

Avoidance of Venomous Sea Snakes by Naive Herons and Egrets

GLORIA SULLIVAN CALDWELL^{1,2} AND ROBERTA WOLFF RUBINOFF^{3,4}

¹Department of Zoology, University of California, Berkeley, California 94720 USA, and

³Smithsonian Tropical Research Institute, P.O. Box 2072, Balboa, Panama

Considerable attention has been paid recently to how closely birds adhere to the principles of optimal foraging (e.g. Kamil and Sargent 1981), but the emphasis has been on the energetic gains of certain foraging tactics. Since the pioneering works of Brower (1969), Coppinger (1970), and Smith (1975, 1977), little work has been done on the extent to which, or the mechanisms by which, birds discriminate between nutritious and noxious potential prey. This can be an especially crucial distinction for birds that are time limited in their foraging, as are the egrets that forage on Pacific tidal mudflats (Caldwell 1979). For many piscivorous birds, one dangerous potential prey is *Pelamis platurus*, the yellow-bellied sea snake. It is the world's most widely distributed species of snake, ranging from southern Siberia to Tasmania, into American Pacific waters, and throughout the Indian Ocean (Minton 1975). *Pelamis* has a venom many times more toxic than that of rattlesnakes, cobras, or coral snakes (Tamiya 1975). It has a brilliant yellow underside, black back, and a strikingly patterned black and yellow tail (Fig. 1). Despite its conspicuous coloration and habit of spending most of its time at the surface, exposed to both aerial and marine predators, *Pelamis* apparently suffers no predation (Kropach 1975). Some species of sympatric fish have been shown not to eat *Pelamis* (Rubinoff and Kropach 1970), but here we present (1) the first demonstration of active avoidance of this potentially lethal snake by inexperienced predators, (2) the first evidence of avoidance of sea snakes by avian predators, and (3) one of the few demonstrations of innate avoidance by any predators of aposematic prey.

Pelamis platurus occasionally washes up alive on the Pacific coast of Central America where herons and egrets regularly feed on fish and eels. Mistaking a sea snake for a harmless eel could be lethal for a heron; yet, passing up an item as nutritious and favored as an eel would be energetically inefficient. We therefore used 12 naive, hand-reared herons to determine whether or not they could distinguish between sea snakes and innocuous serpentine prey available to them in Panama. Two Great Egrets (*Casmerodius albus*), four Snowy Egrets (*Egretta thula*), and six Green-backed Herons (*Butorides striatus*) were taken from their nests at 2 days of age. The Snowy and Great egrets were from islands in the Bay of Panama, where sea snakes can be common, while the Green-backed

Herons were from the Atlantic coast of Panama, where sea snakes do not occur. Each bird was reared in a hardware cloth aviary with a conspecific of the same age ± 1 day and was fed live and dead fish once a day.

At five months, an age when wild herons would be foraging on their own, each bird was tested with seven kinds of snakelike potential prey presented at 1- to 2-week intervals. Testing was carried out with the nestmate present, because solitary birds were reluctant to feed. Potential prey were presented by the same observer at the same time of day and in precisely the same manner as normal food. Each bird previously had attacked other novel prey (dully colored grasshoppers, mice, and skinks) without hesitation.

Each bird was tested with the following potential prey in the order listed: a dead 35-cm sea snake (*P. platurus*), a live 57-cm tree snake (*Imantodes cenchoa*), a dead 22-cm speckled snake eel (*Myrophis punctatus*), a dead 47-cm spotted snake eel (*Myrichthys tigrinus*), a live 30-cm sea snake, a dead 32-cm synbranchid eel (*Synbranchus marmoratus*), and a dead 35-cm sea snake with its strikingly patterned tail removed (Fig. 1). The tree snake and spotted snake eel were both creamy yellow with dark brown to black patterning, while the speckled snake eel and synbranchid eel were essentially grey. *Myrichthys* was chosen because it bore the closest resemblance to sea snakes of all available prey: humans sometimes confuse them in the water, even though, on close inspection, the two might appear dissimilar. Each bird was tested with a sea snake three times, not only to determine whether the snake's behavior or brightly patterned tail was critical to the bird's response but also to ensure that the order of presentation and habituation had not affected responses to the other potential prey.

The reactions of the birds to the offered prey are summarized in Table 1. The initial responses to the sea snakes were dramatic and in each case the same. The bird upon seeing the dead sea snake immediately backed away with crest erect to a distance of about 2 m and then flew erratically around the aviary, trying to escape by scratching at the gate with feet and bill. None of the birds had tried to escape from the aviary before. Although all other presentations of prey had been characterized by begging displays and vocalizations, begging and its concomitant vocalizations did not occur when sea snakes were offered.

After 15 min of attempted escape both Great Egrets approached with neck outstretched and body held as far as possible from the snake, jabbed hard at the back of the snake's head, and flew suddenly back-

² Present address: Smithsonian Tropical Research Institute, APO Miami 34008 USA.

⁴ Present address: Office of Fellowships and Grants, Smithsonian Institution, Washington, D.C. 20560 USA.

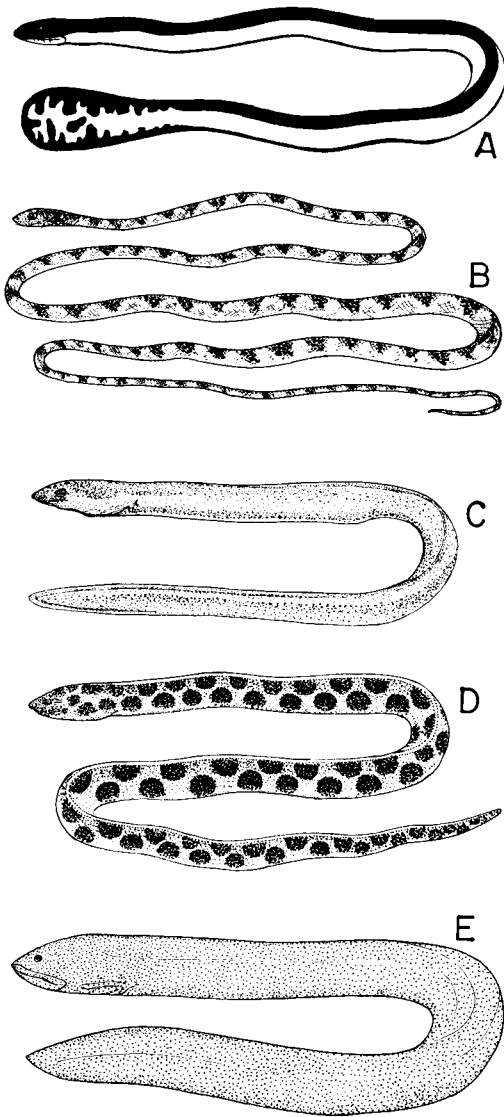


Fig. 1. Potential prey offered to herons. A. Sea snake (*Pelamis platurus*). B. Tree snake (*Imantodes cenchoa*). C. Speckled snake eel (*Myrophis punctatus*). D. Spotted snake eel (*Myrichthys tigrinus*). E. Synbranchid eel (*Synbranchus marmoratus*).

wards. The Snowy Egrets and Green-backed Herons during the same period maintained the farthest possible distance from the snake, staring at it. For the remainder of the hour all birds remained immobile except for feeble attempts to get out of the cage. After the snake was removed, the birds kept their eyes fixed on the place the snake had been but resumed begging 5 min later.

The live sea snake and the dead sea snake with tail removed produced reactions similar to those giv-

TABLE 1. Behavior of hand-reared herons toward offered prey.

Prey	Behavior ^a			
	Flee	Peck	Beg	Eat
Sea Snake (<i>Pelamis</i>)				
Dead	+	**	-	-
Live	+	-	-	-
Tailless	+	-	-	-
Tree Snake (<i>Imantodes</i>)				
Live	-	*	+	-
Dead Eels				
<i>Myrophis</i>	-	-	+	+
<i>Myrichthys</i>	-	*	s	-
<i>Synbranchus</i>	-	-	+	-

^a + = all individuals of three species showed behavior ($n = 12$); * = one Great Egret showed behavior; ** = both Great Egrets showed behavior; s = one Snowy Egret showed behavior; - = no birds showed behavior.

en in the initial encounters with the dead sea snake. Each bird fled to the far corner of the cage and remained immobile with eyes fixed on the snake for the remainder of the trial. Fleeing and immobility, two species-specific defense reactions commonly given in the presence of predators and frightening stimuli (Bolles 1972), occurred only in trials with the sea snakes.

Reactions to the other serpentine stimuli were strikingly different. The birds characteristically begged and either approached or ignored the potential prey. The tree snake was largely ignored, although one Great Egret pecked at the back of the snake's head after the snake had crawled out of the aviary and had been replaced four times. Each bird immediately ate a speckled snake eel (*Myrophis*), even though these birds had no previous experience with eels. Eating did not involve pecking the prey's head but merely grasping and swallowing. The large spotted snake eel (*Myrichthys*) elicited a more ambivalent reaction: the birds alternately approached the eel and backed away for the first several minutes but then ignored it, although a Great Egret struck once at the back of the eel's head. The synbranchid eel was approached and then ignored; stout for its length, it might have been difficult for a small heron to handle.

Dramatic avoidance of sea snakes thus appears to be a genetically based response in three species of herons and egrets. Even though the Green-backed Herons were from a region of Panama where sea snakes do not occur, the mobility and distribution of that species is sufficient (Hancock and Elliott 1978) to allow movement of individuals and/or genes between regions with and without sea snakes. It would be interesting to determine whether or not extreme northern populations of herons, whose members do not winter in regions where sea snakes occur, would display the same response.

The response to sea snakes does not depend upon the movement or behavior of the snake, as the first response was to a dead *P. platurus*. The avoidance response was not simply to novelty, because other novel prey were chased or eaten, and sea snakes were avoided even when presented for the third time. The response was not to serpentine shape nor to general differences between snakes and eels. The response appears to be to a specific color pattern, although the strikingly patterned tail may not be a necessary stimulus, at least not after the birds have seen intact sea snakes. Further testing is needed to determine which aspects of the coloration are aposematic and to eliminate the possibility of olfactory cues.

Interestingly, the sea snake is the only bright yellow and black potential prey in Panama available to herons and egrets. Brightly colored reef fish occur in waters too deep and usually too clear for herons to forage in effectively. Wild herons, in over 3,000 h of observation, were never seen to take brightly colored fish, and 16 analyzed heron stomachs contained no bright fish (Caldwell 1981). We sampled the major habitats favored by herons on the Atlantic and Pacific coasts of Panama with rotenone and quinidine poisoning and reviewed the tidepool and freshwater records of the Smithsonian Tropical Research Institute. The only (non-eel) fishes we found with even a suggestion of color or pattern resemblance to sea snakes were puffers (*Spherooides testudineus*, reticulated brown with a dull yellow belly) and *Abudefduf saxatilis* (a grey, laterally compressed fish that grows to 18 cm in length and possesses sharp dorsal spines, nebulous black bands and a faint yellow wash on the dorsal third of its body). We would consider both these fishes cryptic rather than aposematic in their habitats, even though puffers have poisonous viscera (Böhlke and Chaplin 1968) and might be expected to advertise their noxiousness. Both are also the wrong shape and size to be prey to a heron. Our captive herons stared at live puffers but made no attempt to eat them, probably because of the puffer's habit of inflating itself when faced with a predator rather than because of its color, although this was not tested. The captive herons in this study did attempt to eat dull, laterally compressed fish, when first learning to forage on their own (at approximately 1 month of age), but soon learned not to waste energy on them, as a deep-bodied flat fish over 6½ cm in length is difficult for an adult Great Egret to swallow and can be impossible if it erects a dorsal spine. The birds were therefore not tested with *Abudefduf*. The spotted snake eel *Myrichthys* that we tested bore the closest resemblance to the sea snake of all potential prey in Panama and elicited a reaction intermediate between those elicited by solid-colored eels and those by sea snakes. Thus, the response to sea snakes appears to be specific among the range of prey available to herons in Panama.

The innate recognition of toxic potential prey is

undoubtedly beneficial to both snakes and birds. One might have predicted that the degree of avoidance would correspond to the likelihood of encountering toxic potential prey. The allopatric predatory fishes described by Rubinoff and Kropach (1970) attempted to eat sea snakes, while sympatric predatory fishes refused to eat them but seemed undisturbed by their presence. These herons, on the other hand, actually fled the sea snakes, even though herons are restricted to feeding in shallow water or on land, places where *P. platurus* is rarely found. It seems remarkable that selection is maintaining this response in light of the extremely low probability of a heron encountering a sea snake or anything else (like wasps or lepidopteran larvae) with similar coloring. The combination of low encounter probability and high prey toxicity, however, would favor a genetically based rather than a learned response.

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Winter Distribution of Subspecies of Clapper Rails (*Rallus longirostris*) in Florida with Evidence for Long-distance and Overland Movements

ROBERT L. CRAWFORD,¹ STORRS L. OLSON,² AND WALTER KINGSLEY TAYLOR³

¹Tall Timbers Research Station, Route 1, Box 160, Tallahassee, Florida 32312 USA;

²National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560 USA; and

³Department of Biological Sciences, University of Central Florida, Orlando, Florida 32816 USA

Little is known of the extent of movement and winter ranges of Clapper Rails (*Rallus longirostris*) in the United States despite years of study by ornithologists and game biologists (Stewart 1951, 1954; Mangold 1977). For example, only recently was it learned that the endangered southwestern population, *R. l. yumanensis*, leaves its breeding grounds in

the Colorado River Valley to winter in Mexico (Tomlinson and Todd 1973, Banks and Tomlinson 1974). Populations in the southeastern states are thought to be largely nonmigratory and strictly confined to coastal areas (Adams and Quay 1958). The northern subspecies, *R. l. crepitans*, is known to range south in winter along the Atlantic Coast as far as the vi-

TABLE 1. Recent specimens of migrant or out-of-range Clapper Rails from Florida.

Museum ^a	Locality in Florida	Date	Age/sex	Collector
<i>Rallus longirostris crepitans</i>				
USNM 525849	Franklin Co., Turkey Pt.	4 Nov 1966	Adult ♀	Olson, W. M. Hobbs
USNM 525880	Franklin Co., Turkey Pt.	4 Nov 1966	Adult ♀	Olson, W. M. Hobbs
USNM 525881	Franklin Co., Turkey Pt.	4 Nov 1966	Adult ♀	Olson, W. M. Hobbs
USNM 525850	Wakulla Co., Shell Pt.	23 Sep 1961	Immature ♂	Olson et al.
UCF 206	Orange Co., WDBO tower	11 Sep 1969	Adult ♀	Taylor
<i>Rallus longirostris waynei</i>				
USNM 525848	Franklin Co., Turkey Pt.	4 Nov 1966	Adult ♂	Olson, W. M. Hobbs
TTRS 2811	Leon Co., Tallahassee	6 Oct 1965	Immature ♀	H. M. Stevenson
TTRS 3664	Leon Co., WCTV tower	9 Apr 1980	Adult ♀	Crawford
UCF 900	Brevard Co., Merritt Is., VAB	30 Sep 1971	Adult ♀	L. Ellis, R. Bush
UCF 901	Brevard Co., Merritt Is., VAB	20 Oct 1971	Adult ♀	L. Ellis, R. Bush
UCF 916	Pinellas Co. (northern)	Oct 1969	Adult ♀	V. Morrison
<i>Rallus longirostris scottii</i>				
UCF 875	Brevard Co., Merritt Is., VAB	28 Sep 1971	Adult ♀	L. Ellis, R. Bush
UCF 897	Brevard Co., Merritt Is., VAB	28 Sep 1971	Adult ♀	L. Ellis, R. Bush
<i>Rallus longirostris scottii</i> > <i>waynei</i>				
UCF 899	Brevard Co., Merritt Is., VAB	25 May 1971	Adult ♀	L. Ellis, R. Bush
<i>Rallus longirostris saturatus</i>				
USNM 525878	Franklin Co., Turkey Pt.	4 Nov 1966	Adult ♀	Olson, W. M. Hobbs
USNM 525877	Franklin Co., Turkey Pt.	23 Nov 1966	Adult ♂	Olson, W. M. Hobbs
USNM 525875	Franklin Co., Turkey Pt.	4 Mar 1967	Adult ♀	Olson
TTRS 2810	Leon Co., Tallahassee	27 Jul 1937	Adult ♀	M. K. Gibson

^a USNM = National Museum of Natural History, Smithsonian Institution; UCF = University of Central Florida; TTRS = Tall Timbers Research Station.