    | —                     | Yes                      |
| Diving                  | No                     | Yes                      | Yes                    | —                    | —                     | Yes                      |
| Yawn                    | Yes                    | —                        | —                      | —                    | —                     | No                       |
| <b>Feeding</b>          |                        |                          |                        |                      |                       |                          |
| Assistant swallow       | Yes                    | —                        | Yes                    | —                    | —                     | Yes                      |
| Drink                   | Yes                    | —                        | —                      | —                    | —                     | No                       |
| Swallowing in water     | No                     | —                        | Yes                    | —                    | —                     | Yes                      |
| <b>Conflict</b>         |                        |                          |                        |                      |                       |                          |
| Approaching             | Yes                    | —                        | Yes                    | —                    | —                     | Yes                      |
| Bite                    | Nip, hold biting       | —                        | Bite                   | —                    | —                     | Bite                     |
| Aggressive climbing     | Yes                    | —                        | —                      | —                    | —                     | No                       |
| Rams                    | Yes                    | —                        | —                      | —                    | —                     | Ram wall                 |
| <b>Courtship</b>        |                        |                          |                        |                      |                       |                          |
| Sniff                   | Yes                    | Yes                      | Yes                    | Yes                  | ?                     | Yes                      |
| Bite                    | Nip, biting            | Hold biting              | —                      | Snap\                | Nip, bite             | Females only             |
| Head movement           | Vertically             | Vertically               | —                      | Horizontally*        | —                     | Vertically               |
| <b>Thermoregulatory</b> |                        |                          |                        |                      |                       |                          |
| Water dropping          | Yes                    | No                       | No                     | No                   | No                    | No                       |
| Basking                 | Yes                    | —                        | —                      | —                    | —                     | Dry body                 |
| Burrowing               | Yes                    | —                        | —                      | —                    | —                     | No                       |

\* Cited from Carr (1952)

Therefore, we limit our comparisons to the two species that are more complete, *G. agassizii* and *Tr. triunguis* (Table 3). The main differences in Locomotion, Feeding, and Thermoregulatory behaviors of *G. agassizii*, *Tr. triunguis*, and *S. quadriocellata* are related to the species occurring in different habitats—terrestrial and aquatic. With *S. quadriocellata* and *Tr. triunguis* both being aquatic species, behaviors are much more similar. Both aquatic species have locomotion behaviors of swimming, diving and feed in water, all of which are not present in *G. agassizii*. In Thermoregulatory behavior, *G. agassizii* thermoregulates by Burrowing and Water dropping, whereas *S. quadriocellata* does not. All of them are attributed to different habitats. In addition, *S. quadriocellata* display a milder manner in Conflict behavior (Table 3) that is coincident with former research (Zhou, 1997; Shi et al., 2002)

Ethograms summarizing chelonian behavior should include both structure and function. Combined, states and events are the most basic elements that form animal behavior (Martin and Bateson, 1993; Lehner, 1996). Accordingly, the structure of behavior is composed of at least two levels: the first level includes states and events, and the second level is behavioral patterns. When an ethogram is constructed, the behaviors must be categorized into the two levels to make comparisons valid. Interspecific comparisons of behaviors belonging to different levels are valid. The

two behaviors must be different, because they are from different levels. Thus, the structure criterion is very important in the construction of an ethogram. The functional criterion is also very important when summarizing behavior. Ignoring this distinction may result in confusion. For example, Table 1 shows that “Approaching” occurs both in “Conflict” and “Courtship” behaviors. Similarly, “Sniffing” could be incorrectly combined into a single behavior; “Sniffing food” and “Sniffing and contacting” during “Feeding” and “Courtship,” respectively. When function is not considered, these two behaviors could be confused because the elements have the same state codes and event codes. Our descriptive method will greatly facilitate interspecific comparisons. Although further work needs to be done, our study provides an initial framework for understanding the behaviors of freshwater turtles.

*Acknowledgments.*—Experiment protocols were developed in consultation with, and oversight of, H.-c. Mi, master of Hainan Livestock Modification Centre, Haikou. We thank R. MacCulloch for valuable comments on the manuscript. L.-J. Wang gave us many useful suggestions from the beginning of this study. C. Yun, Y.-g. Ma, M.-g. Hu, and L.-y. He provided valuable assistance. This research was supported by the Natural Science Foundation of China (30260019 and 30660026) and the Hainan Key

Project of Science and Technology (06122). International collaboration was supported by Cleveland Zoo. Grants to RWM were received from the Board of Governors, Royal Ontario Museum, and the Natural Sciences and Engineering Research Council of Canada (Discovery Grant A3148).

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Accepted: 19 August 2008.

APPENDIX 1. Fourteen state types were recorded and given state codes. All states, as defined here, occurred in both males and females.

| State     | Code | Descriptions  |
|-----------|------|---|
| Standing  | 1    | Supporting the body with limbs outside the shell.                     |
| Creeping  | 2    | Slowly crawling forward by alternating limb movement.                 |
| Climbing  | 3    | Supporting body with hind legs, with forelimbs moving as if climbing. |
| Hiding    | 4    | Withdrawing into shell to protect soft body parts.                    |
| Flattened | 5    | Supporting body with plastron while maintaining inactivity.           |
| Running   | 6    | Crawling forward quickly with alternating limb movement.              |
| Swimming  | 7    | Paddling with limbs alternating to move forward.                      |
| Searching | 8    | Fully extending neck underwater while moving forward.                 |
| Smelling  | 9    | Standing still while extending neck toward an object.                 |
| Jumping   | 10   | Moving from a high to low position suddenly.                          |

## APPENDIX 1. Continued.

| State      | Code | Descriptions   |
|------------|------|--|
| Lying      | 11   | Lying on the land by carapace.   |
| Retreating | 12   | Moving limbs alternately to move backward.                             |
| Rearing    | 13   | Standing with all limbs fully extended.                                |
| Sitting    | 14   | Supporting body with fully extended forelimbs and withdrawn hind legs. |

APPENDIX 2. Eighty-four events were recorded, event coded, and assigned to one of these five body regions.

| Event                        | Code |
|------------------------------|------|
| <b>Mouth</b>                 |      |
| Open mouth                   | 1    |
| Bite                         | 2    |
| Close mouth                  | 3    |
| Swallow                      | 4    |
| Pull                         | 5    |
| Vocalize and swallow         | 6    |
| <b>Head and neck</b>         |      |
| Wave neck up and down        | 7    |
| Throat move                  | 8    |
| Draw with neck               | 9    |
| Neck bend                    | 10   |
| Neck turn                    | 11   |
| Unbend neck                  | 12   |
| Head up                      | 13   |
| Extend neck                  | 14   |
| Neck raise                   | 15   |
| Withdraw neck                | 16   |
| Neck lower                   | 17   |
| Head butt                    | 18   |
| Spit out                     | 19   |
| Neck suppress                | 20   |
| Face upward                  | 21   |
| Neck completely withdrawn    | 22   |
| Show snout                   | 23   |
| Neck turn backward           | 24   |
| Relax neck                   | 25   |
| Show head                    | 26   |
| Flattened                    | 27   |
| Head raise up                | 28   |
| <b>Eye and nose</b>          |      |
| Close eyes                   | 29   |
| Open eyes                    | 30   |
| Look over                    | 31   |
| Watch                        | 32   |
| Stare                        | 33   |
| Exhale                       | 34   |
| Inhale                       | 35   |
| Touch with muzzle            | 36   |
| Sniff                        | 37   |
| Vocalize with whiff          | 38   |
| Aspirate                     | 39   |
| Spray water                  | 40   |
| <b>Limbs</b>                 |      |
| Forelimbs supported straight | 41   |

## APPENDIX 2. Continued.

| Event                                 | Code |
|---------------------------------------|------|
| Hind legs supported straight          | 42   |
| Forelimbs supported bent              | 43   |
| Hind legs supported bent              | 44   |
| Withdraw forelimbs                    | 45   |
| Withdraw hind legs                    | 46   |
| Body supported with limbs on one side | 47   |
| Stand without a forelimb              | 48   |
| Stand without a hind leg              | 49   |
| Climbing with forelimbs               | 50   |
| Step with forelimbs                   | 51   |
| Forelimbs scratch back                | 52   |
| Hind legs kick back                   | 53   |
| Forelimbs extend and support          | 54   |
| Hind legs kick back                   | 55   |
| Forelimbs paddle                      | 56   |
| Hind legs paddle                      | 57   |
| Hind legs pat                         | 58   |
| Hind legs extend backward             | 59   |
| Forelimbs extend forward              | 60   |
| Press                                 | 61   |
| Forelimbs scrape mouth                | 62   |
| Claw                                  | 63   |
| Forelimbs scratch side                | 64   |
| Hind legs scratch side                | 65   |
| Forelimbs kick side                   | 66   |
| Hind legs kick side                   | 67   |
| Forelimbs bend backward               | 68   |
| Hind legs extend side                 | 69   |
| Forelimbs step side                   | 70   |
| Hind legs step side                   | 71   |
| Forelimbs support alternately         | 72   |
| Rotate palm of forelimbs              | 73   |
| Hold in arm by forelimbs              | 74   |
| Grasp and relax                       | 75   |
| Hind legs clutch                      | 76   |
| <b>Tail</b>                           |      |
| Straighten                            | 77   |
| Curl into shell                       | 78   |
| Relax                                 | 79   |
| Wave to search                        | 80   |
| Grasp the other tail                  | 81   |
| Open cloaca                           | 82   |
| Close cloaca                          | 83   |
| Insert penis                          | 84   |

## APPENDIX 3

## Ethogram

## Feeding

Pressing food: Pressing food on the ground with forelimbs.

Biting and pulling food: After pressing food, neck is extended and mouth opened to bite food. Next, the neck is withdrawn to tear food.

Assisted swallowing: While swallowing food, scratching mouth from the corner of mouth forward to the snout with alternating forelimbs until the food is swallowed.

Swallowing in water: Opening and closing mouth while extending and retracting the neck quickly, with vocalization (sounds like "ze, ze") until the

food is swallowed. Food that cannot be swallowed is expelled.

#### Conflict behavior

**Approaching:** Approaching slowly, while, with neck extended, staring at another individual.

**Threatening by evading:** While retreating slowly, moves body forward and backward with neck extending and withdrawing repeatedly.

**Evading face-to-face:** When the attack is from the front, withdrawing neck and forelimbs, with hind limbs supporting body.

**Avoiding and escaping face-to-face:** Similar to the "Evading face-to-face," but after recovery, swimming with hind legs to escape.

**Pacification:** After displaying conflict behaviors, the individual lowers its body and withdraws its neck before leaving.

#### Alert behavior

**Evading:** Withdrawing head and limbs completely and closing eyes while quickly exhaling. A vocalization that sounds like "chi" occurs.

#### Resting behavior

**Resting on the wall:** Resting body on a wall using its limbs for support and keeping quiet with head extended.

**Sleeping with extended neck:** Keeping quiet and relaxing limbs, tail, and head with neck extending out of the shell.

#### Locomotion

**Walking while swimming:** Alternating walking and swimming in shallow water.

**Alerted jumping:** When afraid, neck quickly with drawing while forelimbs and hind legs kick back at the same time to move quickly.

**Creeping sideways:** Supporting body with the limbs on one side of the body, while the other limbs move to cause horizontal movement.

**Crowding:** Withdrawing head into the shell and moving limbs vigorously to push body forward, to scramble for cover with other turtles.

**Turning over:** With carapace against the floor, fully extending neck and turning over to use nose as support against the ground, thus making its body return to a standing state.

**Synchronized scratching:** While standing on the floor, the forelimbs scratch together several times.

**Turning about:** Moving limbs on one side of body to move a short distance, while the other limbs step sideways to pivot body.

#### Courtship behavior

**Approaching:** After a male and female encounter each other, the male turns its body toward the female, moving slowly (either swimming or walking on the bottom of the pool) toward female, with its neck protruding and pointing at the female, while the female is quiet. This behavior occurs at the beginning of every courtship interaction.

**Standing by:** When the female stops moving, the male also stops his movement, stands still, and looks around.

**Anterior turning movements:** The male adjust his body to the female's anterior area, with his head pointing toward her head, to begin the next behavior.

**Posterior turning movement:** The male turns toward the female's side or posterior area, to begin his next behavior.

**Head-bobbing:** When male and female are face-to-face, he lifts his fore body with his two hind limbs. With his neck fully extended, he lowers his fore body to touch his chin to her forehead. This pattern occurs rapidly and is repeated many times.

**Mounting:** The male climbs up the female's back from front, rear, or side with his claws grasping her marginal scutes. Simultaneously, the male fully extends his neck to point at the female's head. At this point, the two are parallel.

**Adjusting on female's back:** The male adjusts his angle and relative position with the female, usually by moving backward, to find the most ideal copulation state.

**Copulation:** After obtaining a copulation state with his neck fully extended to point at the female's head, the male grasps the female's tail with his tail, then everts and inserts his penis into the female's cloaca. In this pattern, their bodies form an angle of about 50–60°.

#### Other

**Swinging head:** Swinging head from side-to-side with a bent neck, while body remains still.

**Drawing with head:** With neck parallel to the water surface, bending neck to put mandible in front of an object. Next, neck is withdrawn to pull the object closer to the body.

**Forelimbs pushing aside:** Forelimb pushing an object to move it.

**Hind legs pushing aside:** Hind limb pushing an object to move it