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Diet of yellow bitterns (*Ixobrychus sinensis*) during the breeding season in South Korea

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Abstract

Yellow bitterns (*Ixobrychus sinensis*) are a small wetland bird common to Asian countries including South Korea, Japan, and China. The aim of this study is to describe diet of yellow bitterns during the breeding season in artificial wetland of northeastern South Korea between May to August 1999-2001. For the purposes of this paper, we observe the frequency of nest visiting by parents during the chick rearing period. A total of 98 boluses regurgitated by 52 chicks aged 1 day to 11 days after hatching form the sample and are shown to contain 323 food items. A bolus contained mean 3.8 items and weighs 0.2 g to 7.7 g. The most regularly occurring food items recorded are fish (63%) and insets (33%). In terms of fish, top mouth minnows (*Pseudorasbora parva*) and crucian carps (*Carassius auratus*) are frequently observed. In terms of insects, there are mosquitoes (Diptera), instars of dragonfly (Libelluidae), damselflies (Coenagrinonidae) and water bugs (*Diplonychus japonicus*). Yellow bitterns were also shown to feed on bull frogs (*Rana catesbeiana*), shrimp (Palaemonidae), and spiders (Araneae). The size of fish in a bolus ranged from 15.56 mm to 93.73 mm (mean, 37.08 mm). The amount of food can be observed to increase with the age of chicks ($r = 0.279$, $P = 0.025$, $N = 64$) but parents did not provide larger fish as chicks grew. Parent birds visited nests more frequently when they have a larger brood ($F_{1,21} = 14.529$, $P = 0.001$). Our results suggest that fish is the most important prey during the breeding season and that age of chicks is related to amount of diet in yellow bitterns.

Key words: bolus, breeding, diet, Korea, yellow bitterns

INTRODUCTION

During the breeding season, diet selection often affects breeding success (Pierotti and Annett 1991, Wanless et al. 2007). Parent birds have to select appropriate food, which can meet the nutrient requirements of chicks and maximize the efficiency of parental efforts. Experienced parents often select higher quality prey compared to young parents (Limmer and Becker 2009). Parents must also select prey items depending on the age of chicks, as older chicks need more food than younger ones; as such, prey selection changes in terms of composition or size as chicks age (Navarro et al. 2009, Ramos et al. 2009, Mitrus et al. 2010). Yellow-legged gulls (*Larus michahellis*) feed chicks on smaller prey when chicks are young (Ramos et al. 2009), while great bitterns (*Botaurus stellaris*) exhibit no change of prey size as chicks age (Gilbert et al. 2003). Parents may simply choose prey items depending on food availability within habitats. Gull-billed terns (*Sterna nilotica*) feed chicks on more aquatic prey in the early part of the breeding season (Dies et al. 2005) and rhinoceros auklets (*Cerorhinca monocerata*) quickly change from Japanese sandlance (*Ammodytes personatus*) to Japanese sea greenling (*Pleurogrammus azonus*) when the warm

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current reaches their foraging area (Ito et al. 2009). Preys provided to chicks of little terns (*Sterna albifrons*) changes from year to year, depending on tide and wind speed (Paiva et al. 2006).

Yellow bitterns (*Ixobrychus sinensis*) are small bitterns living in wetlands such as reed beds and rice fields. The population of yellow bitterns is widely distributed from India to South-east Asia. However, their foraging ecology has been rarely studied (Ueda 1985, 1992, Kim 2001, Gerlach and Skerrett 2002). This may be due to their cautious behavior and concealed habitats. The diet of yellow bitterns during the breeding season has been reported as consisting of aquatic insects and freshwater shrimp (Hancock and Kushlan 1984).

In this study, we tested whether yellow bittern parents change diet in terms of amount and/or prey size according to chick development. We also investigated factors affecting the frequency of nest visits during the chick rearing period in yellow bitterns.

MATERIALS AND METHODS

Study areas and collecting boluses

This study has been carried out at the artificial swamp (55 ha) in An-san city (126°50′04″-48″E, 37°16′ 34″-43″N), Republic of Korea from late May to August in 1999 and 2000. To investigate the diet of yellow bitterns during the breeding season, we collected boluses which regurgitated by chicks when they feel stressed, a behavior exhibited by yellow bitterns and other bird species of the family Aredaidae (Kirkpatrick 1940, Olmos et al. 2001). For the purposes of this study, we define a bolus as a food ball regurgitated by a chick in one attempt. We visited 21 nests every day during the late incubation period and during the chick rearing period to identify the age of chicks and to collect boluses. Chicks were individually marked with a non-toxic marker pen on their bills or color rings.

Once chicks regurgitated boluses, we measured the wet weight of a bolus and retrieved them from nests to identify prey items and to record the number of items. Because heads of fish in a bolus are slowly digested compared to other part of the fish (Barrett et al. 2007), we counted the number of fish heads to avoid over-counting. Food items in a bolus were identified based on the guide book of fish (Kim and Kang 1993), insects (Youn 1995) and aquatic insects (Bae 1998). Prey items in a bolus were identified at species level or at family level and the number of food items in a bolus were counted. Body size of a fish in a bolus was measured from mouth to tail to the nearest 0.01 mm using vernier calipers. Boluses were preserved in 60% ethanol for weighing the ash-free dry weight in the laboratory.

For the analysis of the relationship between age of chicks and prey size, only fish of known size were included in the study. The proportion of prey items was estimated as a percentage of the total number of prey in a bolus.

In the laboratory, we used ash-free dry weight (AFDW) to estimate the energy of regurgitated prey. AFDW has been used to estimate actual energy intake of prey in many previous studies of geese (Therkildsen and Madsen 2000) and shorebirds (Ge et al. 2009). Non-prey items such as pieces of reeds were removed to estimate AFDW of regurgitated prey. Boluses were dried at a temperature of 55°C and burnt in a 550°C oven for 5 h. AFDW was estimated in 62 boluses collected from 1999.

Frequency of visiting nests by parents

We estimated the frequency of visiting nests by parent birds from June to August. This estimate is in terms of nest visits per h, based on recordings made with a video camera. We recorded nests with chicks for approximately 2 h per a day between 8.30 and 17.00. A video camera was camouflaged with reeds and placed 2 to 3 m away from the nest. Items of interest in these recordings are age of the oldest chicks in a brood, date of observation, and brood size.

Statistical analysis

All data analysis was performed using SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA). ANOVA was used to investigate the relationship between food amount and other factors. All biologically relevant two-way interactions between explanatory variables were included in the initial model and we removed the stepwise least significant term. Statistics are shown for the last step variables included in the model. The correlation between amount of food and age of chicks was examined using Pearson's rank correlation test. This is significant when the *P*-value is less than 0.05. Mean values are presented with ± 1 SE.

RESULTS

Regurgitated prey items

A total of 98 boluses were collected from 52 chicks aged

from one day to eleven days after hatching. A mean of two boluses per a chick were taken (range, one to six boluses per a chick). Boluses were collected from June to August, 1999-2001.

Yellow bitterns were observed to feed chicks primarily on fish (63%) and insects (33%) (Table 1). A bolus included a mean of 3.8 individual items. With regard to fish in boluses, top mouth minnows (*Pseudorasbora parva*) were the most common (29.1%). Other fish species in regurgitates were crucian carps (*Carassius auratus*) (22.9%), loaches (Misgurnus) (9.2%), and round-tailed paradise fishes (*Macropodus chinenesis*) (1.2%). With regard to insects in boluses, mosquitoes (Diptera) were frequently observed (17.9%). Chicks of yellow bitterns were also fed on instars of dragonflies, damselflies (Coenagrinonidae), and water bugs (*Diplonychus japonicus*). Other prey items include bullfrogs, shrimp, and spiders (Table 1). The composition of prey items in boluses is observed to change as the breeding season progresses. In June, yellow bitterns feed their chicks a diet of equal parts fish and insects, while through the rest of the breeding season more fish than insects are fed to chicks (July, 74% of fish; August, 69% of fish) (Fig. 1).

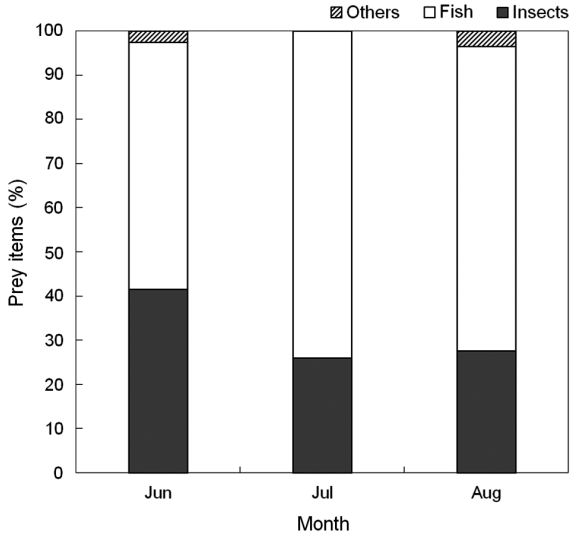

Fig. 1. Composition of prey items in 98 boluses regurgitated by chicks of yellow bitterns during the breeding season. Total amounts of prey items collected were 154, 188, and 29 in June, July, and August, respectively.

Amount of food and prey size

The fish size in boluses was measured in 48 fish, of which the entire body length is estimated. The mean observed length of fish in boluses was 35.8 ± 2.65mm (range, 15.56 to 93.79 mm). The wet weight of a bolus ranged from 0.2 g to 7.7 g and AFDW was from 0.032 g to 1.421 g. AFDW of a bolus was observed to increase with the age of chicks

Table 1. Prey items (%) in 98 boluses regurgitated by 52 chicks of yellow bitterns in 1999 and 2000

Species	Occupancy		
	1999 (78 boluses)	2000 (20 boluses)	Total (98 boluses)
Fish			
Top mouth minnow (*Pseudorasbora parva*)	28.2 (78)	34.7 (16)	29.1 (94)
Crucian carp (*Carassius auratus*)	23.8 (66)	17.3 (8)	22.9 (74)
Loach (Misgurnus)	9.7 (27)	6.5 (3)	9.2 (30)
Round-tailed paradise fish (*Macropodus chinenesis*)	-	8.6 (4)	1.2 (4)
Largemouth Bass (*Micropterus salmoides*)	-	2.1(1)	0.3 (1)
Insects			
Mosquito (Diptera)	18.4 (51)	15.2 (7)	17.9 (58)
Instars of dragonfly (Libelluidae)	10.8 (30)	2.1 (1)	9.5 (31)
Damselfly (Coenagrinonidae)	7.2 (20)	6.5 (3)	7.1 (23)
Water bug (*Diplonychus japonicus*)	0.4 (1)	—	0.3 (1)
Others			
Bull frog (*Rana catesbeiana*)	—	4.3 (2)	0.6 (2)
Shrimp (Palaemonidae)	1.4 (4)	—	1.2 (4)
Spider (Araneae)	—	2.1 (1)	0.3 (1)
Total	100 (277)	100 (46)	100 (323)

Values are presented as number (%). Occupancy was estimated as the number of each item with regard to total items.

(r = 0.279, P = 0.025, N = 64) (Fig. 2). The fish size in boluses is not observed to be related to the age of chicks (r = -0.073, P = 0.623, N = 48).

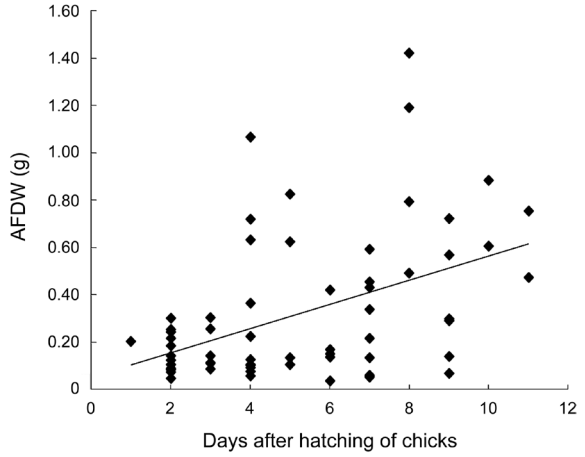

Fig. 2. Relationships between ash-fee dry weight (AFDW) (g) per a bolus in 1999 and the age of chicks.

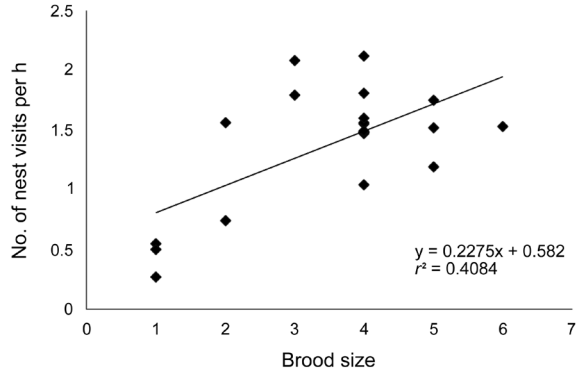

Fig. 3. Relationships between frequency of nest visits by parents and brood size in yellow bitterns

Table 2. Frequency of nest visits by parents for feeding chicks in eight nests related to brood size, age of the oldest chicks in a brood, and date of observation

	F-value	*P*-value
Brood size	$F_{1,21}$ = 14.529	0.001
Age of the oldest chicks in a brood (days after hatching)	$F_{1,20}$ = 0.702	0.412
Date of observation (days from the 1st May)	$F_{1,19}$ = 0.483	0.405

Twenty-three observations are made via video recording for a total of 22 h 10 min and 5 s during the breeding season.

Frequency of visiting nests

In this study, we recorded eight nests containing chicks aged three to ten days after hatching. A total of 23 observations were made for a total recorded time period of 22 h 10 min 5 s. Chicks are not disturbed for more than 10 min after placing a video camera. Parents visited nests 1.39 ± 0.09 times per h (range, 0.27 to 2.12 times per h) during the chick rearing period. Parents visited more frequently when they had a larger brood in a nest ($F_{1,21}$ = 14.529, P = 0.001) (Fig. 3). However, the age of the oldest chicks in a brood ($F_{1,20}$ = 0.702, P = 0.412) and date of observation ($F_{1,19}$ = 0.483, P = 0.405) did not affect the frequency of nests visits by parents (Table 2).

DISCUSSION

In the results of this study, food items fed to chicks by yellow bittern parents are observed to vary throughout the breeding season. In the early breeding season, yellow bitterns feed their young on similar proportions of fish and insects, but later in the breeding season more fish are consumed than insects. This may be related to the change of food availability in the study area over time. As the fries of top mouth minnows and crucian carps, which form the main prey of yellow bitterns, hatch in April (Kim and Kang 1993), small sized fish may become more abundant later in the breeding season. In Japan, yellow bitterns are opportunistic predators (Ueda 1992). They mainly feed fish and insects, but also reptiles and amphibians under poor food conditions (Ueda 1985, 1992).

The diet fed by yellow bitterns to chicks thus consisted of varied items such as fish, insects, and frogs. Fish form the most important prey item during the chick rearing period. In Malaysia, yellow bitterns breeding in rice fields are shown to prey more on invertebrates such beetle larva, blue-bottle flies, and damselflies than fish (Lansdown and Rajanathan 1993). In our results, mosquitoes were observed to be the most frequent insect prey of yellow bitterns. However, it is observed through video recording that parents usually catch mosquitoes when they are with chicks in the nest. Parent birds might catch mosquitoes to protect chicks in the nests.

The rate of food provision by parents varies with chick age and brood size (Adler and Ritchison 2011). The frequency of nest visits by parents in yellow bitterns is related to brood size. Parent birds are observed to visit nests more frequently when they have a larger brood. This may be due to increased food requirements when bitterns

have a large brood. The age of the oldest chick in a brood did not exert an observable influence on the frequency of nest visits by parents.

The wet weight of a bolus increases with a chick's age. The parents of yellow bittern brought more food, but did not alter the frequency of nest visits as chicks grew. One possible explanation is that higher rates of nest visitation may increase predation risk (Eggers et al. 2005). Parents may bring larger numbers of fish in a food-load rather than visit nests more frequently in order to meet increased food demands of chicks. However, parents with larger broods may have to work harder and visit nests more frequently to maximize food quantity for chicks.

To conclude, yellow bitterns are observed to forage opportunistically depending on food availability in habitats. The age of chicks and brood size is shown to affect the amount of food and the number of nest visits, respectively.

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