Post-mortem examination of penguins

DOC SCIENCE INTERNAL SERIES 65

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff, or external contractors funded by DOC. It comprises progress reports and short communications that are generally peer-reviewed within DOC, but not always externally refereed. Fully refereed contract reports funded from the Conservation Services Levy are also included.

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© August 2002, New Zealand Department of Conservation

ISSN 1175-6519

ISBN 0-478-22294-7

This is a client report commissioned by Otago Conservancy and funded from the Unprogrammed Science Advice fund. It was prepared for publication by DOC Science Publishing, Science & Research Unit; editing and layout by Geoff Gregory. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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A B S T R A C T

This document is a guide to finding the cause of death in penguins which have either been found dead, or died in care. In order to find the signs that may indicate a cause of death, a post-mortem examination (necropsy) is required. The document is also a simple guide to dissecting a penguin and gives illustrated examples of dissection of blue penguin (*Eudyptula minor*) and yellow-eyed penguin (*Megadyptes antipodes*). The environment in which the carcass is recovered influences the assessment of cause of death.

Keywords: post-mortem examination, necropsy, dissection, blue penguin, *Eudyptula minor*, yellow-eyed penguin, *Megadyptes antipodes*.

© August 2002, New Zealand Department of Conservation. This paper may be cited as:
Hocken, A.G. 2002. Post-mortem examination of penguins. *DOC Science Internal Series 65*. Department of Conservation, Wellington. 25 p.

1. Introduction

This document is primarily intended to be a guide to finding the cause of death in penguins which have either been found dead or died in care. In order to find the signs that may indicate a cause of death, a post-mortem examination (necropsy) is required. This entails dissecting the bird. It is better that this is done in a systematic fashion, in order to minimise the possibility of overlooking or destroying relevant structures. The document is also intended to be a simple guide to dissecting a penguin and gives examples of dissection of blue penguin (*Eudyptula minor*) and yellow-eyed penguin (*Megadyptes antipodes*). This guide could be used for other wild birds, e.g. sea birds, but the worker needs to be aware of the basic variations that will occur between 'ordinary' birds and the non-flying penguins. It is important to realise and accept that, in about 16% of penguin examinations, no cause of death can be identified. Of the other 84%, a significant proportion have obvious causes such as road and dog kills. Clearly, the environment in which the carcass is recovered will influence the assessment of cause of death. These figures refer to a suburban population (North Otago), and a cause-of-death profile of birds picked up round Port Pegasus, Stewart Island, would be expected to be quite different because of the absence of mustelids and dogs, and rail and road traffic but the presence of, for example, skuas and sea lions.

2. Preservation of the carcass

It is important that the examiner, who may not have been the collector, is aware of the importance of, and insists on, proper collection and storage of the carcass that is to be examined in due course. It is important, not only for future use of the data but sometimes for interpretation of findings, that material is properly labelled as to when, where and by whom it was found. That label must be sealed in a fluid-proof wrapping or envelope and included with the carcass. It is equally important that, if the carcass is to be frozen before examination, it is air-tight sealed in plastic. If heat sealing is not available, zip-lock bags, carefully evacuated and closed will probably suffice. Simple wrapping in a supermarket bag will not prevent drying out, with consequent distortion of body tissues and weights.

3. Causes of death, and associated changes

3.1 AUTOLYTIC CHANGE

Autolysis means the destructive changes that occur naturally in body organs following death, i.e. the commencement of putrefaction. Such changes are fairly clear, organs become soft, lose shape and discoloured. Clearly the dissector will need to be familiar with the normal appearance of organs in order to recognise such comparative changes. It is sometimes of value to note and record the presence of fly eggs and maggots and the size of the latter. For example, if a body which has been recovered from the beach is autolytic but there are no fly eggs or maggots, it may suggest that the period passed since death has been at sea, not on shore exposed to flies.

3.2 NUTRITION

The state of nutritional well-being of the bird is important in assessing the causes of death.

Fat stores

Note the presence and size of the abdominal fat body and the subcutaneous fat. Clearly, the greater the fat stores, the better the bird's nutritional condition and the less likely that simple starvation has been the cause of death. (See Sections 5.5.1 and 5.5.5.)

Pectoral muscles

The word 'pectoral' refers to structures associated with the front limbs, in this case, the flippers. The muscle mass of the chest front are the pectoral muscles, as in breast of chicken. In the penguin, the surface exposed at skinning should be convex. If it is flat, there is minor wasting, and if concave, the degree of protein malnutrition is greater, usually indicating a more gross degree of starvation.

Fat stores are usually absent when pectoral wasting is evident, because fat reserves are exhausted before the bird begins to use its working muscle protein as an energy store. Occasionally, there will be evident muscle wasting but, with fat stores still present, this suggests a short-term severe protein demand, usually indicating severe infection. Egg laying is also very demanding nutritionally, and birds about to lay may have muscle wasting disproportionate to fat loss.

3.3 STARVATION AND STOMACH BLEEDING

Where there is simple lack of nutrition leading to starvation (e.g. new fledglings, inadequately prepared moulters, bad sea conditions) and no other visible disease, it may be difficult to say whether the bird has died '*of* starvation' or '*with* starvation' (which has compounded some other illness). Where starvation is the primary problem, by the time of death there is usually bleeding into the stomach, recognised by the stomach containing a dark red-brown material and a more or less black (not dark green) gut content. (See Section 5.5.7.) The dark material is blood altered by the digestive process. Such findings indicate death *by* starvation; wasting in the absence of bleeding is inconclusive, in this case, in the absence of any other pathology, the diagnosis is 'Unknown', as applies to approximately 16% of all necropsies.

3.4 DROWNING

Drowning as a cause of death is often suggested by the circumstances of recovery of the corpse, which is why it is so important that all the details of the recovery are provided, e.g. sodden corpse found on the tide line, a bird trapped in a net, a bird recovered from a breeding area after a storm on the coast. Each is important information that should be included on the information label.

There may be pale pink fluid in the mouth. The presence of pale pink-tinged fluid in the air sacs is suggestive. (See Sections 5.5.2, 5.5.10, and 5.5.14.) The cut lung is very wet and commonly exudes fluid very freely. Gentle pressure upon the intact lung will express fluid into the main air sac. There may be bruising visible on the inside of the skin if the bird has been trapped in a fish net. This will usually be about the neck and shoulders and, being subtle, may require a careful search.

3.5 ASPERGILLOSIS

Aspergillosis is a fungal disease which affects the respiratory system. (See Sections 5.5.2, 5.5.10, and 5.5.14.) It is contagious between birds, particularly where they are confined, hence its frequent occurrence in captive populations. The veterinary opinion is that apergillosis may be activated by stress interfering with the bird's immune system.

Aspergillosis is seen in wild penguins in three forms.

Granulomatous tumours

These are more or less lobulated masses of very firm tissue arising from the lungs, or more often, the air sacs. The tumour may be as small as a pea or as large as a table tennis ball. The cut surface is off-white with 'concentric' lines of discolouration. This is a chronic form of the disease (slow-acting) and is associated with evident malnutrition.

White plaques

These are pieces of firm, cheesy material lining the air sacs, often with an area of grey-green on the surface, easily recognisable as mould.

Seed-sized nodules

These are found scattered across the air sacs' surface and/or spread through the lung tissue. This is a much more rapidly acting form of the disease, technically referred to as 'miliary'.

3.6 PREDATION

Wherever the question of predation arises, care must be taken that deficiencies of the carcass are not due to scavenging after death by, for example, cats, mustelids or harriers. To be biologically correct, the use of the term 'predation' should be limited to killing for food, which does not apply to dog attacks, but the word provides a useful label.

Mustelid

New Zealand mustelids are ferret, stoat and weasel, the last an unlikely predator of adult penguins. Mustelids attack with a bite on the back of the neck, which penetrates the spinal column just below the skull and damages vital centres of the spinal cord. Then, characteristically, the predator eats out the upper neck muscle, working down toward the trunk. The extreme eating-out is represented by the entire neck being cleaned and the muscle of the trunk being taken by burrowing under the skin. It is unusual for the head to be detached. The decision of which mustelid is responsible depends upon local knowledge and environment.

Dog

The usual dog attack is upon isolated penguins, in which little or no external injury is seen but bleeding from the mouth, due to crushing of the chest causing lung damage, is common. On the *inside* of the skin will be found circular or puncture tears, which mainly do not penetrate to the outside, and represent the impact of canine (eye) teeth, Fig. 1. There will also be damage to the smooth surface of the pectoral muscles, again often without external evidence of injury over the site.

Less characteristic is the 'killing frenzy' pattern, associated with a number of dogs on a rampage running through the birds of a colony. In this case, external bite marks are seen, more or less destructive but usually only one actual bite. Look for the paired, external, punctures (representing canine teeth), with more than one set—upper and lower jaw—on opposite sides of the carcass. In this situation, not only will there be bleeding from the mouth but there will be more or less extensive internal organ damage from the crush of the bite. Furthermore, neck bruising and fracture-dislocation of the neck spine is common. This pattern can be interpreted as one 'savage' bite and a shake before the carcass is dropped and the next victim attacked.

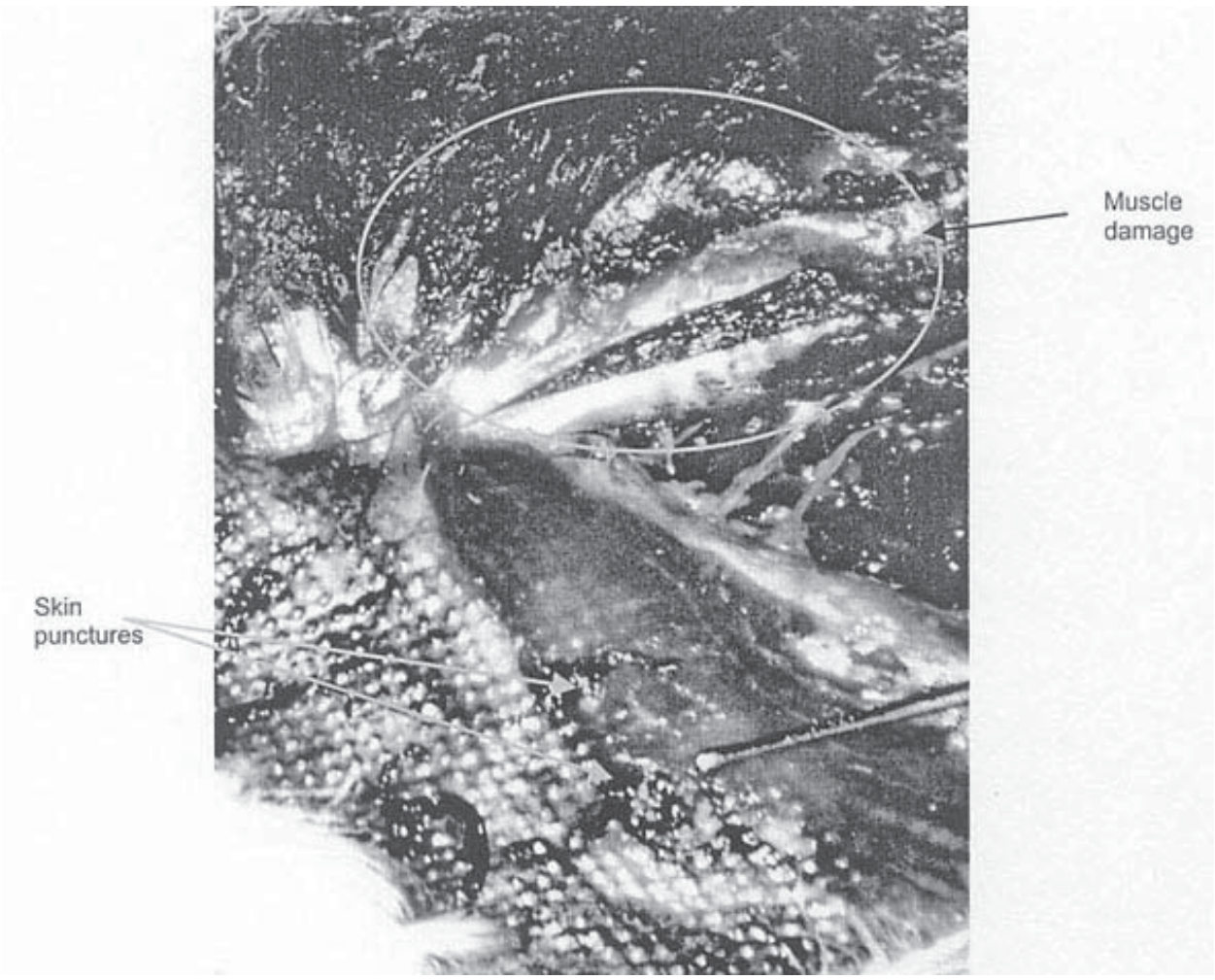

Figure 1. Evidence of dog attack. Note non-penetrating skin punctures on the inside of the skin and the damaged pectoral muscles.

'Shark'

The term shark is used generically, for there can be no evidence of the species of fish responsible for the dead or injured bird. The flesh injuries are linear and reminiscent of a sharp knife cut. Similarly, feather injury is as if cut with a pair of scissors.

3.7 ROAD/RAIL INJURY

There is little comment required here. The circumstances of recovery provide the indication of the cause of death, and the injuries are usually gross and compatible with that degree of trauma.

3.8 ENDOPARASITISM

Examination for intestinal parasites is a specialised process, requiring an experienced laboratory service. In the stomach, round worms occur in about 30% of yellow-eyed penguins but are uncommon in blue penguins; tapeworms are very uncommon in either species. (See Section 5.5.7.)

It is extremely rare in New Zealand birds (although well described in Australian blue penguins) to find parasites in the liver. However, the liver should be removed and sliced open to look for cavities and irregularities containing parasites. (See Section 5.5.6.)

Parasitism visible to the naked eye is not uncommon in the kidneys of New Zealand blue penguins; this is represented by tiny, off-white spheres in the cut surface of the kidney (coccidiosis). There is a universal occurrence of small (c. 2 mm) flukes (nematodes) in kidney tissues. Whilst both of these parasite types require a pathologist to identify them, it is unusual for them to provide any real threat to the well-being of the animal, all other things being equal. (See Section 5.5.10.)

4. Specimen collection

Specimens for microscopic examination (histology) can be taken as samples from any organ examined. The selection is usually dictated by the appearance of an apparent abnormality in the organ. Corpses which are less than fresh will have damaging post-mortem changes (autolysis, see above), and defrosted carcasses will have freezing damage to the tissues, both of which make histological interpretation difficult, if not impossible.

Samples should be not more than 10 mm thick. They should be placed in 10% formol saline, which is made using a 0.9% salt solution ('normal saline' i.e. 90 g common salt per litre of water). To 900 ml normal saline, add 100 ml 40% formaldehyde. Samples are said to be fixed when they have rested in this solution, at room temperature, for about a week. They may then be despatched to your pathologist, who will expect a full history of the animal's death and the post-mortem examination findings.

5. Dissection

5.1 INTRODUCTION

This section is a guide to dissection of a penguin to find abnormalities that might indicate cause of death. It is not a text on penguin anatomy. There are standard texts for birds in general, usually based on the domestic chicken or pigeon. The major reference texts are not always reliable for penguin details, but are adequate for the general picture.

This text describes the dissection and removal of each set of organs. This technique is offered so that the operator may develop a systematic approach to examining organs which are likely to provide information relating to a cause of death. Having used the basic technique, the dissector will be able to take short cuts, when that is required, without destroying the relevant anatomy.

5.2 ORIENTATION

'Directions' all relate to the body of the animal: up (towards the head); down (towards the tail); and left and right.

Occasionally I have used: 'dorsal', which means the bird's back or towards its back; and 'ventral', which is the opposite, referring to the bird's front or belly.

5.3 INSTRUMENTS REQUIRED

- Extension spring balance – 2.0 kg is appropriate for blue penguins but 10 kg will be required for most other species. Body weight is a good basic indicator of body condition.
- Scalpel. A no. 22 blade is best.
- Kitchen scissors. Heavy blades are essential for coarse work, such as opening the chest. Good apposition of the blades is essential.
- Dissecting scissors. 130 mm full length, one pointed, one round blade. Best reserved for cutting soft tissue.
- Dissecting forceps. One pair each of plain and toothed, 130–140 mm.
- Gloves are essential. They should be thin and well enough fitting to allow easy touch sense without being unnecessarily fragile.
- Absorbent cloth. A domestic cleaning cloth for mopping fluid and cleaning preparation.
- Ruler. Either a steel rule or preferably a roller type; it should be stainless to avoid corrosion from body fluid contamination. Clearly, body weight needs to related to size (body length) of the bird.
- Making a record. A voice-activated pocket tape recorder is useful, and a standardised form for written notes. Photographic records may be of value and the

collection and preservation of samples for histology (see Section 4) may be important for final clarification.

5.4 PREPARATION

External appearance. Note external characteristics, wetness, sandy, bony limb injury and wounds and the appearance of the inside of the mouth, e.g. blood, fly eggs or maggots. Note any staining of feathers round the vent.

Weight. Weigh the corpse intact.

Body length. Measure from tip of the bill to the tip of the tail bone, which can be felt just beyond the vent. The tail feathers are so subject to wear as to render the tail useless as a measurement.

5.5 DISSECTION

All directions will assume that the operator is right-handed, the bird being placed across the front of the operator with its head to the left.

5.5.1 Opening the skin

The skin incision will be from chin to vent. Bare or tense the skin/plumage about half way between the top of chest, recognised by feeling the 'V' at the root of the neck (thoracic inlet) (Fig. 2). Use the scalpel to cut along the mid line down to the muscle and about 40 mm to 50 mm long. With a sweeping action of the index finger, separate the skin from the trunk. It is important to keep in the right plane, especially below the chest, for the belly wall is very thin. Having swept upward and to each side, lift the separated skin between the index and middle fingers, spread widely, and use the scalpel to cut down towards the tail as far as the separation has been taken. One could cut the skin at this stage with scissors, but that results in the cutting and messy shedding of feathers. The procedure is repeated until the margin of the vent is reached.

Separation of the skin upward from the initial cut will be obstructed at the firm circle of muscle which binds the skin to the top edge of the chest, along the length of the wish bone, the thoracic inlet (Fig. 2). Using an index finger or thumb, push through into the base of the neck, in the midline, which may require some force. Then, by stages of alternating finger separation and a line of skin cutting, complete the opening of the skin up to the chin. Now the skin may simply be pulled aside by hand, pulling from both sides at once. Pull the skin as far apart as possible from vent to chin (Fig. 2).

At this stage, apply gentle compression to the surface of the chest, over the exposed pectoral muscles. This will cause the thoracic-inlet air sacs to be demonstrated by inflation, out of the base of the neck. (See Section 5.5.10 for a description of a bird's respiratory system.)

Having exposed the full length of the body (Fig. 2). note the following structures:

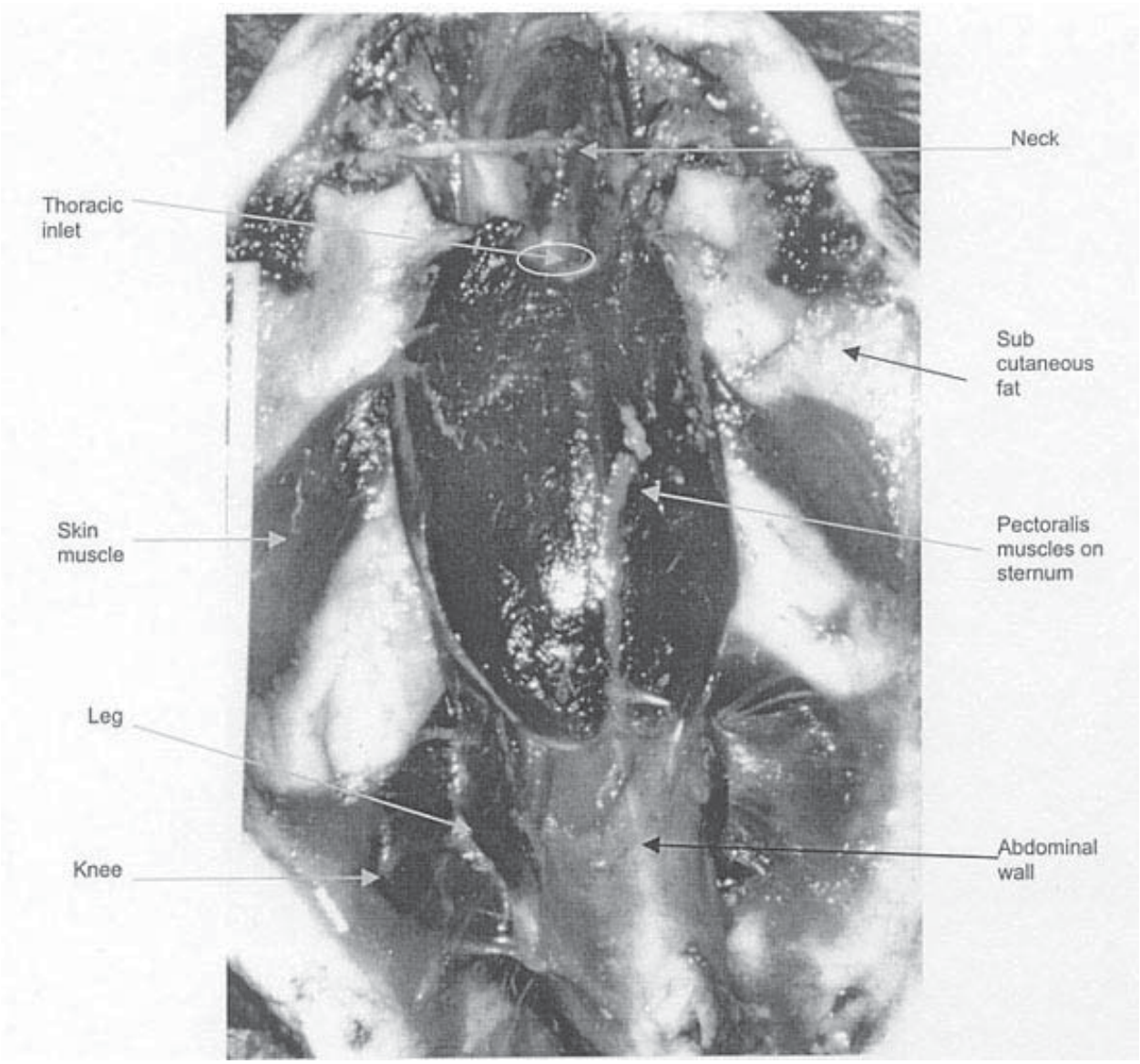

Figure 2. Blue penguin with skin removed.

Fat stores. There may be a layer of fat on the under-surface of the skin (Fig 2). There is a fat store in at the bottom of the abdominal cavity (abdominal fat pad). In starving birds, both of these stores will be totally absent.

From the chin (operator's left), downward:

Trachea (windpipe), semi-rigid with cartilaginous rings, lying in front of the:

Oesophagus (gullet), a soft muscular tube. Both these structures will lie to the right of the forward curve of the lower neck (Fig. 3).

Cervical (neck) spine. Note the heavy muscles surrounding and supporting the spine here, the cervical spine. In the floor of the mouth, the trachea and oesophagus are separated by a linear opening, the edges of which come close when it is necessary to separate the food passage from the air passage.

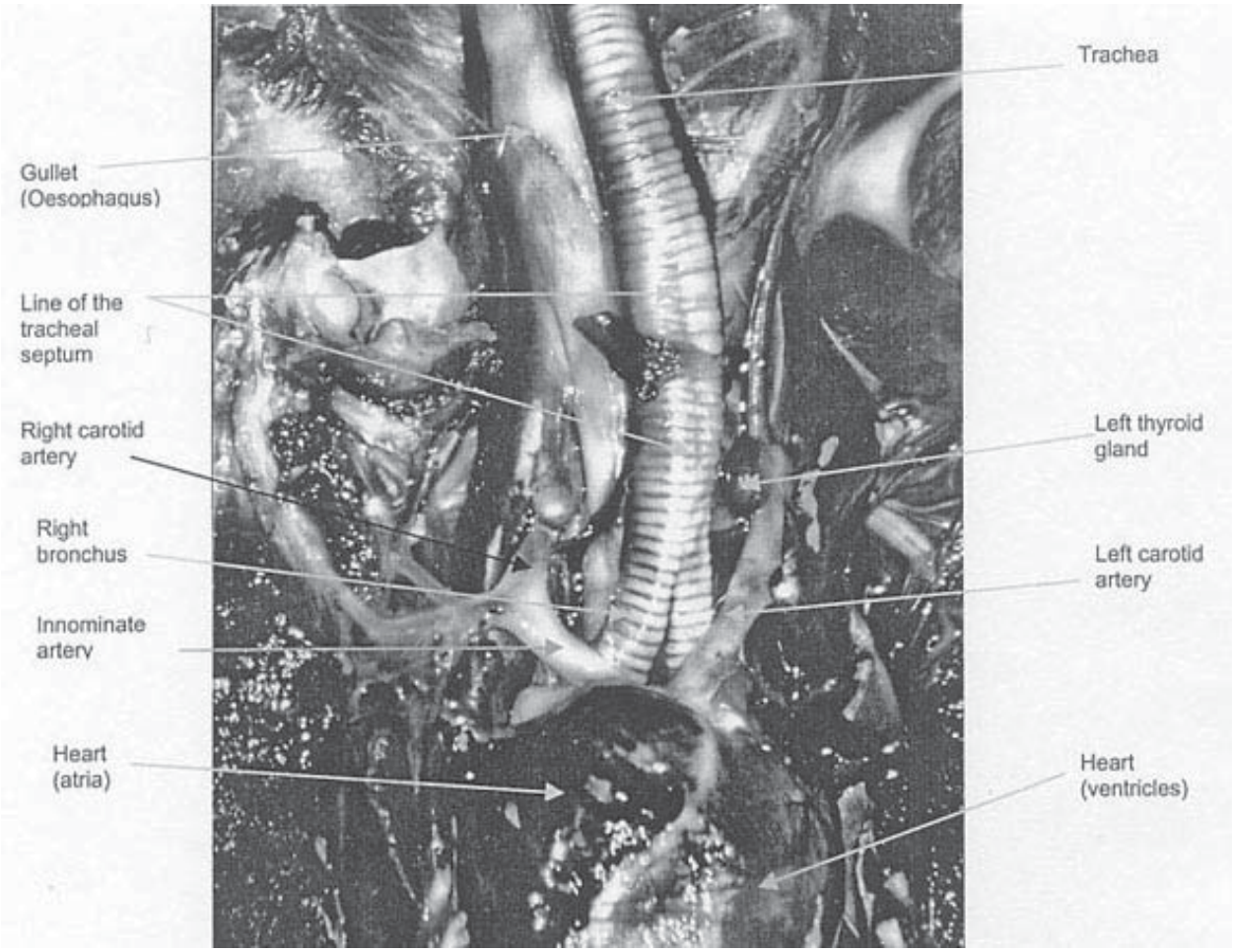

Figure 3. Lower neck of yellow-eyed penguin. Note that in this species the lower third of the trachea is divided by a septum.

Thoracic inlet is the passage from the neck into the chest, through which pass these structures, as well as the major blood vessels to and from the head and neck. The position of the passage has already been illustrated by the demonstration of the thin walled thoracic inlet air sacs.

5.5.2 Opening the chest

Grasp and lift the tip of the broad breast bone (sternum), using the toothed forceps. Use the heavy (kitchen) scissors to cut across the abdominal wall immediately where it meets the sternum. *Keeping the scissors very close to the underside of the sternum*, separate the organs on the inside of the chest from the bone by clipping the soft tissue away, working up towards the head. This manoeuvre usually leaves the front of the heart exposed but intact.

Cut the pectoral muscles parallel to the edge of the breast bone, on each side, until obstructed by the junction of the ribs with the breast bone. The remainder of the pectoral muscle should then be cut in the same line, but using the scissors outside the bony chest wall, right down into the shoulder joint. Maintaining elevation upon the sternum, insert one blade of the scissors inside

the chest cavity, parallel with and close to the edge of the sternum, across the ribs which will now be revealed. There are six sternal-rib junctions; all of these can be cut, close to the edge of the sternum, on each side of the chest. The sternum is now freed from the ribs and anchored only by the thoracic inlet.

Place your (right) hand flat across the trunk to anchor it to the bench and, using a damp cloth in the left hand (for a non-slip grip) forcibly hinge the sternum up, towards the head, extending it back as far as possible over the bird's head. This will tear the soft tissues of the main joint at each shoulder. The main air sacs will be found immediately inside the wall of the chest as a walled cavity between the bony chest wall and the internal organs of chest and abdomen. Note the main air passage opening from the lung into the upper end toward the side wall. The sacs should be dry and their walls clean and pearly (Fig. 4).

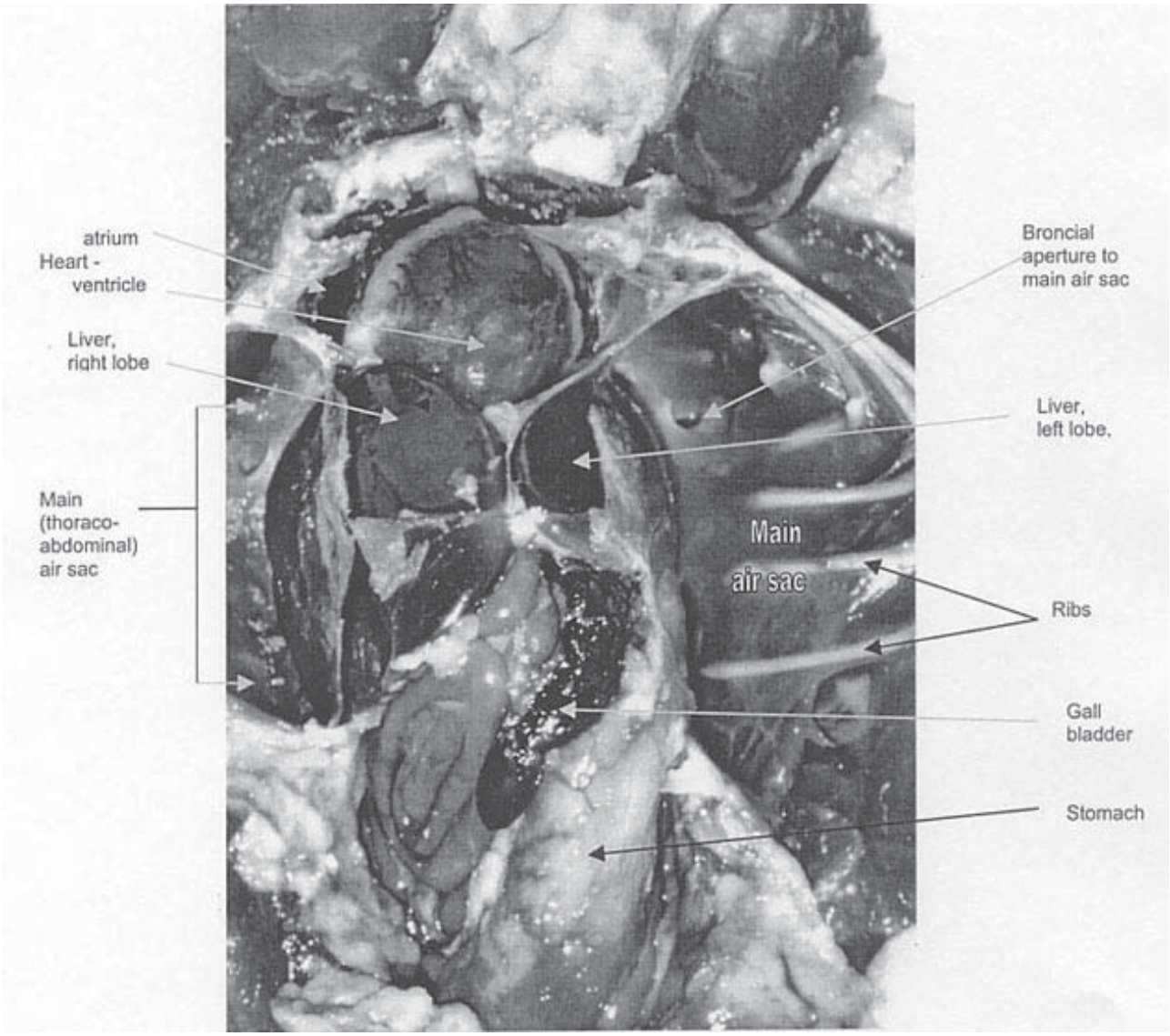

Figure 4. Blue penguin. The sternum is reflected upwards and the abdominal wall is opened.

Before proceeding

It will be as well at this stage to note the structures that have been exposed in the chest and neck. Note firstly that there is no muscular wall separating the chest from the abdomen—birds do not have a diaphragm, that is so important in mammals (Fig. 4).

Heart lies slightly to the left of centre of the upper chest. It consists of thin walled left and right atria on the upper aspect, joined to the left and right ventricles, completing the 'heart shape' of the organ (Fig. 5). It is covered with a thin membrane, the front of which has been removed. There is commonly a minute amount of lubricant fluid visible surrounding the heart within the sac, the surface of which, with the surface of the heart, should be quite smooth and shiny.

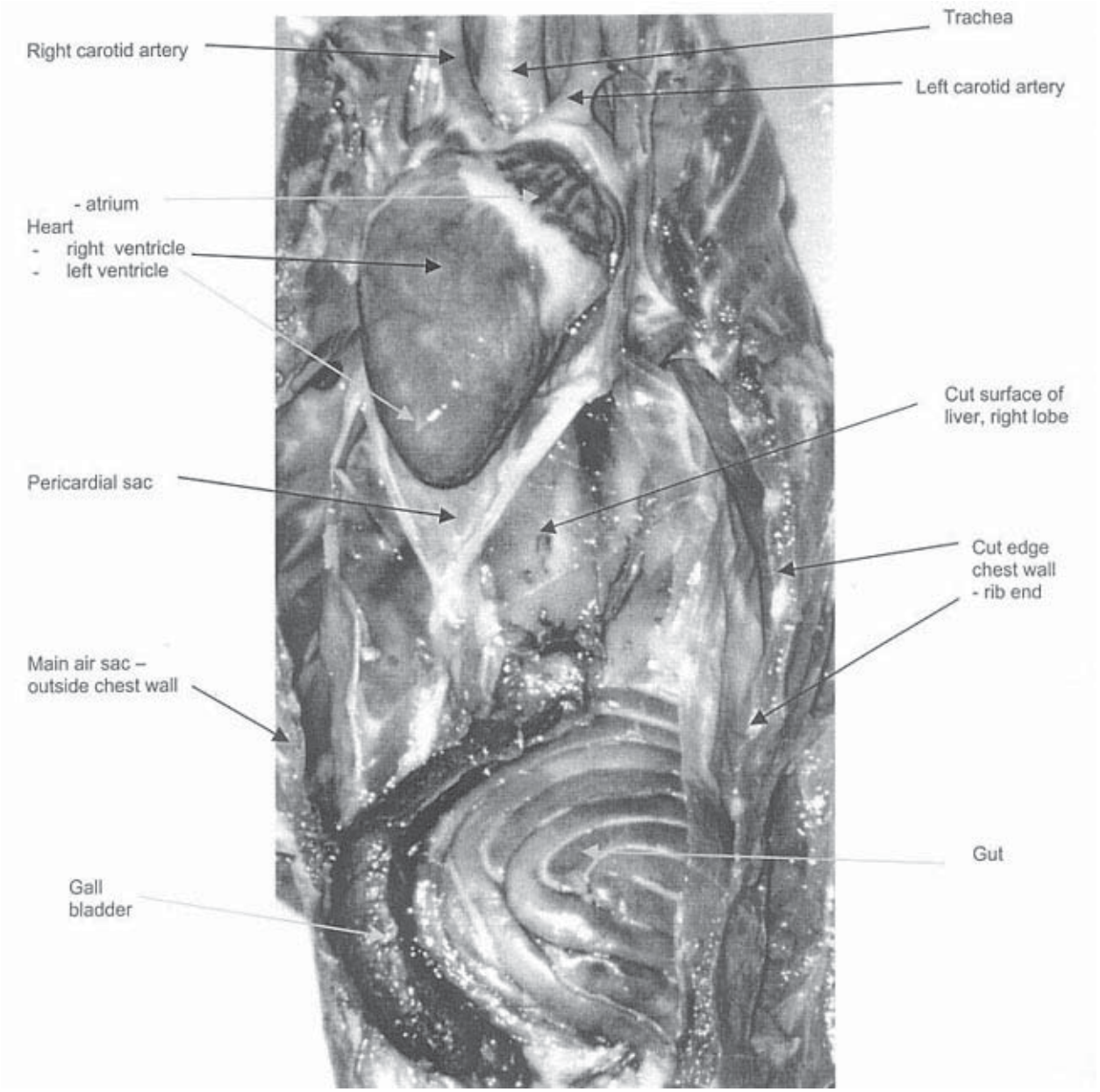

Figure 5. Blue penguin. Front of liver removed. This is a specimen preserved to demonstrate the intestinal fold pattern.

Major arteries. The aorta, the main vessel to the body, emerges from the top of the heart and immediately loops over behind the heart, to travel down, along the vertebral column, to distribute blood to the body and lower limbs. From the root of the aorta can be seen taking off, more or less immediately, the main arteries to the neck and head and the pectoral muscles and the flippers (Fig. 3).

Liver and gall bladder. The front and upper surface of the (larger) right and left lobes of the liver are exposed (Fig. 4) above the cut edge of the abdominal wall which was left behind when the sternum was displaced. The gall-bladder is not clearly seen until the abdomen is opened, although a green stain under the abdominal wall may indicate its presence.

5.5.3 Opening the abdomen

The abdominal wall is very thin. It is important at this stage to be aware of the gall bladder, which, if it is distended, is vulnerable to damage. The gall bladder is a sausage shape, c. 60 mm long and c. 7 mm across, when full. Puncture is to be avoided, for it results in the messy leakage of dark green bile, obscuring the preparation.

Elevate the centre of the cut top edge of the abdominal wall with non-toothed forceps, insert the closed blades of the scissors under and gently push them towards the tail, keeping the blades flat to the wall. Opening and closing the blades will create a tunnel ('open scissors dissection'). When the tunnel is formed, re-insert the round blade of the scissors and cut down the length of the abdominal wall. Repeat until the wall has been cut to the anus. Avoid the possible hazard of a dilated rectum, the puncture of which will also release messy fluid. Now, retaining hold of the cut edges of the abdominal wall flaps, separate and reflect them to the side of the preparation, using the closed scissors points, exposing the abdominal organs (Fig. 4). The fat of a well nourished bird may obscure organs and tissue planes, but it can be separated and pushed to the side or dissected out and removed, more or less intact.

5.5.4 Removal of the gall bladder

The gall bladder emerges from between the left and right lobes of the liver (Fig. 4). Firstly, clear any fatty tissue and identify the tip. Pick up the tip with non-toothed forceps and, holding it up, separate the supporting connective tissue, initially by open scissors dissection, then cut the connective tissue away, parallel to the bladder. Once defined and separated, the bladder is separated right down into the gap between left and right lobes of the liver. Then, with the tip held firmly elevated, cut across the root of the gall bladder, deeply within the fissure and quickly remove the bladder. This manoeuvre will cut the various bile ducts only and there should be no leakage.

5.5.5 Abdominal fat body

A bird in good nutritional condition will have a layer of fat under the skin, and the surface of the pectoral muscles will be *convex*. In such condition there will be a body of fat at the bottom of the abdomen (pelvis), extending more or less upwards. The two lobes of the fat body may be separated by blunt dissection from the midline, then displaced to the side and removed, if required. Care

needs to be taken, in dissecting out and removing the fat bodies, not to puncture the rectum, with which they are closely associated.

5.5.6 Liver

It is probably easiest to control the liver using fingers, rather than instruments, for it is easily torn. There is an envelope of fine membranes (peritoneum) enclosing the liver. Identify these and cut them close, right round the organ, using good scissors. In doing this, three main structures should be identified, each to be cut with scissors as close to the liver as possible.

1. Entering the divide between left and right of the liver is a tissue bundle representing the blood vessels and ducts travelling between the liver and the gut mass
2. The portal vein coming into the upper side of the right lobe.
3. The extremely short but large-diameter main vein returning blood from the top of the right lobe of the liver to the right atrium of the heart.

Once all those structures and the membrane envelope are cut, the liver will be free in the hand.

5.5.7 Stomach

The stomach is visible as a pink, moderately thick-walled, organ lying obliquely downwards from under the left lobe of the liver into the lower right pelvis (Fig. 4). In recently fed chicks it may be grossly filled (up to 20% body weight) and liable to puncture damage. All abdominal organs are supported between a double layer of peritoneum, a structure called the mesentery. The stomach, however, lies in two such double layers hanging from the lower surface, with a cavity between them. The lower end of the stomach is 'anchored' into the right lower abdominal wall by a condensation of tissue, forming a soft 'ligament'.

To remove the stomach, lift up the lower end with toothed forceps and cut the 'ligament' close to the stomach wall. It is now possible to cut the stomach (front) mesentery all the way up to the lower gullet. The top end of the stomach and lowest gullet can be separated from the chest wall by blunt scissor dissection. Keeping the sharp point of the scissors very close to the stomach wall, cut second (back) stomach mesentery. If care is taken, the spleen, lying between the two layers of peritoneum will be bared. It is a small, c. 15 mm long, dark red, sausage-shaped structure. Generally speaking, the spleen is not an informative organ and it can be dispensed with. The remainder of the mesentery may be cut up to just above the junction of the stomach and the gullet before cutting across the latter about the level of the heart. Cut across the gut about 10 mm below its junction with the stomach. The stomach is then removed.

The stomach should be opened lengthways, on the bench, from the cut end of the oesophagus, using the heavy scissors. Inside, note the change of the longitudinal folds of the lower oesophagus into the thick-walled glandular portion, which incompletely encircles the upper two-thirds of the stomach. The lowest portion of the stomach, which empties out into the intestine, is smooth walled. The contents of the stomach (stones, food, worms, blood) should be noted.

5.5.8 Gut

Move the gut mass to the right side by hand, which will expose its lower end. It is easier to remove the gut mass from the body now, before examining the lower gut stump. Holding the mass of the gut to the right, by hand, identify its mesentery, which attaches it to the back of the abdomen. Cut this close to the posterior abdominal wall, working upward. On the way, identify the two kidneys and the sex organs (gonads), which lie over the top end of the kidneys (Fig. 6). Cutting the flimsy mesentery upward will include a 'stalk' of tissue and blood vessels, representing the 'root' of the gut mass. When this is cut, the whole gut organ should be free to be removed from the carcass. It calls for no further examination at the moment, apart from noting its colour, which is normally more or less clean pink in the fresh specimen. If there has been bleeding from the stomach into the gut, its colour will be more or less black.

Now return to the rectal stump in the carcass. Using toothed forceps, lift the cut end. In young birds (up to two years old) the bursa of Fabricius may be more or less easily found lying along and close to the back, that is the underside, of the

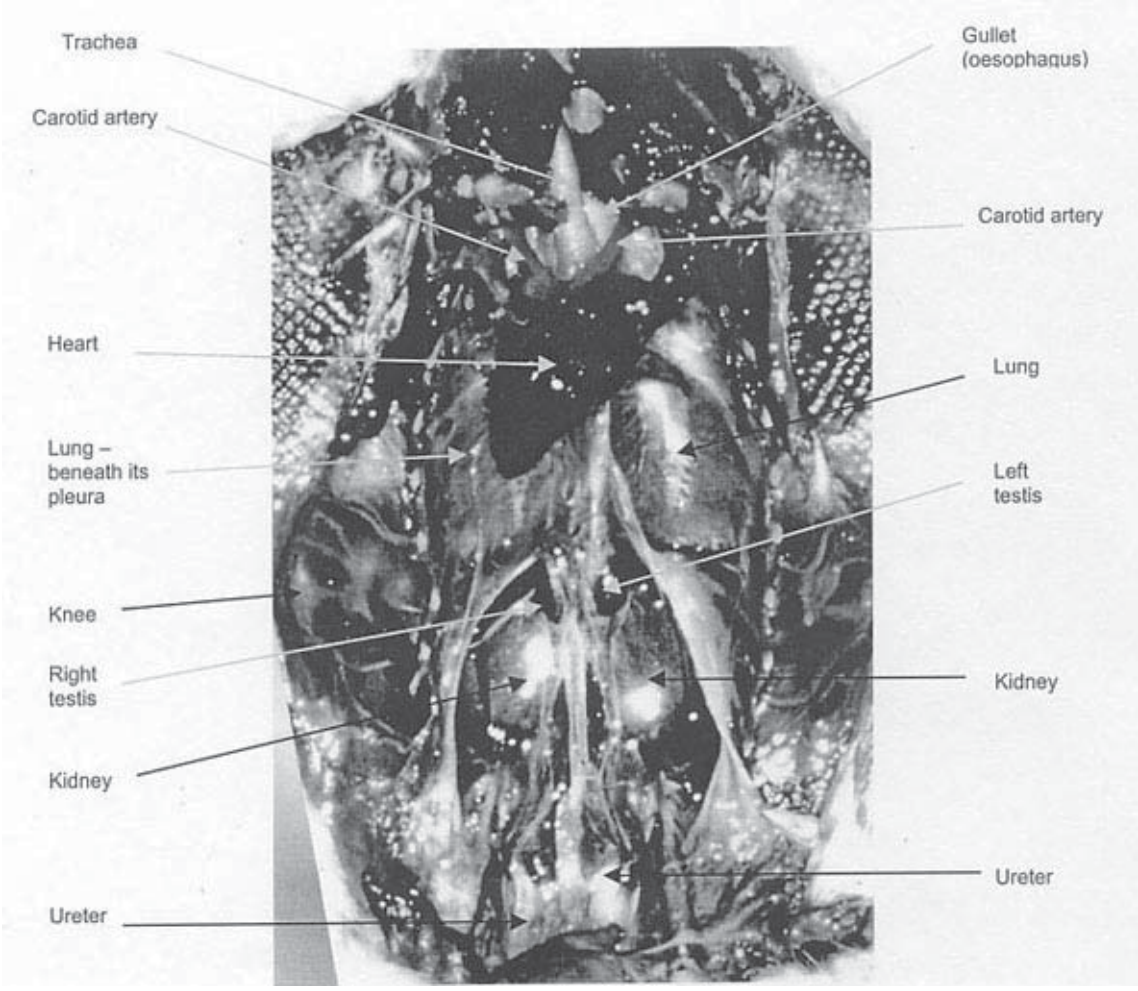

Figure 6. Blue penguin. Juvenile male. The liver, gut, and stomach have been removed.

stump, when it is a thick-walled pouch. In older birds, it is much less easy to find, so that its presence indicates that the bird is probably less than two years old. Whilst the rectal stump is elevated, it is possible to recognise the origin of the oviduct in females (on the bird's left) and both ureters, the tubes which conduct urine from the kidneys to the cloaca, the terminal chamber of the gut (Fig. 6).

5.5.9 Heart

Reference has already been made to the main blood vessels round to the heart (Figs 3, 5). Remove the heart by holding its tip with toothed forceps, identifying and cutting the individual vessels as they emerge, one at a time. Once the heart is on the bench, it is instructive to demonstrate the structural and anatomical relationship of the left and right ventricles. Cut across the intact organ about two-thirds of the way up from the apex, and examine the cut surface. The right ventricle is relatively thin-walled and lies wrapped around the outside of the much more muscular left ventricle.

Re-appraisal

At this stage it is as well to quickly identify the organs that are left in the carcass. (Figs 6, 7).

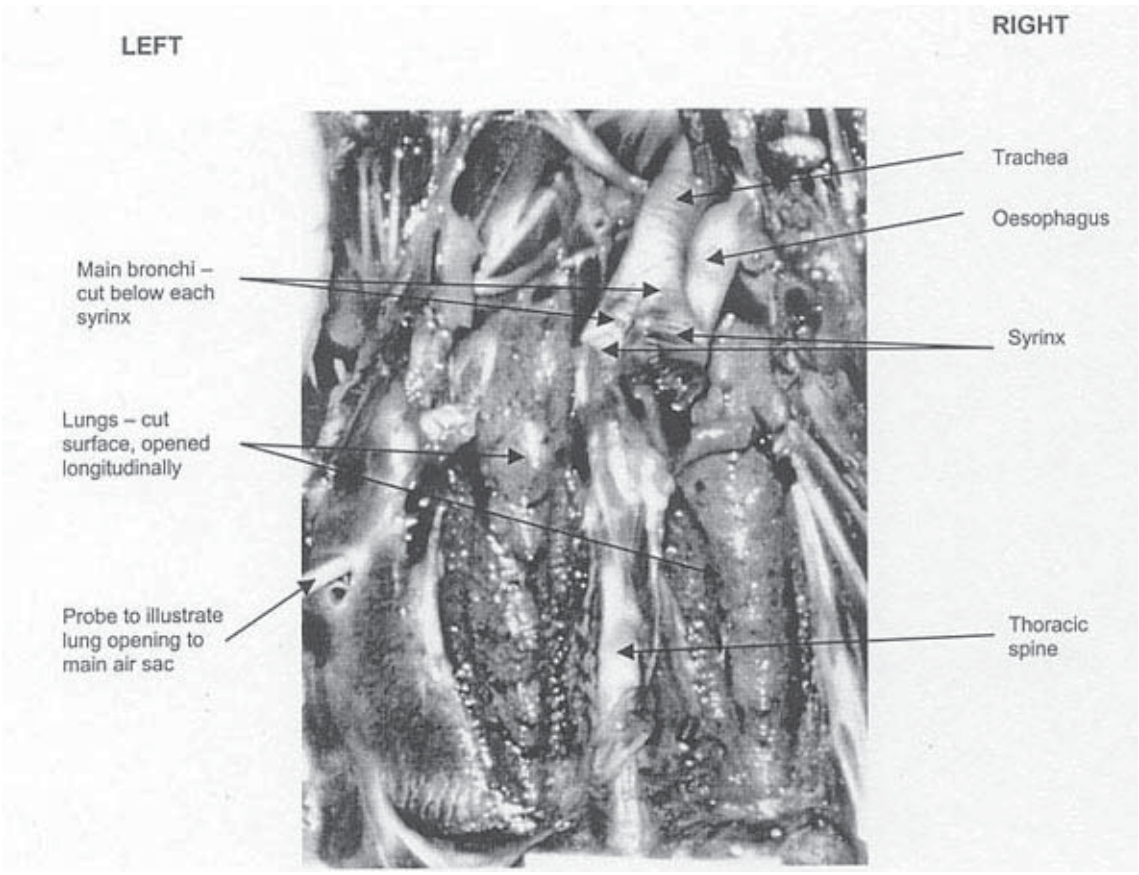

Figure 7. Blue penguin. Heart removed, to display main bronchi (cut) and lungs.

Trachea and bronchi and lungs. The trachea (windpipe) divides into a left and right main bronchus, immediately behind the heart.

Oesophagus (gullet). The cut end of this lies behind the windpipe tree.

Kidneys. These lie in the recessed beds on each side of the backbone. They may be seen as gently convex organs, oval-shaped, on either side of the spine, with a much narrower prolongation downwards, from the bottom end of which projects the ureters, conveying urine to the cloaca, the terminal portion of the gut. Birds do not have a separate urinary bladder.

Gonads. (Fig. 8.) In females there is a single ovary on the left side, an elongated triangle pointing down, lying a little off the midline, over the upper lobe of the kidney. The oviduct conveys eggs from the ovary to the cloaca, prior to laying. The ease of recognition of the oviduct and the appearance of the ovary depends upon maturity of the bird. In males, there are two testes, the left in the same position as that described for the female ovary. The left testis is always the larger, about twice the size of the right. Colour varies with age and season, from very black in juveniles to dove grey in breeding condition.

5.5.10 Respiratory system

Note how the pattern of the cartilaginous rings of the main bronchi changes immediately after their dividing off the windpipe; this represents a part of the bird's vocal apparatus, the syrinx (Fig. 7). Note also that the main bronchi plunge straight into the body of the lungs. The breathing apparatus of birds is quite different from the simple balloon to-and-fro system of mammals. The system of air sacs 'reservoirs' in birds is complicated and not easily demonstrated. In this dissection, the main 'thoraco-abdominal' sacs were opened when the sternum was reflected upwards, and the 'thoracic inlet' sacs were demonstrated at the time of the upward displacement of the sternum (Fig. 4). The remaining four or five air sacs, which open into the lungs are very difficult to recognise.

5.5.11 Oesophagus

The oesophagus may be opened for examination by approaching from each end:

1. Hold the cut lower end of the gullet with toothed forceps and run the coarse scissors up the tube as far as possible, towards the top of the chest. Note the pale, longitudinally ridged mucosa, identical to that already seen in the top end of the opened stomach.
2. Using the heavy scissors, insert a blade into the bird's mouth and cut the lower jaw on the right (mandible) close to its hinge with the skull. Follow that cut through, and the scissors will channel down and open the oesophagus over its full length.

Look for the quite uncommon presence of parasites lining the gullet.

5.5.12 Gonads

The gonads (Fig. 8) are easy to recognise in mature adults, as indicated earlier.

Female

The oviduct is suspended in the usual double-layered mesentery. At the bottom end, where the duct enters the cloaca, cut the duct and, by gentle pulling, free

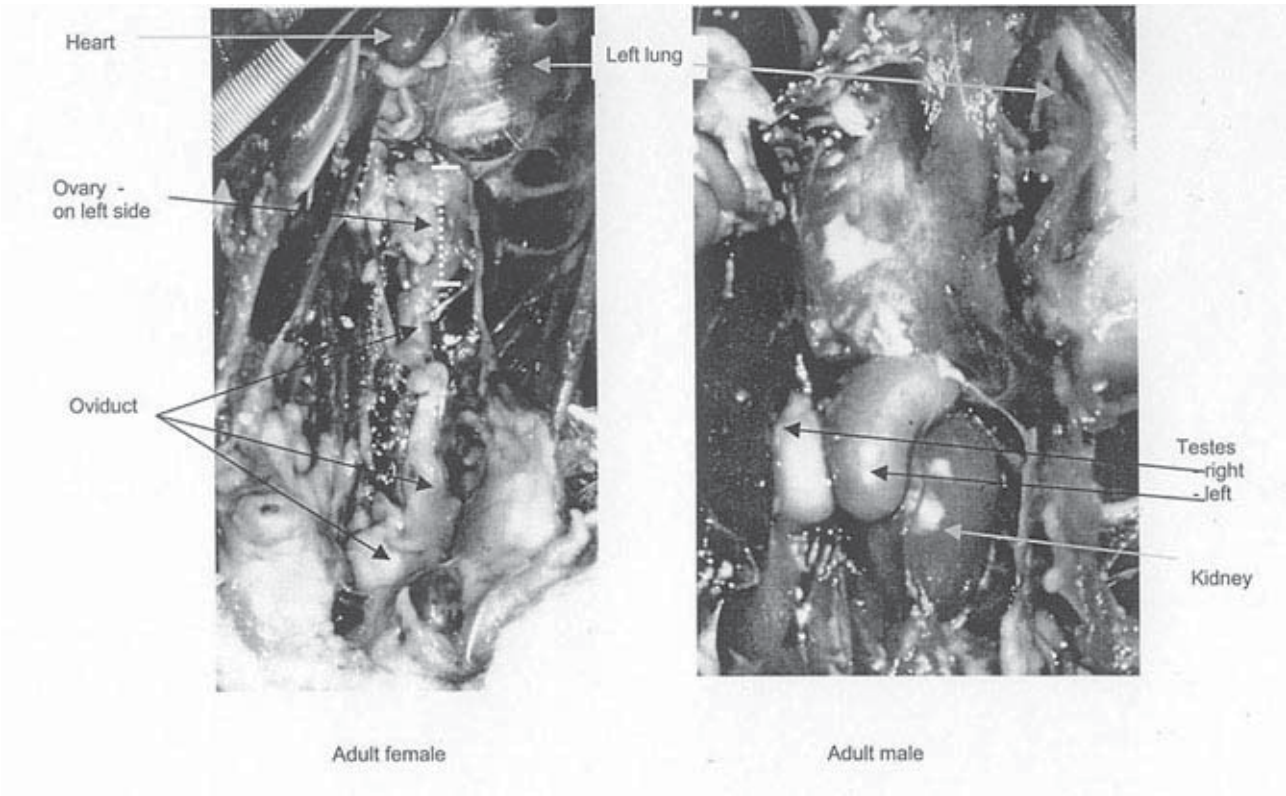

Figure 8. Blue penguin gonads.

the duct by cutting its mesentery close to the posterior abdominal wall. It is best to remove the top end by gentle pulling from around the ovary. Note whether the oviduct is a thin-walled and more or less straight, fine tube or whether it is more or less convoluted, with some degree of thickening or whether it is very convoluted and thick-walled. Those three conditions respectively suggest that the bird has never bred, that has bred in the past, or that it will or has bred in the current season, thus giving an indication of its age.

The ovary will be a fine uniformly textured isosceles triangle of yellow colour in an immature (virgin) bird. The texture of the ovary of a mature bird is variable, depending upon age and time relationship to the breeding season. The potential eggs are recognisable as spherical nodules on the surface of the ovary. They are commonly 3–5 mm diameter in the off season, but birds coming up to laying will have much larger egg-cells destined to become the yolk of the fully formed egg.

Male

The smooth ovoid of the left testis is always considerably larger than the right, usually twice the weight. They are usually grey, but black in juvenile birds, when they are often little more than flat plaques on the posterior abdominal wall and may not be easy to see. In the adult, they are easily removed, which gives better access to the kidney underneath.

5.5.13 Kidneys

The kidneys have already been described. It is probably not necessary to remove them, although they can be lifted up by the ureter and separated from their bony bed behind by snipping. Birds' kidneys excrete relatively insoluble wastes and, if the urine is particularly concentrated (strong), the ureters may be recognised as white lines running downwards from the kidneys (Fig. 6). Removal of the kidneys for examination is very unlikely to yield useful information. However, their internal integrity may be confirmed by simply slicing the full length with a scalpel, as they lie in place. This will demonstrate normal texture and colour.

5.5.14 Lungs

The position and appearance of the trachea and main passages have been noted. The junction of the three air passages may be lifted with forceps, the bronchi cut at their point of entrance to the lungs (the pink masses behind), and the whole tree displaced upward. Note that in the yellow-eyed and the crested penguins, there is a dividing wall (septum) in the trachea, part of the way up. (Fig. 3). This division is not present in blue penguins.

On either side of the chest spine there is a semi-translucent membrane covering the lungs, which themselves lie in the bony cage of the chest wall of either side. The membrane can be nicked at the lower end and a pointed scissors blade run straight up, into the neck of the bird, on either side. This will expose the pale pink 'sponge' of the lungs extending well up into the neck. To recognise their nature and texture, run the knife blade the full length of the lung organ. The normal lung will be pink, not red, and sponge-like, and the cut surface will be more or less dry (Fig. 7). If the bird has drowned, as well as there being fluid in the air sacs, the lungs will be very dark and wet, and will exude a blood-stained fluid when cut.

Your dissection is now complete.

6. Further reading

Within the limits of not specifically considering penguins, Proctor & Lynch (1993) is probably the best book, with excellent pen and ink drawings illustrating the anatomy of birds. Although there might be a problem looking at drawings of the musculo-skeletal system of pigeons and chickens when one has a penguin on the bench, the basic structures and their relationships are readily recognisable from the excellent drawings. Campbell & Lack (1997) is a more academic (general) ornithology treatment and, again, within the restraints imposed by limited reference to penguins (and that not always accurate), this is an excellent anatomy and physiology reference text. King & McLelland (1979–85) is the ultimate general academic ornithological text, but dated in some of its physiology, and of limited value. Watson (1882) is the best, and only, text of which I am aware that deals with penguin anatomy in any detail, albeit limited by his number of specimens.

7. References

Campbell, B; Lack, E. (eds) 1997: A dictionary of birds. London, Poyser. 670 p.

King, A.S.; McLelland, J. (eds) 1979–85: Form and Function in birds. (3 vols) London, Academic Press.

Proctor, N.S.; Lynch, P.J. 1993: Manual of ornithology; avian structure and function. Yale University Press, New Haven & London. 340 p.

Watson, M. 1882: Report on the anatomy of the Spheniscidae collected by HMS Challenger, during the years 1873–1876. Being part of the report upon the "Challenger Expedition, 1872–1876", published for Her Majesty's Government by Neill & Co, Edinburgh, 1880–1895.