THE MORPHOLOGY AND MORPHOMETRICS OF LYMPH NODES OF SHEEP AND LAMBS:

A STUDY OF NORMAL SHEEP AND THOSE WITH ARTHRITIS

A THESIS PRESENTED IN PARTIAL (20 %)
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SUMMARY

Nineteen groups of lymph nodes from six Romney ewes and six female lambs aged seven years and six months respectively as well as 50 popliteal lymph nodes from further 25 lambs were examined.

The size, weight and shape of each node was measured and recorded. Weight was found to be the most objective indirect method of describing the size of a lymph node.

There was a wide range of normal weights, both between left and right lymph nodes from the same animal and between the same node from different animals. In retrospect, more animals should have been examined to determine the extent of these ranges.

The relative total weight of lymph nodes in relation to carcase weight was greater in lambs than in ewes, and the jejunal lymph nodes showed the greatest difference. The dry matter content of lymph nodes from lambs was greater than that from ewes.

Twenty-six stifle and hock joints, which had been classified as arthritic by meat inspectors, together with the associated ipsilateral and contralateral popliteal and medial iliac lymph nodes were examined.

Only 62% of condemned joints had signs of macroscopic pathological change. Only six popliteal nodes and one medial iliac node were enlarged. There was no correlation between enlargement of these nodes and signs of disease in these stifle or hock joints.

Evidence is presented to show that pathological enlargement of lymph nodes may often be indistinguishable, on visual examination, from normal lymph nodes at the upper limits of the normal range. These findings have relevance to a critical evaluation of traditional meat inspection procedures.

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GENERAL INTRODUCTION

During the history of man, the most serious meat borne diseases were probably trichinellosis and tuberculosis. Owen was the first person to recognize Trichinella spirallis (Hoeden, 1964) and Koch the first to isolate Mycobacterium tuberculosis (Martin, 1978) in 1835 and 1882 respectively. These diseases had been a major cause of human morbidity and mortality for many centuries before the infectious agents were described. It is interesting to note that lesions of tuberculosis were found in mummies of the Rameses dynasties which are some 30 centuries old and human trichinellosis occurred in early epochs of European civilization without it being realised.

With the development of modern concepts of disease, greater attention was paid to the source and handling of meat for human consumption (Brandly, Migaki and Taylor, 1966). Since meat is an essential source of human food, a knowledge and understanding of potential meat borne diseases is necessary. It has become accepted that meat inspection is an indispensable branch of meat hygiene in relation to the control of meat borne diseases.

Meat inspection includes two main aspects; ante mortem inspection and post mortem inspection. Post mortem inspection has usually been regarded as the most important single step in the whole of meat inspection procedures (Petersen, 1979). The major aim of post mortem inspection is to detain any carcase, or part of it, which is not fit for human consumption. Therefore, post mortem inspection remains an essential and major part of meat inspection procedures.

Present meat inspection procedures date back approximately one hundred years and are based on the diagnosis of the most prevalent zoonotic diseases of central Europe in the late nineteenth centuries which were tuberculosis and trichinellosis (Blackmore, 1983).

The appearance of lymph nodes has been considered to be useful guides to the presence of disease and also to indicate the extent of disease (Dyett, Huches and Jones, 1981). The examination of lymph nodes visually, by palpation and by incision, has been a fundamental component of meat inspection since the introduction of routine inspection procedures in the mid 19th century (Skovgaard, 1981). In some conditions, changes in the structure of lymph nodes, apart from being a useful indication of the area affected, may indicate the type of disease process. For instance, in many cases of chronic bovine tuberculosis the lymph nodes draining an infected area are both enlarged and show typical granulomatous changes including caseation and calcification (Monlux and Monlux, 1972). In cases of acute enteritis the mesenteric lymph nodes can be swollen and oedematous and show obvious inflammatory changes.

In the more chronic diseases which result in secondary change in the lymph nodes, enlargement may be the only obvious gross sign of abnormality. For instance, longstanding cases of actinobacillosis often result in gross enlargement of the retropharyngeal and mandibular lymph nodes (Thornton and Gracey, 1974).

By incising affected lymph nodes, a meat inspector determines whether or not the carcase or part of it can be passed as normal and fit for human consumption or should be detained due to pathological changes reflected in its

lymph nodes. Thus a knowledge of the normal appearance, location, area of drainage and function of lymph nodes is of fundamental importance in the meat inspection (Wilson, 1980).

The lymphatic system has generally been regarded as consisting of two main elements; (1), an extensive network of vessels containing lymph, in which are found the many proteins of plasma as well as large number of cells, the majority of which are lymphocytes, and (2), scattered masses of lymphoid tissue, often in the form of discrete lymph nodes, with which these vessels communicate (Yoffey and Courtice, 1970). The lymphatic vessels constitute one way channels which run almost in parallel to the venous system and eventually empty into the cranial vena cava or its branches (Frandson, 1972).

The lymphatic vessels begin as a network of very fine lymph capillaries with blind extremities. These capillaries gradually enlarge into thin walled lymphatic vessels which discharge the lymph into the lymph nodes. The lymphatic vessels carring lymph into lymph nodes are known as afferent lymphatics. The lymphatic vessels conveying lymph away from lymph nodes are termed efferent lymphatics.

Lymph nodes are discrete nodules of lymphoid tissue, whose location is usually anatomically constant, found along the course of lymphatic vessels (Miale and Rywlin, 1977). A lymph node is divided into two parts, the outer part or cortex, and an inner part or medulla. The cortex contains lymphatic nodules in which there are germinal centers (sometimes referred to as secondary nodules). A network of reticular fibers from the pyramidal areas continue into the medulla where the narrow ends of the pyramidal areas merge into structures

called medullary cords (Ham and Cormack, 1979).

An area drained by a lymph node by afferent vessels is termed a drainage area. When lymph passes through the nodes, foreign substances such as bacteria and other particulate matter will often be detained by phagocytic activity. Efferent lymphatics may drain to one or more other lymph nodes before they reach the blood stream.

Hemal lymph nodes are also present in cattle and sheep. They are small dark red or black structures, the colour depending on the amount of blood or blood pigment present. They resemble lymph nodes but are interposed on the course of small blood vessels (Frandson, 1972). Hemal lymph nodes vary between 1 to 20 mm in size and in small ruminants they rarely exceed 5 mm. In cattle they are seldom more than 10 mm. The exact number present is unknown but it has been estimated that in sheep there are between 30 and 300 (Vollmerhaus, 1981). Each node consists of an outer capsule, trabeculae and cavernous blood spaces and lymphoid tissue, similar to the structure of the spleen and having no lymph ducts or lymphatic spaces. These nodes are found mainly in the back fat and along the aorta, but many occur elsewhere in the body.

Hemal lymph nodes are entirely absent in humans, horses and pigs, but a few are found in dogs (Macgregor, 1980). They have a well developed peripheral sinus which contains blood, from which secondary sinuses extend into the interior, and form an intercommunicating system of blood spaces. There is no clear division into cortical and medullary substance, and the trabeculae contain smooth muscle cells. Although they resemble the spleen in some respects, their significance is not yet clear (Sisson and Grossman, 1959). They are not

considered important in terms of meat inspection.

The function of lymph nodes includes the formation of lymphocytes and the production of antibodies, as well as the fitration of lymph (Wiale and Rywlin, 1977). If the nodes receive afferent vessels from an area of the body which is infected, secondary infection and inflammatory change of the nodes may occur. Thus an inflammatory reaction in a lymph node may indicate a concurrent inflammatory reaction in its area of drainage. These reactive processes in lymph nodes are generally grouped together under the term acute or chronic lymphadenitis (Nieberle and Cohrs, 1967). In acute lymphadenitis, the node is soft, moist and hyperaemic. The node bulges above the cut surface and may contain areas of necrosis. In chronic lymphadenitis, hyperaemia is less although the nodes may remain oedematous. The affected nodes are initially enlarged and firm but may later become smaller and indurated (Jubb and Kennedy, 1963). Changes in the size, colour and consistency of the lymph nodes are considered to be indicative of acute septicaemic or pyaemic conditions (Thornton, 1970).

The response of a lymph node to an irritant is normally rapid, with enlargement and congestion of its substance and possibly degenerative changes also. Thus the size, colour and consistency of lymph nodes are considered valuable in the estimation of disease processes in the animal body during inspection procedures (Thornton and Gracey, 1974). In many cases of routine meat inspection, lymph nodes are only incised when they are enlarged as judged by palpation or appearance. Thus a knowledge of the size of normal lymph nodes is essential before an enlarged node can be recognized.

Standard texts on veterinary anatomy describe the location and area of drainage of the lymph nodes of the body. However, there is a lack of information on the size, and to a lesser extent, the shape of the lymph nodes in different species. There is also little information in these standard texts regarding changes in size of lymph nodes with age. Yet it has been shown that the lymphatic tissue of humans decreases in amount (involution) with age (Weiss and Greep, 1977).

In New Zealand more than 30 million sheep are slaughtered each year, and subjected to routine post mortem inspection. These procedures involve the palpation of lymph nodes and in certain cases incision also. In spite of this, information on the quantitative morphology of lymph nodes from sheep is lacking. It therefore become apparent that before it could be determined whether or not lymph node enlargement was a useful indication of diseases of relevence to inspection procedures, normal animals would have to be studied.

First, information on the morphology and morphometry of lymph nodes from apparently normal sheep and lambs was collected (Section 1). Secondly, based on the results of this initial work, a study was conducted to determine any possible correlation between arthritis in sheep and the size of the lymph nodes draining an affected area (Section 2).

MATERIALS AND METHODS

Examination of lymph nodes from normal animals

Six clinically normal, seven-year-old Romney ewes and six clinically normal, six-month-old Romney lambs were slaughtered and eviscerated. The live and carcase weight of the animals were recorded and the 19 major groups of lymph nodes of carcase and viscera were removed within three hours of slaughter (see Appendix).

Fifty popliteal lymph nodes from a further 25 Romney lambs, approximately 8 months of age, were removed from carcases of known weight, soon after they had been passed as fit for human consumption by inspectors at a local works.

Nodes were removed by careful dissection, visible fat removed and the nodes were placed in a tray covered by damp cloth until examined further.

Description of location and area of drainage

The location and area of drainage of lymph nodes have been summarised by Vollmerhaus (1981) and Saar and Getty (1975). These descriptions are provided in the results. Newer findings of the caudal mediastinal node by Albertine, et al, (1982) and Landolt, et al (1981) are also included. No contrary evidence was found during the course of this work. No investigations on the course of afferent and efferent lymphatics were undertaken.

Measurement of size and shape

The size, shape and weight of each node was recorded. Size and shape were measured by placing the nodes on a piece of paper with a grid of horizontal and vertical lines 1 mm apart, and tracing round the outline.

First, an outline of the node was made with its two longer axes of length and width parallel to the paper. Then the node was turned through 90°C so that the largest axis of length and the smallest of thickness were parallel to the paper, and a second tracing made. Thus the third dimension of thickness could be measured.

Nodes could be divided according to shape into two types: those which were constantly kidney or oval in shape, were classed as regular. In these nodes, the length, width and thickness were measured at their greatest values. In the other irregular shaped nodes, measurements of width were expressed as means of the greatest and smallest values obtained from the first trace.

Measurement of weight

All individual nodes were weighed as soon as the shape and size had been recorded. In certain cases such as the jejunal nodes, which occur either as a continuous node or a series of nodes, the combined weight of all parts was recorded as one.

For six different groups of nodes from 3 lambs and 3 ewes (Tables 10 and 11), the dry weight was recorded. These nodes were transfered to preweighed glass dishes and left in an oven at 110° C initially for 29 hours. Dry weights were recorded after 17 and 29 hours respectively. As there was no further

reduction in weight after 17 hours heating, only this period of drying was used in the majority of cases.

Arthritis and associated diseases of the joint

Nineteen stifle and seven hock joints from Romney lambs which had been judged as arthritic by meat inspectors were collected at a freezing works. Both the ipsilateral and where possible the contralateral popliteal and medial iliac lymph nodes from the legs were also examined. Both the joints and lymph nodes were transported in plastic bags to the laboratory. All the joints and lymph nodes were examined no more than three hours after they were taken from the works. Since the lymph nodes were put into the plastic bags still surrounded by fat, it was assumed that no significant loss of weight would have occurred before examination. The lymph nodes were examined first. After fat was trimmed off, the nodes were weighed and their size measured by the method described above.

The joints and surrounding tissue, including tendon sheaths, were examined carefully to determine whether or not there was evidence of pathological change of the joint or surrounding tissues.

The joints were divided into four categories;

(a) normal; in which no gross pathological changes were observed.

(b) Arthritis; as evidenced by intra-articular inflammatory changes of the capsule, abnormal changes on the surface of joint cartilage or an increase in the amount of synovial fluid.

(c) Periarthritis; in which there were inflammatory changes of the periarticular tissue and evidence of periarticular fibrosis.

(d) Tendovaginitis; in which there was evidence of inflammatory change of the tendon sheaths with an associated excessive amount of fluid within the sheaths.

SECTION ONE

MORPHOLOGY AND MORPHOMETRICS OF LYMPH NODES FROM NORMAL LAMBS AND EWES

RESULTS

The lambs and ewes examined were of normal weight and confirmation for their age and sex. Tables 1 and 2 give details of their body and carcase weights.

Table 1. Age, and live and carcase weights of lambs examined

Reference number of lamb	Age (months)	Live weight (kg)	Carcase weight (kg)	Percentage of carcase to live weight
L 1	6	31	13.8	45%
L 2	6	28	13.5	48%
L 3	6	30	14.0	47%
L 4	6	27	12.0	44%
L 5	6	27	12.4	46%
L 6	6	27	11.2	41%

Table 2. Age, and live and carcase weights of ewes examined

Reference number of ewe	Age (years)	Live weight (kg)	Carcase weight (kg)	Percentage of carcase to live weight
E 1	7	31.9	11.2	35%
E 2	7	33.9	13.9	41%
E 3	7	34.5	12.6	37%
E 4	7	34.0	12.6	37%
E 5	7	42.0	16.4	39%
E 6	7	31.7	15.6	49%

A general description of each of the nodes examined together with diagrams of their outlines (Figures 1-31) is presented in the following pages of this section. Tables 3, 4 and 5 at the end of this account give details of the weight of each node examined, and Tables 6 and 7 show the average measurement of each of the lymph nodes of lambs and ewes. Tables 8 and 9 give the total weight of lymph nodes of each of the lambs and ewes and as percentages of their body and carcase weights.

The following description of each node is divided into five parts; location, area of drainage, efferent routes, number, and shape and size. As mentioned previously, the information on number, and shape and size was obtained by the author.

MANDIBULAR

Location

The mandibular nodes lie at the level of, or immediately caudal to, the vascular notch of the mandible, covered by cutaneous muscle.

Area of drainage

Ventral portions of the head including the skin of the lower jaw, nose and lips, the oral cavity including the tongue, the gum of the lower jaw, part of the muscle of mastication and the tongue, and the mandibular salivary gland.

Efferent routes

The nodes drain to either the lateral or the medial retropharyngeal nodes.

Number

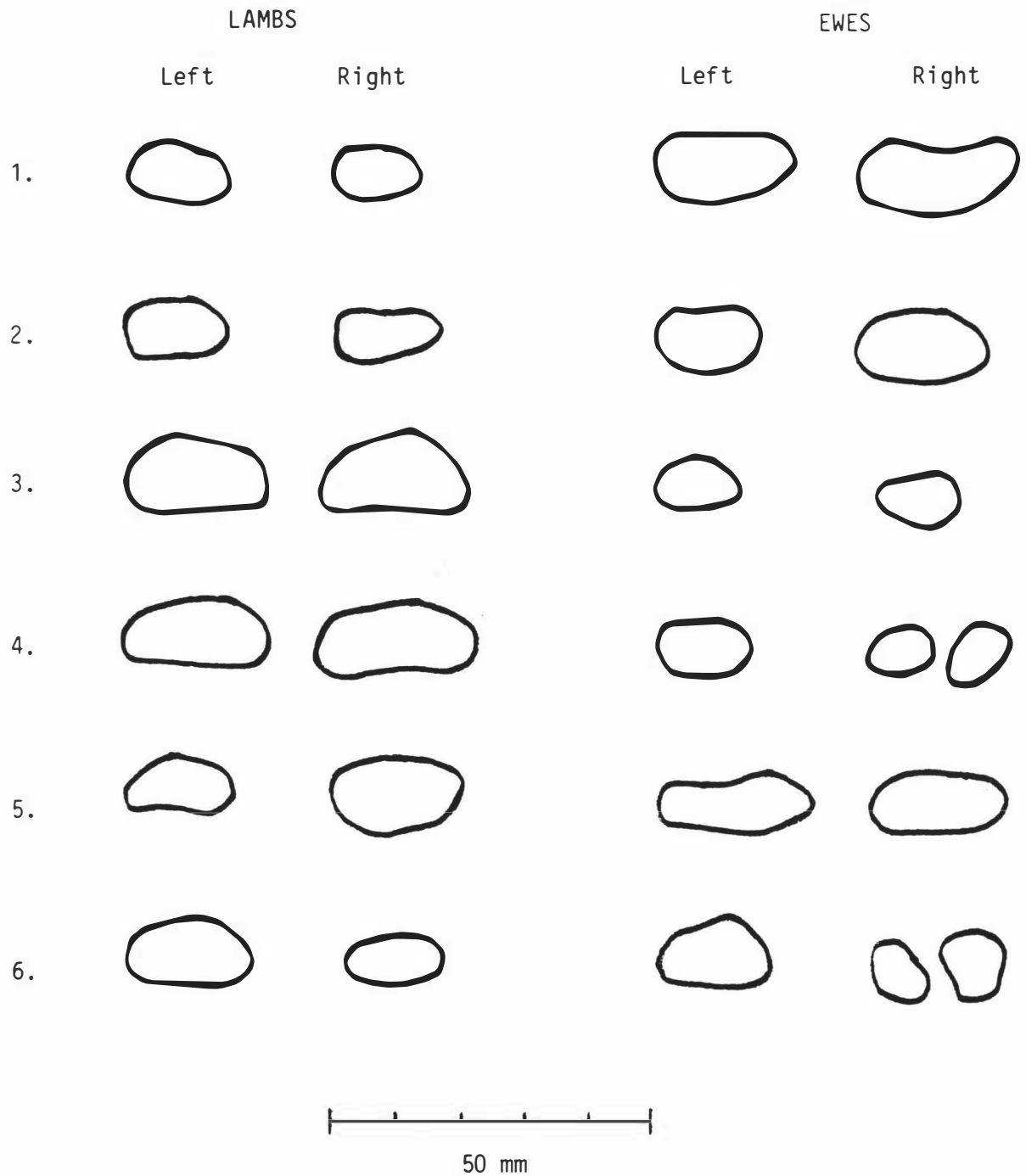
In all of the lambs and four of the ewes one node was found on each side. In two of the ewes there were two nodes on the right side and one on the left.

Shape and Size (see Figure 1)

The nodes were irregular kidney to oval in shape, somewhat flattened and of variable size.

In lambs, they ranged from 13-22 mm in length, 6-12 mm in width and 4-7 mm in thickness and from 0.23-1.19 g in weight with a mean of 0.65 g. In ewes, they ranged from 10-29 mm in length, 6-11 mm in width and 4-7 mm in thickness and from 0.23-1.12 g in weight with a mean of 0.69 g.

Figure 1 : SHAPE OF MANDIBULAR NODES



These and subsequent outlines (Figures 1 - 31) are drawn at actual size.

PAROTID

Location

The parotid nodes are situated ventral to the temporo-mandibular joint at the caudal border of the masseter muscle, completely covered by the parotid salivary gland.

Area of drainage

The skin of the upper half of the head, including nostrils, mouth and nasal cavity, tongue, gums, muscles of mastication, lips, eyelids, the parotid salivary gland, the rostral half of the lower jaw and the external ear.

Efferent routes

The lateral retropharyngeal nodes.

Number

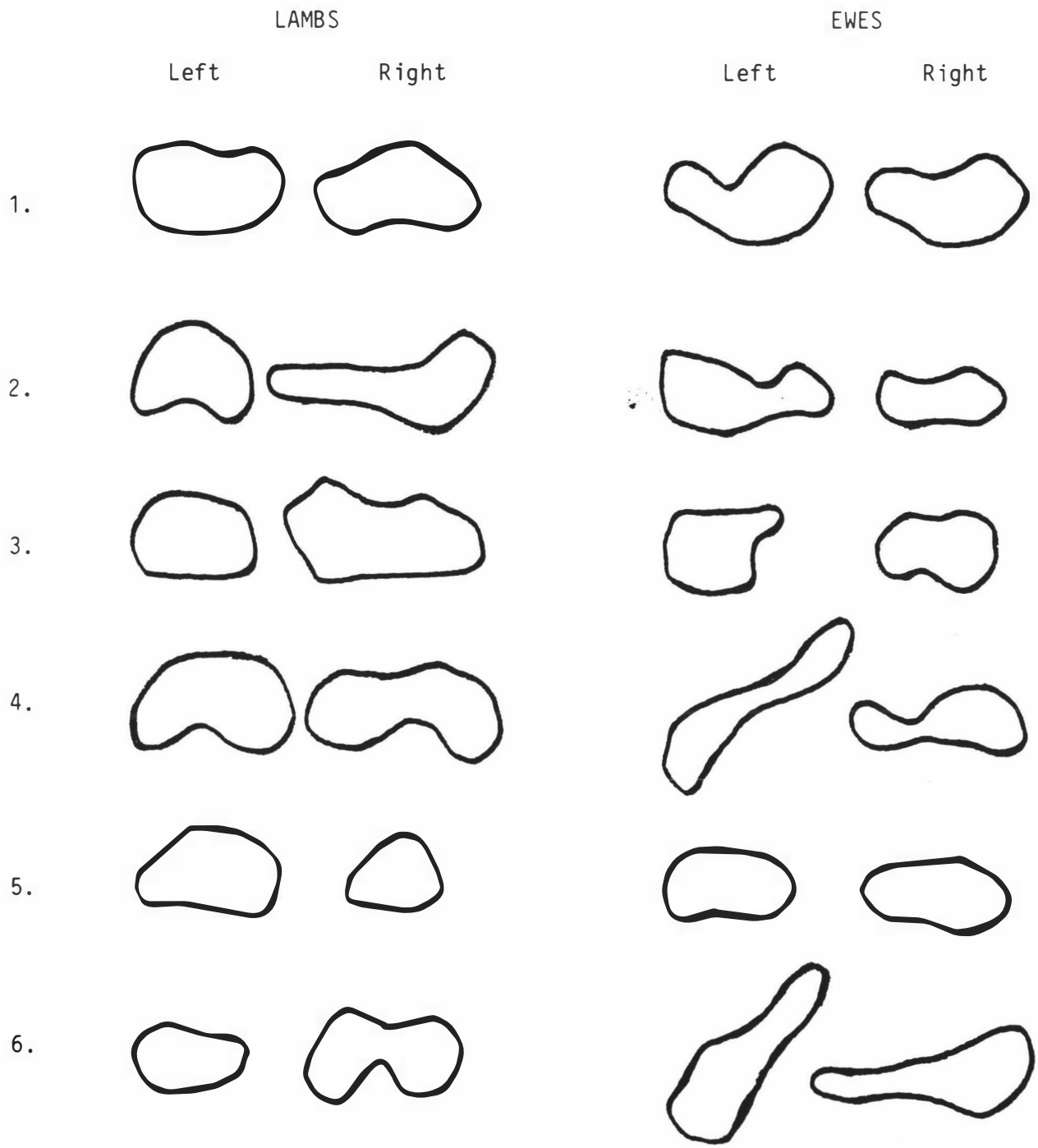
One node was found on each side in all the animals examined.

Shape and Size (see Figure 2)

The nodes were of dumbbell or kidney in shape, and sometimes elongated and of variable size.

In lambs, they ranged from 14-35 mm in length, 7-15 mm in width and 4-7 mm in thickness and from 0.63-1.96 g in weight with a mean of 1.30 g. In ewes, the nodes varied from 19-36 mm in length, 7-14 mm in width and 4-8 mm in thickness and from 0.60-1.29 g in weight with a mean of 1.02 g.

Figure 2 : SHAPE OF PAROTID NODES



LATERAL RETROPHARYNGEAL

Location

The lateral retropharyngeal nodes lie ventral to the wing of the atlas on the left border of the parotid salivary gland, covered by the aponeurosis of the cleido-occipitalis muscle.

Area of drainage

The skin of the parotid region and deeper parts of the nuchal region, caudal and deeper structures of the head, and parotid and medial retropharyngeal nodes.

Efferent routes

They form the lateral root of the jugular trunk, or unite to form the tracheal trunk.

Number

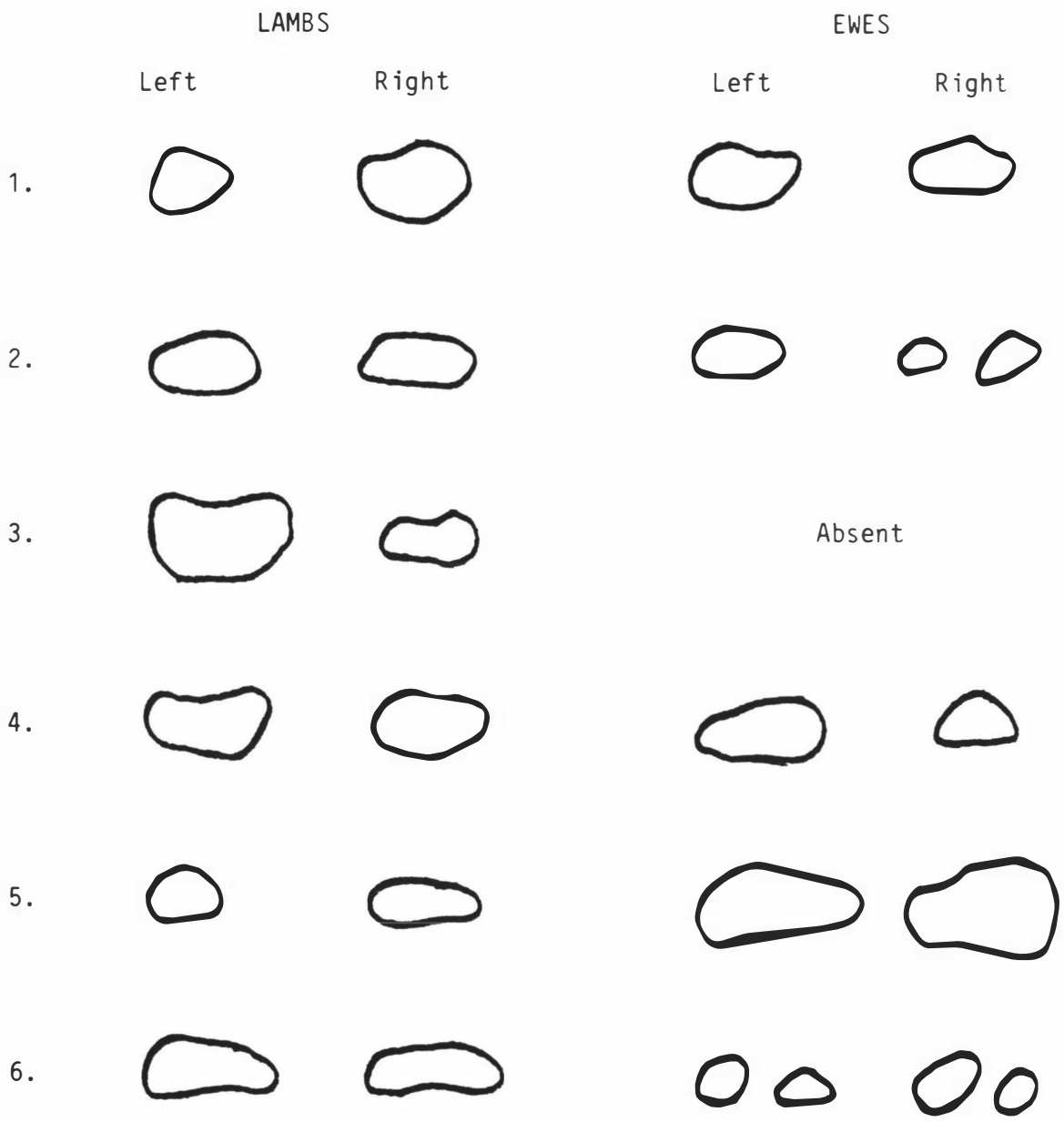
In nine of the twelve animals examined, one node was found on each side. One ewe had two nodes on the right side and one on the left. Another had two nodes on both sides, and in one ewe, no nodes on either side could be demonstrated.

Shape and Size (see Figure 3)

They were of flattened kidney to oval in shape and of variable size.

In lambs, they ranged from 10-20 mm in length, 5-10 mm in width and 4-6 mm in thickness and from 0.25-0.86 g in weight with a mean of 0.43 g. In ewes, they ranged from 7-23 mm in length, 5-14 mm in width and 2-7 mm in thickness and from 0.22-1.17 g in weight with a mean of 0.46 g.

Figure 3 : SHAPE OF LATERAL RETROPHARYNGEAL NODES



MEDIAL RETROPHARYNGEAL

Location

The medial retropharyngeal nodes are situated just dorsal to the laryngo pharynx. The right and left nodes are about 5 mm apart.

Area of drainage

Mouth and nasal cavity including gums, masticatory muscles, muscles of the tongue, pharynx, larynx and soft palate, the sublingual and mandibular salivary glands and the mandibular lymph nodes.

Efferent routes

To the lateral retropharyngeal nodes, and they may also be involved in the formation of the jugular lymphatic trunk.

Number

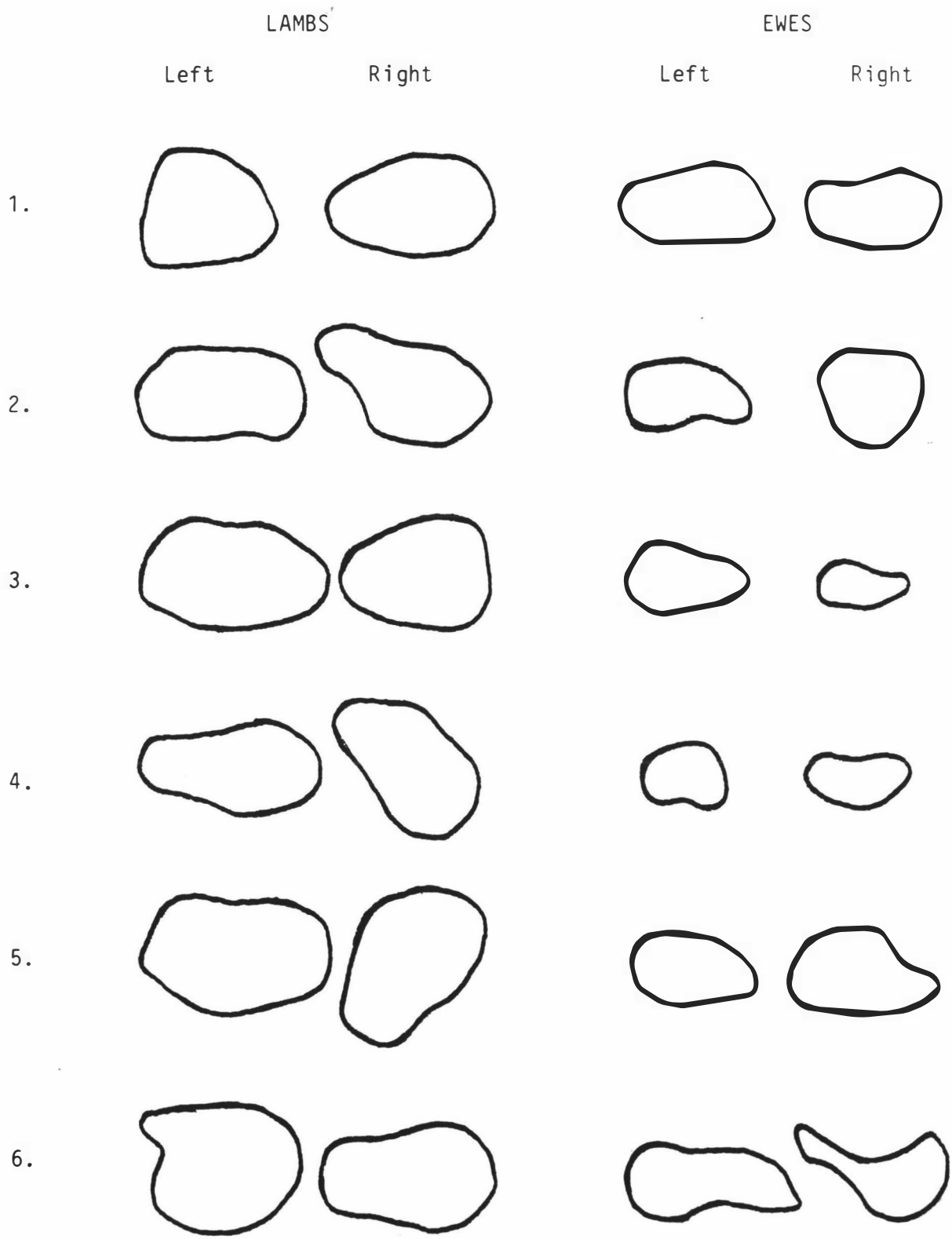
One node was found on each side in all of the animals examined.

Shape and Size (See Figure 4)

They were of somewhat flattened, triangular to oval in shape and of variable size.

In lambs, they ranged from 25-33 mm in length, 12-22 mm in width and 6-14 mm in thickness and from 2.12-4.18 g in weight with a mean of 2.98 g. In ewes, they varied from 15-29 mm in length, 8-16 mm in width and 4-7 mm in thickness and from 0.39-1.63 g in weight with a mean of 1.09 g.

Figure 4 : SHAPE OF MEDIAL RETROPHARYNGEAL NODES



SUPERFICIAL CERVICAL

Location

The superficial cervical nodes are at the cranial border of the supraspinatus muscle, covered by the cervical part of the trapezius, the omotransversarius and the cleido-occipitalis muscle.

Area of drainage

The skin and musculature of the neck, caudal part of the head, external ears, and lateral wall of the thorax up to the tenth intercostal space, the thoracic limb including all deep structure distal to the carpal joint and accessory superficial lymph nodes

Efferent routes

The left node drains into the jugular trunk. The right node drains either, to the venous angle or, may join the right tracheal trunk and form the right lymphatic duct.

Number

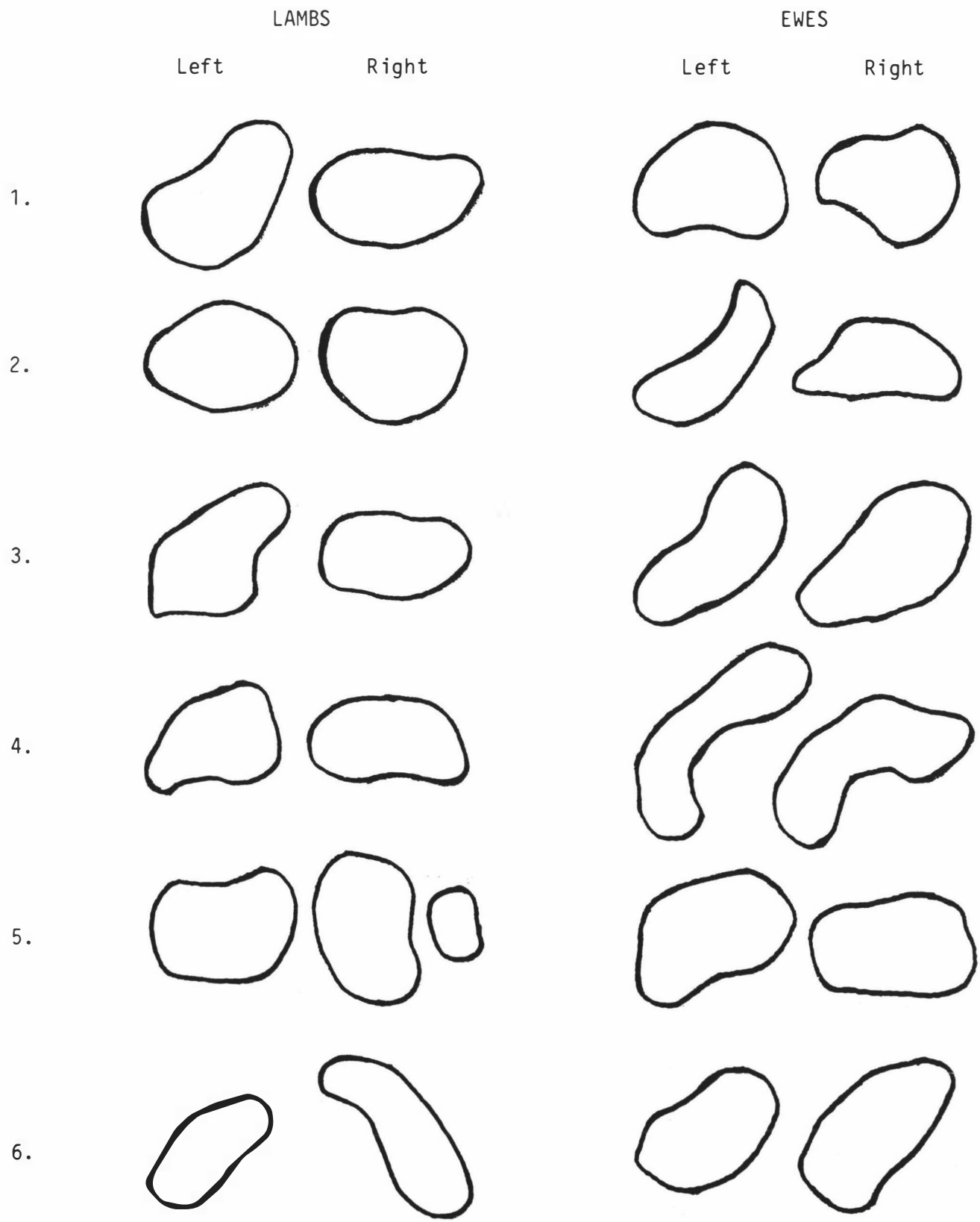
One node was found on each side in 11 animals. One lamb had two nodes on the right side and one on the left.

Shape and Size (see Figure 5)

They were of irregular, oval to kidney in shape and of variable size.

In lambs, they ranged from 12-35 mm in length, 9-20 mm in width and 5-10 mm in thickness and from 1.67-3.03 g in weight with a mean of 2.64 g. In ewes, the nodes varied from 30-44 mm in length, 12-21 mm in width and 5-7 mm in thickness and from 1.47-3.02 g in weight with a mean of 2.20 g.

Figure 5 : SHAPE OF SUPERFICIAL CERVICAL NODES



PROPER AXILLARY

Location

The proper axillary nodes are on the medial surface of the teres major muscle, in the angle formed by the subscapular artery and vein and by the thoracodorsal artery and vein.

Area of drainage

Distal and proximal limb including the carpus, the medial surface of the scapula, skin of the caudal part of the shoulder, the ventral and lateral part of the thoracic area and most of the muscles of the shoulder, brachium and antebrachium, the deep and superficial pectoral muscles and the cutaneous muscles of the shoulder region, and from the cubital and accessory axillary lymph nodes.

Efferent routes

Axillary nodes of the first rib.

Number

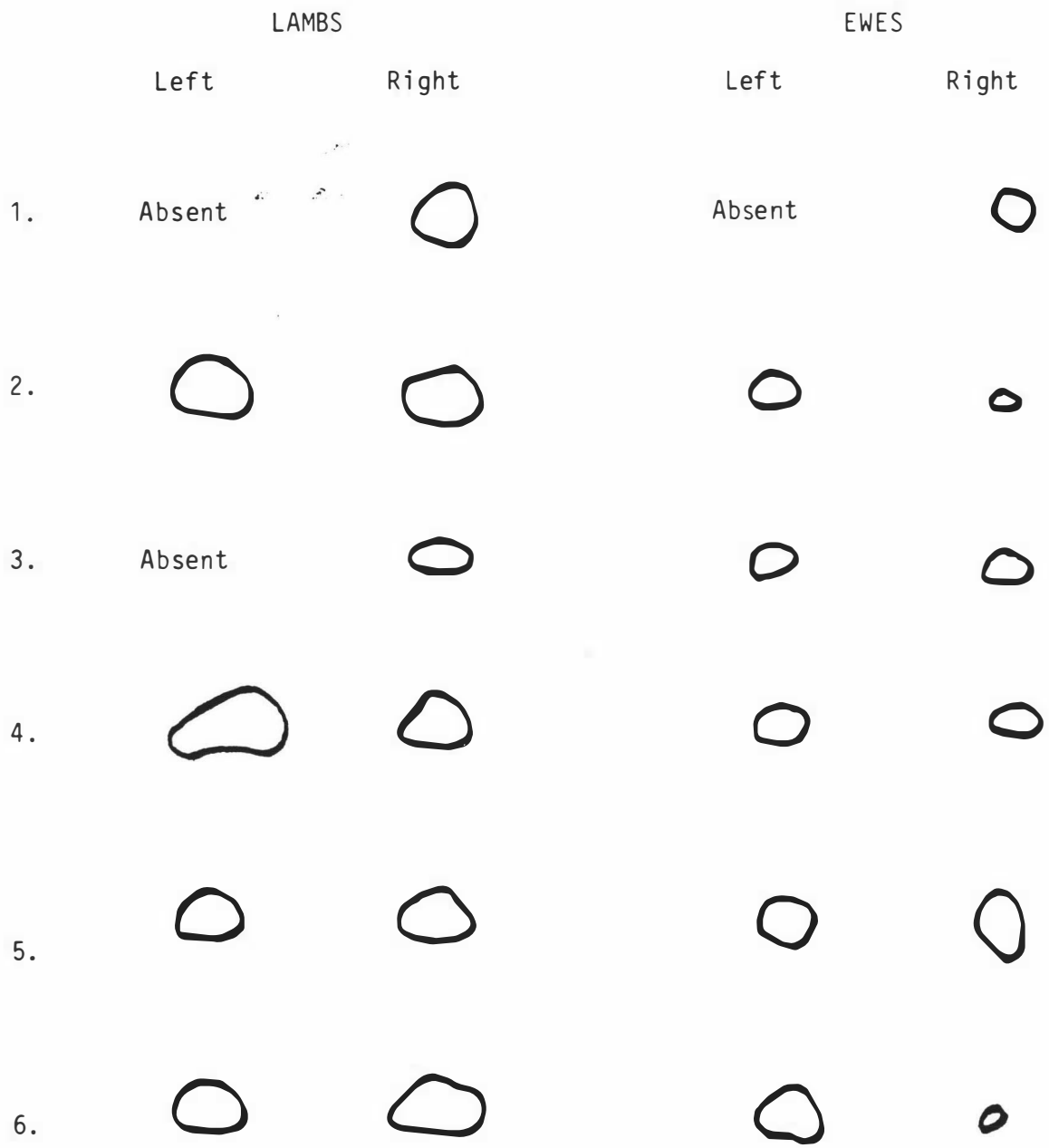
In four lambs and five ewes one node on each side was recorded. In two lambs and one ewe one node was found on the right side and no nodes on the left.

Shape and Size (see Figure 6)

They were oval in shape and of variable size.

In lambs, they ranged from 9-17 mm in length, 6-10 mm in width and 2-8 mm in thickness and from 0.13-0.46 g in weight with a mean of 0.24 g while in ewes they varied from 4-11 mm in length, 3-7 mm in width and 2-4 mm in thickness and from 0.03-0.20 g in weight with a mean of 0.09 g.

Figure 6 : SHAPE OF PROPER AXILLARY NODES



POPLITEAL

Location

The popliteal nodes lie in the popliteal fossa, 25 mm deep in the space between the gluteobiceps and semitendinosus muscles.

Area of drainage

Foot, crus, skin and subcutis distal to the location of the lymph nodes. Although afferent vessels from muscles, tendons and joints distal to the popliteal lymph nodes have not been described, it is assumed that they are present.

Efferent routes

Ischiatic nodes, the pelvic cavity and the sacral and medial iliac nodes.

Number

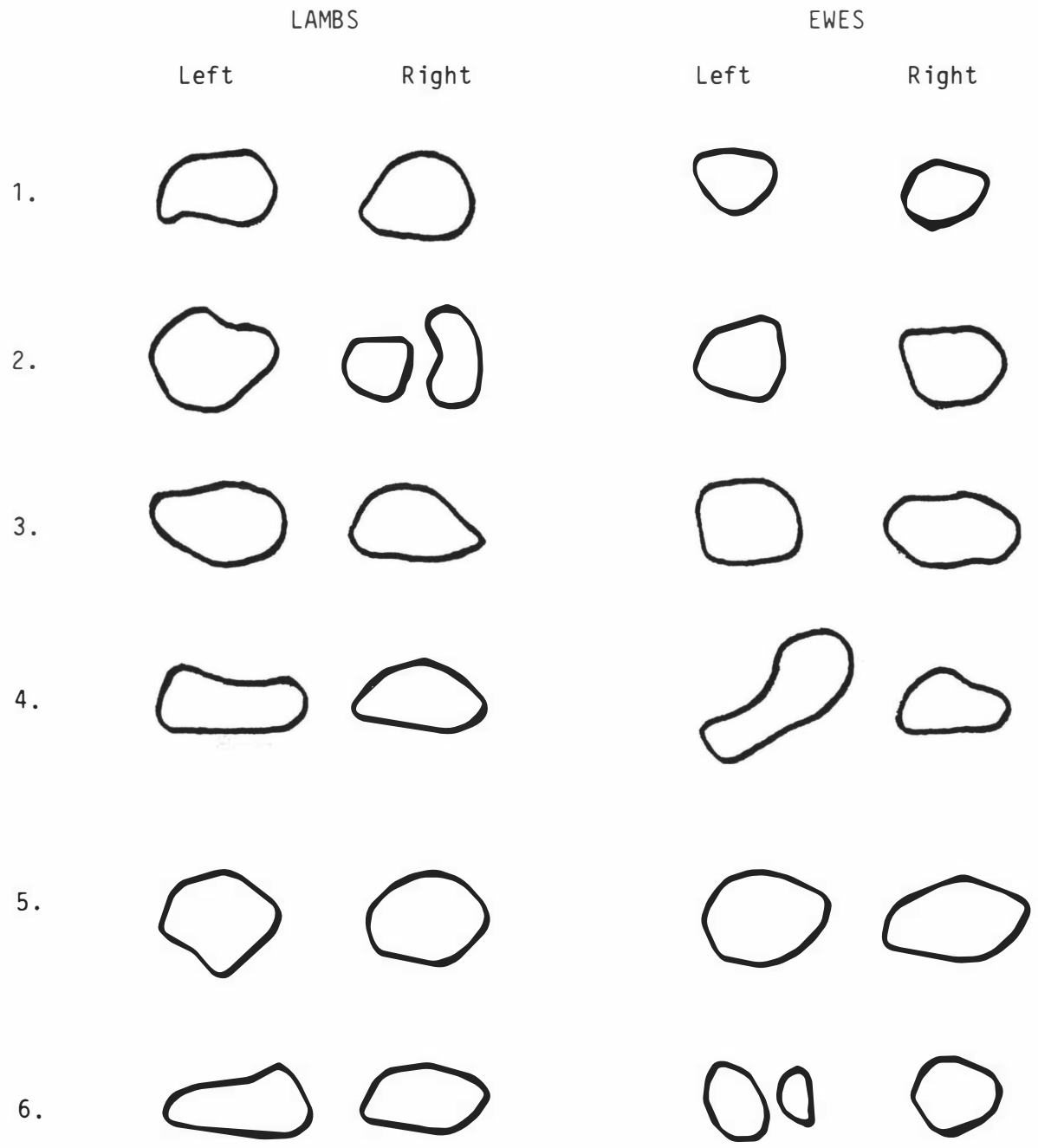
One node was found on each side in five lambs and five ewes. In one lamb two nodes were recorded on the right side and one on the left, and in one ewe two nodes were found on the left side and one on the right.

Shape and Size (see Figure 7)

They were irregular, oval in shape and of variable size.

In the initial six lambs examined, the nodes ranged from 10-24 mm in length, 6-15 mm in width and 3-6 mm in thickness and from 0.74-2.04 g in weight with a mean of 1.06 g. In the further 25 lambs examined the nodes ranged from 1.70-5.45 g in weight with a mean of 3.03 g (See Table 4). In ewes, they ranged from 8-27 mm in length, 5-15 mm in width and 4-10 mm in thickness and from 0.51-1.56 g in weight with a mean of 0.90 g.

Figure 7 : SHAPE OF POPLITEAL NODES



ISCHIATIC

Location

The ischiatic nodes lie against the lateral surface of the broad sacrotuberal ligament near its caudal border.

Area of drainage

Tail, ischiatic and thigh regions. In some cases, secondary afferent vessels arise from the popliteal and the inconstant tuberal nodes.

Efferent routes

Sacral or medial iliac nodes.

Number

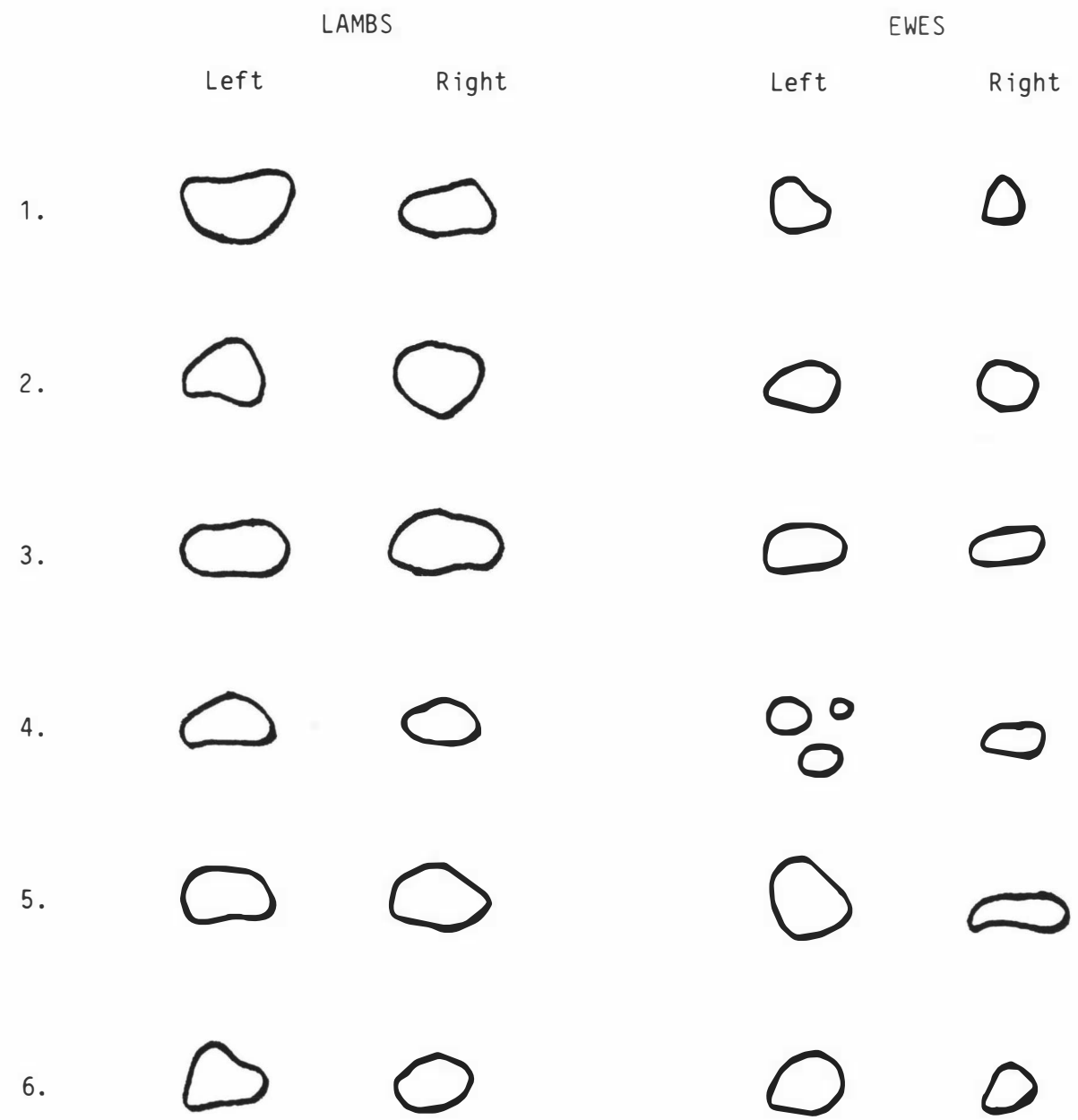
In all of the lambs and five ewes one node was found on each side. In one ewe three nodes were recorded on the left side and one on the right.

Shape and Size (see Figure 8)

They were irregular, oval in shape and of variable size.

In lambs, they ranged from 7-16 mm in length, 5-12 mm in width and 3-6 mm in thickness and from 0.14-0.74 g in weight with a mean of 0.42 g. In ewes, the nodes ranged from 3-14 mm in length, 3-10 mm in width and 2-5 mm in thickness and from 0.13-0.42 g in weight with a mean of 0.24 g.

Figure 8 : SHAPE OF ISCHIATIC NODES



SUBILIAC

Location

The subiliac nodes lie midway between the tuber coxae and the patella.

Area of drainage

The lateral and cranial part of the thigh, lateral and ventral abdominal wall, the skin and subcutis of the pelvic region.

Efferent routes

Lateral and medial iliac nodes.

Number

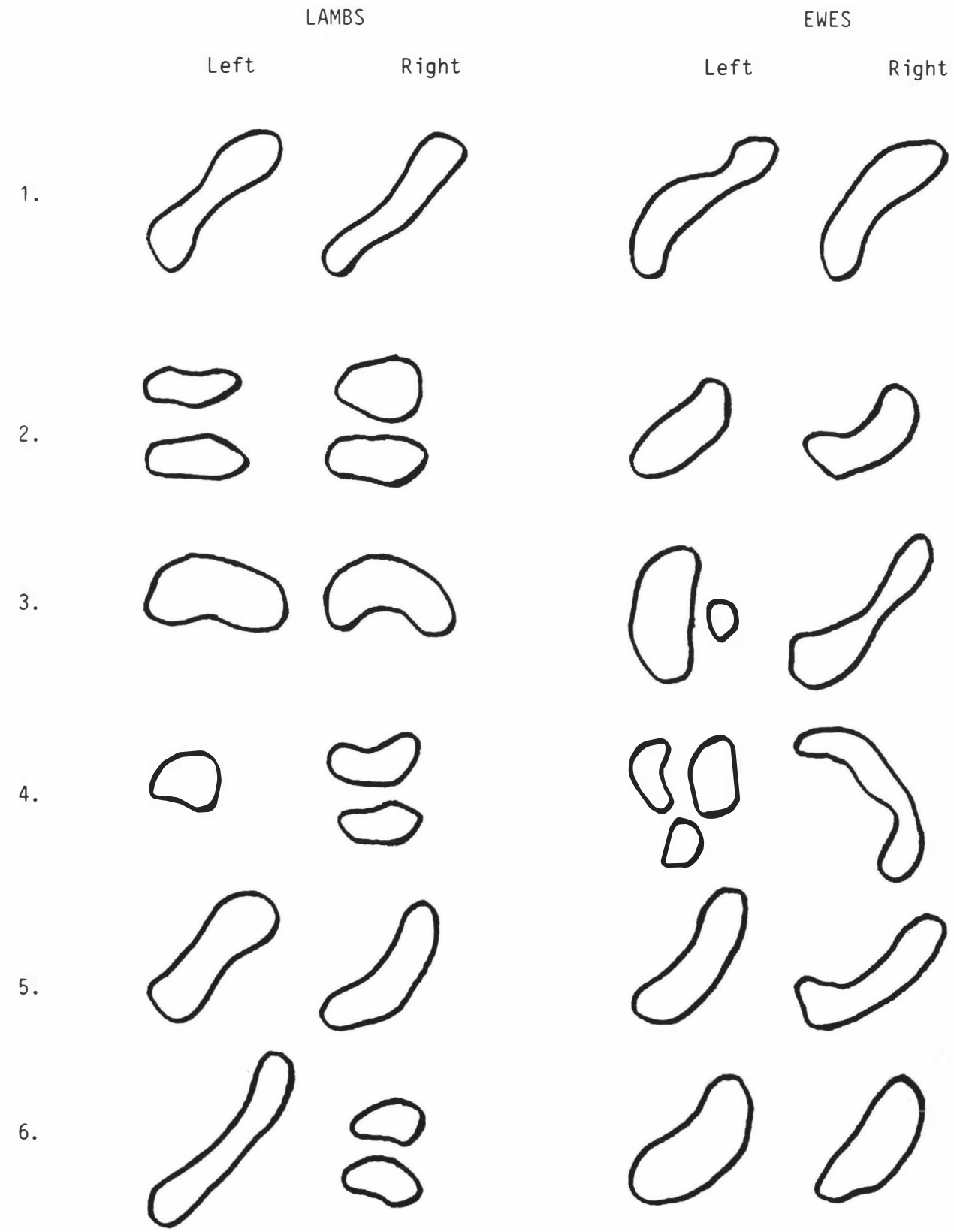
Three lambs and four ewes had one node on each side. One lamb had two nodes on both sides and two lambs had two nodes on the right side and one on the left. One ewe had two nodes on the left side and one on the right and another had three nodes on the left side and one on the right.

Shape and Size (see Figure 9)

The nodes were irregular, banana to oval in shape and of variable size.

In lambs, they ranged from 11-35 mm in length, 5-12 mm in width and 3-5 mm in thickness and from 0.36-1.16 g in weight with a mean of 0.89 g. In ewes, they varied from 8-36 mm in length, 5-11 mm in width and 3-6 mm in thickness and from 0.69-1.23 g in weight with a mean of 0.90 g.

Figure 9 : SHAPE OF SUBILIAC NODES



MEDIAL ILIAC

Location

The medial iliac nodes are located on the external iliac artery. The most craniomedial of these lies in the angle between the aorta and external iliac artery and the origin of the deep circumflex iliac artery.

Area of drainage

The skin of the foot, hock and crus, the hock and stifle joints, and testes and epididymis or ovary. Afferent vessels also come from the sacral, ischiatic, superficial inguinal and subiliac lymph nodes and partly from the popliteal, deep inguinal, tuberal, gluteal, coxal and lateral iliac lymph nodes.

Efferent routes

The efferent vessels give rise to the lumbar trunk and some go to the lumbar aortic lymph nodes.

Number

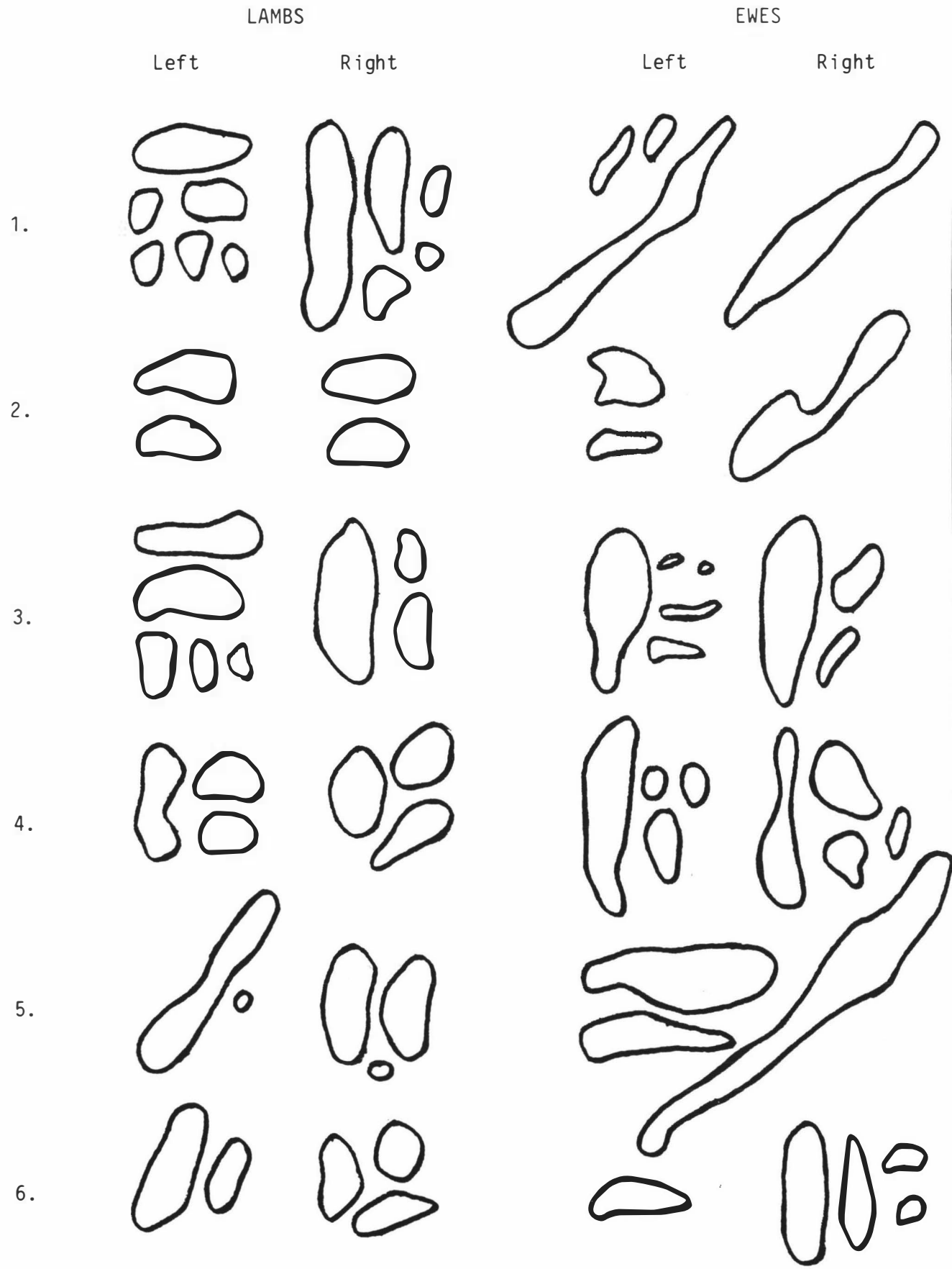
One lamb had two nodes on both sides and another had three on each side. In two lambs, two nodes were recorded on the left side and three on the right. One lamb and one ewe had five nodes on the left side and three on the right. One lamb had six nodes on the left side and five on the right. In two ewes, two nodes were present on the left side and one on the right, and another had four nodes on both sides. One ewe had three nodes on the left side and one on the right, and another had one node on the left side and four on the right.

Shape and Size (see Figure 10)

The nodes were irregular, oval to kidney in shape, elongated and of variable size.

In lambs, they ranged from 3-40 mm in length, 3-13 mm in width and 2-10 mm in thickness and from 0.51-1.70 g in weight with a mean of 1.17 g. In ewes, the nodes ranged from 4-80 mm in length, 2-13 mm in width and 2-5 mm in thickness and from 0.36-1.81 g in weight with a mean of 1.24 g.

Figure 10 : SHAPE OF MEDIAL ILIAC NODES



RENAL

Location

The renal nodes are located immediately caudal to the renal blood vessels.

Area of drainage

The afferent and efferent lymphatics have not been described.

Number

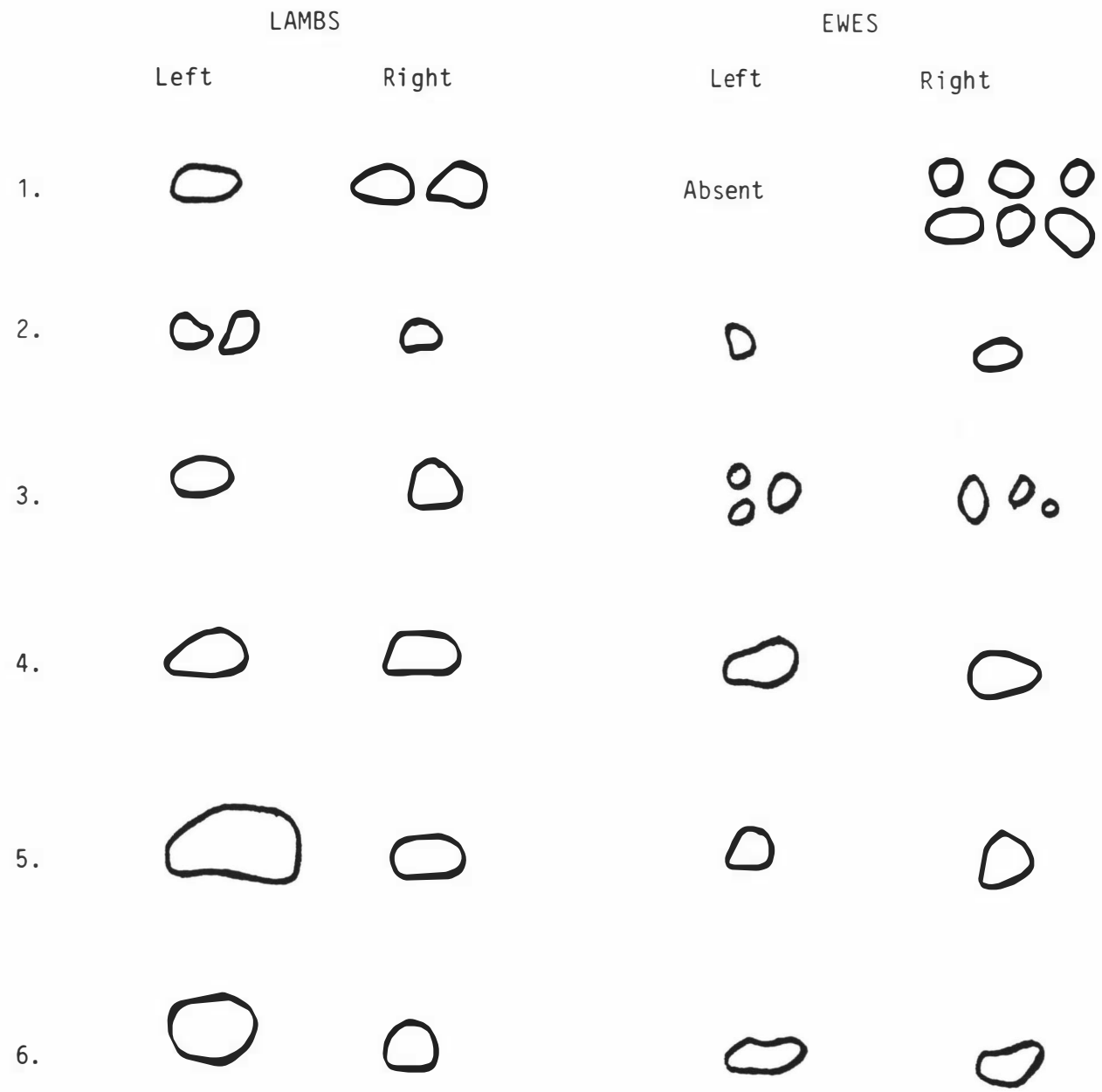
Four lambs and four ewes had one node on each side. In one lamb, two nodes were recorded on the right side and one on the left, and another had two nodes on the left side and one on the right. In one ewe, three nodes were demonstrated on both sides, and another had six nodes on the right side and no nodes were recorded on the left.

Shape and Size (see Figure 11)

They were oval in shape and of variable size.

In lambs, the nodes ranged from 4-20 mm in length, 4-10 mm in width and 3-7 mm in thickness and from 0.14-1.00 g in weight with a mean of 0.32 g. In ewes, they ranged from 3-12 mm in length, 2-6 mm in width and 1-5 mm in thickness and from 0.10-0.63 g in weight with a mean of 0.20 g.

Figure 11 : SHAPE OF RENAL NODES



SUPERFICIAL INGUINAL

Location

The superficial inguinal nodes lie close to the external pudendal artery and vein at the base of the udder.

Area of drainage

Anus, udder, vulva, umbilical area and medial surface of the thigh.

Efferent routes

Medial iliac nodes.

Number

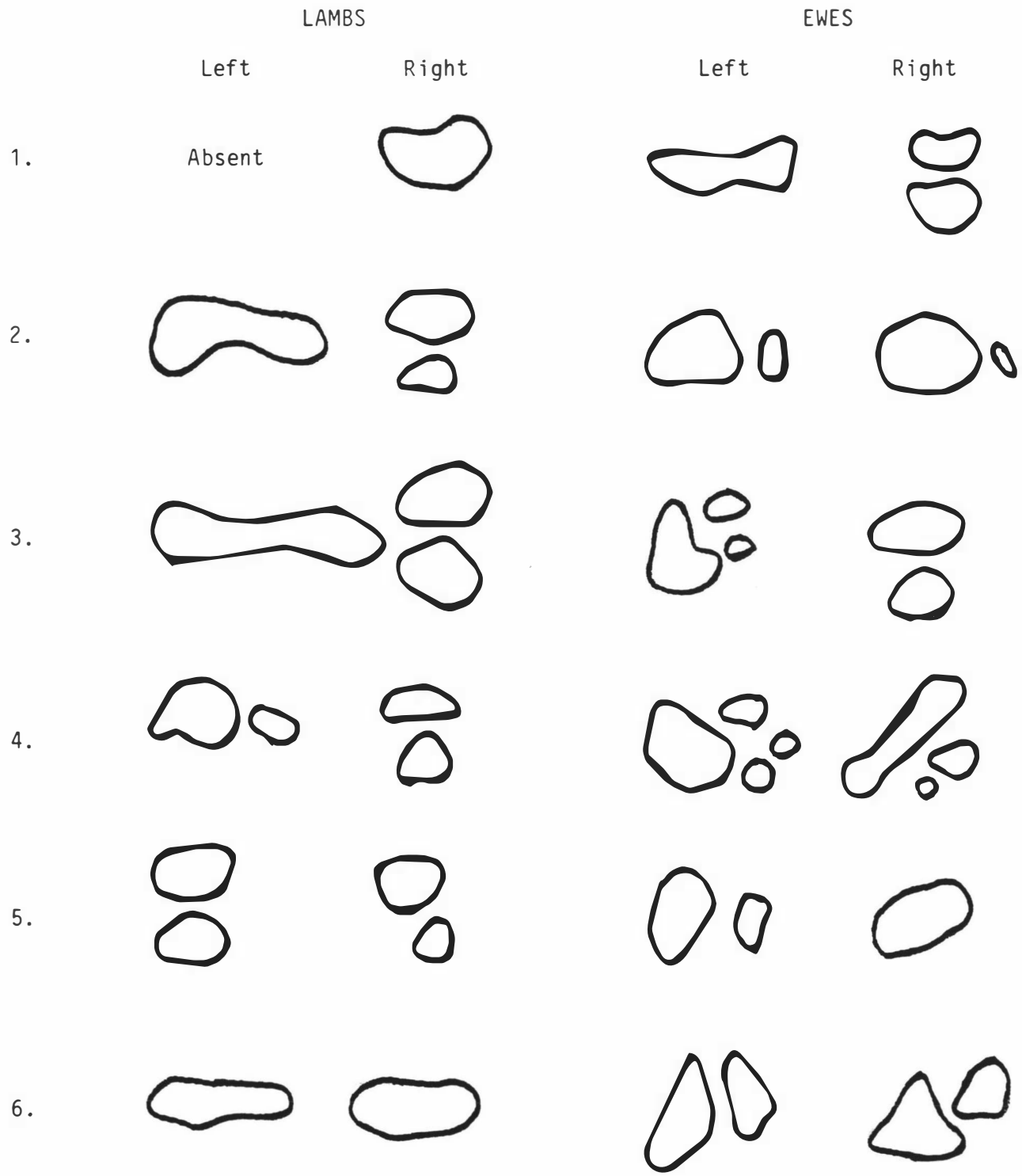
In two lambs and two ewes, two nodes were recorded on both sides. Two lambs and one ewe had one node on the left side and two on the right. One lamb had one node on both sides, and another had one node on the right side and no node was found on the left. In one ewe, three nodes were demonstrated on the left side and two on the right, and another had four nodes on the left side and three on the right. One ewe had two nodes on the left side and one on the right.

Shape and Size (see Figure 12)

The nodes were irregular, oval to kidney and dumbbell in shape and of variable size.

In lambs, the nodes ranged from 5-37 mm in length, 5-10 mm in width and 3-5 mm in thickness and from 0.35-1.14 g in weight with a mean of 0.68 g. In ewes, they varied from 4-30 mm in length, 4-13 mm in width and 2-5 mm in thickness and from 0.49-0.95 g in weight with a mean of 0.75 g.

Figure 12 : SHAPE OF SUPERFICIAL INGUINAL NODES



LEFT TRACHEOBRONCHIAL

Location

The left tracheobronchial nodes lie cranial to the origin of the left principal bronchus. The left azygos vein passes over these nodes.

Area of drainage

Cranial lobe of the left lung (Albertine et al, 1982), trachea, oesophagus, mediastinum and heart. Secondary lymphatic vessels come from the inconstant middle tracheobronchial lymph node.

Efferent routes

Cranial mediastinal nodes.

Number

In two lambs, one node was recorded and another had two. Two ewes had two nodes. In one lamb and three ewes, three nodes were demonstrated and two lambs and one ewe had four nodes.

Shape and Size (see Figure 13)

The nodes were irregular, triangular to oval and kidney in shape and of variable size.

In lambs, the nodes ranged from 4-28 mm in length, 3-14 mm in width and 2-8 mm in thickness and from 1.35-2.41 g in weight with a mean of 1.78 g. In ewes, they ranged from 4-30 mm in length, 3-10 mm in width and 2-7 mm in thickness and from 0.73-2.12 g in weight with a mean of 1.28 g.

Figure 13 : SHAPE OF LEFT TRACHEOBRONCHIAL NODES

CRANIAL TRACHEOBRONCHIAL

Location

The cranial tracheobronchial nodes lie ventral to the tracheal bronchus.

Area of drainage

Cranial lobe of the right lung, trachea, oesophagus and pericardium.

Efferent routes

Cranial mediastinal nodes.

Number

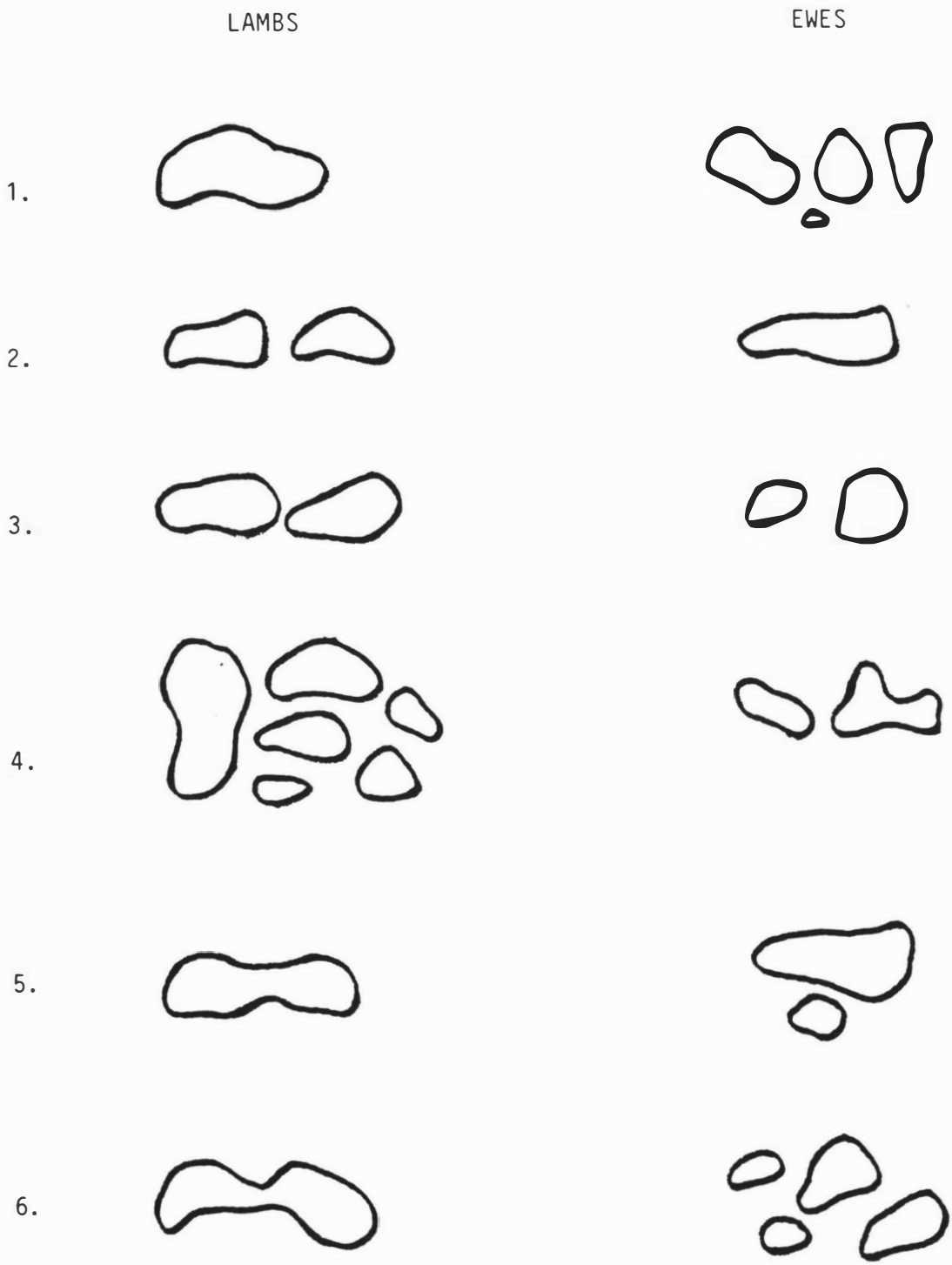
In three lambs and one ewe, one node was recorded. Two lambs and three ewes had two nodes. In two ewes, four nodes were found, and in one lamb, six nodes were demonstrated.

Shape and Size (see Figure 14)

The nodes were irregular, oval to kidney in shape and of variable size.

In lambs, the nodes ranged from 7-30 mm in length, 5-12 mm in width and 3-6 mm in thickness and from 0.45-2.84 g in weight with a mean of 1.28 g. In ewes, they varied from 6-25 mm in length, 5-12 mm in width and 2-8 mm in thickness and from 0.50-1.41 g in weight with a mean of 0.91 g.

Figure 14 : SHAPE OF CRANIAL TRACHEOBRONCHIAL NODES



CAUDAL MEDIASTINAL

Location

The caudal mediastinal nodes lie in the postcardiac mediastinum between the thoracic aorta and the oesophagus.

Area of drainage

Diaphragm, oesophagus, mediastinum, pericardium and part of the caudal lobes of both lungs, dorsolateral thoracic wall between about the 6th and 13th ribs. Albertine et al (1982) show that the node drains also the caudal lobe of both lungs.

Efferent routes

The efferent vessels join the thoracic duct (Landolt et al, 1981).

Number

In three lambs and three ewes only one large node was recorded. Another three lambs and three ewes had one large node and one small node.

Shape and Size (see Figures 15 and 16)

The large nodes were irregular, elongated in shape and the small nodes were kidney or banana in shape and of variable size.

In lambs, the large nodes ranged from 68-115 mm in length, 9-13 mm in width and 5-9 mm in thickness and the small nodes ranged from 12-42 mm in length, 6-11 mm in width and about 5 mm in thickness and from 5.52-7.51 g in weight with a mean of 6.34 g. In ewes, the large nodes ranged from 98-132 mm in length, 7-13 mm in width and 5-7 mm in thickness and the small nodes ranged from 5-36 mm in length, 5-9 mm in width and 3-5 mm in thickness and from 3.85-6.77 g in weight with a mean of 5.16 g.

Figure 15 : SHAPE OF CAUDAL MEDIASTINAL NODES

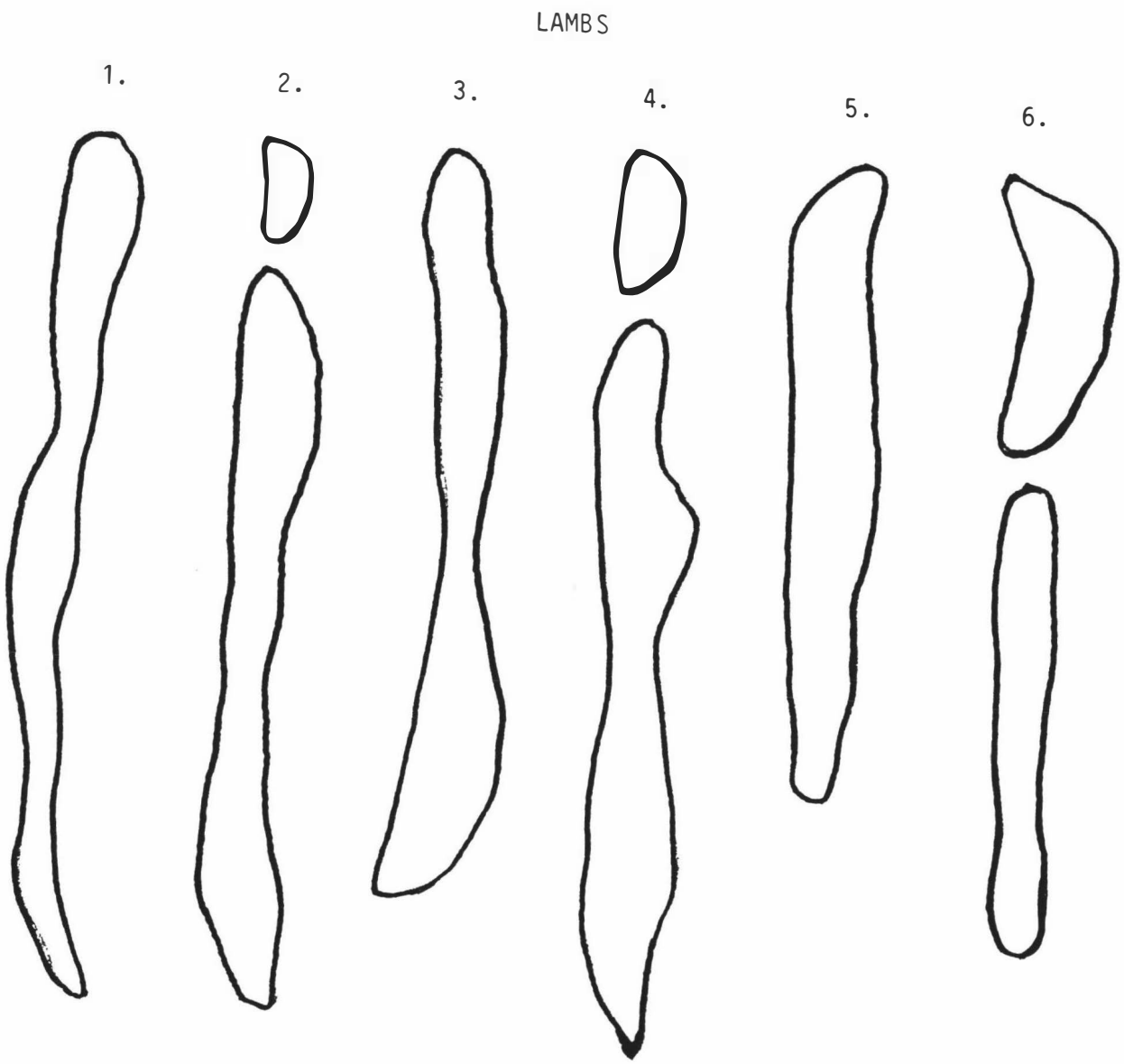
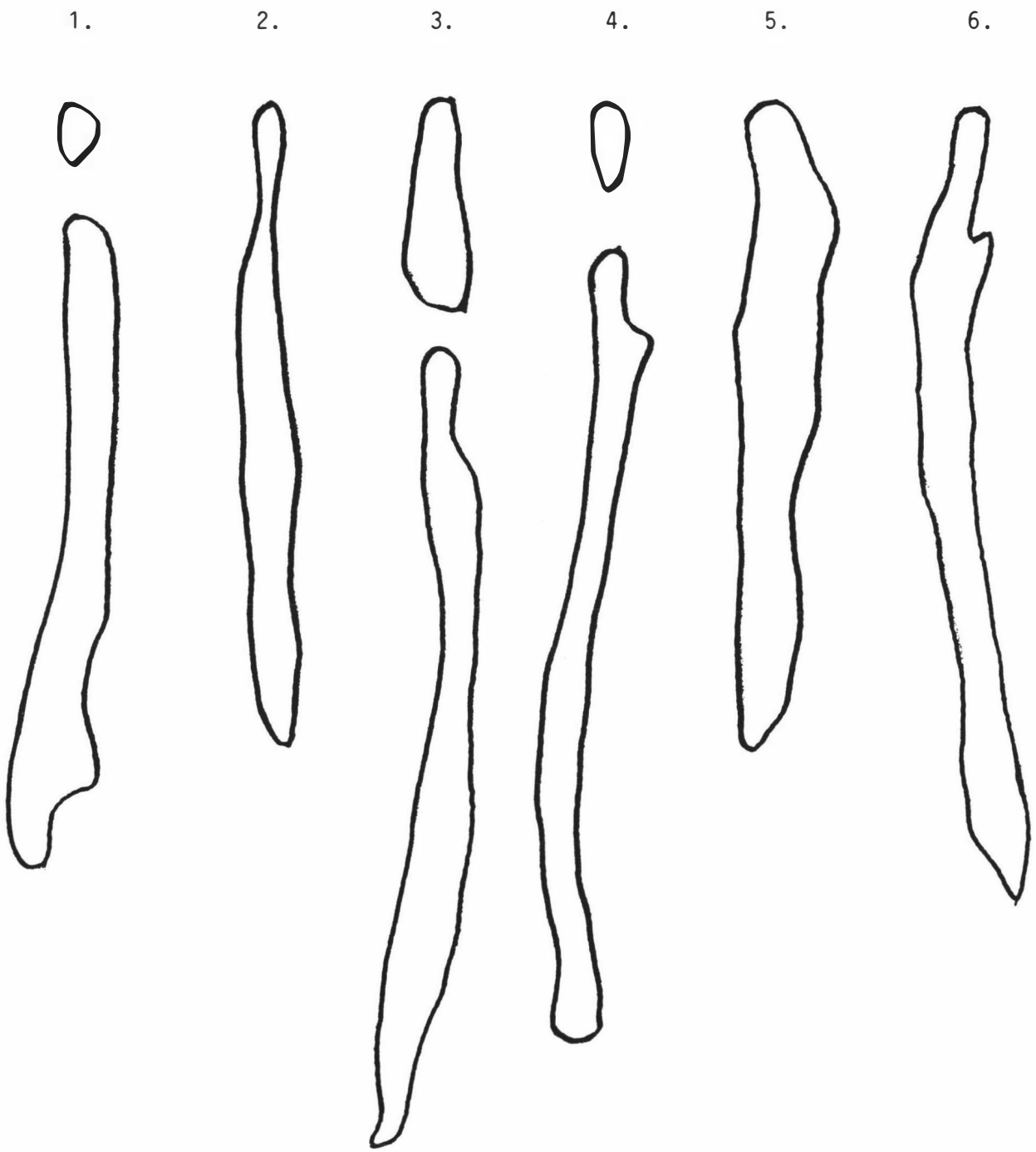


Figure 16 : SHAPE OF CAUDAL MEDIASTINAL NODES

EWES



HEPATIC

Location

The hepatic nodes are situated around the porta of the liver, in association with the portal vein.

Efferent routes

The efferent vessels form the hepatic trunk which terminates in the end of the intestinal trunk.

Number

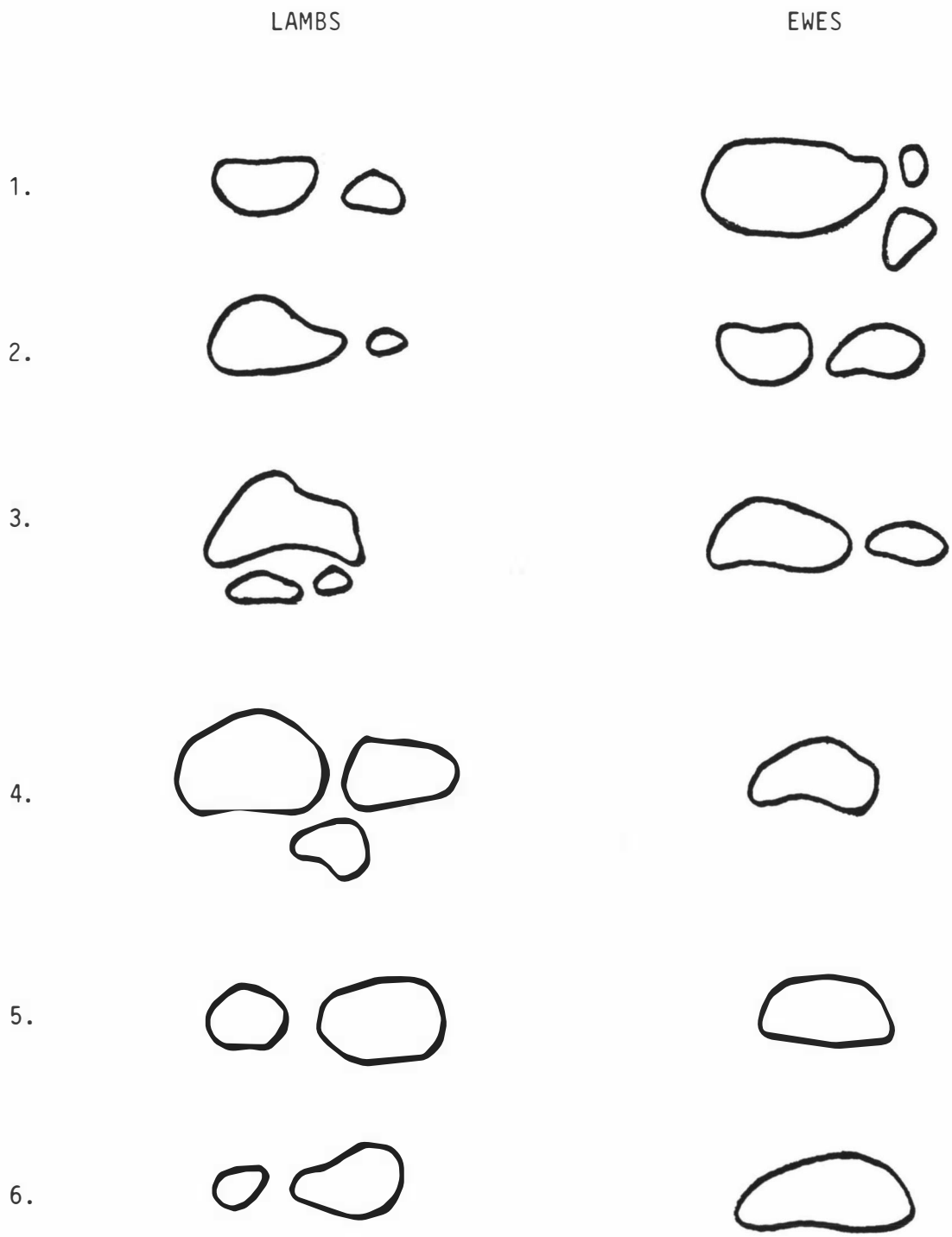
In four lambs and two ewes, two nodes were recorded. Two lambs and one ewe had three nodes, and in three ewes only one node was found.

Shape and Size (see Figure 17)

The nodes were oval to kidney in shape and of variable size.

In lambs, the nodes ranged from 5-23 mm in length, 4-15 mm in width and 3-10 mm in thickness and from 0.75-3.23 g in weight with a mean of 1.46 g. In ewes, they ranged from 4-28 mm in length, 4-16 mm in width and 3-10 mm in thickness and from 0.89-2.17 g in weight with a mean of 1.32 g.

Figure 17 : SHAPE OF HEPATIC NODES



COLIC

Location

The colic nodes lie both superficially on the right side of the colonic spiral and also between the individual coils. Individual nodes, are present in the proximal part of the mesentery.

Area of drainage

The afferent vessels are received from the ascending colon, caecum and ileum.

Efferent routes

The efferent vessels go to the intestinal trunk or, to the jejunal trunk or, to the other colic lymph nodes.

Number

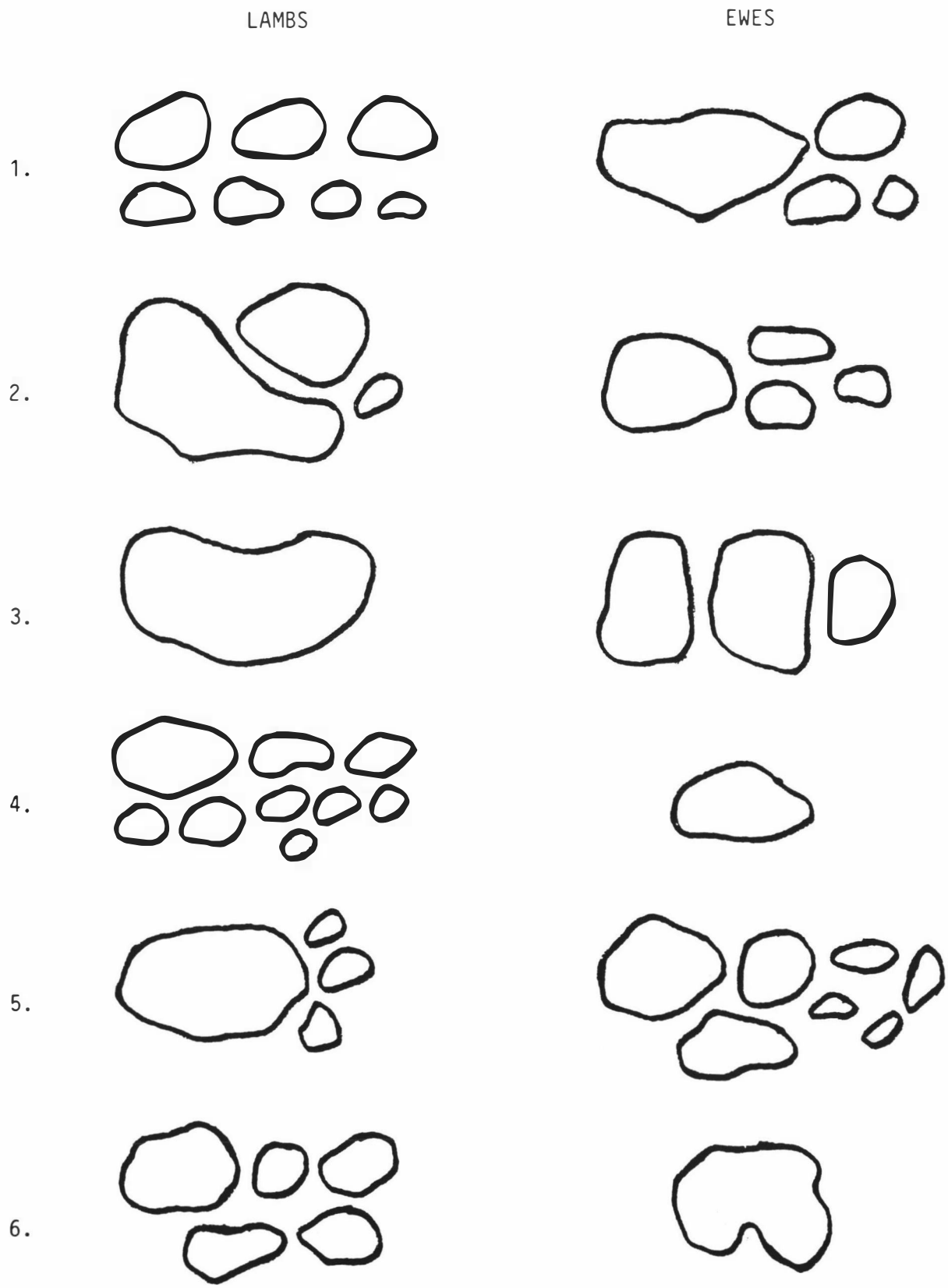
In one lamb and two ewes, one node was recorded. One lamb and one ewe had three nodes. In one lamb and two ewes, four nodes were found. One lamb had five nodes and another had nine. In one lamb and one ewe, seven nodes were demonstrated.

Shape and Size (see Figure 18)

The nodes were irregular, oval in shape and of variable size.

In lambs, the nodes ranged from 4-42 mm in length, 4-22 mm in width and 3-9 mm in thickness and from 2.60-6.17 g in weight with a mean of 4.04 g. In ewes, they varied from 6-39 mm in length, 4-19 mm in width and 2-12 mm in thickness and from 1.14-5.42 g in weight with a mean of 3.34 g.

Figure 18 : SHAPE OF COLIC NODES



ILEOCOLIC

Location

The ileocolic nodes are situated on the ileocolic artery in the ileoceacal fold.

Area of drainage

Caecum and ileum.

Efferent routes

The colic nodes or, directly to the intestinal trunk.

Number

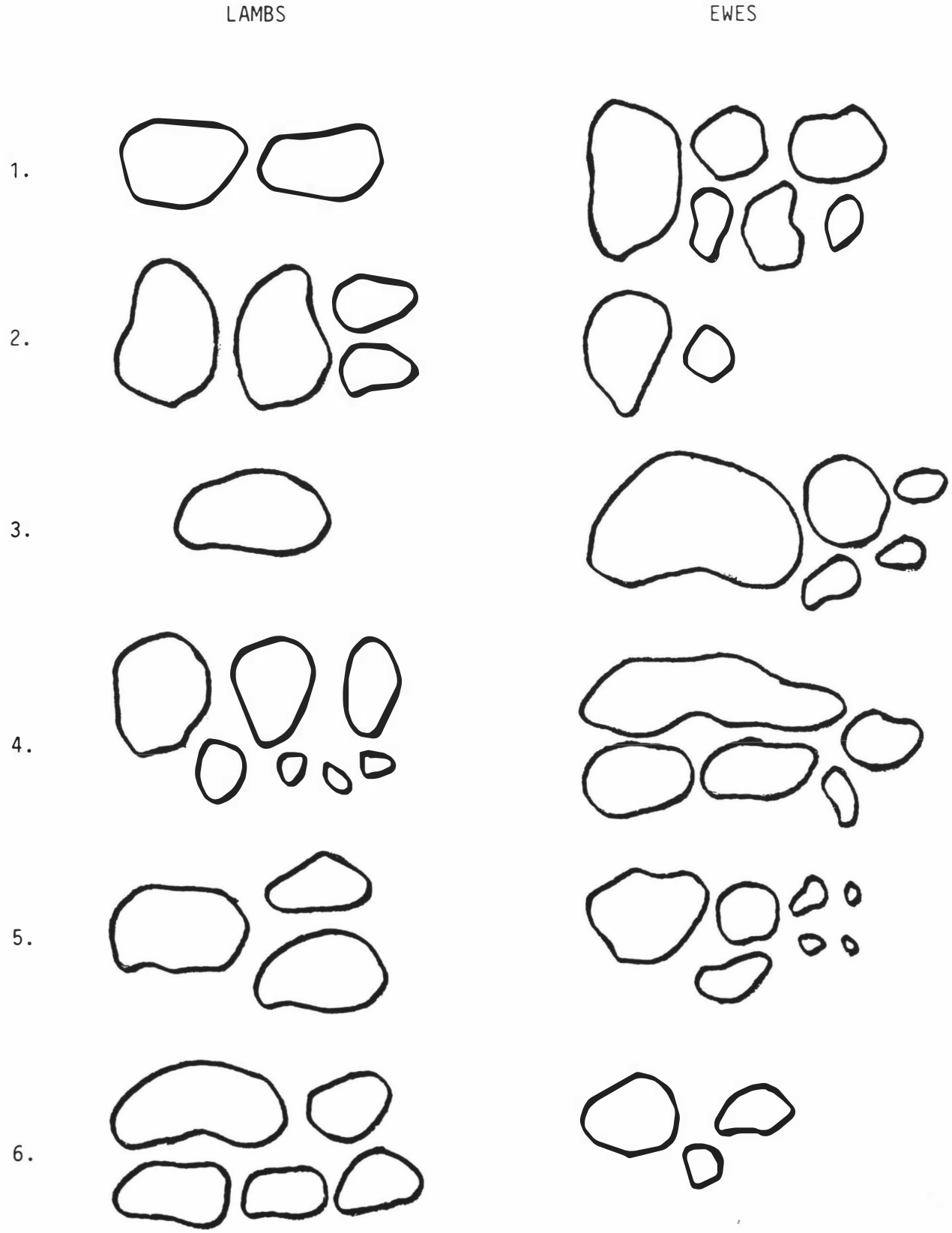
One lamb had one node and another had four. One lamb and one ewe had two nodes. One lamb and one ewe had three nodes. In one lamb and two ewes, five nodes were recorded. In one lamb and one ewe, seven nodes were demonstrated. In one ewe, six nodes were found.

Shape and Size (see Figure 19)

The nodes were irregular, oval in shape and of variable size.

In lambs, the nodes ranged from 5-33 mm in length, 5-16 mm in width and 3-12 mm in thickness and from 2.51-6.31 g in weight with a mean of 4.86 g. In ewes, they ranged from 5-46 mm in length, 5-23 mm in width and 3-11 mm in thickness and from 1.61-7.13 g in weight with a mean of 4.43 g.

Figure 19 : SHAPE OF ILEOCOLIC NODES



JEJUNAL

Location

The jejunal nodes lie in the mesentery between the first centrifugal and the last centrifugal coils of the spiral loop of the ascending colon.

Area of drainage

The jejunum and ileum, last centrifugal coil of ascending colon.

Efferent routes

The efferent vessels form the jejunal trunk.

Number

In one ewe, one node was recorded and another had five. In one lamb, two nodes were demonstrated and another two had five. In two ewes, six and seven nodes were recorded respectively and another two had eight. In two lambs, eleven nodes were demonstrated and another had thirteen.

Shape and Size (see Figures 20-31)

The nodes were elongated and oval to kidney in shape and of variable size.

In lambs, the nodes ranged from 5-540 mm in length, 5-38 mm in width and 2-19 mm in thickness and from 63.64-90.41 g in weight with a mean of 74.68 g. In ewes, they ranged from 9-380 mm in length, 5-28 mm in width and 3-11 mm in thickness and from 19.79-30.43 g in weight with a mean of 25.52 g.

The weights of all the nodes comprising specific groups from the six lambs and six ewes examined initially as well as the weight of 50 individual popliteal nodes from a further 25 lambs are presented in Tables 3, 4 and 5.

Figure 20 : SHAPE OF JEJUNAL NODES

LAMB 1

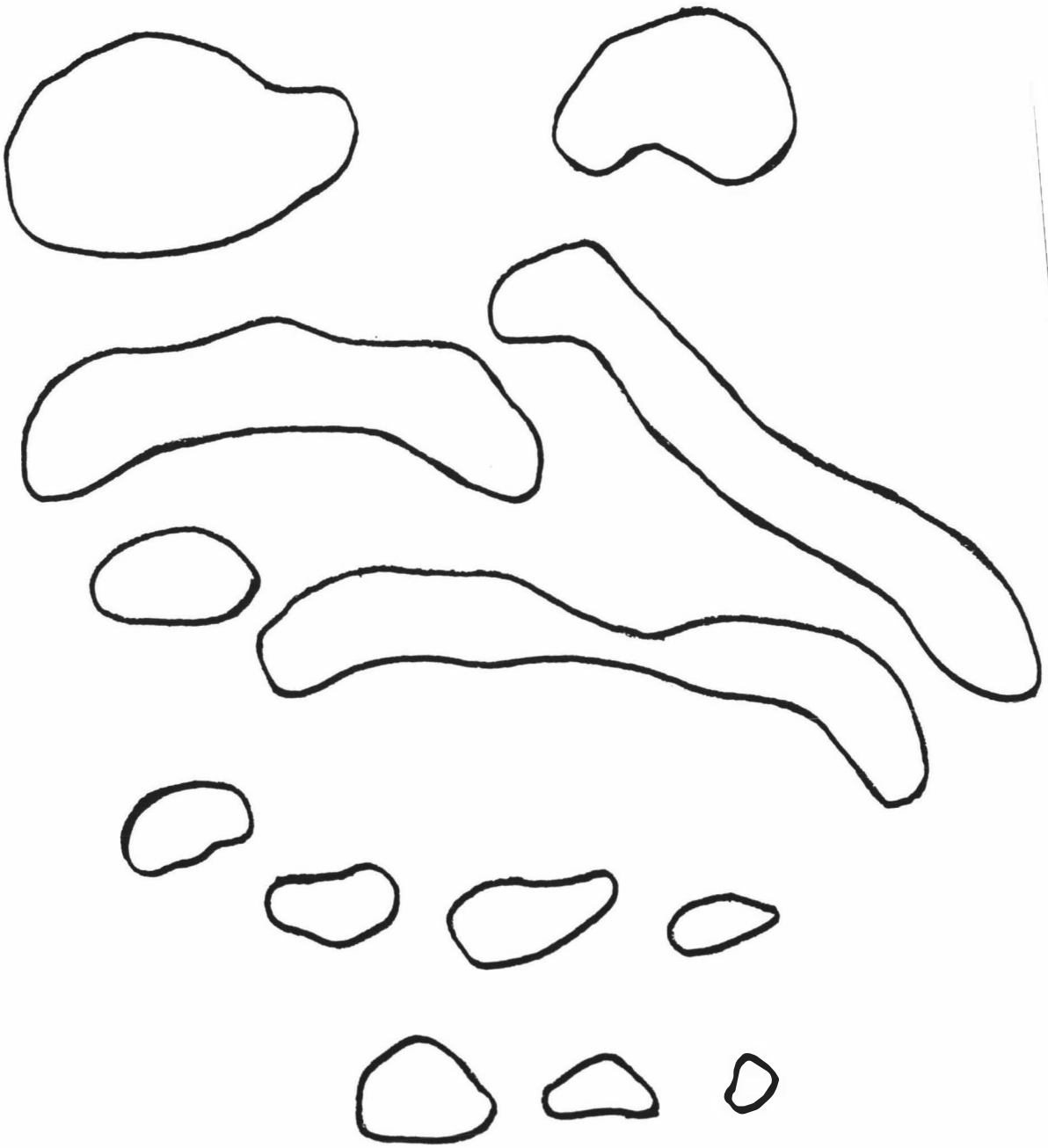


Figure 21 : SHAPE OF JEJUNAL NODES

LAMB 2

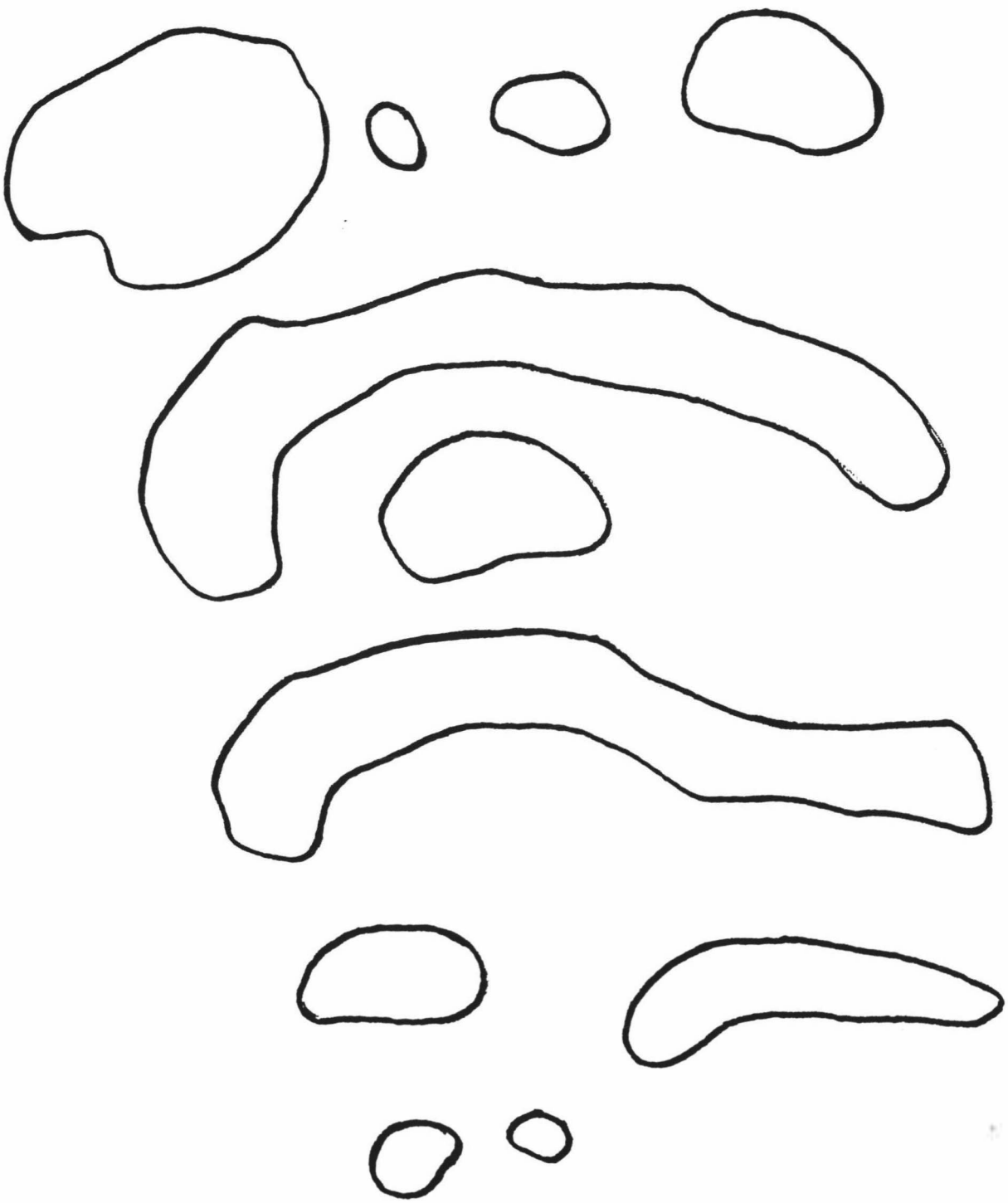


Figure 22 : SHAPE OF JEJUNAL NODES

LAMB 3

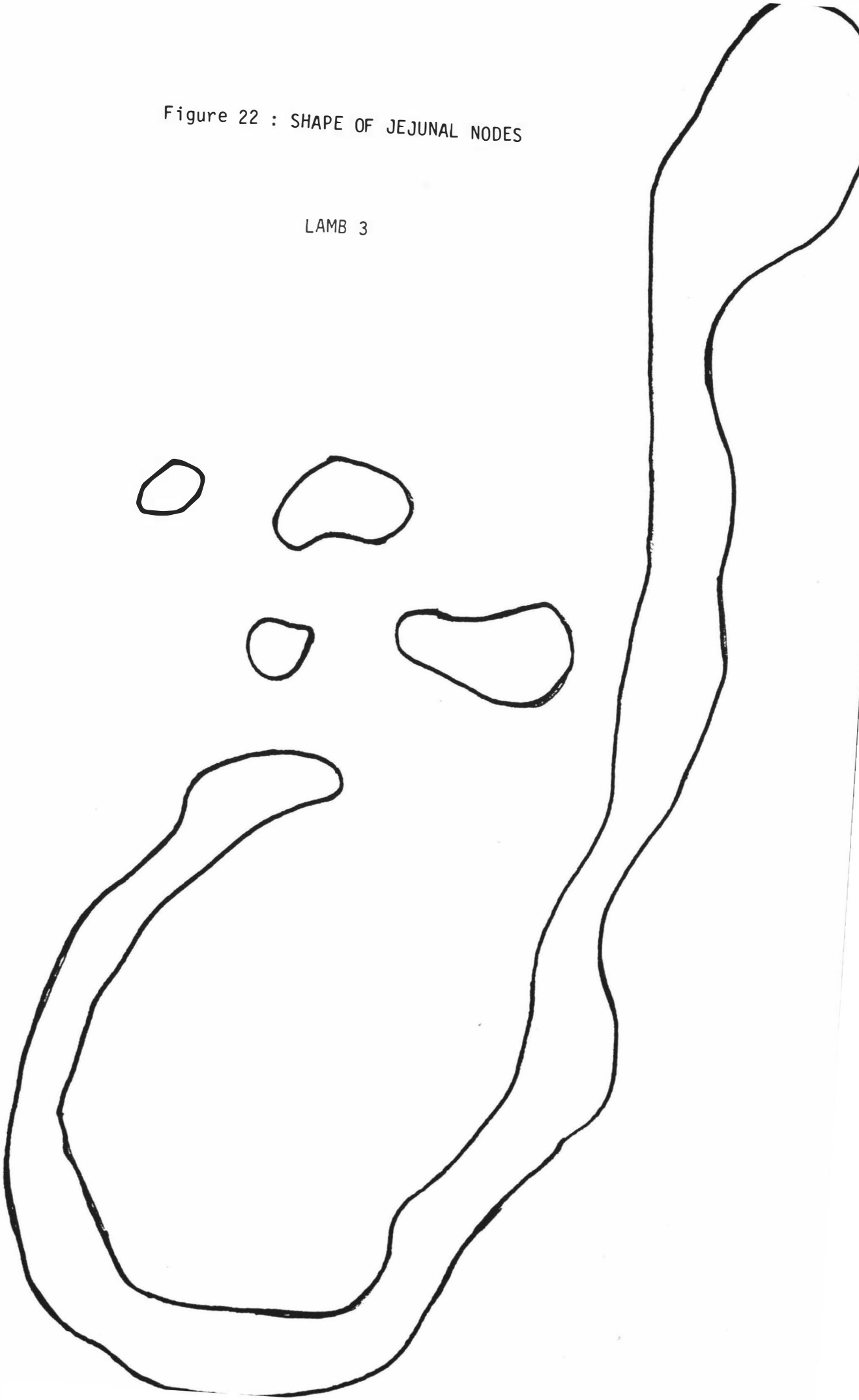


Figure 23 : SHAPE OF JEJUNAL NODES

LAMB 4

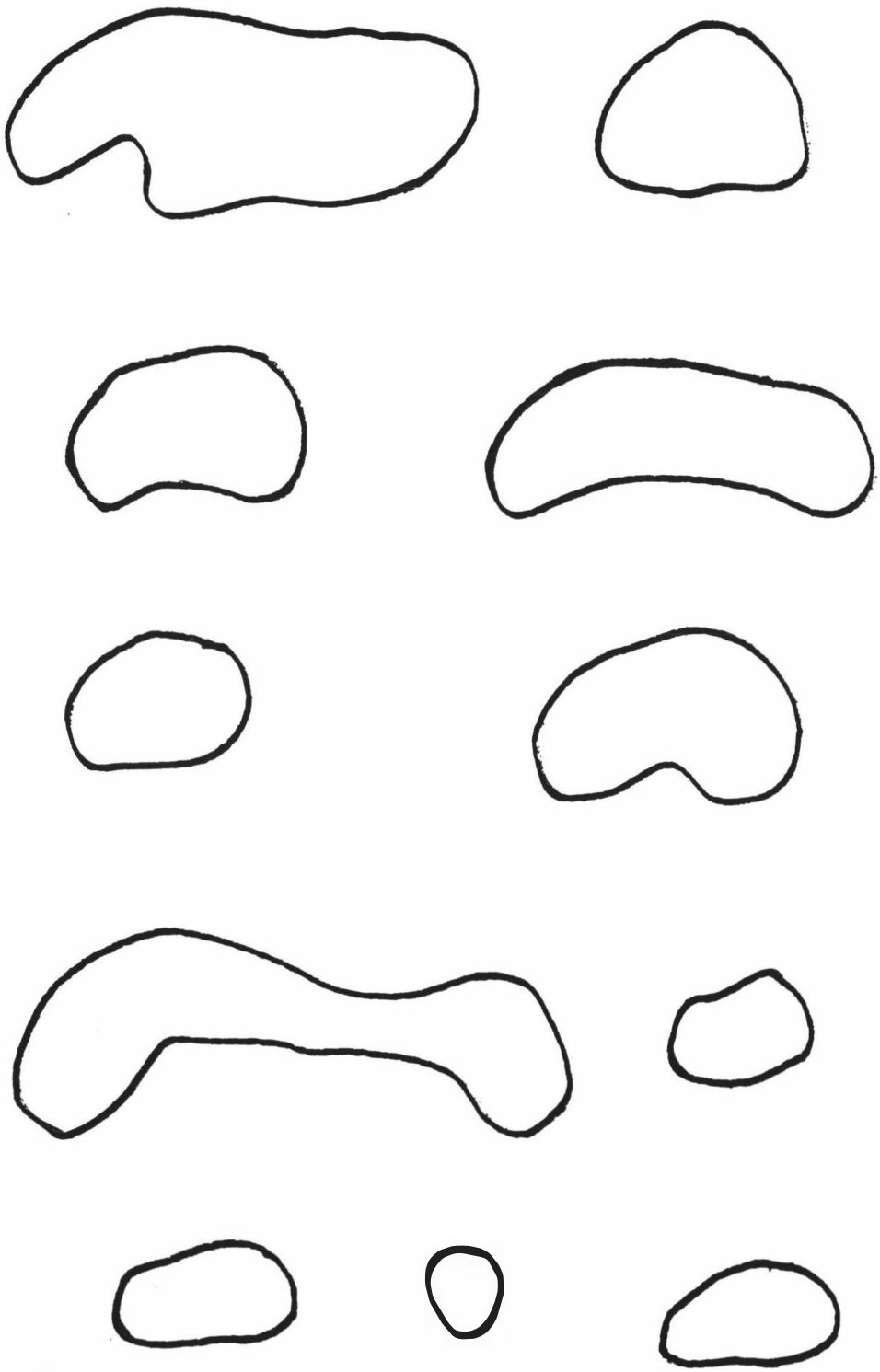


Figure 24 : SHAPE OF JEJUNAL NODES

LAMB 5

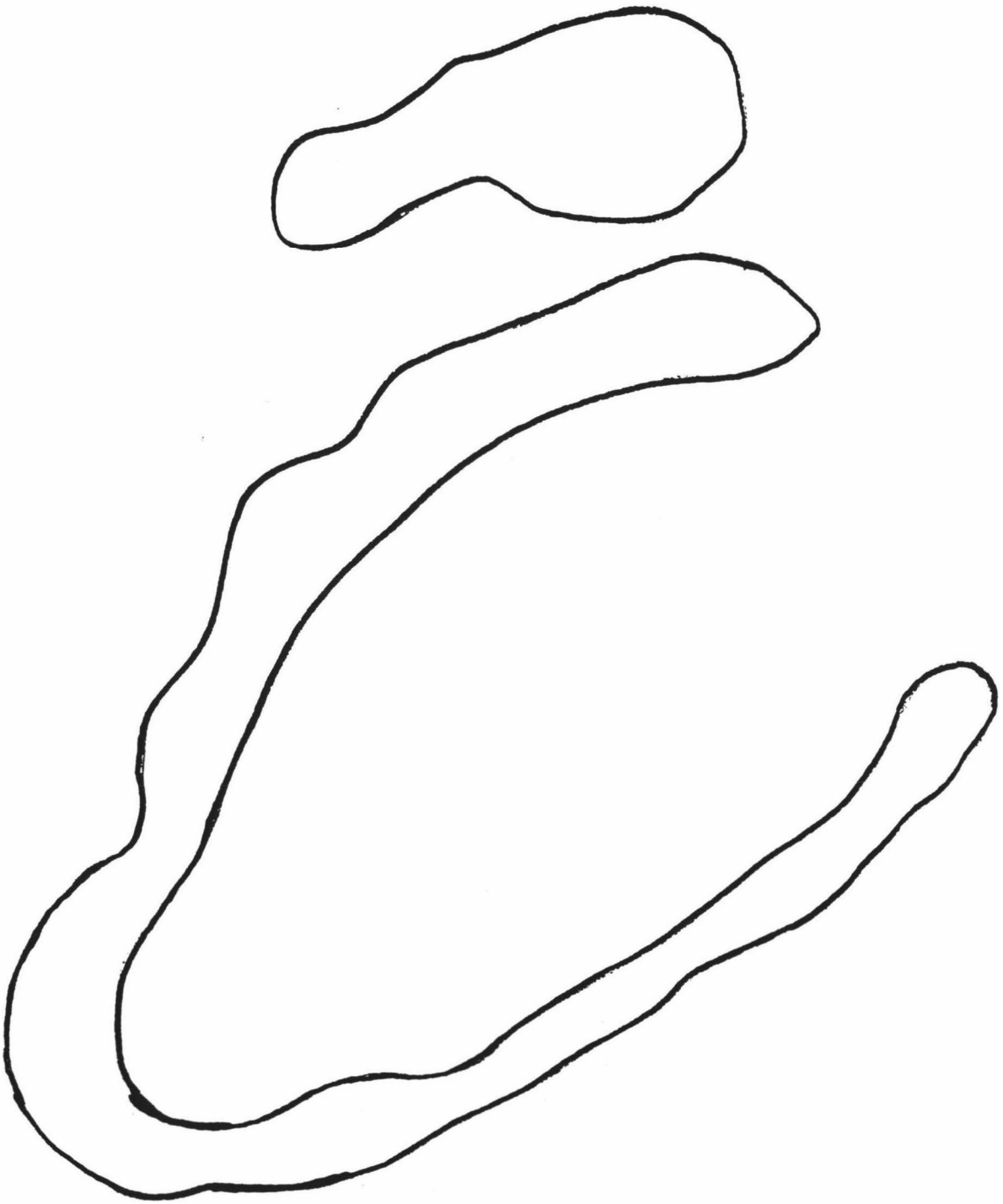


Figure 25 : SHAPE OF JEJUNAL NODES

LAMB 6

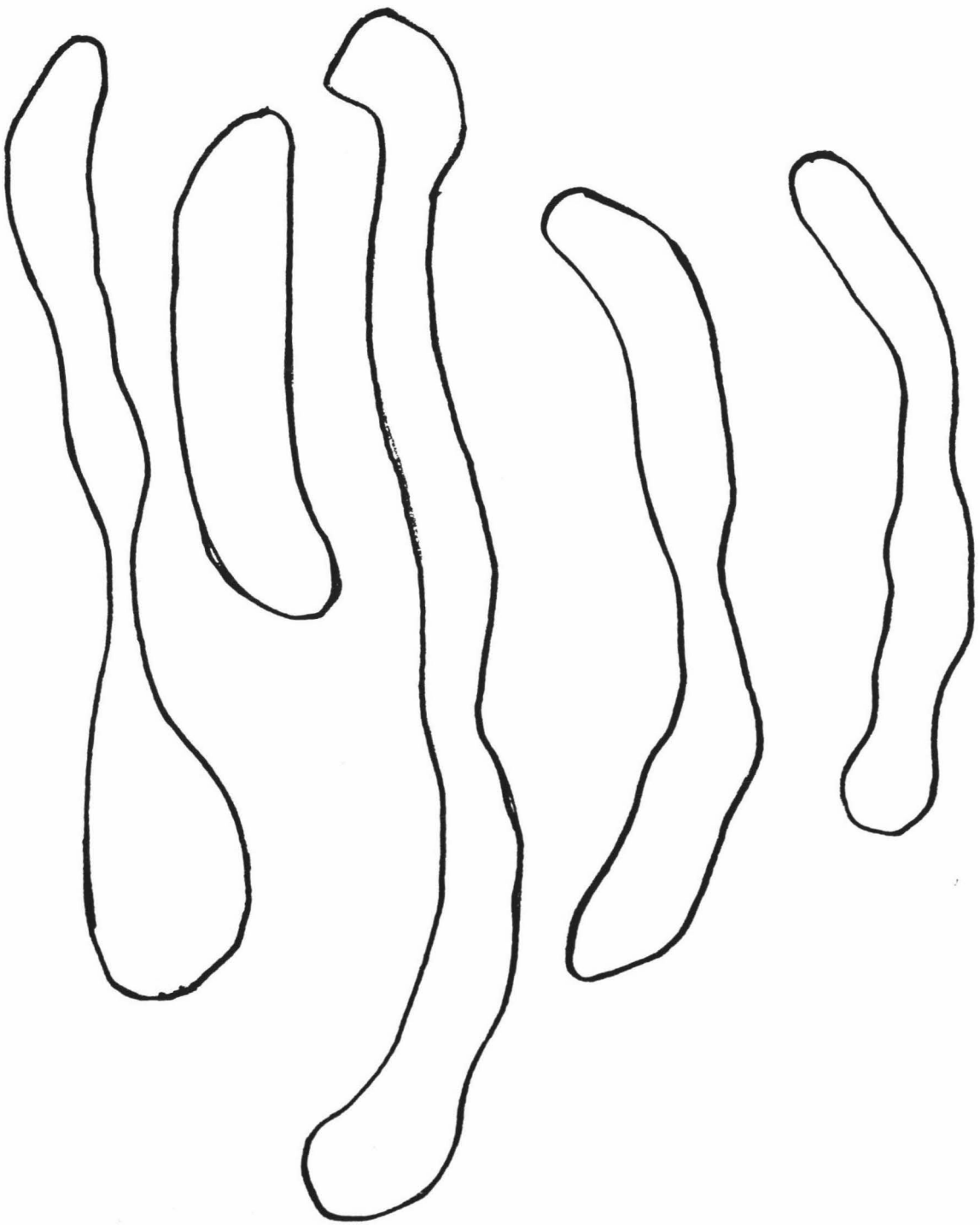


Figure 26 : SHAPE OF JEJUNAL NODES

EWE 1

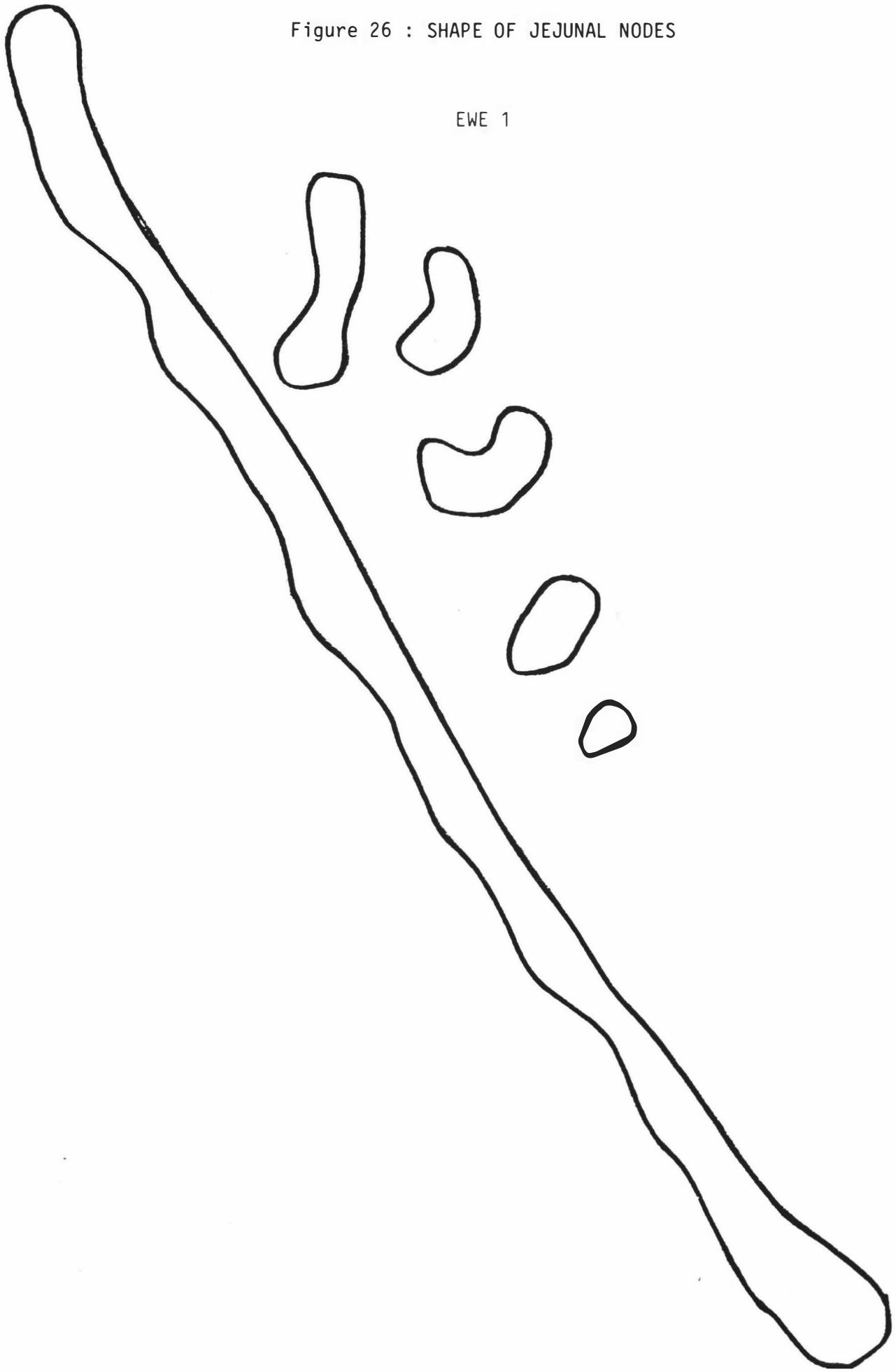


Figure 27 : SHAPE OF JEJUNAL NODES

EWE 2

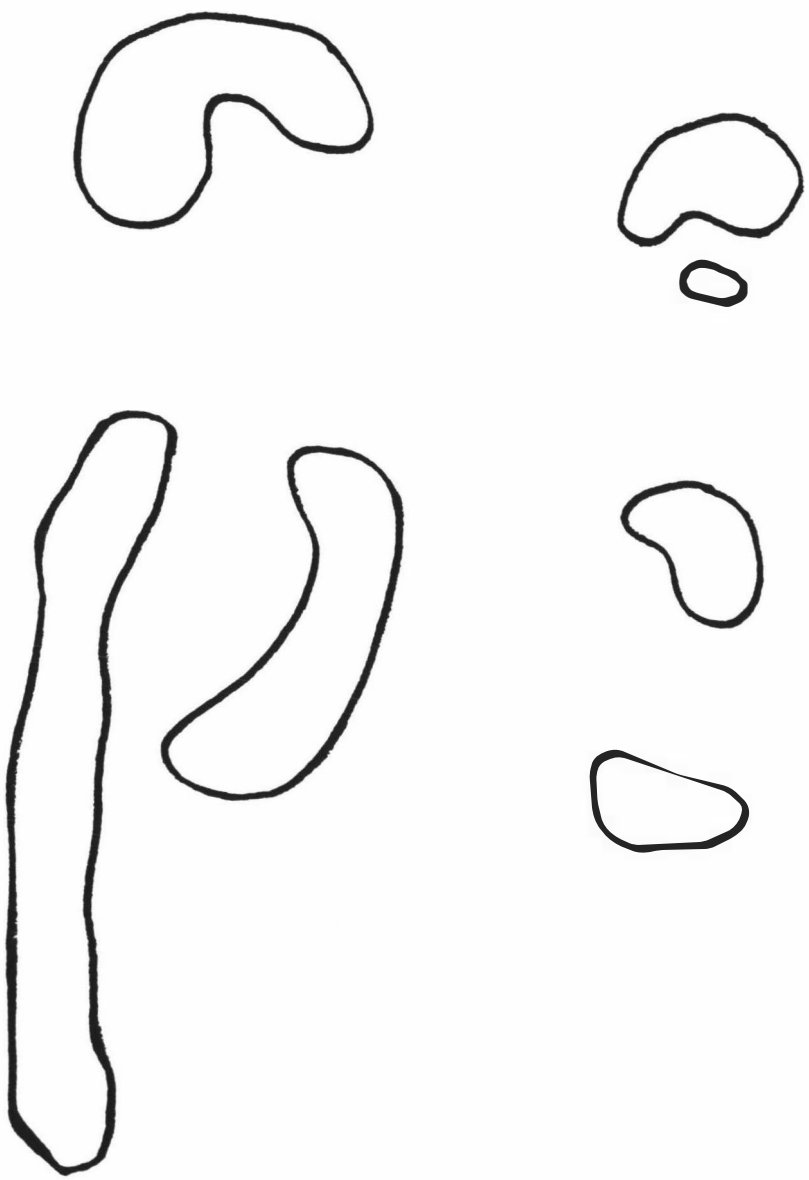


Figure 28 : SHAPE OF JEJUNAL NODE

EWE 3

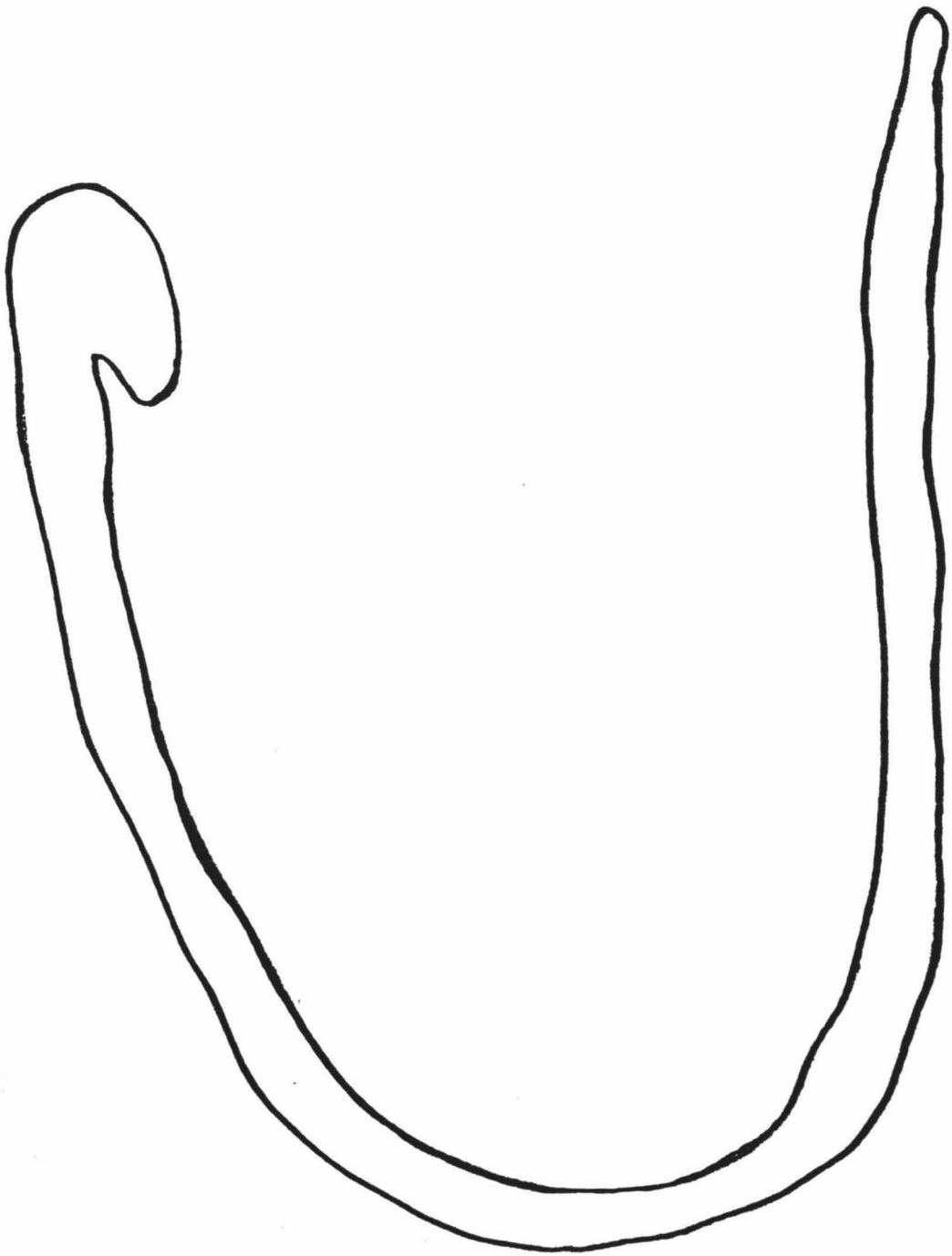


Figure 29 : SHAPE OF JEJUNAL NODES

EWE 4

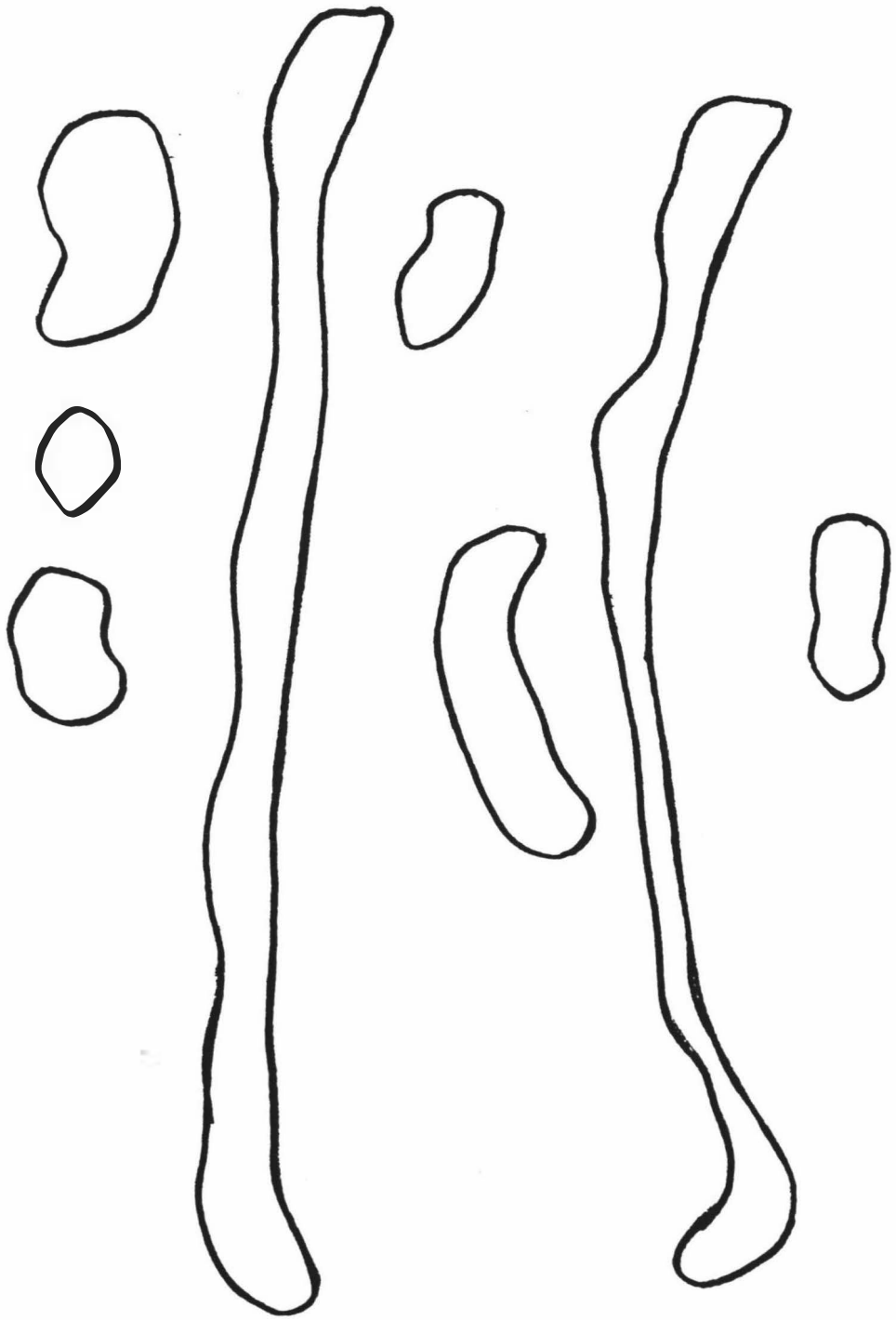


Figure 30 : SHAPE OF JEJUNAL NODES

EWE 5

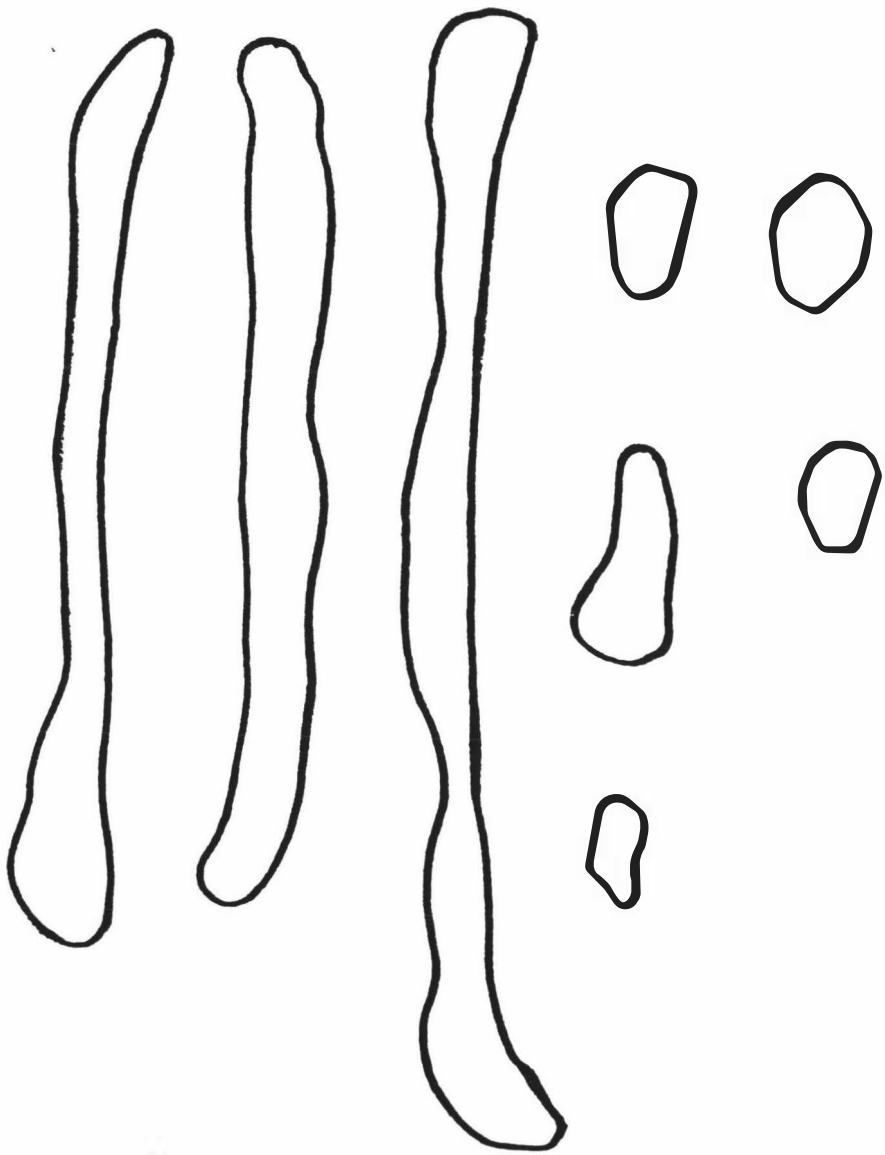


Figure 31 : SHAPE OF JEJUNAL NODES

EWE 6

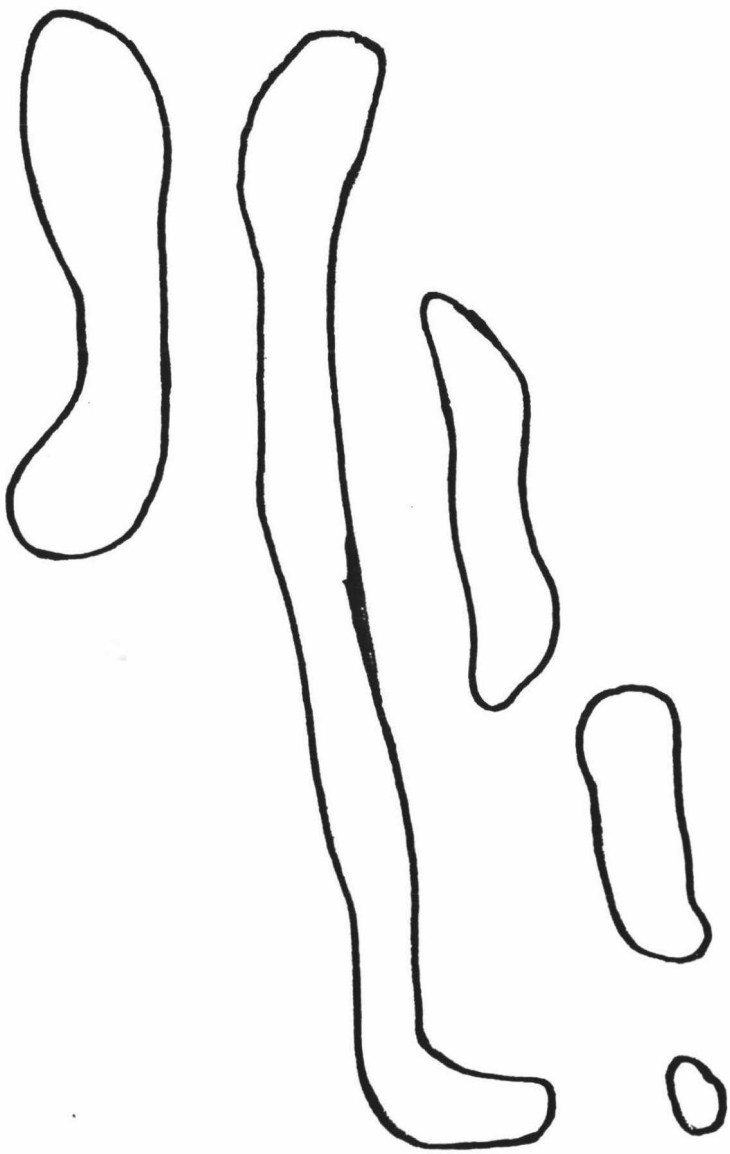


Table 3. Weight(g) (including left and right) of 19 groups of lymph nodes from six lambs

Lymph nodes	1	2	3	4	5	6	Mean	Range
Mandibular	0.70	0.72	1.71	2.21	1.41	1.01	1.29	0.70-2.21
Parotid	3.09	2.50	3.30	3.37	1.74	1.98	2.66	1.74-3.37
Lateral retropharyngeal	1.08	0.74	1.11	1.11	0.42	0.82	0.88	0.42-1.11
Medial retropharyngeal	4.78	4.98	5.62	5.61	7.93	6.79	5.95	4.78-7.93
superficial cervical	5.89	5.15	6.02	5.32	5.69	3.58	5.28	3.58-6.02
Proper axillary	0.18*	0.62	0.15*	0.64	0.41	0.40	0.46	0.30-0.64
Popliteal	2.11	1.67	3.28	2.01	2.07	1.58	2.12	1.58-3.28
Ischiatic	1.16	0.85	0.97	0.61	0.95	0.44	0.83	0.44-1.16
Subiliac	2.05	1.86	2.30	1.16	1.92	1.41	1.78	1.16-2.30
Superficial inguinal	0.59*	1.20	2.28	1.18	1.13	1.11	1.35	1.11-2.28
Renal	0.51	0.33	0.50	0.68	1.23	0.62	0.65	0.33-1.23
Medial iliac	3.07	1.28	3.38	2.88	2.28	1.12	2.34	1.12-3.38
Cranial tracheobronchial	1.16	0.45	0.98	2.84	1.25	1.02	1.28	0.45-2.84
Left tracheobronchial	2.20	2.41	1.52	1.35	1.63	1.59	1.78	1.35-2.41
Caudal mediastinal	5.72	7.51	6.02	6.77	6.49	5.52	6.34	5.52-7.51
Hepatic	0.75	0.88	1.06	3.23	2.00	0.85	1.46	0.75-3.23
Colic	2.60	6.17	4.90	3.18	4.16	3.21	4.04	2.60-6.17
Ileocolic	3.48	5.80	2.51	4.96	6.31	6.07	4.86	2.51-6.31
Jejunal	63.64	85.21	90.41	69.30	69.03	70.51	74.68	63.64-90.41

* = Lymph nodes only present on the right side.

Table 4. Weight (g) of 50 popliteal lymph nodes from 25 Romney lambs

Lamb no.	Carcase weight(kg)	Weight of left side	Weight of right side	Difference of weights between left and right	Combined weight
1	15.5	1.60	2.47	0.87	4.07
2	18.5	1.58	1.65	0.07	3.23
3	14.0	1.51	1.80	0.29	3.31
4	13.5	1.63	1.23	0.40	2.86
5	14.5	1.58	1.47	0.11	3.05
6	15.0	1.41	1.20	0.21	2.61
7	16.5	0.94	0.88	0.06	1.82
8	12.5	0.98	0.95	0.03	1.93
9	16.5	1.12	1.32	0.20	2.44
10	15.5	2.18	1.40	0.78	3.58
11	17.5	1.45	1.51	0.06	2.96
12	14.5	1.08	0.62	0.46	1.70
13	16.5	0.88	1.21	0.33	2.09
14	15.0	1.18	1.18	0.00	2.36
15	15.5	1.38	2.42	1.04	3.80
16	15.5	1.71	3.27	1.56	4.98
17	12.5	1.00	0.89	0.11	1.89
18	15.5	1.67	1.45	0.22	3.12
19	14.5	1.38	1.69	0.31	3.07
20	12.0	1.36	0.83	0.53	2.19
21	12.5	2.10	1.91	0.19	4.01
22	18.0	1.74	1.67	0.07	3.41
23	16.5	1.90	2.13	0.23	4.03
24	13.5	0.91	0.82	0.09	1.73
25	12.5	2.44	3.01	0.57	5.45
Mean	15.0	1.47 (S.D 0.41)	1.56 (S.D 0.68)		3.03

Range of difference of weight between left and right---0.00-1.56
Range of weights of individuals----------0.62-3.27

Table 5. Weight(g) (including left and right) of 19 groups of lymph nodes from six ewes

Lymph nodes	1	2	3	4	5	6	Mean	Range
Mandibular	1.68	1.80	0.58	1.12	1.89	1.21	1.38	0.58-1.89
Parotid	2.55	1.85	1.74	2.05	1.87	2.20	2.04	1.74-2.55
Lateral retropharyngeal	0.70	0.54	N*	0.95	1.90	0.49	0.92	0.49-1.90
Medial retropharyngeal	2.93	2.12	1.24	1.33	2.73	2.77	2.19	1.24-2.93
Superficial cervical	3.75	3.02	5.19	4.55	5.35	4.49	4.39	3.02-5.35
Proper axillary	0.07*	0.10	0.15	0.13	0.35	0.24	0.19	0.10-0.35
Popliteal	1.08	1.65	1.93	1.43	3.11	1.61	1.80	1.08-3.11
Ischiatic	0.30	0.42	0.55	0.39	0.56	0.69	0.49	0.30-0.69
Subiliac	1.72	1.78	2.13	1.45	1.65	2.08	1.80	1.45-2.13
Superficial inguinal	0.99	1.64	1.38	1.68	1.49	1.79	1.50	0.99-1.79
Renal	0.63*	0.23	0.33	0.39	0.33	0.30	0.47	0.23-1.26
Medial iliac	2.02	2.20	3.17	2.48	3.39	1.66	2.49	1.66-3.39
Cranial tracheobronchial	0.81	0.82	0.50	0.63	1.29	1.41	0.91	0.50-1.41
Left tracheobronchial	1.20	0.79	2.12	0.73	1.85	1.01	1.28	0.73-2.12
Caudal mediastinal	4.72	3.85	5.92	4.14	6.77	5.55	5.16	3.85-6.77
Hepatic	2.17	0.97	1.12	0.94	0.89	1.85	1.32	0.89-2.17
Colic	4.48	2.42	5.42	1.14	4.45	2.11	3.34	1.14-5.42
Ileocolic	5.92	3.18	7.13	5.50	3.22	1.61	4.43	1.61-7.13
Jejunal	29.89	19.79	22.56	30.43	24.39	26.04	25.52	19.79-30.43

* = lymph nodes only present on the right side.
N* = Lymph nodes not present on either side.

As can be seen from the tables above, the weight of jejunal nodes of lambs was approximately threefold that of ewes. The combined weight of popliteal nodes from all 31 lambs had a range of 1.58 g to 5.45 g and the range of individual nodes was from 0.62-3.27 g. These latter results are shown in the form of a histogram in Figure 32 superimposed on which is an estimate of their possible distribution.

Figure 33 is the hypothetical distribution of weight of normal and abnormal popliteal lymph node.

Figure 32 : DISTRIBUTION OF WEIGHT OF POPLITEAL LYMPH NODES OF LAMBS

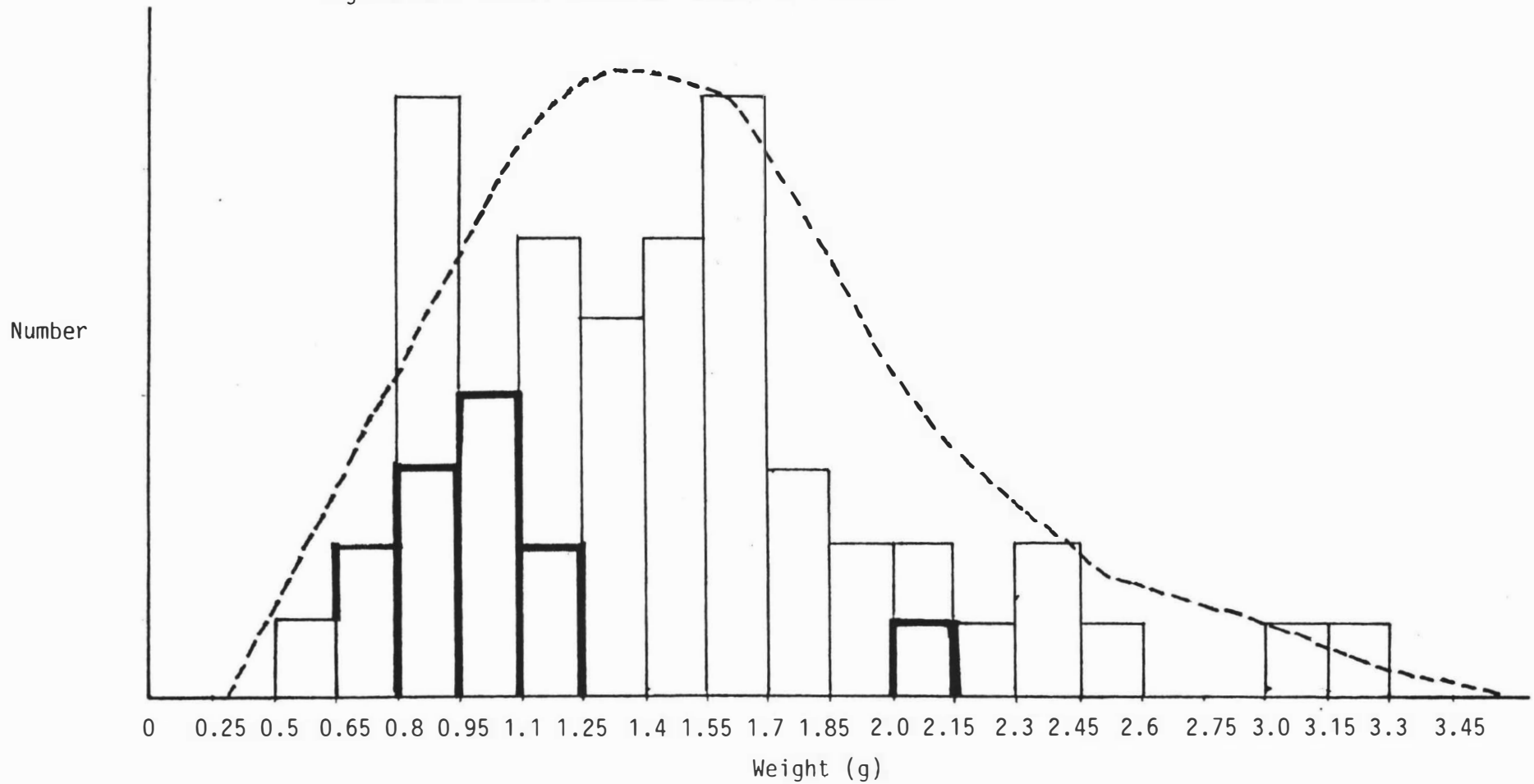


Figure 33 : HYPOTHETICAL DISTRIBUTION OF WEIGHT OF NORMAL AND ABNORMAL POPLITEAL LYMPH NODE

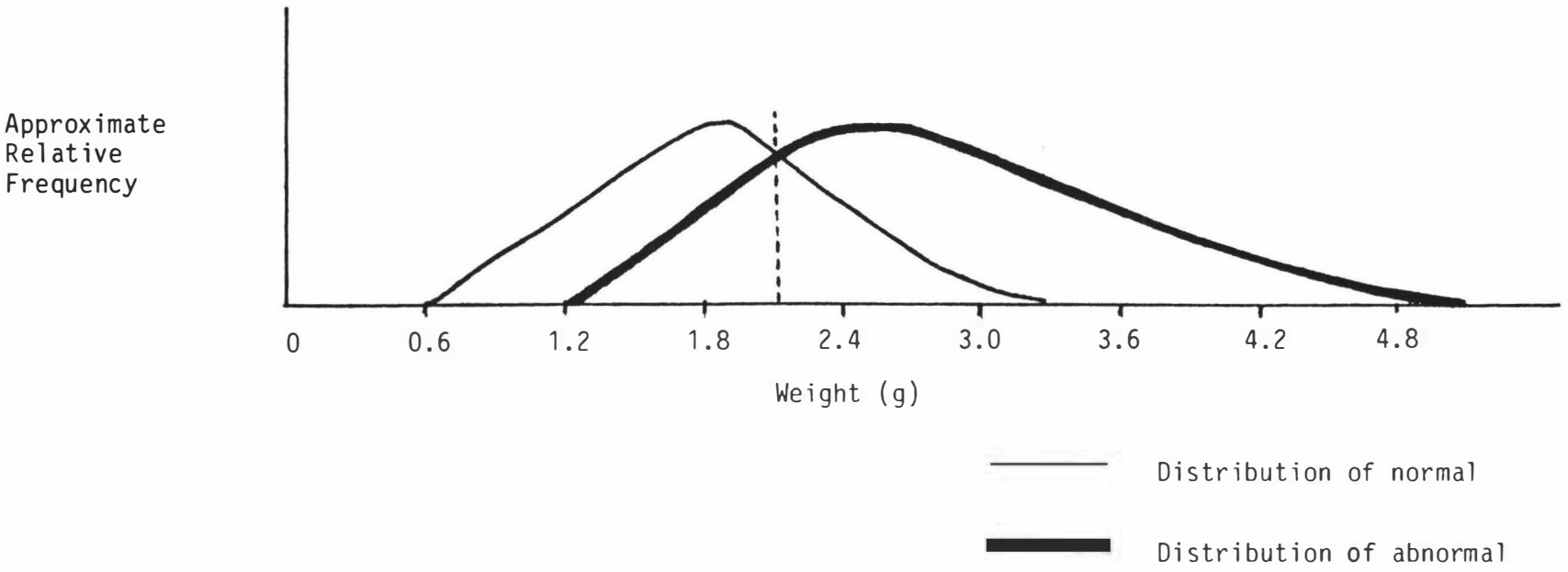


Table 6. Average measurements of lymph nodes of lambs (mm)

	Left			Right		
	Length	Width	Thickness	Length	Width	Thickness
Mandibular	18	9	5	19	10	5
Parotid	22	12	6	27	10	6
Lateral retropharyngeal	15	7	5	14	7	5
Medial retropharyngeal	29	17	10	30	16	10
Superficial cervical	27	17	8	29	16	8
Proper axillary	12	7	4	12	8	4
Popliteal	19	9	5	16	10	5
Ischiatic	12	7	5	11	7	4
Subiliac	20	7	4	16	6	4
Superficial inguinal	23	8	4	12	8	4
Renal	12	7	5	9	6	5
Medial iliac	17	7	4	13	7	4

	Length	Width	Thickness
Hepatic	13	9	6
Cranial tracheobronchial	18	7	5
Left tracheobronchial	14	7	5
Caudal mediastinal	63	9	7
Colic	15	9	5
Ileocolic	17	10	8
Jejunal	114	16	6

Table 7. Average measurements of lymph nodes of ewes (mm)

	Left			Right		
	Length	Width	Thickness	Length	Width	Thickness
Mandibular	27	10	5	18	9	6
Parotid	28	10	5	26	11	6
Lateral retropharyngeal	16	9	6	14	8	4
Medial retropharyngeal	22	16	6	22	12	6
Superficial cervical	34	16	7	35	17	6
Proper axillary	8	6	3	7	5	2
Popliteal	17	11	7	17	11	6
Ischiatic	11	7	4	10	6	4
Subiliac	25	9	4	30	8	6
Superficial inguinal	16	7	4	14	9	4
Renal	7	5	3	8	5	4
Medial iliac	23	7	3	39	8	4

	Length	Width	Thickness
Hepatic	19	9	7
Cranial tracheobronchial	13	7	5
Left tracheobronchial	14	7	4
Caudal mediastinal	114	10	6
Colic	21	13	6
Ileocolic	15	10	6
Jejunal	111	12	7

From the data so far presented it can be seen that there are considerable differences in the weight and shape of different nodes, and in the same nodes from different animals. The weight of jejunal node of lambs accounted for 63 percent of the total weight of lymph nodes examined, while the weight of jejunal node of ewes only 40 percent of total weight of the lymph nodes examined. The weight of jejunal nodes in lambs was at least ten times greater than any other nodes and in sheep more than twice of that of any other nodes. Furthermore the relative size of these nodes in lambs was threefold greater than in ewes. The weights of the medial retropharyngeal, proper axillary and ischiatic nodes of lambs were twice that of those from ewes. However, the weight of all other nodes were similar in both lambs and ewes.

From examination of Figures 1-31 and Tables 6 and 7 it can be seen that nodes such as the mandibular and proper axillary were relatively constant in shape, although there were differences in size. Conversely, nodes such as the medial iliac, superficial inguinal and jejunal showed considerable variation in both shape and size.

It should also be noted that although most nodes consisted of bilaterally symmetrical bodies, with the obvious exception of those such as the hepatic and jejunal, in one ewe the lateral retropharyngeal nodes were absent on both sides, in two lambs and one ewe the left proper axillary nodes were not present.

It would also appear that a group of nodes could either be combined in one single node or subdivided into several smaller entities, the most obvious example being the jejunal. In one ewe the left ischiatic node appeared to be subdivided into three.

The total weight of the lymph nodes of each lamb and each ewe expressed as a proportion of body and carcase weight, are shown in Tables 8 and 9 respectively.

Table 8. Total weight(g) of lymph nodes of lambs and percentage of body and carcase weight(kg)

Lambs no.	1	2	3	4	5	6	Average	Range
total weight of lymph nodes	105	130	138	118	110	110	120	105 - 138
Live weight	31.0	28.0	30.0	27.0	27.0	27.0	28.3	27.0-31.0
Carcase weight	13.8	13.5	14.0	12.0	12.4	11.2	12.8	11.2-14.0
% of lymph nodes to live weight	0.34	0.46	0.46	0.44	0.44	0.41	0.43	0.34-0.46
% of lymph nodes to carcase weight	0.76	0.96	0.99	0.98	0.95	0.98	0.94	0.76-0.99

Table 9. Total weight(g) of lymph nodes of ewes and percentage of body and carcase weight(kg)

Ewes no.	1	2	3	4	5	6	Average	Range
Total weight of lymph nodes	68	49	63	61	67	59	61	49 - 68
Live weight	31.9	33.9	34.5	34.0	42.0	31.7	34.7	31.7-42.0
Carcase weight	11.2	13.9	12.6	12.6	16.4	15.6	13.7	11.2-16.4
% of lymph nodes to live weight	0.21	0.14	0.18	0.18	0.16	0.19	0.18	0.14-0.21
% of lymph nodes to carcase weight	0.61	0.35	0.50	0.48	0.41	0.38	0.46	0.35-0.61

The average total weight of lymph nodes of lambs was twice that of ewes. Although the live weight of ewes was heavier than that of lambs the carcases weights were almost the same. Thus the proportion of weights of lymph nodes to live and carcase weight of lambs were also twice that of ewes.

Differences between the wet and dry weight of the six groups of lymph nodes examined from three lambs and ewes are shown in Tables 10 and 11 respectively.

Table 10. Wet and dry weight of lymph nodes of lambs

	Wet weight (g)			Dry weight (g)			Mean of dry matter	Range of dry matter
Lambs no.	1	2	3	1	2	3	%	%
Cranial tracheobronchial	1.16	0.45	0.98	0.24	0.08	0.16	19	16.3-20.7
Left tracheobronchial	2.20	2.41	1.52	0.47	0.45	0.30	20	18.7-21.4
Caudal mediastinal	5.72	7.51	6.02	1.13	1.61	1.29	21	19.8-21.4
Superficial cervical	5.89	5.15	6.02	1.03	0.89	1.19	18	17.3-19.8
Popliteal	2.11	1.67	3.28	0.40	0.31	0.63	19	18.6-19.2
Ischiatic	1.16	0.85	0.97	0.21	0.14	0.18	18	16.5-18.6

P = 0.1048

Table 11. Wet and dry weight of lymph nodes of ewes

	Wet weight (g)			Dry weight (g)			Mean of dry matter	Range of dry matter
Ewes no.	1	3	6	1	3	6	%	%
Cranial tracheobronchial	0.81	0.82	1.29	0.11	0.15	0.22	16	13.6-16.2
Left tracheobronchial	1.20	0.79	1.85	0.18	0.14	0.35	17	15.0-18.9
Caudal mediastinalst	4.72	3.85	6.77	0.66	0.66	1.16	16	14.0-17.1
Superficial cervical	3.75	3.02	5.35	0.46	0.49	0.85	15	12.3-16.2
Popliteal	1.08	1.65	3.11	0.18	0.37	0.51	18	16.4-22.4
Ischiatic	/	0.42	0.56	/	0.07	0.12	19	16.7-21.4

P = 0.4335

The maximal differences of weights of lymph nodes from six lambs and six ewes are shown in Table 12.

Table 12. The maximal differences of weights(g) of lymph nodes from six lambs and six ewes: A comparison of intra and inter animal differences.

Name of lymph node	Maximal difference between left and right nodes from the same animal		Maximal difference between the same node from different animals	
	Lambs	Ewes	Lambs	Ewes
Mandibular	0.65	0.44	0.96	0.87
Parotid	0.64	0.65	1.17	0.69
Left retropharyngeal	0.61	0.44	0.69	0.95
Medial retropharyngeal	0.55	0.49	2.06	1.25
Superficial cervical	0.32	0.85	1.36	1.55
Proper axxilary	0.28	0.16	0.33	0.17
Popliteal	1.60*	0.41	2.65	1.05
Ischiatic	0.32	0.15	0.60	0.29
Subiliac	0.44	0.33	0.80	0.54
Superficial inguinal	0.50	0.22	0.79	0.46
Renal	0.77	0.11	0.86	0.53
Medial iliac	0.28	0.94	1.19	1.51

* These figures derived from 31 lambs.

Statistical analysis of these results show that there are no significant differences between the wet and dry weight of different nodes ($P>0.1$) and thus the weight of a node is a satisfactory indirect measurement of its size. Although the mean range of dry matter percentage of lymph nodes of lambs was similar to ewes, the dry matter content of the lymph nodes from lambs was significantly ($P<0.01$) greater than that of ewes.

DISCUSSION

Before discussing the results, it is appropriate to reconsider the technique employed. Although care was taken to remove the majority of the fat covering lymph nodes, it was almost impossible to remove every remnant. Thus the accuracy of the dry weight measurement of the lymph nodes could be affected, particularly in the case of smaller nodes where the relative effect of residual fat would be greater than in larger nodes. However, the data presented in Tables 10 and 11 indicate that there were no significant differences between the percentage dry matter in large and smaller nodes. Another effect on the accuracy of the measurement of the wet weight of nodes was dehydration following dissection. As all nodes were weighed within three hours of removal and covered with a damp cloth, such a weight loss from evaporation was mimimal. The presence of untrimmed fat could also have an effect on the accuracy of dry weight recordings, but as already discussed, this effect should also small.

Several different ways of describing the size of lymph nodes have been attemped. In many texts the traditional way of describing of the size of lymph nodes, is by measurements of length, width and thickness. Expression of the size of lymph nodes by such linear measurements only is most difficult. Usually, the measurement of the length and thickness can be easily expressed. However, it is extremely difficult to give a satisfactory description of the width of an irregular shaped node especially those with a dumbbell or key shape. As already mentioned, width was expressed as a mean of the largest and smallest values, but this was not a satisfactory value for asymmetrical and grossly irregular nodes such as the parotid and medial iliac.

Secondly, the size of the lymph nodes could be expressed by units of volume. This could theoretically be achieved by putting the nodes into a graduated measuring cylinder filled with water, and measuring the increase in volume, which should reflect the volume of the lymph node. Experience has shown that, using conventional measuring cylinders, the technique is not sufficiently sensitive for measuring the volume of lymph nodes of the size encountered in sheep (A.S.Davies, personal communication).

Thirdly, the size of lymph nodes, can be expressed by weight. This overcomes many of the shortcomings and inaccuracies associated with the other methods desribed, providing the specific gravity of nodes remains constant. Although there were significant differences between the mean dry weight of lymph nodes from lambs compared with adult sheep, these differences were less than the range of weights in both age groups. Thus weight appears to be the most accurate and objective criterion for indirectly measuring the size of a lymph node.

An example of these differences in describing the size of lymph nodes is illustrated by comparing the results presented in Tables 6 and 7 and Tables 3 and 5.

Although there was comparatively little difference in the linear measurements of size of the jejunal lymph nodes in lambs and ewes, there was a threefold difference in weight (74.7 g v 25.5 g). This difference was probably due to both the fewer individual jejunal nodes in the ewes compared with lambs, and the difficulties of expressing the size of an irregularly shaped organ in units of only length, width and thickness.

Although careful attention was paid to the detection and removal of the lymph nodes required, some contralateral nodes, of those expected to be paired, were not detected. It would appear that there are two possibilities for the failure to find nodes in their expected location. First, inexperience could have been coupled with a relatively small size of the missing nodes. Secondly, the nodes may have been absent as a development defect. A meticulous search for all missing nodes was made. It is therefore believed that the nodes were either totally absent or so vestigial to be undetectable by macroscopic techniques.

The major aim of the work outlined in this section was to determine the range in size of lymph nodes from normal sheep and lambs. Unfortunately, this aim was only partially achieved owing to the great variation in size recorded, and the small number of animals examined. This point is well illustrated by comparing the range of weights of the popliteal lymph nodes from the six lambs initially examined, with the range of weights from the subsequent group of 25 lambs (Figure 32). (Figure 33 is similar to Figure 32 which combines the data from all 31 lambs, but shows separately the data collected from the six lambs examined initially). It is apparent from this comparison that six animals did not provide sufficient information on the large variation in the size of popliteal lymph nodes of lambs. It is therefore probable that the possible range in weights of all other lymph nodes examined was greater than the data suggests.

In retrospect, it could be argued that it would have been preferable to examine fewer nodes from more animals. However, it is "easy to be wise after the event" and other important data, to be discussed later, would not have been obtained.

If it is accepted that there is a large range in size of those lymph nodes examined for the purposes of meat inspection, then serious problems arise, related to the accuracy of such procedures. As the size of normally large nodes may be up to three times that of a naturally small node, there must be considerable overlap of the distribution curves of normal size and abnormal enlargement. This theoretical concept is illustrated in Figure 33.

If the intersection of the two curves was taken as the arbitrary point to determine whether or not a node was enlarged, then a large number of both false positives and false negatives would be obtained. In other words, the procedure would lack both sensitivity and specificity. This point will be discussed again with respect to the data relating to the size of lymph nodes associated with arthritis.

Carcase lymph nodes showed only a slight degree of bilateral symmetry. In three lambs and one ewe, the left nodes, of those which are usually paired, were absent. There is little information on embryological development of lymph nodes in standard textbooks (Noden and De Lahunta, 1985). However, Maximow and Bloom (1948) suggest that some lymph nodes in humans do not develop until after birth. It is therefore difficult to discuss the possibility of an embryological defect as a cause for these missing nodes.

Both lateral retropharyngeal lymph nodes were absent in one ewe. In view of the decreasing relative weight of lymphoid tissue in ewes compared with lambs, and an obvious decrease in weight of certain nodes such as the proper axillary (0.19 g in ewes compared to 0.46 g in lambs), it is possible that

certain nodes might totally regress with increasing age. However, this hypothesis does not alone explain the absence of nodes in individual lambs.

Associated with the lack of knowledge on the embryological development of lymph nodes, there is no information as to whether adult nodes develop from a series of smaller nodes, or from a single precursor. It is therefore difficult to explain why nodes such as the ischiatic can occur either singly or as a multiple group. With respect to the jejunal nodes, it is interesting to note that there were more nodes recorded in lambs than in ewes (see Figures 20-31). This suggests either fusion of adjacent nodes or regression of some of them with increasing age. However, such hypotheses must be treated with caution because of the small number of observations.

The difference in weight between the ipsilateral and contralateral nodes in the same animal were apparently less than the difference in weight of the same node of different animals (see Table 12).

It will be noted from this table that these differences were similar in both lambs and ewes, and often more than a twofold difference occurs.

The lymph nodes of lambs were heavier (larger) than those of ewes in both absolute and relative terms. These differences were most obvious in relation to the jejunal and medial retropharyngeal nodes. A possible explanation is that older lymph nodes have fewer germinal centers and a concurrent reduction in cellularity associated with fewer lymphocytes and a thinning of the cortex and medullary cords (Weiss and Greep, 1977). The significantly greater dry matter weight of the lymph nodes of lambs compared with ewes, would also be compatible

with a theory of greater cellularity. Further histological studies on this topic would be of interest.

SECTION TWO

THE EFFECTS OF ARTHRITIS ON THE SIZE OF POPLITEAL AND MEDIAL ILIAC LYMPH NODES

RESULTS

Of the 26 joints (19 stifle and 7 hock) classified as arthritis by meat inspectors, and examined in detail by the author, only ten had definite arthritic changes, six had periarticular pathological changes and ten were apparently normal. Of the ten joints with arthritis, three also showed evidence of tendovaginitis. In all cases, the pathological changes were of a chronic nature.

In this small sample, the validity (predictive value) of inspectors in relation to detecting true arthritis was 38% and for detecting abnormal joints was 62%.

Table 13 gives details of the changes noted in the joints examined, together with the weights of the popliteal and medial iliac lymph nodes in both the affected and non-affected limb.

Table 13. Disease status of joints examined and weights(g) of popliteal and medial iliac lymph nodes

Number, side and name of joints	Classification of affection	Weight of the ipsilateral and contralateral popliteal and medial iliac lymph nodes			
		Popliteal		Medial iliac	
		Ipsi.	Contra.	Ipsi.	Contra.
1. Right stifle	Arthritis	0.60	0.71	N*	1.71
2. Right stifle	Arthritis	0.83	1.26	2.86	1.45
3. Left hock	Arthritis	3.93	1.47	2.25	0.66
4. Right stifle	Arthritis	1.21	0.90	2.66	1.27
5. Left stifle	Arthritis	0.82	N	N	N
6. Left stifle	Arthritis	0.82	N	N	N
7. Left hock	Arthritis	0.80	0.42	1.23	0.81
8. Left stifle	Arthritis and tendovaginitis	9.02	2.28	14.49	1.56
9. Left stifle	Arthritis and tendovaginitis	0.83	0.65	3.07	0.34
10.Right stifle	Arthritis and tendovaginitis	1.34	N	N	N
11.Left stifle	Periarthritis	1.49	11.32	0.51	3.12
12.Left stifle	Periarthritis	1.79	1.42	2.27	1.42
13.Left stifle	Periarthritis	1.49	N	N	N
14.Left hock	Periarthritis	6.59	N	N	N
15.Left hock	Periarthritis	2.60	1.02	3.33	1.03
16.Left hock	Periarthritis	2.76	2.27	2.97	3.78
17.Left stifle	normal joint	4.82	1.14	1.26	0.73
18.Left stifle	normal joint	4.07	0.85	3.04	1.15
19.Left hock	normal joint	0.83	0.54	0.81	0.97
20.Left hock	normal joint	1.57	1.79	1.03	1.41
21.Right stifle	normal joint	0.80	0.51	0.95	0.91
22.Right stifle	normal joint	2.22	N	N	N
23.Left stifle	normal joint	1.35	N	N	N
24.Left stifle	normal joint	2.07	2.41	2.27	1.07
25.Left stifle	normal joint	2.65	1.20	1.70	1.58
26.Right stifle	normal joint	0.89	1.07	0.97	2.00
Data from] Section 1]	Range of normal	0.62---3.27		1.12---3.38	
	Maximal difference between left and right	1.60		0.28	

N* = Nodes not available.

Scrutiny of the data in Table 13 in relation to the weight of lymph nodes reveals several points of interest, as listed below:

1; The weight of only six popliteal lymph nodes was above normal range. In five of these the difference between the weight of the ipsilateral and contralateral nodes was also greater than the normal maximal difference (in one case the contralateral node was not examined).

2; Three of these enlarged popliteal lymph nodes were associated with arthritis, while the other three were not (in Case 11 the enlarged node was contralateral to the arthritic joint and Cases 17 and 18 had apparently normal joints).

3; Two medial iliac nodes had weights greater than the normal range (Cases 8 and 16), but only one of these (Case 8) was the increase in weight fourfold greater than the normal.

4; In case 8, the weight of the ipsilateral medial iliac node was nine times greater than the contralateral node.

DISCUSSION

It would appear that the stifle joint is more frequently affected by arthritis and periarthritis than the hock joint. In the present studies, 11 of the 16 (69%) diseased joints were stifles. Marero (1980) recorded similar data in that of 34 diseased stifle and hock joints, 22 were stifles (65%).

From the results of this work, the predictive value of meat inspection procedures for detecting hock and stifle joints with arthritis or periarthritis was 62%. This compares with a value of 89% calculated from the data of Marero (1980). This latter author carried out a similar study on 118 joints, 38 of which were stifles and hocks. It also appears that he failed to appreciate the difference between the accuracy and predictive value of a test. The differences between the predictive value recorded in this study and in the one by Marero (1980) could be due to a variety of factors, including the relatively small number of joints examined, and possible differences in the prevalence of arthritis in sheep at the times when both studies were carried out. There could be also differences between the two workers, in terms of their respective abilities of detecting pathological changes of the joints.

Unfortunately, the data from both studies was not sufficient to assess the true accuracy of meat inspectors in detecting arthritis, as the joints of animals passed as normal were not examined. This type of problem has been discussed in greater detail by Robertson and Blackmore (1985).

Only three of the 16 affected joints had associated enlarged popliteal nodes, and conversely, three nodes were enlarged which were associated with

apparently normal joints. The only case of a grossly enlarged medial iliac node was contralateral to the affected joint.
It would therefore appear that enlargement of the popliteal lymph node has no predictive value in relation to whether or not a stifle or hock joint is involved in a pathological process.

The enlargement of nodes not associated with a diseased joints, is of interest. As stated in Section 1 of this thesis, the popliteal node drains all distal portions of the leg including the foot. Foot lesions in sheep including foot rot and foot abcesses are not uncommon (Manktelow, 1984), and the feet of sheep are removed from the carcase before inspection. It is believed that a proportion of these enlarged popliteal and medial iliac nodes could have been associated with undetected foot lesions.

When attempting to decide whether or not a lymph node is enlarged, one can use two techniques. First, one can compare the weight with the range of weights of nodes from normal animals. Secondly, if the contralateral node is available, it can be calculated whether or not the difference in weights between ipsilateral and contralateral nodes is greater than in normal animals. In the case of the popliteal lymph nodes, where the normal range was derived from 31 animals, both techniques gave similar results in terms of indicating abnormal enlargement. In the case of medial iliac lymph nodes, (only one node was definitely enlarged), this strict correlation did not apply. The range of normal weights and differences in weight between ipsilateral and contralateral nodes was based on a sample from only six animals. These results provide further evidence that more work on the size of individual nodes from normal animals using much larger numbers is required.

GENERAL DISCUSSION

It is hoped that the preceeding discussions of the results from Sections 1 and 2 of this thesis have covered most of the specific work undertaken. However, it needs to be re-emphasized that considerably more work needs to be carried out before a precise description of the size of lymph nodes of the normal sheep can be given. Present results indicate that there is a wide range of normal values of lymph nodes in the sheep, and presumably a similar comparative wide range of size would apply to cattle and pigs. If further work showed a similar range in normal cattle and pigs, it would have similar implications to meat inspection procedures for all classes of stock.

It is believed that this work already indicates that detectable lymph node enlargement is of no value in the diagnosis of arthritis in the carcases of lambs. Because of the wide range of size in normal nodes, only a small proportion of enlarged nodes could ever be detected, particularly if only palpation or visual examination were carried out. Conversely, the very large size of the jejunal nodes of the lambs could be described easily as abnormal in comparison to those of older sheep, if these normal age differences were not appreciated. Thus in many instances a meat inspection judgement based on only the size of a lymph node lacks both sensitivity and specificity; palpation of lymph nodes is an inaccurate technique in meat inspection unless detection of only grossly enlarged nodes is required. With the exception of caseous lymphadenitis, it is difficult to envisage a condition of importance to meat hygiene where gross enlargement of a lymph node occurs without obvious gross lesions in the area of drainage of the node.

As already discussed, pathological changes of a node are not only related to changes in size. Incision of a diseased node may reveal gross morphological change, which may provide useful information on the extent and type of disease. However, the incision of a node which is infected can result in certain problems. The work of Samuel et al. (1980) has already demonstrated how meat inspection procedures, including the incision of nodes, can significantly increase the contamination of cattle carcases and viscera with Salmonellae. There is also the possibility of increasing the risk of occupationally acquired zoonoses for inspectors; the incision of an active lesion of tuberculosis could create an aerosol of infected particles.

In summary, it is believed that in the future, less emphasis should be placed on the size of lymph nodes during inspection procedures. If lymph nodes are to be palpated it is probably more appropriate to attempt to determine whether or not there are changes in texture rather than changes in size.

It is believed that the work reported in this thesis is just one small example of how traditional meat inspection techniques are in need of reappraisal.

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APPENDIX

Appendix. The name of the 19 groups of the lymph nodes examined.

1. MANDIBULAR
2. PAROTID
3. LATERAL RETROPHARYNGEAL
4. MEDIAL RETROPHARYNGEAL
5. SUPERFICIAL CERVICAL
6. PROPER AXILLARY
7. POPLITEAL
8. ISCHIATIC
9. SUBILIAC
10. SUPERFICIAL INGUINAL
11. RENAL
12. MEDIAL ILIAC
13. CRANIAL TRACHEOBRONCHIAL
14. LEFT TRACHEOBRONCHIAL
15. CAUDAL MEDIASTINAL
16. HEPATIC
17. COLIC
18. ILEOCOLIC
19. JEJUNAL