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Food selection of the White Stork *Ciconia ciconia* under captive conditions

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ABSTRACT: Observation on food selectivity were performed in 2004 and 2005 at the Poznań Zoological Garden. Altogether 29 individual storks provided the basis for research (20 males and 9 females). The data were recorded during digestion efficiency research. During a10 day cycle the birds were fed according to a Cafeteria test. The diet contained mammals, birds, fishes, amphibians, insects and earthworms. The storks showed a strong preference towards mammals which constituted 40% of all food. The second most popular item were birds – 36% of the total. Fish were also popular and constituted to 39% of the diet. Storks virtually avoided insects: only 2% attempted to eat them. Earthworms were totally ignored.

KEY WORDS: diet, food selection, White Stork, *Ciconia ciconia*

Introduction

Food acquisition is one of the major factors determining the ecological continuity of species and populations (Kendeigh et al. 1977, Walsberg 1983). Research on nutritional needs and food preferences may also have some importance in breeding and restoration of threatened species (Fasta-Biabchet & Apollonio 2003).

The effectiveness of the use of food resources is determined by a variety of physiological and ecological factors (Newton 1998). Numerous authors researching the diet of the white stork or closely related species like wood stork *Mycteria americana* point out that food preferences are dependent on climatic conditions, type of habitat and prey densities (Karpivny 1957, Ogden et al. 1976, Profus 1986, Pinowska et al.1989, Pinowska et al. 1991, Pinowski et al. 1991, Alonso et al. 1991, Muzinić & Rasajski 1992, Lawrence et al. 1995, Gonzales 1997, Tsachalidis & Goutner 2002,

Antczak et al. 2002, Tryjanowski & Kuźniak 2002, Tryjanowski et al. 2005, Profus 2006 in press).

Therefore the research under controlled ecological conditions (known availability and nutritional quality of food, identical environmental conditions, known sex and nutritional status of birds) allows to differentiation between real food preferences and those observed under natural conditions influenced by other factors. Knowledge on real preferences allows the formulation of an optimal diet composition for white storks in captivity.

Material and methods

The observation on food selectivity was performed in 2004 and 2005 at the Poznań Zoological Garden. The subjects of research were birds hatched in the wild and delivered to the zoo due to various factors. All birds were sexed on the base of measurements and DNA samples (Ćwiertnia et al. 2006). Altogether 29 individuals 20 males and 9 females formed the research group. During research the birds were kept in individual boxes ca. 10 sq. m each. To allow easy observation from a distance the walls of boxes were wire-netted. Each bird was individually marked through color rings and corresponding number was placed on a visible location in the box to prevent mistaken in records.

The birds were offered a varied diet of mammals, birds, amphibians, fish, insects and earthworms (see details in Kwieciński et al. 2006).

Each bird was the subject of detailed observation for 10 days (Barton & Houston 1993), divided into two five days bouts. During the first period mammals, birds, fish and insects were given. During the second period the fish were removed from the diet and replaced by earthworms and amphibians.

The composition of the experimental diet was based on available results from field resarch (Cramp & Simmons 1988, Pinowska, Pinowski 1989, Pinowska et al. 1991, Pinowski et al. 1991, Antczak et al. 2002). The food was offered on plastic trays according to a "Cafeteria test" (test of free selection) at the same time each day (4 p.m) (Rychlik & Jancewicz 2002). To allow easy observation from a hide (to avoid disturbance) on the sequence of food intake small mirrors were strategically placed (see Fig. 1). The observation lasted for 4 hours following presentation of food. The birds were classified in two groups. First group coded 0 were birds that did not show any interest in the presented food. In the second group individual birds were coded with the numbers 1–5 according to selected and consumed food items.

Results

The sequence of diet selection by storks

During the first hour since food presentation 25 birds (85%) took food. Only 3 birds (10%) were not interested. During the second hour 3 birds fed (10%), 19 (65%) lifted food but didn't eat it and 7 (24%) were not interested at all. During

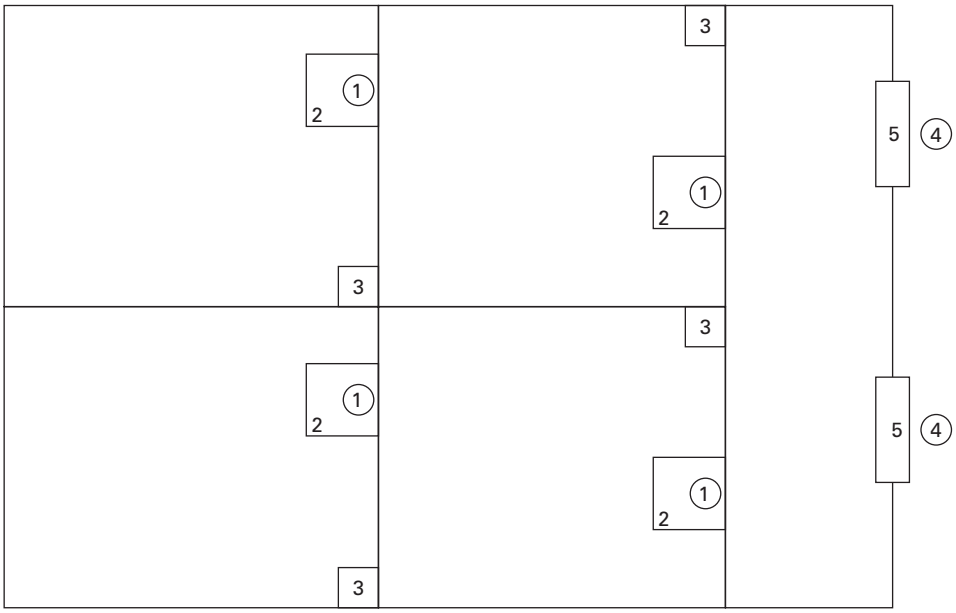

Fig. 1. A sketch of the boxes used for the research on food preferences
1 – mirror, 2 – plastic trays, 3 – water, 4 – observer location, 5 – window

third the hour only one bird actually fed (3%), 11 (38%) played with food and 17 (59%) were not interested. None of the birds actually consumed food during the fourth hour but 6 (21%) played with food whereas 17 (59%) were not interested.

Analyzing the sequence of 3 different diet items during 10 days of observation it is clear that the mammals were eaten first (40%) followed by birds (36%). Insects were consumed by just 2% of occasions. As second choice, mammals also dominated (37%) followed by birds (30%). Insects were taken by 6% of occasions. Altogether 23% of all storks (in the "0" category) didn't show any interest in the provided insects.

The dominating food item selected as first choice during the first five days were mammals (52%) and fish (39%). Birds were preferred by 11% and insects by 3% of storks.

As second choice birds were preferred by 43% of storks, mammals were taken by 27% and insects by 8%. As third choice most of the storks (28%) preferred fish followed by birds (26%) and insects (23%). In this group (third choice) only 4% of storks eat mammals. 43% were interested in insects as fourth choice.

In the second period of observation, from day 6 to 10 storks changed preferences to birds (61%) in the first choice. Mammals accounted for 29% and amphibians 11%. The insects were consumed < 1% of all storks and earthworms were ignored completely.

As second choice the tendencies reversed and most of the storks preferred mammals (47%). Birds were selected by 19%, amphibians by 11%, insects by 3% and earthworms by 3% of storks.

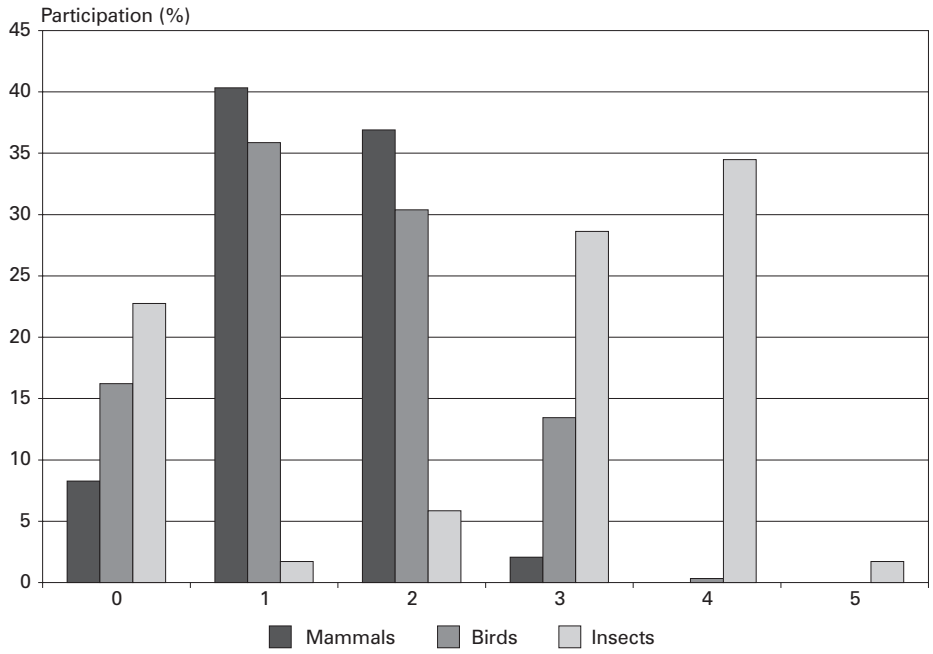

Fig. 2. The sequence of food selection by white storks of three most commonly consumed food items from day 1 to 10
„0" – no interest in food offered; 1–5 – the sequence of consumption of food items

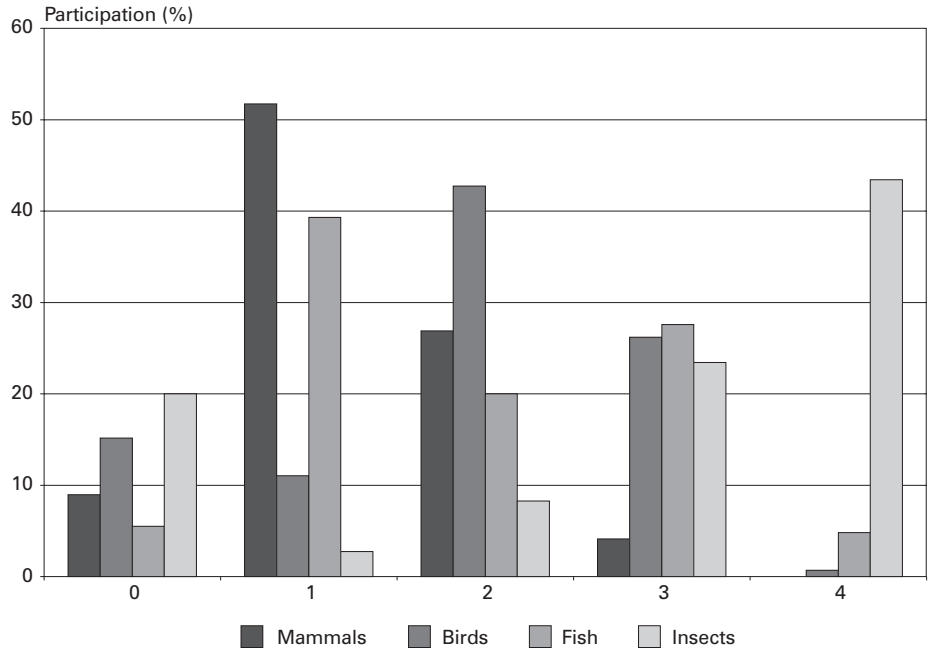

Fig. 3. The sequence of selection of four diet categories from 1st until 5th day of observation

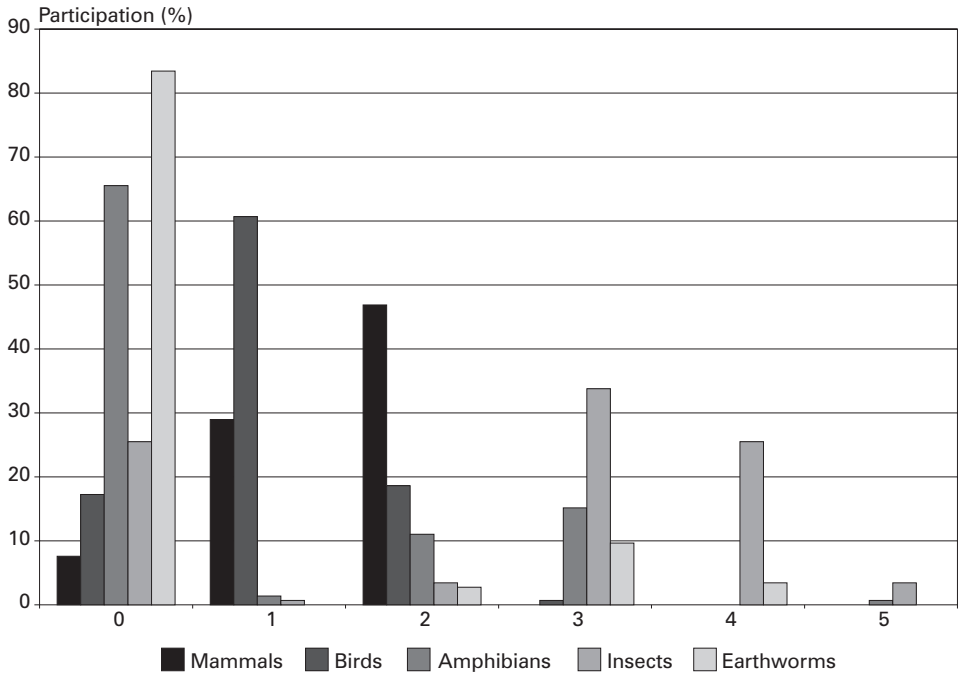

Fig. 4. The sequence of selection of four diet categories from 6th until 10th day of observation

The increase of consumption of amphibians was noted in the third choice where 15% of storks chose this kind of food. In the third and fourth turn the interest in insects (34% and 26% respectively) and earthworms (10% and 3% respectively) increased greatly.

In the "0" category 83% of storks were not interested in earthworms, 66% in amphibians, 26% in insects, 17% in birds and just 8% in mammals.

Food preferences in relation to sex of storks

Males differed significantly from females in food selection preferring mammals as a priority food item. Females selected birds more often ($\chi^2 = 19.18$ $P < 0.0001$). The active avoidance of certain food items also differed between sexes and males where more reluctant to take insects ($\chi^2 = 14.05$, $P < 0.025$).

Discussion

Under field conditions the white stork utilizes food resources that are currently most available and can thus be best described as an opportunistic feeder. Numerous research confirms this (Profus 1986, Pinowska et al. 1989, Pinowski et al. 1991, Antczak et al. 2002, Tryjanowski & Kuźniak 2002, Tryjanowski et al. 2005, Profus 2006 in press). Similar results had been achieved on a related species – the

American wood stork *Mycteria americana* (Ogden et al. 1976, Lawrence et al. 1995, Gonzales 1997).

The most important food selected by storks under captive conditions were mammals, selected by 40% (Fig. 1) of all birds during 10 days of research. During the first 5 days it even accounted for 51% of the total. A number of authors show that during the called "mouse years" the percentage of rodents in the diet of wild storks rapidly increases and becomes a main item of the diet (Profus & Mielczarek 1981, Pinowska, Pinowski et al. 1989, Alonso et al. 1991, Antczak et al. 2002, Tryjanowski & Kuźniak 2002). This can be explained by the easy accessibility of high-energy food (Schulz 1998, Tryjanowski & Kuźniak 2002). It is however interesting that captive storks selected mammals in the presence of an abundance of other food items.

Birds were also readily taken and accounted for 35% (Fig. 1) of preferred food. During the days from 6 till 10 of research birds even accounted even for 60% (Fig. 3). Some of the field researches showed that under field conditions the birds share of the diet was very small or marginal (Pinowska et al. 1989, Pinowski et al. 1991, Antczak et al. 2002). Sometimes however storks use easily accessible bird prey, such as robbing a colony of white-winged terns *Chlidonias leucopterus* on Biebrza Marshes (Profus 2006 in press). Research in captivity show that birds can play an important role in stork nutrition. A low percentage of birds in the diet of wild storks may simply reflect the lower acceptability of this food item. It is worth noting that the percentage of birds in the diet increased during the second half of the research. Does this mean that storks needed some variation in nutrition?

Compared to the black stork *Ciconia nigrsa*, fish are rare item in white stork food (Pinowska et al. 1989, Zawadzka et al. 1990, Pinowski et al. 1991, Hampl et al. 2005). In the vicinity of intensive fish-farming in shallow ponds fish are used more often. Storks utilize this source of food to a maximal degree and fishes may for some time form the bulk of food taken (Profus 2006 in press). Captive storks also took fish quite eagerly. This kind of food was only given during the first five days and was selected as a priority by 39% of storks (Fig. 2). Fish are also high-energy food which explains the comparatively high interest in this food item. It is worth noting that in many zoos fish are the staple food offered to storks.

Amphibians appear in the diet of white storks only seasonally and their availability In the field is closely related to weather conditions (especially the humidity and precipitation, as well as temperature). Research in the field shows that in some periods, amphibians may have some significance in the diet, but also they may be lacking completely (Karpivny 1957, Hornberger 1967, Schirer 1967, Profus 1986, Pinowska et al. 1989, Pinowski et al. 1991, Antczak et al. 2002, Profus 2006 in press).

Captive storks ate amphibians only sporadically. This item was only given in the second part of the research. Only 1% selected this food item and in contrast to popular belief 65% were not at all interested (Fig. 3).

Among invertebrates earthworms are a very significant item of the stork diedfoo in the wild. The importance of this food has been noted both immediately after return from winter quarters and during intensive agricultural activities

(Hornberger 1967, Lingner 1982, Profus 1986, Pinowska et al. 1989, Pinowski et al. 1991, Alonso et al. 1991, Antczak et al. 2002, Profus 2006 in press). Some researchers however found a negligible percentage of earthworms in the diet (Karpivny 1957, Profus 2006 in press).

Our storks didn't show any interest in earthworms in 83% of cases. Only as a fourth choice 9% of all storks choose earthworms (Fig. 3).

A number of authors document a high percentage of insects taken by storks in the wild. The percentage of insects in the diet is not related to the life cycle of birds (nesting, pre-nesting) and is always significant (Profus 1986, Pinowska et al. 1989, Pinowski et al. 1991, Alonso et al. 1991, Antczak et al. 2002, Profus 2006 in press). The insects may account for the majority of food taken, although they only account for only third of biomass taken (Pinowska et al. 1989, Pinowski et al. 1991, Antczak et al. 2002). According to widespread although not scientifically confirmed, information locusts are probably the most important, food item in some periods of wintering and migrations.

Our storks mostly avoided insects, similarly to earthworms. They were chosen in the as first choice by just 2% of storks and 22% were not interested at all. The increase in insect consumption was noted in the fourth choice only (Fig. 1).

The selection of mammals, birds and fish larger food items of high nutritional value and requiring low energy input in collecting shows that the white stork is an opportunistic feeder. Although under field conditions amphibians, insects and earthworm may be an important food item, sometimes even dominating, the situation changes in the presence of an abundance of other kinds of food in captivity.

It is also of interest that the sexes show different preferences. It is a well known phenomenon that in many bird species the feeding ecology of opposite sexes is quite different, but it is usually reflected in body size or bill structure. It is somehow unexpected in white stork that lacks any significant sexual dimorphism.

As far as we know the presented results are the first collected under controlled conditions in a zoological garden, where the real food preferences can be established. We do hope this will help in formulating an ample feeding regime and will increase the welfare of captive storks. Our research also gives a basis for comparisons of the food composition of the white storks in the wild.

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