

ORGAN WEIGHT AND WEIGHT RELATIONSHIPS IN TAKAHE AND PUKEKO

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ABSTRACT

The internal organs of four adult, one juvenile and one chick Takahe (*Porphyrio [Notornis] mantelli hochstetteri*) were dissected, weighed and measured to determine the digestive capacity based on anatomical measurement. Organ dimensions were compared with those of the Pukeko (*P. porphyrio melanotus*). Because the Takahe were 3 - 4 times larger than the Pukeko, organ weights were scaled by the weight of the femur and length measurements by the length of the femur to enable comparison between the species. The Takahe had significantly deeper beaks, shorter intestines and larger recta than the Pukeko. The pyloric caeca were longer but not significantly so. Although ecological comparisons based on gut morphology are fraught with difficulty, a tentative theory that Takahe may be better at digesting fibre than currently thought is presented.

INTRODUCTION

The Takahe is an endangered species of rail which is endemic to New Zealand. Since European times, at least, it has been restricted in distribution to parts of Fiordland, particularly the extensive low-alpine grasslands in the Murchison Mountains (Williams 1960, Mills *et al.* 1984). Because it occupies a highly specialised niche, being dependent for food for a large part of the year on three species of tussock (*Chionochloa pallens*, *C. flavescens* and *C. crassiuscula*) and the mountain daisy (*Celmisia petriei*), it has been regarded as a specialist tussock grassland feeder adapted to the alpine grasslands (Mills *et al.* 1984). The Takahe eat only the basal meristems of the tussock tiller and the white leaf bases of the *Celmisia* leaf. Much of the plant material ingested by the birds passes through the gut apparently undigested, only readily digestible juices being removed by the gut (Mills *et al.* 1984).

A knowledge of the internal anatomy of the Takahe, particularly the alimentary tract, might shed some light on its digestive capacity. Benham (1899) examined the alimentary tract of one female Takahe. Although he observed that the oesophagus, the proventricular stomach and the intestine presented no feature of special interest, he remarked on the large size of the gizzard and the paired pyloric caeca. This may indicate that the bird has a capacity for hindgut fermentation, which would aid in the digestion of some fibre.

The present study examines the internal organs of six Takahe (four adults, one juvenile and one chick). Organ weights were compared with those of the closely related Pukeko.

MATERIALS

As the birds were presented for dissection in different conditions it is relevant to describe each separately.

Takahe 1: A female found dead in the Murchison Mountains in June 1983, which arrived at Invermay on 24 June 1983. The bird had been skinned with head and feet removed before arrival. In addition the peritoneum had been cut open and small parts of the liver and heart removed.

Takahe 2: A male (reference number R31860), which was recovered from the Waterfall Creek area of the Murchison Mountains on 1 July 1983 and was delivered to Invermay on 6 July 1983. This bird had been used for radio tracking studies and it had been dead for some weeks before recovery, although frozen in the snow. The bird was whole on arrival at Invermay, but had some decomposition and feather loss. Organ weight where possible was recorded but should be interpreted with caution.

Takahe 3: An aged male from the Wildlife pens at Te Anau found dead 11 September 1984 and which arrived whole at Invermay 12 September 1984.

Takahe 4: A 3-year-old male (reference number R13882), which was hatched at the rearing station in 1983. It was transferred to Maud Island, where it contracted gout. It was flown to the Wildlife Park in Te Anau, where it lost condition rapidly and died on 27 January 1987. It arrived at Invermay the next day. The body was in very poor condition and the pathologist's report confirmed gout as the cause of death (J. Gill, pers. comm.).

Takahe 5: A day-old chick which was hatched at Te Anau 18 November 1984, died on 19 November and arrived whole at Invermay on 20 November.

Takahe 6: An 8-week-old juvenile, which died at the rearing station on 8 February 1987 of a massive blow (of unknown cause) to the upper neck and head. It arrived next day at Invermay in good condition.

Pukeko 1 and 2: Two female Pukeko procured during the open season 1986 from the Waipori wetland area of the Taieri Plain.

METHODS

Examination and dissection

Each bird was weighed on arrival, and the head, feet and skin were removed (for taxidermy) and weighed. The remainder of the body was weighed. (This was the first weight for Takahe 1.) It was not possible to skin Takahe 2. A ventral incision was made from the cloaca to the syrinx, cutting through the sternum close to the keel. The liver, heart, kidneys, spleen, gonad and lungs were dissected and weighed. The gut was removed and divided into the (1) oesophagus and proventricular stomach, (2) gizzard, (3) intestine, (4) pyloric caeca, and (5) rectum. Each part was weighed full, and the length was measured. The values for each pyloric caecum were combined. The gut contents of Takahe 1 and 3 were examined for internal parasites.

Both femurs were removed, weighed and measured. The pectoralis muscles (breast) and flexor cruris lateralis (leg) muscles were dissected and weighed.

Biometrics

As sample sizes are small individual data are presented. In order to compare the species adequately, a scalar is required as the Takahe were 3-4 times larger than the Pukeko. It was not possible to use body weight because of

inconsistencies in the availability of Takahe weights, and so the femur weight and length have been used to scale weight and linear measurements respectively. Least significant differences (lsd) have been calculated between means for the scaled data. Takahe 5 (day-old chick) and Takahe 6 (juvenile) were not used for interspecific comparisons.

TABLE 1 — Body size, component weights and dimensions for the two Pukeko and four Takahe

	Pukeko		Takahe			
	1	2	1	2	3	4
Body weight (g)	961	844	. ¹	3630	2499	1851
Component weights (g)						
Skin, head & feet	241	215	-	-	812	677
Carcass & viscera	715	625	-	-	1663	174
Carcass	528	444	666	-	850	650
Heart	6.4	6.0	-	18	22	14
Liver	21	22	-	49	75	67
Lungs	8.5	7.5	26	-	34	21
Kidneys	5.3	5.2	13	-	22	16
Spleen	0.4	0.6	1.7	-	NM ²	2.1
Gonad	0.5(ov)	0.4(ov)	1.0(ov)	-	NM	0.9(t)
Gizzard	58	56	172	155	209	89
Muscle weights (g) -						
M. pectoralis (combined; A)	117	91	43	-	45	33
M. flexor cruris lateralis (B)	5.5	9.5	27	-	27	25
Muscle weight ratio B/A	.047	.11	.63	-	.60	0.76
Femur dimensions						
Weight (g)	5.9	5.1	17.9	20.3	23.4	21.8
Length (cm)	7.3	7.6	10.3	10.6	11.3	10.9
Bill dimensions (cm)						
Length	4.2	4.1	-	5.0	5.5	5.6
Depth	2.2	2.0	-	5.0	5.1	5.1
Alimentary tract lengths (cm)						
Oesophagus	16	15	-	19	27	28
Intestine	100	96	110	102	142	100
Caeca	21	22	37	36	58	58
Rectum	10	9	21	20	25	19

¹ Tissues not available;

² NM, not measured

ov - ovary

t - testis

RESULTS

The Takahe were much larger than the Pukeko and the few data suggest a weight about 3 times greater for the Takahe (Table 1). The breast muscles (*M. pectoralis*) of the Takahe were smaller than the Pukeko's but the leg muscles (*M. flexor cruris lateralis*) were larger. In addition, the leg muscles of the Takahe were larger relative to the breast muscles than in the Pukeko (0.66 and 0.08 respectively, lsd = 0.57, $p < 0.05$).

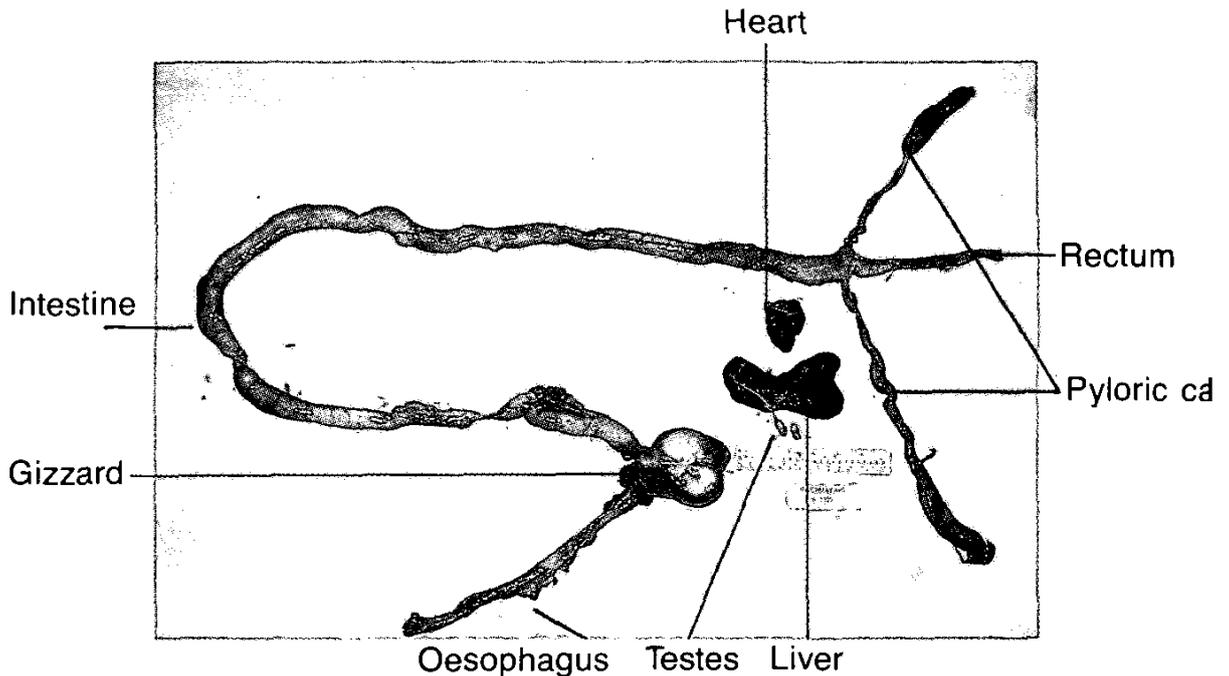


FIGURE 1 — Dissected gut and organs of an adult male Takahe (number 4 in the series described in the text). The scale ruler was 15 cm long. The gizzard was opened with a longitudinal incision. Note the long pyloric caeca.

A labelled dissection of the Takahe alimentary tract is shown in Figure 1. The organ weights were consistently larger in the Takahe than the Pukeko, while the lengths of the various parts of the gut were also greater, although the lengths of the intestines in the Takahe were only about 20% longer than in the Pukeko, whereas the length of the oesophagus, caeca and rectum were markedly greater in the Takahe. The caeca were long and simple (i.e. not sacculated) in both species.

Analyses of organ size in relation to the femur size revealed that the liver, heart, kidney and gizzard were all slightly, but not significantly, heavier in the Pukeko than the Takahe (Table 2). There was little difference in relative oesophagus length, but the intestine was relatively much longer in the Pukeko ($p < 0.05$). In contrast, the beak was deeper and the rectum longer in the Takahe ($p < 0.05$). The caeca were relatively large in the Takahe but this was not statistically significant ($p > 0.05$). The Pukeko entirely lacked a crop but the Takahe had a small pouch some 2.0 cm long by 1.0 cm deep 12 cm distal to the gizzard. This pouch was empty in each of the birds examined.

The data for Takahe 4 (chick) are presented in Table 3. The chick was covered in blue-black down. There was a pronounced 3 mm claw on each wing. An "egg tooth" was present 0.5 cm from the tip of the maxilla.

The juvenile was covered in blue-grey down except that the back from the wings to the tail was feathered with green-grey feathers. The anal area was white and the tip of the upper bill was horny white. Weight data for the juvenile Takahe are presented in Table 3.

Takahe 1 and 3 had *Capillaria* parasites in their intestines (J Gill, pathologist's report).

TABLE 2 — Organ weight or length relative to femur weight or length. Values are means with least significant difference (LSD 5%.)

	Pukeko	Takahe	LSD
<u>Organ Weight/Femur weight ratio</u>			
Liver	3.90	2.89	1.18
Heart	1.18	0.82	0.36
Kidney	0.96	0.85	0.47
Gizzard	10.34	7.72	3.53
<u>Organ Length/Femur length ratio</u>			
Beak depth	0.29	0.47	0.17
Oesophagus	2.04	2.25	0.56
Intestine	13.18	7.96	4.47
Caeca	2.85	4.28	1.67
Rectum	1.37	1.97	0.59

TABLE 3 — Body size, organ weights or lengths of a day-old Takahe chick (5) and an 8-week-old juvenile (6)

	Takahe 5	Takahe 6
Body weight (g)	58.7	601.9
Yolk sac, weight (g)	8.0	-
Liver weight (g)	1.9	21.6
Heart weight (g)	0.3	4.4
Kidneys weight (g)	0.5	5.8
Lungs weight (g)	0.7	4.1
Total gut weight (g)	4.4	-
Gizzard (full) (g)		57.7
Beak length (cm)	1.6	
Beak depth (cm)	1.6	
Oesophagus length (cm)	7.5	20.3
Intestine length (cm)	23.5	73.0
Caeca length (combined) (cm)	9.4	24.8
Rectum length (cm)	4.5	11.0
Pectoral muscles (g)		2.3
Leg muscles (g)		9.9
Femur weight (g)		3.5
Femur length (cm)		5.9

DISCUSSION

The measurements of the Takahe reported here are based on a small highly variable sample; one of the birds had been dead for some weeks before dissection, although frozen in deep snow, and the causes of death of the birds are poorly known. Thus age, seasonal, sex and possible pathological conditions interfere with interpretation of the data. Nevertheless the data are defensible on the grounds that better-quality material is extremely limited from such an endangered species.

As accurate body weights were not available for three of the four Takahe, the femur size has been used to scale the measurements and make interspecific comparison possible. Whether flightlessness has resulted in a relative increase in femur size compared with the Pukeko is not known. Any error would tend to underestimate the relative size of the Takahe body parts (assuming flightlessness led to an increase in femur size). Thus, relative comparisons where Takahe body parts are just significantly smaller than Pukeko body parts should be treated with caution. Comparisons where Takahe body parts are much smaller or are indeed bigger than Pukeko body parts could be treated with rather more confidence, based on the above argument. A final caution rests in trying to extrapolate from gut morphology to dietary (and thus habitat) requirement and the type of feed the organism is adapted best to eating. There is a limited correlation between the development of the caeca and diet in birds, with plant feeders tending to have longer caeca than carnivores (McClelland 1989). The caeca can act as fermentation chambers (Gasaway 1976) in birds. However, changes in gut length due to fibre selection in the diet can take place even within a species (Moss & Parkinson 1982).

The body weights of the female Pukeko were within the normal adult range of 700-1100 g quoted by Ripley (1977) for this subspecies. Takahe 3 was within the range for female Takahe of 1.85-2.60 kg (Williams 1960), but Takahe 2 was larger than the normal adult male range of 2.30-3.25 kg (Williams 1960); the specimens can then be regarded as normal or better than normal for their species. The breast muscles of the Takahe were grossly smaller than the Pukeko's, in contrast to the Takahe's leg muscles, and the leg muscles were proportionately greater than its breast muscles. This is not surprising and merely represents the differences between volant and non-volant representatives of the genus.

The intestine of the Takahe measured by Benham (1899) was 106.7 cm long and the caeca were 45.7 cm long. Both these values agree closely with those in the present study. Benham made no mention of the small crop but noted the presence of the remains of the vitelline stalk (former link with the yolk sac). This was also noted in the present study about half-way between the gizzard and the junction between the caeca and the small intestine.

There is relatively little difference between the scaled organ weights and the oesophagus length of the Pukeko and the Takahe. However, the beak of the Takahe is relatively much deeper, the intestine tends to be shorter and the caeca and rectum tend to be longer. The greater beak depth is likely to be an adaptation for feeding on a diet which requires either cracking or powerful cutting and pulling. The longer caeca may favour further digestion of fibre in the fermentation chambers.

If the Takahe is adapted for limited digestion and absorption from the intestine and for considerable diversion of ingesta into the caeca for fermentation, some absorption would take place from the caeca, and a longer rectum would make further absorption possible before the soft liquid caecal droppings are voided. (Contrast with the rather fibrous faecal droppings.) The concentrates selected by the Takahe in Fiordland are the basal meristems of low-alpine tall tussock tillers, which their heavy beak seems well able to prepare for ingestion. Digestion of these plant parts, although perhaps limited in the small intestine, may be considerable in the hindgut. Thus the Takahe may be capable of digesting more fibre than previously thought. In contrast the Pukeko with its relatively long small intestine and short caeca may be adapted for eating less fibrous plant material, digesting it more thoroughly in the small intestine and having limited caecal fermentation. A further contrast can be drawn from the gut of the Red Grouse (*Lagopus lagopus scoticus*), which eats solely a diet of rather fibrous heather. Although the bird weighs only about 600 g its small intestine is about 100 cm long and the combined caeca length is 150 cm. Thus, a bird well adapted for consuming and digesting fibre has both a long intestine and long caeca (Moss & Parkinson 1972).

The study of gut morphology of the Takahe sheds little light on why the current habitat of the bird is alpine grassland. However, the large beak suits the birds well for a diet of tussock meristems and so may be the reason that the high-fertility alpine grasslands are the preferred habitat of these unique birds. The caeca may be capable of some fermentation allowing fibre digestion. Alternatively the distribution in this region may be a relict which the bird is co-incidentally capable of utilising.

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