Chapter 12
On the feeding ecology of the pied kingfisher, *Ceryle rudis* at Lake Nokoué, Benin. Is there competition with fishermen?

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Abstract

Lake Nokoué, in southern Benin, is a heavily exploited fishery, but it is also inhabited by numerous piscivorous birds, especially kingfishers. This chapter considers the similarity between the diet of kingfishers and fish available on the local market between mid-February to mid-May 1999, during a low water level period. Excretory pellets were collected on the top of breeding banks and inside brood chambers. The diet was determined by comparing the bones recovered from the pellets with a reference collection. Eighteen prey categories were recognised in the 1099 diagnostic items. Kingfishers preyed mostly on cichlids (*Sarotherodon melanotheron* Rüppell and *Hemichromis fasciatus* Peters), clupeids (*Ethmalosa fimbriata* (Bowdich)), eleotrids (*Kribia* sp.) and *Hyporhamphus picarti* (Val.). Prey size of *H. fasciatus* ranged from 22 to 73 mm (46.4 ± 11.6 mm) and for *S. melanotheron* from 24 to 65 mm (44 ± 9.2 mm). The composition of the diet varied depending on time and location. Overlap with marketed fish is limited to *S. melanotheron*.

Keywords: Benin, *Ceryle rudis*, diet, feeding ecology, fisheries.

12.1 Introduction

Lake Nokoué is a large lagoon situated near Cotonou, the economic capital of the Republic of Benin, and is crucial to the local economy. It covers an area of approximately 150 km^2 in the dry season extending to 1000 km^2 at the peak of the floods. It is the largest permanent lake of the country and is connected by a 5-km long channel with the Atlantic Ocean. A dense human population is established in villages built on piles. The main activities are agriculture, trade and fishing, the latter of which involves about 90 000 persons (Laleye 1995). Fish are caught by various types of nets, long lines and especially in privately-owned brush park enclosures called 'akadjas'. These enclosures are made of immersed tree branches that allow the development of a rich plankton and provide good shelter to the fish. Twenty years ago, the annual production of this system was estimated at 4 t ha^{-1}, but this has dropped to 1–2 t ha^{-1} (Aglinglo 1998). Local

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fishermen also use other methods, such as crab pots or traps, designed to catch estuarine fish that move with the current.

Some otters and many fish-eating birds, namely cormorants, egrets, herons, terns and hundreds of kingfishers also exploit this important resource (Schockert 1998). As fish is the most important animal protein source for the human population, these birds are often considered as potential competitors. This chapter examines the possible impact of one of the most common piscivorous groups – fish-eating birds – on the fish resources, using a study carried out on the pied kingfisher, *Ceryle rudis* (L.), the most numerous piscivorous bird species. This species was chosen because its nests or resting perches are not difficult to locate and its food-remains are conspicuous pellets, available on the banks or in the nest brood chambers. Moreover, cichlids, a target species of the fishery, were the dominant food of kingfishers (Tjomlid 1973; Douthwaite 1976; Whitfield & Blaber 1978; Reyer *et al.* 1988). As they are able to catch cichlids larger than 10 cm (Douthwaite 1976), pied kingfishers may be a potential competitor of fishermen, especially as the size of fish in the market has decreased due to overfishing.

Pied kingfishers also occasionally prey on frogs, crustaceans, aquatic insects and even termites (Tjomlid 1973; Douthwaite 1976; Cooper 1981) and are able to survive and even to thrive, feeding mainly on small pelagic fish: clupeids, or cyprinids where cichlids are rare (Junor 1972; Jackson 1984). Their adaptability to strong changes in the ichtyocenoses was illustrated in Lake Victoria after the introduction of the Nile perch, *Lates niloticus* (L.) (Wanink & Goudswaard 1994), where they shifted their diet from cichlids to the small pelagic cyprinid, *Rastrineobola argentea* (Pellegrin). They hunt either from a perch or hovering flight. This regularly observed behaviour allows the birds to fish in pelagic waters, which is uncommon in other kingfisher species. Rough estimates of their food consumption indicate a daily intake varying from 17.5 to 26.5 g (Tjomlid 1973).

12.2 Study area

Southern Benin is in a subequatorial climate zone (Fig. 12.1), with a high relative humidity (77–93%) and a high mean monthly temperature ranging from 22.4 to 32.9°C. Annual rainfall is about 1000 mm distributed into a long rainy season from March/April to July and a short season from September to mid-October (Pliya 1980).

Lake Nokoué (6°23′–28′N, 2°22′–33′E) is a shallow lagoon not exceeding 2.50 m in depth. In 1990 and 1991, its mean depth ranged from 1.07 m at the end of the dry season (April) to 1.72 m during the floods (September). Its waters are relatively turbid, especially during the floods: Secchi depth varies between 50 and 120 cm in Vêki, in the vicinity of the study sites. Salinity also fluctuates widely: from 25–30 mg litre^{-1} in April–June to 0–5 mg litre^{-1} in August–November (Laleye 1995).

The fish community comprises at least 78 species from freshwater, brackish or marine origin, but is dominated throughout the year by three families: clupeids (*Ethmalosa fimbriata* (Bowdich), *Pellonula leonensis* Boulenger, *P. vorax* Günther), cichlids (*Sarotherodon melanotheron* Rüppell, *Tilapia guineensis* (Günther)) and bagrids (*Chrysichtys auratus* Geoffroy St Hilaire, *C. nigrodigitatus* (Lacépède)) (Laleye 1995).

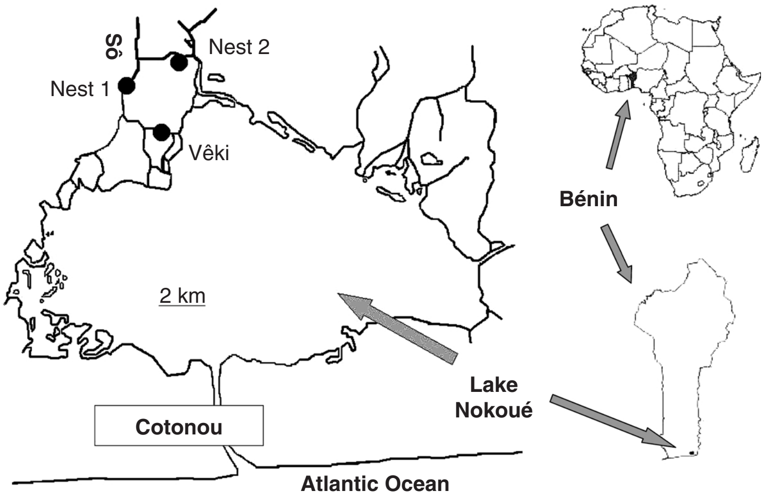

Figure 12.1 Schematic map of Lake Nokoué indicating the three study sites

12.3 Methods

This study was based on analysis of the excretory pellets (Doucet 1969; Douthwaite 1976; Whitfield & Blaber 1978; Hallet-Libois 1985). To identify the remains, a reference collection of the skull bones of the main fish species present in the area was made from fish bought on the local markets and identified by P. Laleye (see Fig. 12.2 for examples). Diagnostic bones were chosen in this collection to make possible the specific or generic identification of the fishes.

Pellets were collected approximately every 2 days in the delta of the River Sô, northwest of Lake Nokoué (Fig. 12.1) from mid-February to mid-May 1999. They were found on the top of the breeding banks or excavated from three nest brood chambers. When recovered from the banks, they were analysed without further treatment whereas the brood chamber material was cleaned by immersion in water for a few days. Soaked pellets were then sieved under a weak water jet and dried before the characteristic skull bones were sorted, counted and some measured. In each sample, right and left bones were counted separately and the minimum number of prey belonging to a taxonomic category was considered as the maximum value of either count for this category. For *S. melanotheron* and *Hemichromis fasciatus* Peters, the standard length of the preyed fish was determined from the length of the diagnostic bones using fish length–bone length relationships developed for local fishes (Fig. 12.3).

The *G* test was used to compare the differences between the diets of different groups of birds, i.e. by time, location and size. Similarity between the diet of birds with the catch of fishermen was made using Pianka's equation:

$$O = 1 - \frac{\sum \left| p_{ij} - p_{ik} \right|}{2}$$

where p_{ij} is the proportion of species i in the diet and p_{ik} its proportion in the marketed fish.

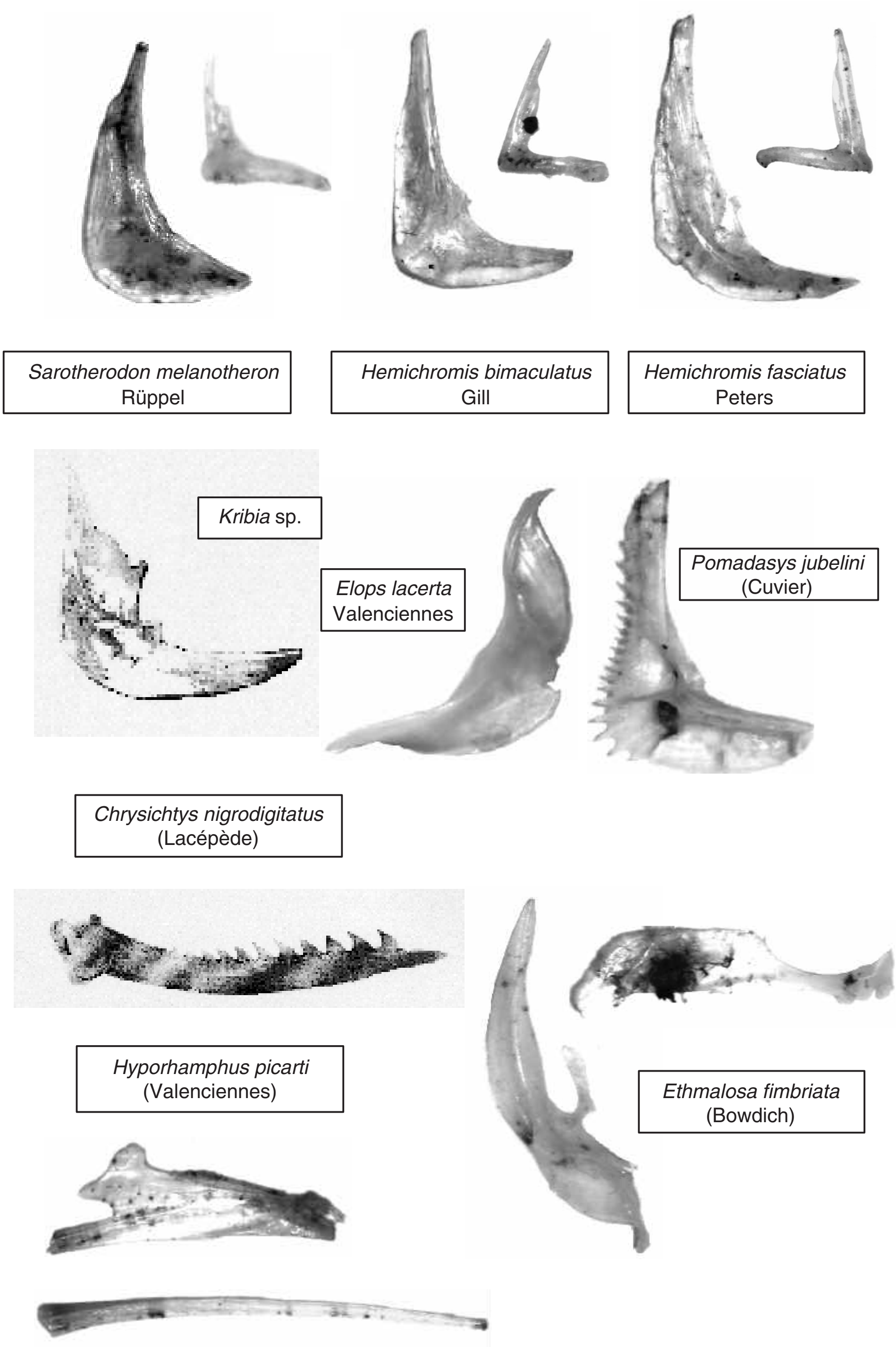

Figure 12.2 Diagnostic bones of some of the fish species present in lake Nokoué. The pre-opercular bones of three cichlids are shown (top left) as well as their premaxillary (top right)

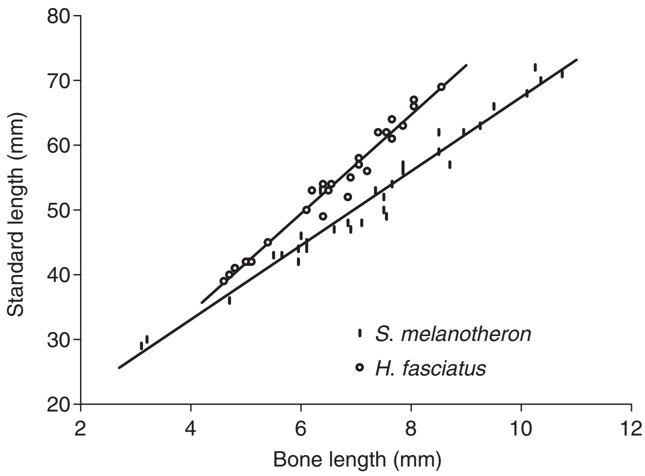

Figure 12.3 Relationships between the standard length and the preopercular bone length in *Sarotherodon melanotheron* ($SL = 5.731 \times BL + 10.132$; $r = 0.981$; $n = 32$) and in *Hemichromis fasciatus* ($SL = 7.638 \times BL + 3.600$; $r = 0.987$; $n = 27$)

12.4 Results

The main prey of pied kingfisher at lake Nokoué were *E. fimbriata* (29%), *S. melanotheron* (24%) and *H. fasciatus* (22%). Other important species were the small *Kribia* species (10%) and *Hyporhamphus picarti* (Val.) (8%). Seven other fish species and arthropods accounted for the remanding 7.5% of the diet. However, the diet varied according to location, season and the age of birds. This was illustrated by comparing content of pellets taken from different parts of the lake at different times (Table 12.1).

A sample taken from a nest along the River Sô 2 days before hatching (mid-February) contained 54% and 37% of *H. fasciatus* and *S. melanotheron* respectively. The remainder comprised *Kribia* (4%) and *Clarias* sp. (6%). This is in contrast to pellets taken from a nest situated along an oxbow, where one 8-day-old nestling was present and the diet comprised mainly *H. fasciatus* (42%) and *E. fimbriata* (33%), with few *S. melanotheron* (4%), although Mugilidae were also important (14%). During the fledgling period (mid-March–mid-May, the diet from Vêki, along the shores of the lake, was much more diversified, comprising 15 different prey categories, of which *E. fimbriata* was the most important (36%). *Hemichromis fasciatus* was much less frequent than in the other places and than *S. melanotheron*. The importance of *H. picarti* and *Kribia* also increase at this site. These differences observed were highly significant ($G_{\mathrm{corr}} = 85.4$; $P < 0.001$; 16 d.f.). (Note, the G-statistic was computed on the basis of the species of fish, except the clupeids which were considered as one category, the three species of cichlids which were considered separately, and the Bagridae and Clariidae as a single category. *Elops* sp., *Gerres melanopterus* (Bleeker), *Tilapia guineensis* and the arthropods were also grouped, as were *P. jubelini, Monodactylus sebae, H. picarti, Kribia* sp. and *Yongeichtys thomasi.*) The partial G's were highly significant for individual prey categories, with the exception of *Y. thomasi* (Boulenger).

Table 12.1 Local variations in the diet of the pied kingfisher in the western part of Lake Nokoué

	Nest 1 adults mid-Feb	Nest 2 adults (+nestlings?) late Feb	Vêki adults mid-March–early May
Ethmalosa fimbriata		37	259
Unidentified Clupeidae			13
Hyporhamphus picarti			88
Hemichromis fasciatus	61	47	110
Sarotherodon melanotheron	42	4	174
Tilapia guineensis			6
Gerres melanopterus			10
Kribia sp.	4	2	95
Yongeichtys thomasi		5	14
Elops sp.			4
Clarias sp.	6		
Chrysichtys nigrodigitatus	1	2	2
Mugil sp.		16	
Unidentified fish			1
Crustaceans			4
Coleoptera			2
Termites			1
Other insects			1
Number of prey items	114	113	784

To illustrate temporal variations, the samples collected in Vêki were grouped by ten-day periods, the first collected in mid-March and the last at the beginning of May (Fig. 12.4). As a whole, the temporal differences were highly significant ($G_{corr} = 109.3$; $P < 0.001$; 25 d.f.) except for the category 'other prey', grouping *T. guineensis, Y. thomasi, Elops* sp., *Chrysichtys nigrodigitatus* and the arthropods. However, samples taken during March were not statistically different from each other, as were the two samples from early April and the samples from late April and early May. In March, cichlids were the dominant prey, contributing about 50% of the food items. The contribution of cichlids fell considerably in early April but recovered thereafter, whereas the proportion of the other fish remained constant with the exception of clupeids, which increased from about 10 to 60%. The contribution of *E. fimbriata* decreased slowly to 35% at the beginning of May. It should be noted the contribution of *H. fasciatus* declined progressively over the 2-month period but the importance of *S. melanotheron* remained relatively stable.

Differences in the diet of adults and nestlings were assessed by comparing the diet of the adults from Vêki during late April with that of old nestlings found in a nest situated nearby at the same time. As adults brood their offspring until they are about 10–11 days old, the first adult nestling sample was taken on day 11 to eliminate the mixing of young and adult pellets previously excreted. The same prey categories appeared in the diets of the adults and nestlings (Table 12.2) and the differences were not significant ($G_{corr} = 7.5$; $P > 0.05$; 7 d.f.). However, the partial G's for the cichlids,

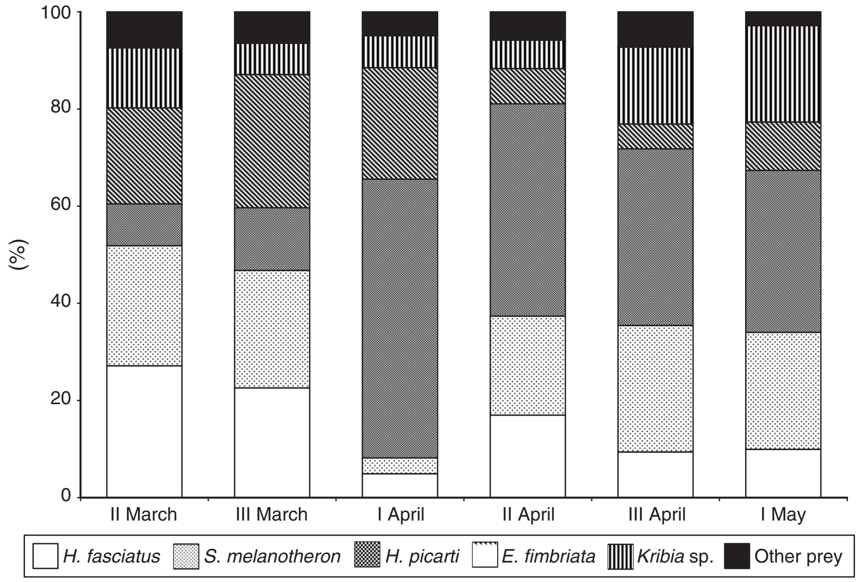

Figure 12.4 Temporal shifts in the relative abundance of prey items in the diet of pied kingfisher at Vêki

Table 12.2 Comparison of the composition of adult and nestling pied kingfishers diet at Vêki

	Nestlings	Adults
Ethmalosa fimbriata	15	157
Unidentified Clupeidae		13
Hyporhamphus picarti		27
Hemichromis fasciatus	27	54
Sarotherodon melanotheron	38	102
Tilapia guineensis		3
Gerres melanopterus		6
Kribia sp.	5	49
Yongeichtys thomasi	2	10
Elops sp.		4
Mugil sp.	1	
Crustaceans		2
Coleoptera		2
Other insects		1
Number of prey items	88	430

E. fimbriata and *H. picarti* were significant ($P < 0.01$); the proportion of both cichlids being much more important (74% vs 36%) to nestlings, whereas *E. fimbriata* was the main prey of the adults. *Hyporhamphus picarti* was not found in the diet of the nestlings. There were, however, differences in the size of the two main prey species

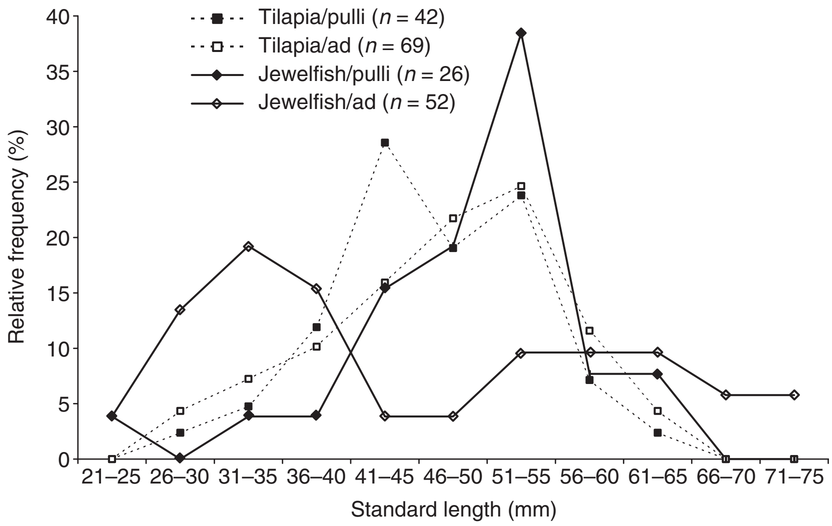

Figure 12.5 Size distribution of two species of fish in the diet of adult and nestlings of pied kingfishers at Vêki

in the diets of adults and nestlings (Fig. 12.5). In *S. melanotheron*, the size of fish consumed were not statistically different ($P = 0.284$, Kolmogorov-Smirnov test) whereas the *H. fasciatus* eaten by adults were much smaller than the fish brought to the nestlings ($P = 0.015$).

The catch from four akadjas (Aglinglo 1998) in the same area as the kingfishers were feeding included the same species, except *Pomadasys jubelini* (Cuvier), *Monodactylus sebae* (Cuvier) and *Chrysichtys auratus,* but the proportional representations were very different (Table 12.3). More than one-half of the akadjas catch was *S. melanotheron*, but this species comprised less that 25% of the diet of kingfishers. By contrast, *H. fasciatus* and *E. fimbriata* each contributed about 25% to the kingfisher diet but <5% to the commercial catch. *Tilapia guineensis* is an important (20%) commercial species but rarely preyed upon by kingfishers. Conversely, important prey of the kingfisher, *Kribia* sp. and *H. picarti*, were not found in the marketed fish. These differences were highly significant ($G_{corr} = 157.8$; $P < 0.001$; 8 d.f.). (Note, the *G*-statistic was computed on the basis of the families of fish, except the three species of cichlids which were considered separately, Bagridae and Clariidae were grouped, as were *P. jubelini, Monodactylus sebae*, on the one hand and *H. picarti, Kribia* sp. and *Y. thomasi* on the other hand.) Overlap between the composition of the kingfisher diet and commercial catches was therefore rather limited ($O = 0.349$). Taking into account the size distributions of *H. fasciatus* and *S. melanotheron* preyed upon by kingfishers and caught by the akadjas (Fig. 12.6), the similarity fell to $O = 0.082$. Indeed, there was also little similarity ($O = 0.082$) in the sizes frequency distributions of *S. melanotheron* and *H. fasciatus*, preyed upon by kingfishers and caught by the akadjas (Fig. 12.6); most cichlids harvested by the akadjas were >70 mm while they were <75 mm in the kingfisher diet.

Table 12.3 Comparison of pied kingfisher diet and catch from four akadjas in the western part of Lake Nokoué (*Source:* Aglinglo 1998)

	Akadjas	Kingfisher diet
Ethmalosa fimbriata	40	311
Unidentified Clupeidae		13
Hyporhamphus picarti		88
Hemichromis fasciatus	28	245
Sarotherodon melanotheron	435	258
Tilapia guineensis	170	6
Gerres melanopterus		10
Pomadasys jubelini	47	
Kribia sp.		106
Yongeichthys thomasi		21
Bagridae/Clariidae	51	11
Elops lacerta	10	4
Liza falcipinnis	36	
Unidentified Mugilidae		17
Other fish	7	1
Number of items	824	1091

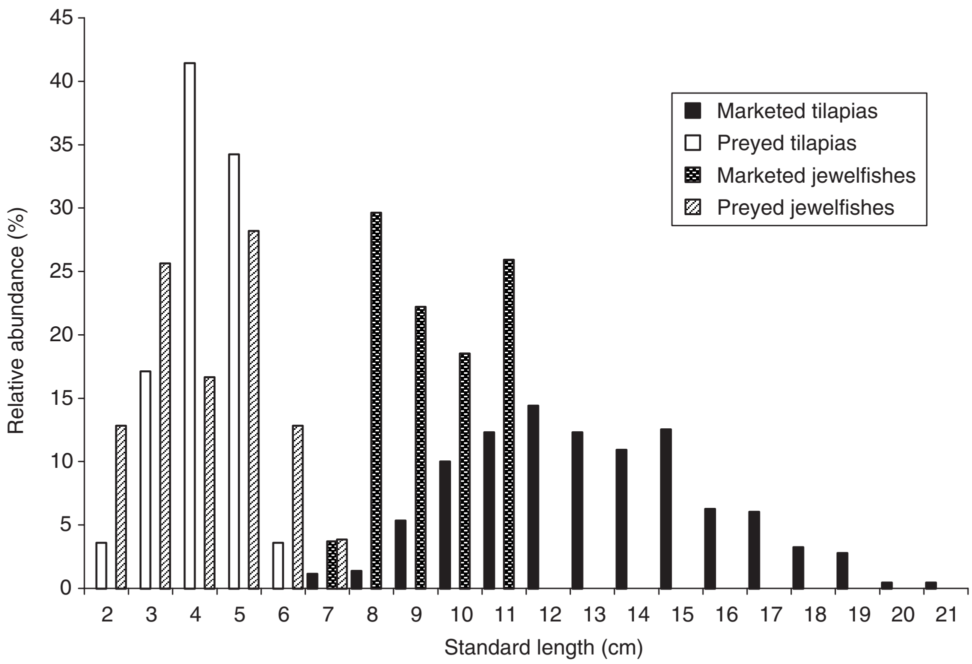

Figure 12.6 Size distributions of two species of fish in akadjas catches (*Source*: Aglinglo 1988) and in the diet of the pied kingfisher. For *S. melanotheron*, $n = 430$ and 256 respectively in the akadjas and in the kingfisher diet. Corresponding numbers for *H. fasciatus* are 27 and 229

12.5 Discussion

The main prey of the pied kingfisher around lake Nokoué is cichlids. These species are demersal and strictly should not be available to the bird. However, small-sized individuals of *H. fasciatus* and *S. melanotheron* are often found in shallow waters near the banks (Gosse 1963) where they are more vulnerable to predation by kingfishers. The second most important prey was Clupeidae, especially *E. fimbriata*. This pelagic species lives in dense shoals, and its availability is therefore limited to birds fishing offshore (hovering flight). Other pelagic species of minor importance in the diet are *Elops* sp. and the mullets. The third important group is *Kribia* (*Kriba nana* (Boulenger), *Kribia kribensis* (Boulenger), or both). These are small demersal freshwater fish, measuring less than 6 cm (total length) (Maugé 1986), occasionally found on the sandy bottom of streamlets or among aquatic vegetation in running waters (Roman 1975). These requirements may be met in the delta of the River Sô, especially where the akadjas are located. *Hyporhamphus picarti* is a benthic species, feeding on algae and organic debris. However, its eggs are attached to the aquatic vegetation (Collette & Parin 1990), thus during the reproductive season, it may be more vulnerable to the kingfisher. *Y. thomasi, G. melanopterus, Clarias* sp. and *C. auratus* are also demersal species but their contribution to the diet is very limited.

The general view of the diet reflects not only the different ways the kingfisher hunts for prey (near the banks or offshore), but also the diversity of habitats it exploits, from freshwater (presence of *Kribia*) to brackish areas. For example, differences were found in the diets of kingfishers between nest 1 and 2 (Table 12.1), such that *S. melanotheron* was less abundant in nest 2, while *E. fimbriata* and mullets were not present in nest 1. This was probably because nest 2 was much closer to the shores of the lakes than nest 1 ($\approx$600 m vs $\approx$2600 m) and there were probably more opportunities for these breeding birds to hunt for pelagic fish.

Temporal variations in diet were evident around the end of March, when the first rains were registered. At this time the lake level rose about 10 cm, strong winds were evident, the surface became turbulent and the waters became turbid. These changes probably induced some modifications in the fishing behaviour of the bird, as were reported on Lake Victoria where, in normal conditions, pied kingfishers made about 80% of dives from perches but, in unsettled weather only 14% of dives were from perches while the rest were made from a hovering position (Douthwaite 1976). The sudden shift in the diet in late March, from the cichlids to the *E. fimbriata* correlates with a possible change in feeding behaviour. Once the weather settled, cichlids again became relatively important numerically but the proportion of *E. fimbriata* remained high, a probable consequence of ongoing rains. The increased representation of *Kribia* at the end of the period could indicate that the kingfishers search for more sheltered places, preferably hunting along the river than near the banks of the lake.

The comparison between the diet of the nestlings and of the adults suggested that adults eat smaller and thinner fish (*H. picarti*, *Kribia* and *E. fimbriata*) than those they bring to their offspring (*S. melanotheron* and *H. fasciatus*). This observation is partially explained by the ability of pied kingfisher nestlings to digest bones (Douthwaite

1976). However, while adult birds can eat small fish on the wing (Wanink *et al.* 1993) or close to their fishing post, when feeding their young they have to carry prey some distance. It is probably more energy saving to carry larger than small prey. When the energy demand of the brood becomes more important, i.e. when the nestlings are 10–12 days old, the parents face an increasing feeding effort. The difference observed in prey category (slender vs stout) or size (small vs large) probably reflects a difference in the behaviour of the parents if fishing for themselves or for their offspring. Similar observations were found for *C. rudis* (Douthwaite 1976) and the European kingfisher, *Alcedo atthis* (L.) (Hallet-Libois 1985).

The study suggests that kingfishers take a lot of fish that have no economic interest (*Kribia* sp., *H. picarti, Y. thomasi*) or that are of low market value (*H. fasciatus*). The negative economic impact of the bird seems restricted to *S. melanotheron*. However, the prey items are only small individuals, under the market size. Despite the possibilities that these small tilapias could grow to a marketable size, their predation by the kingfisher is likely counterbalanced by the capture of *H. fasciatus* in a ratio of about 1 : 1, which reduces predation pressure from this source. This cichlid is a voracious predator of small fish (Hickley & Bailey 1987), and sometimes used to control tilapias (Robins *et al*. 1991).

12.6 Conclusions

This chapter emphasised the high degree of adaptability of the diet of the pied kingfisher. Indeed, even in a similar environment, variations were found either between sites or over very short periods of time. Around Lake Nokoué, pied kingfishers prey mainly on cichlids, *E. fimbriata*, *H. fasciatus* and *Kribia*. However, the importance of these prey items varies depending on the location of the nests, the age of the birds and seasonal climatic events. These modifications in the diet result in a complex decision process integrating environmental factors as well as proximal stimuli from the offspring. Competition with fishermen seems minimal because the overlap between the composition of the bird diet and the marketed fish is restricted mainly to *S. melanotheron*. However, the individuals taken by the birds are small, out of the range of those caught by fishermen. Nevertheless, the impact of the kingfisher on small *S. melanotheron* remains difficult to assess, although bird predation on one of the major fish predators of *S. melanotheron* could have a positive influence on the overall survival of the small tilapias.

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References

Aglinglo C. (1998) Production de poissons dans les acadjas du Lac Nokoué et de la lagune de Porto-Novo en république du Bénin. Situation actuelle et perspectives pour une gestion rationelle. *Mémoire DES Sciences Naturelles appliquées et Écodéveloppement*. Univ. Liège, 58 pp. + ann (in French).

Collette B.B. & Parin N.V. (1990) Hemirhamphidae. In P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen & E. Tortonese (eds) *Fish of the North-East Atlantic and the Mediterranean*, Vol 2. Paris: UNESCO, pp. 620–622.

Cooper A.S. (1981) Pied kingfisher catches crab at sea. *Cormorant* **9**, 135–136.

Doucet J. (1969) Coup d`oeil sur le régime alimentaire du Martin-pêcheur. *Aves* **6**, 90–99 (in French).

Douthwaite R.J. (1976) Fishing techniques and foods of the pied kingfisher on Lake Victoria in Uganda. *Ostrich* **47**, 153–160.

Gosse J.P. (1963) Le milieu aquatique et l'écologie des poissons dans la région de Yangambi. *Annales du Musée de l'Afrique centrale, Tervueren, N.S.* **116**, 113–270 (in French).

Hallet–Libois C. (1985) Modulations de la stratégie alimentaire d'un prédateur: Eco-éthologie de la prédation chez le martin-pêcheur *Alcedo atthis* (L., 1758), en période de reproduction. *Cahiers d'Éthologie Appliquée* **5**(4), 1–206 (in French).

Hickley P. & Bailey R.G. (1987) Food and feeding relationships of fish in the Sudd swamps (river Nile, Southern Sudan). *Journal of Fish Biology* **30**, 147–159.

Jackson S. (1984) Predation by Pied kingfisher and whitebreasted cormorants on fish in the Kosi estuary system. *Ostrich* **55**, 113–132.

Junor F.J.R. (1972) Offshore fishing by the Pied Kingfisher, *Ceryle rudis*, at lake Kariba. *Ostrich* **43**, 185.

Laleye P. (1995) *Écologie comparée de deux espèces de Chrysichtys du complexe lagunaire Lac Nokoué – Lagune de Porto Novo au Bénin.* PhD thesis, Univ. Liège, 186 pp.

Maugé L.A. (1986) Eleotridae. In J. Daget, J.P. Gosse & D.F.E. Thys van den Audenaerde (eds) *Checklist of the Freshwater Fishes of Africa*. Vol. 2. Paris, Brussels and Tervueren: ORSTOM, IRScNB and MRAC, pp. 389–398.

Pliya J. (1980) *La pêche dans le sud-ouest du Bénin. Étude de géographie appliquée sur la pêche continentale et maritime.* Paris: ACCT, 296 pp. (in French).

Reyer H.U. (1986) Breeder-helper-interactions in the Pied Kingfisher reflect the cost and benefits of cooperative breeding. *Behaviour* **96**, 277–303.

Reyer H.U., Migongo-Bake W. & Schmidt L. (1988) Field studies and experiments on distribution and foraging of pied and malachite kingfishers at lake Nakuru (Kenya). *Journal of Animal Ecology* **57**, 595–610.

Robins C.R., Bailey R.M., Bond C.E., Brooker J.R., Lachner E.A., Lea R.N. & Scott W.B. (1991) World fishes important to North-Americans exclusive of species from the continental waters of the United States and Canada. *American Fisheries Society Special Publication* **21**, 243 pp.

Roman B. (1975) Poissons de la Volta et de la Haute Kemal. Notes sur l'écologie des formes naines. *Notes de documentation voltaïque* **8**, 54–67 (in French).

Schockert V. (1998) *Étude préliminaire de l'avifaune du lac Nokoué et des milieux humides adjacents (bas delta de la Sô et de l'Ouémé): perspective de développement d'un tourisme ornithologique?* Mémoire DES Sciences naturelles appliquées et écodéveloppement. Univ. Liège: Freeman & Co., 61 pp.

Sugg M.S.J. (1974) Mensural and moult data from a breeding colony of pied kingfishers. *Ostrich* **45**, 227–234.

Tjomlid S.A. (1973) Food preferences and feeding habits of the pied kingfisher *Ceryle rudis*. *Ornis Scandinavica* **4**, 145–151.

Wanink J.H. & Goudswaard K.P.C. (1994) Effects of Nile perch (*Lates niloticus*) introduction into Lake Victoria, East Africa, on the diet of pied kingfishers (*Ceryle rudis*). *Hydrobiologia* **279/280**, 367–376.

Wanink J.H., Berger M.R. & Witte F. (1993) Kingfisher at fishburger queens: eating Victorian fast food on the wing. *Proceedings of the VIII Pan-African Ornithological Congress,* pp. 331–338.

Whitfield A.K. & Blaber S.J.M. (1978) Feeding ecology of piscivorous birds at lake St Lucia Part 1: diving birds. *Ostrich* **49**, 185–198.