# Common aquatic invertebrate taxa vary in susceptibility to capture by Black Stilt chicks

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## ABSTRACT

I tested the ability of captive Black Stilt chicks (*Himantopus novaezelandiae*) to capture and consume common aquatic invertebrates. Waterboatmen (*Sigara* sp.), segmented worms (Oligochaeta), and larvae of a damselfly (*Xanthocnemis zealandica*), midge (*Chironomus zealandicus*), mayfly (*Deleatidium* spp.), and caddisfly (*Aoteapsyche colonica*) were captured and consumed quickly and easily by chicks of all ages (2 – 30 days). They were also consumed in the greatest numbers. In contrast, two aquatic snails (*Physa acuta* and *Lymnaea tomentosa*) and larvae of two cased caddisflies (*Triplectides* sp. and *Hudsonema amabilis*) were captured and consumed with difficulty and in low numbers by young chicks (< 7 days). Young chicks appeared to take longer than older chicks to capture prey, to spend more time manipulating prey in their bills before swallowing, and to drop prey frequently. In contrast, 21 – 30 day old chicks appeared to capture, manipulate and swallow most types of prey efficiently and quickly. These results augment biomass as a measure of the value of aquatic invertebrate food supplies in wetlands.

KEYWORDS: Black Stilt, *Himantopus novaezelandiae*, Upper Waitaki Basin, prey capture

## INTRODUCTION

The Department of Conservation manages several constructed wetlands in the Upper Waitaki Basin, with the aim of providing safe and productive habitat for wetland fauna. Management and research at these wetlands has focussed on wetland birds, especially the critically endangered Black Stilt (*Himantopus novaezelandiae*). One management objective is to ensure that wetlands provide abundant and suitable food supplies for Black Stilts, which feed almost exclusively on aquatic invertebrates (Pierce 1985). Recent research has shown that aquatic invertebrate biomass, abundance, and species composition in experimental wetlands in the Upper Waitaki Basin varies dramatically among sites, and can be strongly influenced by substratum manipulations within sites (Sanders & Maloney 1994, Sanders 1996). For example, in a series of experimental ponds, Sanders (1996) showed that, at some sites, aquatic invertebrate biomass was greater in ponds to which barley straw had been added than in ponds without straw. In contrast, invertebrate biomass was consistently low in ponds excavated in coarse stony substrata.

Managers can therefore influence the type and amount of food at wetlands by their choices of site and substratum. However, they currently lack sound information on which to base such choices. Evaluations of invertebrates as food for birds are often based on measures of aquatic invertebrate biomass or abundance (e.g. Phillips 1991, Gardarsson & Einarsson 1994). Biomass may be a reasonable measure, in purely nutritional terms, because the nutritional composition per unit mass of most aquatic invertebrates does not vary dramatically (Driver *et al.* 1974, Driver 1981). It may also be a reasonable measure where one species dominates the invertebrate standing crop (e.g. Danell & Sjöberg 1977, Rehfisch 1994). However, measures of biomass ignore wide variation in the behaviour and morphology of aquatic invertebrates, which may dramatically affect the ability of birds to capture and consume these prey (Goss-Custard 1969, 1984, Britton 1983, Pierce 1986, Colwell & Landrum 1993). Evaluations of aquatic invertebrates as food for birds need to consider, in addition to biomass, the susceptibility of the prey to capture and consumption. As a step toward understanding the susceptibility of common aquatic invertebrate taxa to capture and consumption by Black Stilts, I conducted feeding experiments on Black Stilt chicks in captivity to test two hypotheses:

1. That different types of prey are consumed at different rates by Black Stilt chicks.

2. That rate of prey consumption by Black Stilt chicks varies with chick age.

The experiments also provided an opportunity to describe how various prey were captured, manipulated, and consumed by Black Stilt chicks.

## METHODS

### Aviary routine

I conducted the experiments at the Department of Conservation's captive rearing facility in Twizel. Chicks are reared in 1.2 m × 1.2 m brooders under a controlled temperature and light regime (for details, see Reed 1994). A one-way window enables chicks to be observed without disturbing them. Chicks older than *c.* 7 days have daytime access to a small (1.8 × 4 m) outdoor aviary. After chicks have fledged, at 39 - 55 days of age, they are transferred to large (98 - 196 m$^2$) outdoor aviaries.

Newly hatched chicks are precocial, and have continuous access to aquatic invertebrates, which are collected from streams and ponds near the aviaries and presented to the chicks in a tray. They also have continuous access to a tray of minced ox heart mixed with live 'mealworms' (*Tenebrio molitor* larvae). The tray of aquatic invertebrates typically includes many or all of the prey species investigated in this experiment. Fresh invertebrates are provided four to five times each day and fresh ox heart mix is provided as required. Once chicks are feeding well on the ox heart mix (3 - 10 days) they are no longer fed aquatic invertebrates.

## Experimental procedure

Each brooder houses a 'brood' of four uniquely colour-banded chicks, of similar age, but not necessarily of the same parentage. The brood was defined as the experimental unit in the experiment described below. The experiment consisted of five feeding 'trials'; two on broods aged 2 - 3 days and one on broods aged 6 - 7 days, 21 - 22 days and 26 - 30 days. One brood was used twice, at 2 - 3 and 6 - 7 days of age.

In each feeding trial, a brood of chicks was presented with 11 prey types, one type at a time, at 30-minute intervals. Thirty individuals of each prey type were presented, and each presentation lasted for five minutes. Note, however, that in the first trial on 2 - 3 day old chicks only ten prey types were available. Timing of each five-minute presentation began as soon as any chick was within one body length of the plate. Prey types were presented in random order, with the constraint that any given prey type could be presented first to only one brood. This constraint was imposed to minimise any possible bias associated with the first presentation.

Prey were presented on a standard substratum of 190 g stones (1 - 35 mm long), four leaves (40 - 76 mm long, 15 mm wide) and four sticks (58 - 81 mm long), which were spread evenly on a 23 cm diameter plastic plate and covered with 1.5 cm deep water. The density of prey (790 $m^{-2}$) was within the range of prey densities in samples taken during recent substratum manipulation experiments in the Upper Waitaki Basin (Sanders & Maloney 1994, Sanders 1996). Prey were distributed evenly on the substratum at least one minute before each presentation to allow the prey to find cover. Trays of aquatic invertebrates and ox heart mix that were normally in the brooder were removed during the presentations. To minimise variation in the hunger of chicks in the experiment, all feeding trials began at least one hour after chicks had first been fed in the morning.

The 11 prey types included nine of the most abundant invertebrate taxa found at various Black Stilt habitats in the Upper Waitaki Basin (Pierce 1982, Sanders & Maloney 1994, Sanders 1997, 1999). These were: oligochaete worms, two species of snails (*Physa acuta* and *Lymnaea tomentosa*), and six species of insect (waterboatmen *Sigara* sp., and larvae of the damselfly *Xanthocnemis zealandica*; the midge *Chironomus zealandicus*; the mayfly *Deleatidium* spp.; and the caddisflies *Aoteapsyche colonica* and *Hudsonema amabilis*). Two additional prey types were presented. These were sticks similar in size to the invertebrate prey species, (8 - 13 mm long), and larvae of *Triplectides* sp., a caddisfly that uses small sticks as its case. Sticks were included in the trial to test whether chicks would peck at inanimate insect-sized objects. *Triplectides* sp. was included to test whether Black Stilt chicks would peck at a highly cryptic prey species. Individuals of each prey type were similar in length, but prey types varied in size, ranging from 7 mm high (*P. acuta*) to 15 mm long (*Triplectides* sp., including case).

After each prey presentation, the number of prey consumed was calculated from the number that remained. When empty snail shells or caddisfly cases remained, the occupant was considered to have been consumed, unless a shell-less or case-less individual also remained. During feeding trials, I also recorded qualitative observations of prey handling error rates, consumption times, and pecking rates for each prey type.

**Statistical analysis**

Friedman's two-factor non-parametric ANOVA was used to test whether the median number of prey consumed varied among prey types or among different aged broods. For the purpose of this analysis, the missing datum for *P. acuta* in the first trial on 2-3 day old chicks was estimated as the mean number of *P. acuta* consumed in all trials (19.3). Rank correlation was used to test whether order of presentation affected the number of prey consumed.

## RESULTS

The median number of prey consumed by Black Stilt chicks varied among prey species (Friedman test statistic, $\chi^2_r = 41.5$, d.f. = 10, $P < 0.0001$; Table 1), and among chicks of different ages ($\chi^2_r = 27.6$, d.f. = 4, $P < 0.0001$). On average, number of prey consumed tended to increase with age (Table 1). Order of presentation was not correlated with number of prey consumed (Spearman's rank correlation, $-0.02 < r_s < 0.45$, n = 11, $P > 0.05$ for all trials).

All 30 *Sigara* sp. were consumed by chicks of all ages. The fast movements of *Sigara* sp. appeared to excite chicks, which clearly pecked more rapidly at *Sigara* sp. than they pecked at other prey species. Two to three day old chicks dropped *Sigara* sp. more often than older chicks, which consumed most *Sigara* sp. within two to three minutes.

Most *Xanthocnemis zealandica*, *Chironomus zealandicus*, *Deleatidium* spp. and *Aoteapsyche colonica* were consumed in most trials (Table 1), and these species were pecked at more rapidly than oligochaetes, molluscs and cased caddisflies. Although oligochaete worms elicited slower peck rates than the former four prey species, most Oligochaeta were also consumed in most trials.

Larvae of *X. zealandica* struggled vigorously when captured, and were sometimes able to escape from 2 - 3 day old chicks, by 'flicking' their abdomens while the chicks were manipulating them in their bills. *Deleatidium* spp. and *A. colonica* struggled when captured, but not as vigorously as *X. zealandica.*

Although 2 - 3 day old chicks frequently pecked at both snail species, the snails' smooth, hard shells usually slipped out of the chicks' bills, and only 5 of 30 *P. acuta* and 6 of 60 *L. tomentosa* presented to chicks of this age were consumed (Table 1). In contrast, chicks older than 2 - 3 days, particularly 26 - 30 day old chicks, appeared better able to capture, manipulate and consume snails, including shells.

*A. colonica* and *H. amabilis,* were easily captured by chicks of all ages, but few *Triplectides* sp. were consumed, and high numbers of *H. amabilis* were consumed only by 21 - 22 and 26 - 30 day old chicks (Table 1). Chicks younger than 7 days

TABLE 1 - Number of prey eaten by Black Stilt chicks of different ages. Thirty individuals of each prey type were presented to broods of four Black Stilt chicks, for five minutes. Prey types were presented in random order, at 30-minute intervals, on a standard substratum (see text for details).

| | Age of chicks (days) | | | | | |
|---|---|---|---|---|---|---|
| Prey type | 2-3 [a] | 2-3 | 6-7 [a] | 21-22 | 26-30 | Mean |
| *Sigara* sp. | 30 | 30 | 30 | 30 | 30 | 30.0 |
| *Xanthocnemis zealandica* | 20 | 27 | 29 | 30 | 30 | 27.2 |
| *Chironomus zealandicus* | 28 | 18 | 23 | 30 | 30 | 25.8 |
| *Deleatidium* spp. | 25 | 27 | 19 | 28 | 29 | 25.6 |
| *Aoteapsyche colonica* | 12 | 25 | 28 | 28 | 28 | 24.2 |
| Oligochaeta | 16 | 25 | 28 | 21 | 26 | 23.2 |
| *Physa acuta* | - | 5 | 19 | 24 | 29 | 19.3 |
| *Hudsonema amabilis* | 4 | 7 | 6 | 30 | 28 | 15.0 |
| *Lymnaea tomentosa* | 2 | 4 | 7 | 12 | 26 | 10.2 |
| *Triplectides* sp. | 0 | 0 | 3 | 7 | 11 | 4.2 |
| Sticks | 0 | 0 | 0 | 1 | 2 | 0.6 |
| Mean | 13.7 | 15.3 | 17.5 | 21.9 | 24.5 | 18.7 |

[a] These two trials were conducted on the same brood.

usually dropped cased caddisfly larvae after picking them up and manipulating them in their bills. However, chicks older than 21 days usually consumed individuals of *H. amabilis*. When feeding on cased caddisflies, chicks directed their pecks at the heads and legs of larvae, and appeared to peck at moving larvae more frequently than they pecked at stationary larvae.

Although sticks were frequently pecked at and picked up by chicks, only three disappeared, during trials with chicks older than 21 days. It is likely that these were lost in the brooder, rather than eaten, because sticks were frequently dropped away from the plate by old chicks.

The efficiency with which chicks captured and manipulated prey increased dramatically with age. Although prey handling times were not measured, two to three day old chicks clearly took longer than older chicks to capture prey, and spent more time manipulating prey in their bills before swallowing. They also frequently dropped prey, whereas 6 - 7 day old chicks rarely dropped prey. Chicks older than 21 days captured and swallowed prey efficiently and quickly.

Distinct swallowing actions by stilts have often been interpreted as representing the ingestion of prey items (e.g. Burger 1980, Pierce 1982, 1985, 1986, Espin *et al.* 1983, Tinarelli 1987, but see Cullen 1994). The occurrence of a distinct swallowing action is invariably assessed from a distance, through binoculars or a telescope. During the experiment reported here, I often observed Black Stilt chicks consume prey with little or no swallowing action. This was true even for 26 - 30 day old chicks, which are almost the same size as adult Black Stilts. My observations were made from *c.* 50 cm.

## DISCUSSION

Measurements of the biomass and abundance of aquatic invertebrates provide convenient, but approximate, indications of the value of foraging habitats for wetland birds. Aquatic invertebrate community composition is widely considered to influence the value of foraging habitat to wetland birds (e.g. Goss-Custard 1969, 1984, Goss-Custard *et al.* 1977, Britton 1983, Fredrickson & Reid 1988, Eldridge 1990, Phillips 1991, Colwell & Landrum 1993). However, the value of different aquatic invertebrate species as food for wetland birds is poorly understood. My study provides additional information for the evaluation of aquatic invertebrates as prey for Black Stilt chicks.

Different invertebrate species were consumed in markedly different numbers by Black Stilt chicks, particularly by those younger than 7 days. Variation in the number of prey consumed in this experiment appeared to be mainly a result of variation in prey morphology and behaviour. In natural wetlands, the number of prey consumed by Black Stilt chicks will also be influenced by factors such as substratum, water turbidity and velocity, weather, light conditions (Pierce 1985, 1986), and presumably chick experience. Nevertheless, the variation in the number of prey consumed, and variation in the ease with which they were captured and manipulated, suggest that in nature, all else being equal, some prey species may be more accessible than others to Black Stilt chicks.

A potential alternative explanation for the significant age effect is that older chicks, which were fed on only the ox heart-mealworm mix before the trials, ate more invertebrates because they were 'starved' of invertebrates. However, it seems more likely that differences were related to the relatively poor ability of young chicks to capture, manipulate and consume prey. The low numbers of snails (*P. acuta* and *L. tomentosa*) and cased caddisflies (*H. amabilis* and *Triplectides* sp.) consumed by chicks younger than 7 days accounted for most of the variation in the number of prey consumed. Young chicks appeared to consume few snails because they had difficulty picking up and manipulating the smooth shells, and it seems likely that Black Stilt chicks in the wild would experience similar difficulties manipulating these and other species of snails. Although cased caddisflies were easily captured and manipulated, they were often dropped, suggesting that they may have been intentionally rejected by chicks.

In contrast, chicks of all ages were easily able to capture, manipulate and consume invertebrates that lacked a shell or hard case, although the efficiency with which they did so appeared to increase with chick age. However, some of these prey species may be less easily captured in nature than they were in this experiment. Specifically, *Sigara* sp. and *Deleatidium* spp. may be better able to escape because they are highly motile, and oligochaete worms may be less vulnerable because they burrow out of sight within the substratum. Although *A. colonica* was easily captured and consumed in this experiment, in nature this species inhabits shelters constructed from stones, plant fragments and silk (Cowley 1978). These shelters would camouflage the larvae, and reduce their movement. Consequently, larvae of *A. colonica* in nature are probably less prone to capture by Black Stilts than they were in this experiment.

*C. zealandicus* and *X. zealandica* are likely to be easily captured and consumed in the wild, as they were in this experiment. Larvae of *C. zealandicus* burrow through the substratum, but their bright red bodies are often partly visible at the surface of mud. Their visibility, relatively large size, and lack of hard body suggest they are a highly suitable prey for Black Stilt chicks. Furthermore, field observations indicate that *C. zealandicus* is a highly attractive prey species to adult Black Stilts. For example, Sanders (1996, 1999) observed that Black Stilts on lake deltas congregated in areas where *C. zealandicus* was abundant, and pecked at high rates. *X. zealandica* should also provide highly suitable food for Black Stilt chicks because it too is a large, slow, easily visible species.

During this experiment I observed that Black Stilt chicks were able to consume prey with little or no apparent swallowing action. In a field study of the foraging behaviour of black-necked stilts (*Himantopus mexicanus*), Cullen (1994) also observed prey captures, of waterboatmen, that were not accompanied by distinct swallowing motions. My observations, and those of Cullen, emphasise that indices of pecking success based on the proportion of swallows observed (e.g. Burger 1980, Espin *et al.* 1983, Pierce 1985, 1986, Tinarelli 1987) may underestimate ingestion rates.

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