INSECTS AS IMPORTANT DELICACY FOR BIRDS: EXPANDING OUR KNOWLEDGE OF INSECT FOOD ECOLOGY OF BIRDS IN THE TROPICS

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Abstract

Eighty percent of birds include insects in their diet. The species of insect more or less consumed often depend on the bird species and its stage in life. In terms of nutritional value, insect diet is adequate; because of its rich and easily digestible protein and fat although the digestibility of various parts largely depends on their chitin content. This study was carried out in three sites; Kurra Falls Forest ($9^0$23'N, $8^0$42'E), the Fobur Forest ($9^0$51'N, $9^0$01'E) and the Jos Wildlife Park (09° 52', 08° 53') all located in Plateau State, Nigeria. In general all the study sites constitute similar vegetation structure and lanscape. All sites are typically savanna woodlands interspersed with gallery forests, patches of grasslands and rocky outcrops. Insect diet of insectivorous passerines and cattle egret Bubulcus ibis were studied through faecal sample analysis. The methods generally involved collection of faecal droppings from roost sites and mist-netting. Insects were also sampled using sweep net and pitfall traps to correlate results of field and faecal sample data. Results showed that the Order hymenoptera, orthoptera and coleoptera constitutes main insect Orders whose fragments were found in the diet of insectivorous passerines and the cattle egret. Analyses of faecal droppings of the study species generally revealed that birds preyed primarily on the insect Orders hymenoptera (36%), coleoptera (23%), orthoptera (12%) and diptera (9%) which together represent 80% of the avian insect diet. The study concludes therefore, that tropical birds may show a direct correlation between habitat resource availability and utilization which perhaps confirm that birds choose food opportunistically.

Key words: *insect diet, cattle egret, birds, insectivorous passerines, fragment*

1. INTRODUCTION

Insect are important food resource for birds irrespective of their feeding mode. This is why eighty percent of birds are reported to include insects in their diet (Morse, 1975). The species of insect consumed often depend on the bird species and its stage in life. In terms of nutritional value, insect diet is adequate; because it is rich in easily digestible protein and fat although the digestibility of various parts largely depends on their chitin content (Kaspari 1991, Klassing 2000).

Abundance, ease of capture, body patterns, familiarity and digestibility could render some insect species or an insect developmental stage susceptible to predation by birds. For example, when provisioning nestlings, most parent birds prey on insect developmental stages such as larvae and nymphs, as these insect stages are easily digested. Insectivorous birds could also show preference to familiar insect prey as these lessens the number of unpleasant surprises such as feeding on poisonous or otherwise dangerous prey. Preference for familiar prey could also result from the ability to develop specific "search image" for such familiar prey (Boar, 1971; Murton, 1971). By feeding on insects, birds are known to gain protein, non-chitin carbohydrates, lipids, phosphorous, most of the trace minerals and vitamins that are essential for growth (Klassing, 2000).

The cattle egret, *Bubulcus ibis* (Ardeidae) is a known Intra-African migrant. They are common to abundant in damp and open fields, flooded plains and short grassy margins of rivers and lakes also found around marshes and swamps. In northern Nigeria, cattle egrets are common all year round however, in the south, they are present only from mid October to mid May. They are often in flocks of 10-20 birds (but could be solitary) and in close association with livestock and game mammals. The cattle egret's roost could consist of 2,000 or sometimes up to 10,000 individuals. Feeding is done mainly in the mornings and afternoons (Elgood *et al.*, 1994). Diet has been previously reported to

include crickets, grasshoppers, ticks, spiders, frogs, crustaceans, mollusc and fish (Snoody, 1969; Mckilligan, 2005).

Food availability for birds is fundamental to somatic development, functioning and maintenance with consequential influence on reproductive and population processes **(**Martin, 1987; Byholm and Kekkonen, 2008). Insectivory is the most common pattern of food consumption in birds (Klasing, 2000; Nakano *et al.*, 2007; Dorn *et al.*, 2011; Buij *et al*., 2012), and it is known that insectivorous passerines are by far the most numerous of all birds (Moreau, 1972; Klasing, 2000; Asokan *et al.*, 2009). It is common that most granivorous, frugivorous, nectarivorous and herbivorous birds feed their fast-growing young a diet of insects, spiders, and other invertebrates. Many birds are however, primarily, insectivorous and eat little plant material; about 46% of the families of passerines are primarily insectivorous while about 51% are of small terrestrial non-passerines (Klasing, 2000). Some birds are highly insectivorous during certain parts of the year depending on species, availability and environmental conditions. Whereas some birds are specialized in the consumption of a few species of insects, others opportunistically prey on a large variety. The value of insects as a complete food is seen in the winter food of a small insectivorous passerine, Golden-crowned Kinglet *Regulus satrapa* (Heinrich and Bell, 1995). This bird is among the smallest of birds (5 g), yet they winter in an environment that routinely drops to -30^{o}C by feeding almost exclusively on hibernating insect larvae. The White Ibis *Eudocimus albus* in southern Florida has been shown to switch between prey types from crayfish to fish by changes in abiotic factors namely landscape water depth. The ibises fed on crayfish at relatively higher landscape water depth when more preferred habitat was available, and utilised fish during drier conditions when the wetlands around the colony were simultaneously shallower and reduced in area (Dorn *et al.*, 2011).

Most records of avian diet in tropical Africa have often been based on common observations with few detailed quantitative records (Mckilligan, 2005). In this study, faecal analysis of insectivorous passerines and cattle egret colonies were used to quantify the insect diet of the cattle egret and the digestibility of various insect parts. In specific terms, the study sets out to determine the insect Orders and Families utilise as food by insectivorous passerines and cattle egret colonies.

2. MATERIALS AND METHODS

2.1 Study area

This study was carried out in three sites of Plateau State, Nigeria. The first is Kurra Falls Forest (9°23'N, 8°42'E), located 70 km southwest of Jos city, the capital of Plateau State, Nigeria. The second site is the Fobur Forest (9°51'N, 9°01'E) located about 30 km northeast of Jos. Only the Kurra Falls Forest and the Fobur Forest study sites had a roost colony of cattle egrets of between 2000 and 3000 birds.

Thirdly, another similar study was carried out in the Jos Wildlife Park, a semi-degraded savanna woodland located in close proximity to the Jos City, Nigeria. The Park is located to the south west of Jos, Plateau State, Nigeria, at (09° 52', 08° 53') and covers an area of 12 km^{2}. In general all the study sites have a similar vegetation structure and lanscape. All sites are typically savanna woodlands interspersed with gallery forests, patches of grasslands and rocky outcrops with annual rain fall of between 131.15 mm to 146.00 mm with average daily temperature during period of study ranging between 20 and 30 Degree Celsuis. The study sites relatively show temperate climate for a greater period of the year compared with other parts of Nigeria. The Forest is characterised by altitudinal gradients with elevations ranging from about 600 to 1,414 meters above sea level.

2.2 Sampling design

The two sites with cattle egret colonies were visited thrice for faecal collection at one week intervals. On each sampling day, faecal droppings were collected. This was done by placing a plastic sheet of 5 × 5 m under cattle egret nest colonies at 18:00 hours in the evening and harevested at 06:00 hours in

the morning. Felled droppings collected 12 hours after placement of plastic sheets were transferred into sampling bottles and analysed in the laboratory.

For the third study sites which involve capture of insectivorous passerines, mist netting was carried out. Three 9 m and two 12 m long mist nets were randomly placed in the reserve to trap insectivorous passerines. The five mounted mist nets were intermittently checked for possible catch after every 20 minutes. Mist netting was carried out every other month for a period of five days for one year. When an individual bird was caught, it was extracted (removed from the mist-net) and identified, aged (as adult or juvenile), sexed (where possible) and kept in a wooden box measuring 45x30x20 cm for 15 minutes; this was to create a dark interior suitable for the discharge of faeces. During laboratory analysis, samples were transferred to petri dishes containing 70% alcohol to allow faecal crumbs to break up. Dissolved sample were searched for any identifiable prey remains using a hand lens and light Microscope (Olympus CX31-P) prey remains were separated into the following categories; head parts, thoracic segments, semi-circullar markings, wings, abdominal segments, appendages (leg parts) and whole insects. Prey remains were identified to family level using entomological keys described by (Skaife, 1979; Castner, 2000 and Shattuck, 2000).

2.3 Insect survey design

Insects were sampled along 1000 m transect length placed randomly in different parts of the reserve. This involved the use of sweep netting and pitfall trapping techniques as described by Kent and Coker, (1992) and Sutherland, (1996). Samples were collected at 200 m section along the 1000 m transects. This was carried out to relate insects orders identified in the faecal samples of insectivorous passerines and those insects collected in the field across the savanna woodlands.

3. RESULTS

3.1 Insect diet of the cattle egret and insectiovorous passerines

A total of 385 insect fragments obtained from the cattle egret in Kurra Falls Forest (258 / 67%) and Fobur Forest (127 / 43%), the two sites where cattle egret colony were found. Samples collected from Kurra Falls Forest revealed 3 insect Orders and 7 Families, while the one from Fobur Forest constituted 2 Orders and 2 Families with the Family Curculionidae occuring only in droppings collected from the Fobur site. The Family Acrididae (short-horned grasshoppers) constituted about half (44.42 %) of the total collection from Kurra falls. Insect distribution based on the study sites showed that 91.34 % of samples from Kurra Falls Forest are from the Family Acrididae compared with 21.32 % of samples from Fobur Forest. The Family Formicidae was however the dorminant family (53.10 %) in cattle egret droppings collected from Fobur Forest (Table 1).

For the insectivorous passerines, there was a significant difference in the choice of insects found in the diet by trapped insectivorous passerines (One-sample t-test; $t=5.05$, $df=18$, $P<0.001$). Identification of insect fragments in droppings revealed Hymenoptera, Coleoptera, Orthoptera and Diptera together constituted 80% of the passerine insect prey while 13% was made up of the remaining Orders (Table 3). Examination of faecal droppings of insectivorous passerines also showed undigested insect body parts distributed in 13 insect Orders with only 10 Families identified from the fragments (Table 2; Table 3).

Insects collected from the field exhibited the following hierarchy of abundance; Order Hymenoptera> Diptera> Coleoptera> Orthoptera (Figure 2). A comparison between insect Orders identified from the faecal droppings of trapped insectivorous passerines and insects sampled from the field using sweep-net and pitfall traps showed that the Orders Hymenoptera, Diptera, Coleoptera, Orthopthera, Lepidoptera, Odonata, Isoptera, Hemiptera, Mantodea, Homoptera and Trichoptera were all represented in both insects sampled from faecal droppings and those from the field, while Neuroptera, Mecoptera, Thysanoptera, Dermaptera, Phasmatodea and Blatteria were only represented from the field (Figure 4).

Table 1. Insect diet of cattle egret *Bubulcus ibis* at Kurra Falls and Fobur Forests

Order	Family	Common name	Number/% from Kurra Falls Forest	Number/% from Fobur Forest	% of the total sample
Coleoptera	Carabidae	Ground Beetle	4 (1.55)	-	1.04
	Cicindelidae	Tiger Beetle	1 (0.39)	-	0.26
	Elateridae	Click Beetle	5 (1.94)	-	1.30
	Curculionidae	Snout Beetle	-	1(0.79)	0.26
Hymenoptera	Formicidae	Ants	137 953.10)	-	35.58
Orthoptera	Acrididae	Short-horned Grasshopper	55 (21.32)	116 (91.34)	44.42
	Gryllidae	Cricket	48 (18.60)	-	12.47
	Tetrigidae	Pygmy Grasshopper	3 (1.16)	-	0.78
Unidentified Fragments				10 (7.87)	3.90
Total			258(100)	127(100)	100

- Indicate no record

Table 2. Frequency and Percentage Composition of Insect Diet of Some Insectivorous Passerines Collected from Faecal Droppings (N=385)

Prey item (Insect Order)	Frequency	% Composition	Rank
Thysanoptera (thrips	1	0.5	X
Odonata (dragonflies)	8	2.29	VII
Mantodae (mantids)	1	0.5	XI
Orthoptera (grasshoppers and crickets)	42	12	III
Isoptera (termites)	5	1.43	VIII
Anoplura (sucking lice)	1	0.5	X
Hemiptera (bugs)	4	1.14	IX
Homoptera (cicadas and hoppers)	5	1.43	XI
Coleoptera (beetles and weevils)	84	23.14	II
Tricoptera (caddisflies)	1	0.5	X
Lepidoptera (butterflies and moths)	15	4.29	VI
Diptera (flies)	33	9.43	IV
Hymenoptera (ants, bees, wasps)	125	35.71	I
Unidentified insect fragment	25	7.14	V
Total	350	100	

Table 3. Frequency and Percentage Composition of Insect Families in Faecal Droppings of Some Insectivorous Passerines (N=385)

Prey item (Insect Family)	Frequency	% Composition	Rank
Mantidae	1	0.74	VIII
Acrididae (grasshoppers)	15	11.11	III
Termitidae (Termites)	5	3.75	IV
Haematopinidae	1	0.74	VIII
Curculionidae (weevils)	4	2.96	V
Culicidae	1	0.74	VIII
Tachinidae	1	0.74	VIII
Formicidae (ants, wasps)	56	41.48	I
Braconidae (wasps)	1	0.75	VI
Scarabidae (beetles)	2	1.4	VI
Unidentified Insect Family	48	35.50	II
Total	135	100	

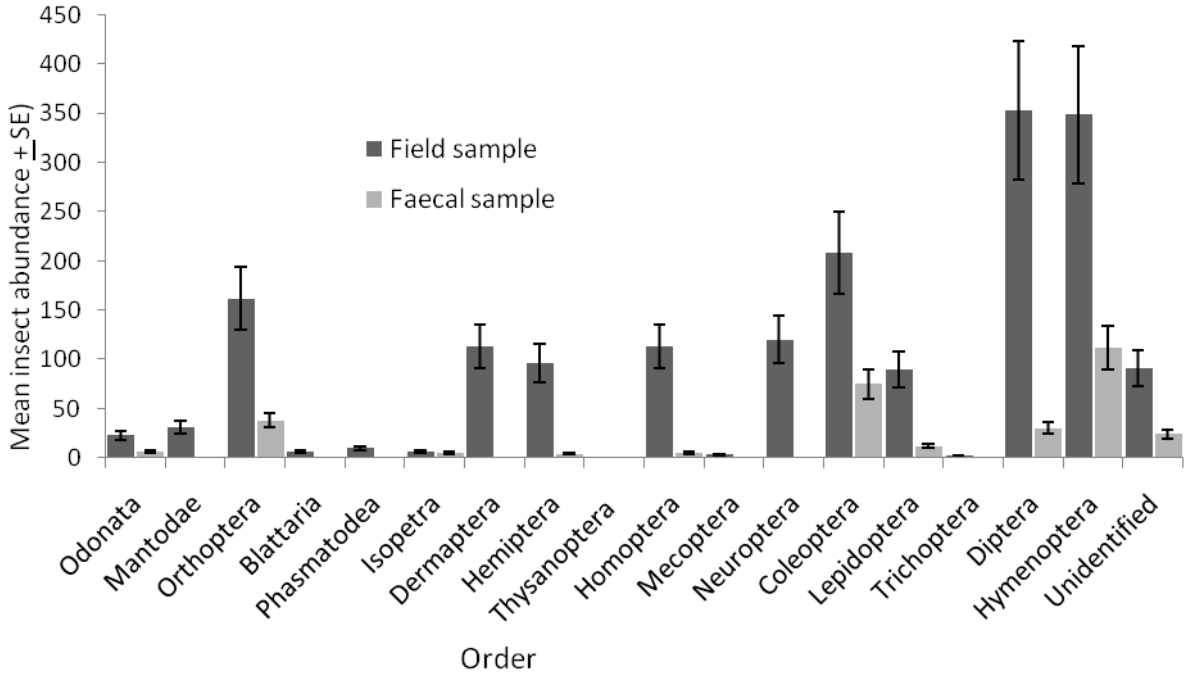

Figure 1. Comparison of Insect Orders Collected from the Field and Faecal Samples

3.2 Digestibility of insect parts

Undigested insect fragments from cattle egret droppings include head parts, thoracic segments, wings, abdominal segments and appendages (leg parts). Whole insects were also encountered belonging to the families Acrididae, Formicidae, Gryllidae and Tetrigidae. More than half of the total undigested fragments (51 %) were insect appendages. However, 50.98 % of the samples from Kurra Falls Forest

were head parts while 73.50 % of samples from Fobur Forest were appendages. Distribution of undigested insect fragments however did not differ significantly between the two study sites.

4. DISCUSSION

The Insect diet of the cattle egret, *B. ibis* found in two roost colonies in northcentral Nigeria, slightly differ from Snoody's findings of gut analysis in Georgia, America where Dipterans (horse flies) constitute 59 % of total recovered specimen (Snoody 1969). However, findings are largely similar to reports from other regions of Australia where faecal analysis showed Orthopterans (grasshoppers and crickets) as constituting a major part of the diet of cattle egrets outside breeding season (Mckilligan 2005). Examination of specimen collected from the two study sites however showed differences in the composition of insect families fed by birds. Such differences could be influenced by the diversity and abundance of insect species present in the areas where cattle egrets from these two roost colonies forage.

Other prey observed in the study, were Hymenopterans of the family Formicidae (ants) and Coleopterans (beetles). Two possibilities could explain the high occurrence of ants in the cattle egret droppings from Fobur Forest; first, the wingless nature of the identified ants, could subject them to easy predation. Secondly, its likely that preffered prey occur in low frequency as compared to ants at the site where these particular cattle egrets forage. Because coleopterans are among the most diversed group of insects (Asokan 1998), birds may capitalised on their diversity to feed opportunistically on them. This may be driven especially by the lost of habitats that result in norrowing down the available habitat of insects into just few **(**Frankham *et al.* 2010, Mwansat and Turshak 2010**).**

Undigestibility of fragments such as appendages (legs), thoracic regions, heads and mouthparts, wings, semicircular markings etc is likely a result of high chitin content. Chitin is a mucopolysaccharide that serves a structural role in many invertebrates forming a primary constituent of the exoskeleton of arthropods (Klasing 2000). The chitin content of insects have been pointed out to vary in proportion across different parts and is the major factor affecting their digestibility. This component is known to act by physically limiting the access of digestive enzymes to lipids and proteins of such parts (Kaspari 1991, Kaspari and Joern 1993, Klasing 2000). Thus, many birds prepare insects by removing the parts high in chitin before swallowing or feeding their young. For example, Grasshopper Sparrows, *Ammodramus savannarum* (Fringillidae) usually remove the wings and tibia from grasshoppers prior to consumption. These parts are documented to contain more than 50 % chitin as against less than 10 % found in abdominal regions which is often consumed (Klasing 2000). Whole insects found in cattle egret droppings from the two colonies might indicate satiation due to high food abundance.

Insect diet studied by collection of insectivorous passerines affirmed that birds exhibit preference for certain insect orders, as they fed primarily on insect Orders Hymenoptera, Coleoptera, Orthoptera and Diptera thereby generating 36%, 23%, 12% and 9% insect remains in their droppings respectively. This finding is does not only reflect insects remains found in cattle egret diet, it is also consistent with results of earlier studies (Sen, 1944; Mukherjee, 1975; Wilson *et al.*, 1999; Hughes *et al.*, 2000; Yahya, 2001; Asokan *et al.*, 2009; Wichaikam *et al.*, 2010; Onadeko, 2011). In another study carried out in Malaysia (Burton, 1998), insects mostly ants, beetles and grasshoppers were observed to be the main diet of White-breasted Kingfisher *Halcyon smyrnensis*. This study confirmed that there were more ants in the diet than other insects. Similar results were obtained by Yard, Van Riper, Brown and Kearsley (2004) and Pincheira-Donoso (2008). Earlier, Asokan (1998) found that Hymenopterans (dominated by ants) and Coleopterans (dominated by beetles) were the principal food items of the Bee-eater *Merops oreintalis* in Nagapattinan District, India.

5. ACKNOWLEDGEMENTS

We are most grateful to the University of Jos and the A. P. Leventis Conservation Foundation for funding this project. We appreciate the Kurra Falls, Fobur Districk and the Jos Wildlife Park communities for their support during the field work.

6. REFERENCES

Asokan, S. (1998). Food and feeding habits of a small green bee-eater *Merops orientalis* in Mayiladuthurai. *Journal of Ecobiology*, 10(3), 199-204.

Asokan, S., Ali, A.M.S. and Manikannan, K. (2009). Diet of three insectivorous birds in Nagapattinam district, Tamil Nadu India- a preliminary study. *Journal of Threatened Taxa*, 1(6), 327-330.

Buij, R., Van Der Goes, D., De Iongh, H.H., Gagare, S., Haccou, P., Komdeur, J. and De Snoo, G. (2012). Interspecific and intraspecific differences in habitat use and their conservation implication for Palaerctic harriers on Sahelian wintering grounds. *Ibis*, 154, 96-110.

Burton, N.H.K. (1998). Notes on the diet of nestling White-throated Kingfisher *Halcyon smyrnensis* in Malaysia. *Folktail*, 14, 79-80.

Castner, J.L. (2000). Photographic Atlas of Entomology and Guide to Insect Identification, Feline Press Inc.

Dorn, N.J., Cook, M.I., Herring, G., Boyle, R.A., Nelso, J. and Gawlik, D.E. (2011). Aquatic prey switching and urban foraging by the White Ibis *Eudocimus albus* are determined by wetland hydrological conditions. *Ibis*, 153, 323-335.

Elgood, J. H.; Heigham, J. B.; Moore, A. M.; Nason, A. M.; Sharland, R. E. and Skinner, N. J (1994). The birds of Nigeria (2nd edn.). British Ornithologists Union, U.K.

Frankham, R., Ballou, J.D and Briscoe, D.A. (2010). Introduction to Conservation Biology. Cambridge University press. 18pp.

Mwansat, G.S. and Turshak, L.G. (2010). Preliminary investigation of insect community of Ologbo Forest Edo State, Nigeria. *African Journal of Natural Sciences*, 13, 1-10.

Heinrich, B. and Bell, R. (1995). Winter food of a small insectivorous bird, the Golden-crowned Kinglet. *Wilson Bulletin*, 107, 558-561.

Hughes, J.B., Daily, G.C. and Ehrlich, P.R. (2000). Conservation of insect diversity: a habitat approach. *Conservation Biology*, 14(6), 1788-1797.

Klasing, K. C. (2000). Comparative Avian Nutrition. CABI Publishing.

Mckilligan, N. (2005). Herons, Egrets and Bitterns: their biology and conservation in Australia. CSIRO Publishing.

Moreau, R. E. (1972). The Palaearctic-African bird migration systems. Academic Press, London and New York. pp 100-109.

Morse, D. H. (1975). Ecological aspects of adaptive radiation in birds. *Biological Reviews* 50: 167-214.

Mukherjee, A.K. (1975). Food habit of water birds of the Sundarban 24 Paraganas District, Bengal, India. *Journal of the Bombay Natural History Society*, 72, 85-109.

Nakano, D., Akasaka, T., kohzu, A. and Nakamura, F. (2007). Food sources of Sand Martin *Riparia riparia* during their breeding season: insight from stable isotope analyses. *Bird Study*, 54, 142-144.

Onadeko, A.B. (2011). Food and feeding habits of some anuran species in south western Nigeria. *The Zoologist*, 9, 57-69.

Pincheira-Donoso, D. (2008). Testing the accuracy of faecal-based analyses in studies of trophic ecology in lizards. *Copaei*, 2, 322-325.

Sen, S.N. (1944). Food of White-breasted Kingfisher. *Journal of the Bombay Natural History Society*, 44, 475-480.

Snoody, E. L. (1969). On the behaviour and food habits of the cattle egret, *Bubulcus ibis* (L.). *J. Georgia Entomol. Soc.* 4: 156-158.

Wichaikam, N., Anusontpornperm, S., Sakchoowong, W. and Amornsak, W. (2010). Seasonal and Habitat-Specific Differences in Soil Insect Abundance from Organic Crops and Natural Forest at the Ang Khang Royal Agricultural Station, Chiang Mai, Thailand. *Thai Journal of Agricultural Science,* 43(4), 231-237.

Wilson, J.D., Antony J. Morris, A.J., Arroyo, B.E., Clark, S.C. and Bradbury, R.B. (1999). A review of the abundance and diversity of invertebrate and plant foods of granivorous birds in northern Europe in relation to agricultural change. *Agriculture, Ecosystems and Environment,* 75, 13–30.

Yahya, H.S. (2001). Feeding habits of the White-breasted Kingfisher *Halcyon smyrnensis*. Family Alcedinidae. *Journal of the Bombay Natural History Society,* 98, 450-451.

Yard, H.K., Van Riper III, C. Brown, B.T. and Kearsley, M.J. (2004). Diet of insectivorous birds along the Colorado River in Grand Canyon, Arizona. *The Condor,* 106, 106-115.