イノシシにおける複合T字迷路を用いた学習能力の測定

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著者名	堂山,宗一郎 江口,祐輔 上田,弘則 植竹,勝治 田中,智夫
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— Original Article —

Learning ability of wild boar using complex T-maze

Soichiro DOYAMA[1], Yusuke EGUCHI[2*], Hironori UEDA[2], Katsuji UETAKE[1], Toshio TANAKA[1]

[1] School of Veterinary Medicine, Azabu University, Sagamihara-shi, 252-5201, Japan
[2] National Agricultural Research Center for the Western Region, Ohda-shi, 694-0013, Japan

* Corresponding author. E-mail address: eguchiy@affrc.go.jp

Abstract

A maze learning test was conducted to investigate the learning ability of wild boars. Five wild boars were run through a complex T-maze that had two choice points. The maze test was conducted in four consecutive sessions with six trials per session. The time required to reach the goal in the maze (running time) and the number of blind alleys entered (errors) were used to measure maze performance. The number of reverse runs in the starting direction was used to measure nervousness and vigilance. The running time and number of errors decreased through four consecutive sessions. This result suggested wild boars have spatial learning ability equal to domestic animals. The running time and number of errors were considered to constitute a learning index for wild boars. The decrease in the number of reverse runs was consistent with habituation to a novel environment.

Key words : wild boar, maze test, learning ability, complex T-maze

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Introduction

Agricultural damage caused by wild boars (*Sus scrofa*) has been reported in many parts of the world, mainly from the EU (Herrero et al. 2006; Schley et al. 2008; Vidrih & Trdan 2008). In Japan, agricultural damage by Japanese wild boars is increasing and it has become a serious problem. However, more information about the wild boar is necessary to institute appropriate damage control methods. Recent ethological studies, especially about the physical and sensory abilities (e.g. jumping, lifting power, and color vision), of wild boars have been reported (Eguchi 2002; Eguchi et al. 1997), and these study results have been applied to new damage control techniques. However, learning ability has hardly been studied in the wild boar. Therefore, this ability may be over- or underestimated, and ineffective methods of damage control based on these estimations are sometimes implemented. To solve this problem, the learning ability of wild boar must be investigated, and knowledge of this ability may suggest more effective damage control techniques.

Maze tests are one of the experimental techniques to measure learning ability of animals (Kilgour 1981). They have been used mainly in the study of rodents because these animals are small and easy to handle. Over the past few decades, use of this technique has been expanded to domestic animals, e.g. cattle (Bailey et al. 2000; Kilgour 1981), horses (McCall et al. 1981), and pigs (Jansen et al. 2009; Laughlin & Mendel 2004), but the maze test has rarely been used for testing the learning ability of medium- to large- sized wild mammals. Wild mammals have not been subjected to learning tests because they are very difficult to handle and train (Gustafsson et al. 1999). However, an operant learning test using handled and trained wild boars was successful in a previous study in our laboratory (Eguchi et al. 1997). Thus, we have acquired the techniques to handle and train wild boars to perform a maze test.

The purpose of this study was to ① develop a method to measure the learning ability of the wild boar using a maze test, and ② acquire basic knowledge about the learning ability of wild boars by using a complex T-maze.

Materials and Methods

Five wild boars were used as the test animals. All test animals were captured in Misato Town, Shimane Prefecture, Japan, with the permission of Misato. After capture, they were kept at the National Agricultural Research Center for the Western Region (Ohda, Shimane, Japan). Test animals were habituated to the experimenter and rearing environment for 8–12 months. The test animals were fed formula feed once a day and

fasted for 16–18 hours before the start of a test. Identification number, age, sex, and body weight of test animals are given in Table 1.

The test animals were trained to enter a carrying cage (W 43 cm × D 105 cm × H 76 cm; made by the experimenter) and were carried to an outdoor test field constructed at the National Agricultural Research Center for the Western Region. The field was enclosed by a 2-m high plywood fence, and its area was 110 m^2. The carrying cage was placed in the maze and used as the starting box.

Table 1. Data on test wild boars

Code	Age [1] (month)	Sex	Body weight [2] (kg)
A	16	Female	33.5
B	17	Female	30.5
C	10	Male	26.5
D	10	Male	26.0
E	10	Male	26.0

[1] Age at commencement data was estimated from captured day.

[2] Measurement day was commencement data of the test.

Fig. 1 shows the maze used for this experiment. This maze had two T choice points, and the shortest distance was about 10 m from start to goal. The maze walls were 0.9-m high plywood, and a wire mesh (grid size 0.1 m) 0.3 m high was attached to the top of plywood. The height of the maze wall was decided by reference to a Skinner box used for the study of the wild boar (Eguchi et al. 1997). The maze had passages 1-m wide and a concrete floor.

Before the beginning of the test period, training and habituation to the maze were conducted for 10 days. The straight line path and the T-maze part (Fig. 2) of the maze were used in the training and habituation periods. For the first three days, the test animals were placed in the straight line path and ate the food reward (five-grain baked goods) put at the end point. They were trained in one session per day. One session consisted of 10 trials. For the next seven days, the animals were placed in the T-maze. The rewards were placed at random in either end of the arm. They were trained in one session consisting of 10 trials a day.

The test period for animals that had completed training was four consecutive days. Each animal was placed at the start point of the maze. The reward was same as that used in the training period and was put at the goal point. A test animal that stayed in the maze for 5 minutes without eating the reward was led by the experimenter to the goal point. Each animal was tested

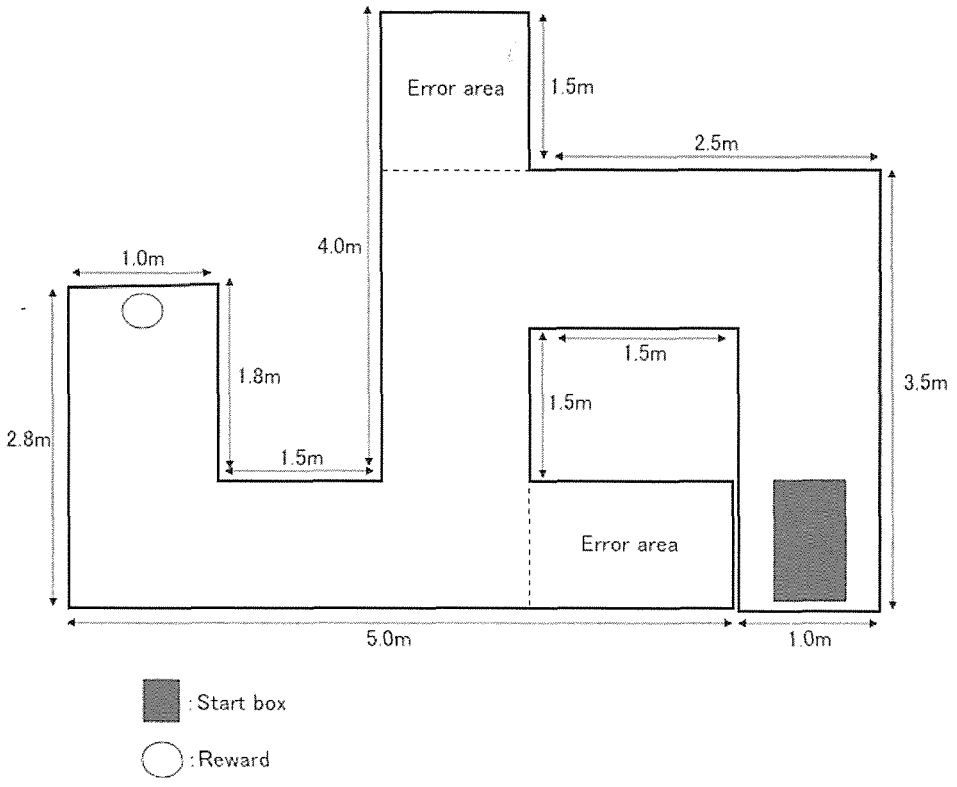

Fig. 1. Configuration of the complex T-maze

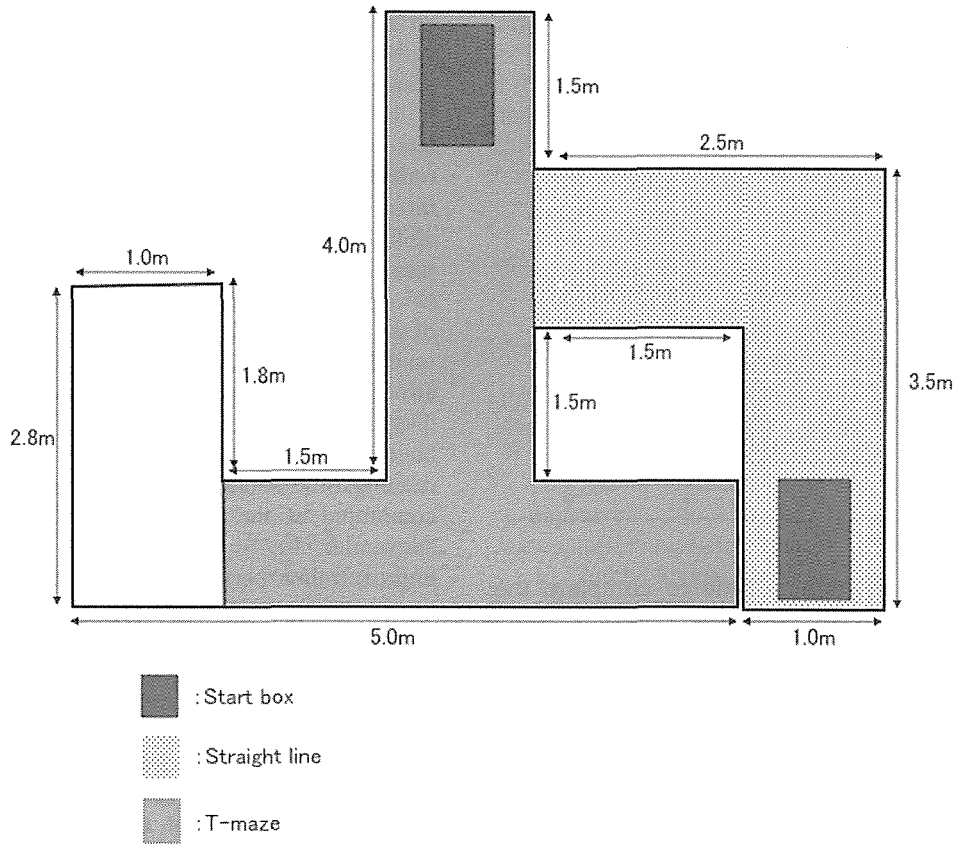

Fig. 2. Part of maze used in training and habituation period

in one session per day. One session consisted of six trials. In habituation, training, and test periods, animals that ate the reward were returned to the start box through the maze.

The behavior of the test animals was recorded by two video cameras. The running time, in seconds, was calculated from the moment the test animal was released at the start box to the attainment of the goal. An error was counted when both forelimbs of the test animal entered the error areas. The return of a test animal to the start on the correct pathway was counted as a reverse run.

Only the results of animals that completed the test were used for statistical analysis. The Friedman test was performed to clarify whether changes of the running time, errors, and reverse runs in a session by an individual existed or not. If a difference was shown, Holm's multiple comparison was performed. All analysis was performed using R (Version 2.11.1).

This study was conducted in accordance with the guidelines for animal experimentation of the National Agricultural Research Center for the Western Region of Japan.

Results and Discussion

Three test animals, B, C, and D, completed training and habituation, and learned the maze, but two animals, A and E, did not complete the maze test because they tried to jump over the maze wall many times and did not stay in the maze. Previous studies reported that the wild boar is very cautious (Eguchi 2002; Eguchi et al. 2000; Quenette & Desportes 1992; Quenette & Gerard 1992). Although the test animals had been well habituated to the experimenter and test field, animals that failed training showed more vigilance and verification behavior toward the complex T-maze. Thus, they may have become nervous in the novel environment of the maze, and suggested that tame wild boars also have powerful vigilance. In this study, the method and periods of the training and habituation were based on previous studies of domestic animals (Laughlin & Mendel 1999; Lee et al. 2006; Marinier & Alexander 1994). However, two of five test animals did not complete training and habituation during this period. This result suggests that the method and periods of training and habituation for wild boars should be reconsidered.

The mean running times to complete the maze of each session is shown in Fig. 3. The mean running times (sec) were 640.0 on session 1, 305.3 on session 2, 168.6 on session 3, and 80.3 on session 4. This time was shorter on session 3 ($P < 0.05$) and session 4 ($P < 0.01$) compared to session 1, and they showed a tendency to complete it more quickly on session 2 than session 1 ($P = 0.07$).

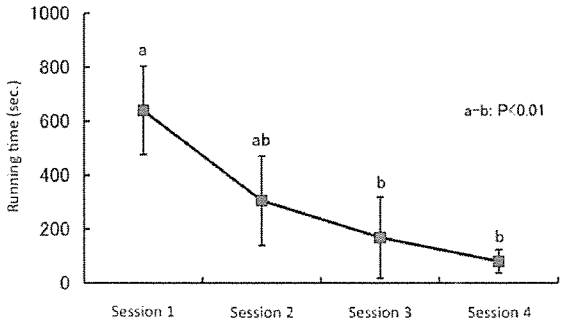

Fig. 3. The mean running time to complete the maze (±SD) in sessions 1-4. Different letters indicate significant differences (P < 0.05).

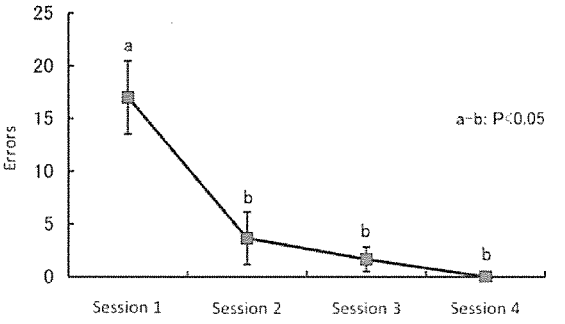

Fig. 4. The mean number of errors to complete the maze (±SD) in sessions1-4. Different letters indicate significant differences (P < 0.01).

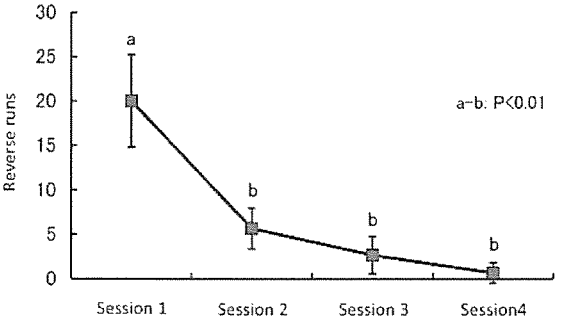

Fig. 5. The mean number of reverse runs to complete the maze (±SD) in sessions 1-4. Different letters indicate significant differences (P < 0.01).

The mean numbers of errors of the test animals in each session are shown in Fig. 4. Mean numbers of errors were 17.0 on session 1, 3.6 on session 2, and 1.6 on session 3. All three test animals reached the goal without error in session 4. Fewer errors were made in sessions 2, 3, and 4 compared to session 1 ($P < 0.01$).

The running times and number of errors in a maze test are an important index of the learning ability of rodents. In the radial arm maze, double entries are interpreted as evidence of impaired spatial working ability (Inagawa 1997). The running time is used to measure performance in the Morris water maze test (Morris 1981). These indexes are also used in the study of domestic animals.

Sheep decreased their total running times and errors in the maze in each session during three days of testing, and their learning ability was evaluated based on these times (Lee et al. 2006). For horses, the running time shortened per trial, and no errors were committed at the mean of 12.7 trials (Marinier & Alexander 1994). In our study, three wild boars improved their performance by decreasing the running time to traverse the maze and committed fewer errors over four consecutive sessions. This result suggested that wild boars learned the complex T-maze, and thus running time and error may be important indexes to measure their maze performance.

Although the results are not necessarily comparable, because the maze device and test conditions were different, the maze performance of the wild boars in this study was similar to those of domestic animals. In a maze test of sheep, the running time to reach the goal and time spent in incorrect areas were significantly shortened on day 2 compared to day 1 (Lee et al. 2006). In a maze test of pigs, the running time was shortened and the number of errors was decreased on test day 2 (Jansen et al. 2009). In a maze test of cattle, the running time was shorter on test day 2 and 3 than day 1 (Arave et al. 1992). The wild boars in this study also showed drastic changes in running time and number of errors from session 1 to session 2. In session 4, individual differences in running time became smaller and the number of errors was zero. Thus, the wild boar has sufficient learning ability to learn two choices in a complex T-maze within 20 trials. This result suggested that the spatial learning ability of the wild boar is equal to or greater than that of domestic animals, and that they can learn the experimental maze in a short time.

The mean numbers of reverse runs for the test animals in each session are shown in Fig. 5. The mean number of reverse runs was 20.0 on session 1, 5.6 on session 2, 2.6 on session 3, and 0.6 on session 4. Reverse runs were fewer in sessions 2, 3, and 4 compared to session 1 ($P < 0.01$)

Reverse runs may be attributed to habituation to the novel environment. The start box was a familiar and safe place for the test animals, and thus those who were wary and fearful in the maze returned to the start

box. After numerous runs through the maze, test animals may no longer perceive it as a novel environment and the number reverse runs decreased. In the maze test of domestic animals, habituation has not been described in detail. However, these behavioral responses are important parts of the study of wild mammals. In the future, the habituation of the wild boar should be investigated by using the experimental devices such as a maze.

The maze design used in this study had a visual difference between the correct and incorrect paths. The correct path had an open travel direction, and the incorrect path had blind alleys that could easily be recognized as a dead end visually. This difference will affect maze performance greatly because the wild boar and pig discriminate human beings and objects by visual information (Eguchi 2002; Tanaka et al. 1998; Tanida & Nagano 1998). The wild boars in this study could easily reach the goal when they went only in the open direction. This issue will be clarified by using a maze that does not have a visual difference between correct and incorrect paths, such as a Biel maze (Biel 1940).

These results indicated that a wild boar could complete an experimental maze test as well as domestic animals and rodents, and that the wild boar has spatial learning ability equivalent or better than domestic animals. These results also suggested that wild boars can learn the relationship between food and a location.

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イノシシにおける複合T字迷路を用いた学習能力の測定

堂山宗一郎[1]・江口祐輔[2]・上田弘則[2]・植竹勝治[1]・田中智夫[1]

[1]麻布大学大学院獣医学研究科，相模原市　252−5201
[2]近畿中国四国農業研究センター，大田市　694−0013

要　約

イノシシの学習能力を測定するために、迷路学習実験を行なった。実験装置としてT字迷路を2つ組み合わせた複合迷路を作製した。実験には飼育イノシシ5頭を供試した。迷路内の一部を利用した馴致および訓練の後、本試験を行なった。本試験は6試行／セッション、1セッション／日とし、連続4日間行なった。迷路のゴール地点には報酬を設置し、供試個体がそこに到達するまでの時間（到達時間）、袋小路になっているエラーエリアへの侵入回数（エラー回数）およびスタート方向へ逆走した回数（逆走回数）を記録した。到達時間は、セッションを重ねるごとに短縮した。エラー回数は、セッションを重ねるごとに減少し、セッション4ではエラーが無くなった。これらの結果を家畜における迷路実験と比較すると、イノシシが家畜と同等もしくはそれ以上の学習能力を持つことが示された。そして、イノシシにおいても到達時間とエラー回数が、齧歯類の迷路実験と同様に学習能力を測定する指標として有用であることも示唆された。逆走回数はセッションを重ねるごとに減少した。スタート地点は、供試個体にとって安全で非常に慣れた場所であったため、逆走回数の減少がイノシシの新奇環境に対する慣れと関連していることが考えられた。

キーワード：イノシシ、迷路実験、学習能力、複合T字迷路

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