

# The topographical anatomy and arterial supply of the thyroid and parathyroid glands in the budgerigar (*Melopsittacus undulatus*)

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*This investigation was conducted on 30 adult, male and female budgerigars. The thyroid and parathyroid glands adhere to each other on both sides of the body and are surrounded by a common connective tissue capsule. The glandular "cluster" on the right side was cranial and dorsal in relation to that on the left.*

*The thyroid glands were most often supplied with blood by the following glandular arteries: the caudal thyroid (1–4), the cranial thyroid (1–3) and the middle thyroid (1 or 2). The caudal thyroid generally branched from the oesophago-tracheobronchial artery. On the right side the cranial and middle thyroid arteries most commonly originated from the ascending oesophageal artery, whereas on the left side they separated from the common trunk of the comes nervi vagi and the ascending oesophageal artery. On each side of the body a single gland was supplied with blood by between 1 and 6 arteries (in most cases by 2–3). On average, the number of thyroid arteries on the right side was statistically significantly higher than the number on the left. The parathyroid artery (1–2) most commonly originated from the caudal thyroid artery, generally separating from this artery under the fibrous capsule of the glandular "cluster".*

**Key words:** budgerigar, thyroid gland, parathyroid glands, topography, thyroid artery, parathyroid artery

## INTRODUCTION

On the basis of the information available in the standard textbooks as well as in some research papers [7], the impression may be gained that in all avian species the thyroid and parathyroid glands are supplied with blood by the cranial and caudal thyroid arteries, which originate separately and directly from the common carotid artery. The results of thorough examinations of this region of the thyroid gland and carotid body of domestic birds have revealed a certain variety from species to species [5, 11] in terms of both the layout and the blood supply of

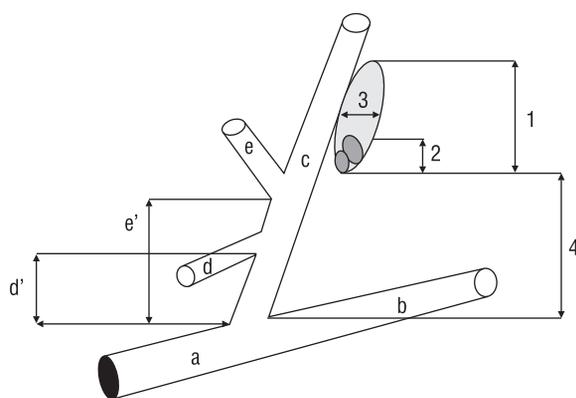
the thyroid and parathyroid glands. There were also variations within a given species [1]. According to Raether [11], these differences are determined by topographical relationships between the organs and the large blood vessels situated within the thoracic inlet.

There are few published works on the layout and the histological structure of the thyroid and parathyroid glands in budgerigars [6–8]. However, we have not traced any research paper which provides a detailed description of the thyroid arteries in the budgerigar.

The aim of this paper is to describe the thyroid and parathyroid arteries in the budgerigar, at the same time taking into account the topographic relations in the thyroid region between the thyroid glands and the parathyroid glands, the thyroid arteries, the surrounding organs and the large vessels.

## MATERIAL AND METHODS

Thirty adult budgerigars (19 males and 11 females) were used in the investigation. The dead birds were obtained from the Wrocław Zoological Garden during the period 1997–98; 12 of them came from May and June, the remainder from November and December. The birds' arterial vessels were injected with coloured latex through the left ventricle (latex injection kit ZPK — 580 Griffing & George). The material was fixed in 10% formalin, and was then dissected at 17–25-fold magnification using a Technival 2 microscope. After putting aside the ingluvies, the length and width of the thyroid and parathyroid glands were measured bilaterally (Fig. 1). Their topographical location was established separately on each side, with regard to the trachea, oesophagus, common carotid arteries and jugular veins, as well as on the basis of the measurement of the distance between the division site of the brachiocephalic trunk into the common carotid artery and subclavian artery and the caudal extremity of the glands. On the basis of a similar measurement, the position of the origin of the oesophagotracheobronchial artery and vertebral trunk was established (Fig. 1).



**Figure 1.** Diagram of the measurements conducted on both sides of the body; 1 — length of thyroid and parathyroids; 2 — length of parathyroids; 3 — width of the thyroid; 4 — distance between the division site of the brachiocephalic trunk and the caudal extremity of the glands; a — *Truncus brachiocephalicus*, b — *A. subclavia*; c — *A. carotis communis*, d — *A. esophagotracheobronchialis*, d' — distance between the division site of the brachiocephalic trunk and the origin of oesophago-tracheobronchial artery, e — *Truncus vertebralis*, e' — distance between the division site of the brachiocephalic trunk and the origin of the vertebral trunk.

During the investigation of the arterial vessels of the glands, the following evaluation criteria were taken into account: 1) the number, site of origin and separation pattern of the thyroid and parathyroid arteries; 2) the course of the arteries against the background of the surrounding organs before they join the glands; and 3) the site on the gland surface where the thyroid and parathyroid arteries penetrate into the gland parenchyma.

The statistically significant differences between the average gland dimensions and the average number of vessels were determined using Student's t-test at a level of significance  $\alpha = 0.05$  and  $n_1 + n_2 - 2$  degrees of freedom [10]. Three hypotheses were assumed: 1) the arithmetical average for the dimensions of the gland (length, width) between the two sexes does not differ significantly; 2) the arithmetical average for the number of right and left vessels does not differ significantly between the two sexes; and 3) the arithmetical average for the number of vessels on the right and left sides, irrespective of a bird's gender, does not differ significantly. These hypotheses were confronted with alternative hypotheses.

## RESULTS

In all the budgerigars examined the thyroid and parathyroid glands situated on both sides of the body were in the form of gland "clusters" which were surrounded by a common capsule. The results showed that in a "cluster" (of average dimensions: right:  $3.38 \times 1.47$  mm; left:  $3.33 \times 1.66$  mm), the thyroid glands took up 2/3 of its cranial part. Two parathyroid glands pressed into the thyroid occupied the remaining caudal part. The average length of the parathyroid glands was 1.09 mm on the right and 1.04 mm on the left.

On the basis of the bilateral tests conducted for the hypothesis that the arithmetical averages of the dimensions of the glands on the right and left sides in females and males are not essentially different, there are no grounds to reject the hypothesis adopted. The statistical values  $t$  are lower than the critical value  $t_{\alpha}$  from the tables of Student's-t distribution [10].

The bilateral glands were situated asymmetricaly with regard to each other. The right-hand ones were caudal to the angle between the ingluvies and the distal part of the oesophagus, on average 3.85 mm (2.32–5.24 mm) from the division site of the brachiocephalic trunk. Their medial surface adhered partly to the common carotid artery and partly to the oesophagus. The dorsal border of the "cluster" touched the right jugular vein and the vagus nerve.

The left-hand glands were positioned more caudally and dorsally than those on the right. The average distance between the caudal pole of the glands and the division point of the brachiocephalic trunk was 3.34 mm (1.19–5.20 mm). Their medial surface adhered to the jugular vein and the vagus nerve. In the case of the left common carotid artery, the glands only touched this artery with their ventral border.

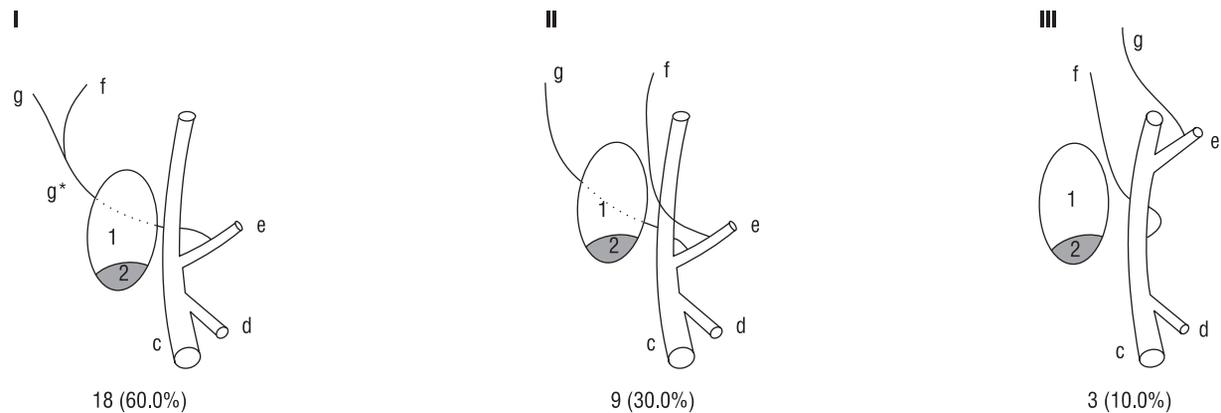
In the vicinity of the glands each common carotid artery gave off two large arteries, one being the oesophagotracheobronchial, on the right on average 3.18 mm and on the left 3.26 mm from the division site of the brachiocephalic trunk, the other the vertebral trunk, on average 4.15 mm and 3.93 mm from this site respectively (Fig. 2 d, e). 3 parrots additionally had their ascending oesophageal artery (Fig. 2-III-f) on the right at a point halfway along the glands.

The vertebral trunk gave off the *comes nervi vagi* artery and sometimes the thyroid arteries (Table 1). In 9 specimens this right vertebral trunk sent out the ascending oesophageal artery (Fig. 2-II-f). The variants mentioned in the patterns of the large arteries on each side of the body are summarised in Figure 2.

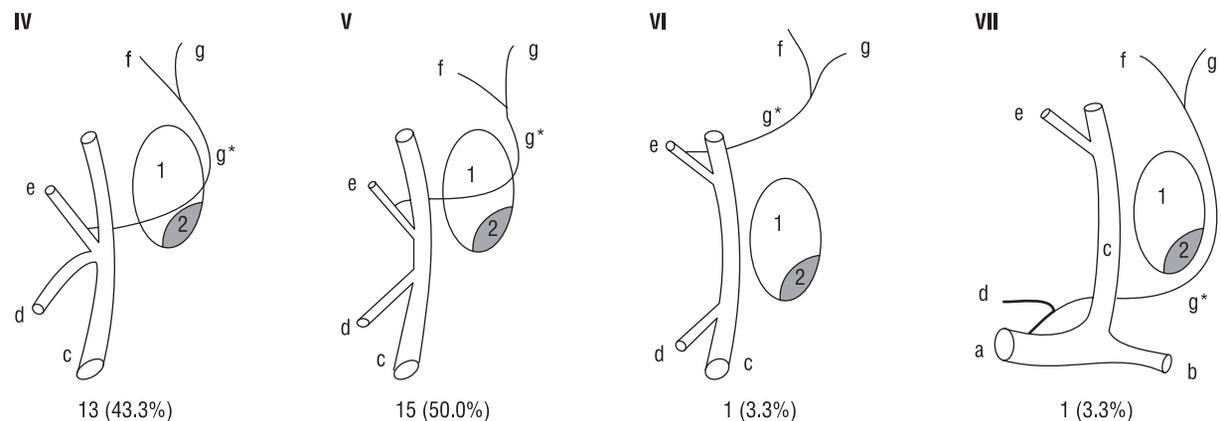
The topographical relationships between these arteries (especially the *comes nervi vagi* artery and the ascending oesophageal artery) and the glands had a clear influence on the position of the separation site and course of the gland arteries.

Bilaterally, the *comes nervi vagi* arteries were found to follow a different course. Initially, the right-hand artery ran laterally and dorsally from the thyroid gland and jugular vein (Fig. 5g\*). It then curved cranially and passed alongside the lateral aspect of the jugular vein.

**Right side**



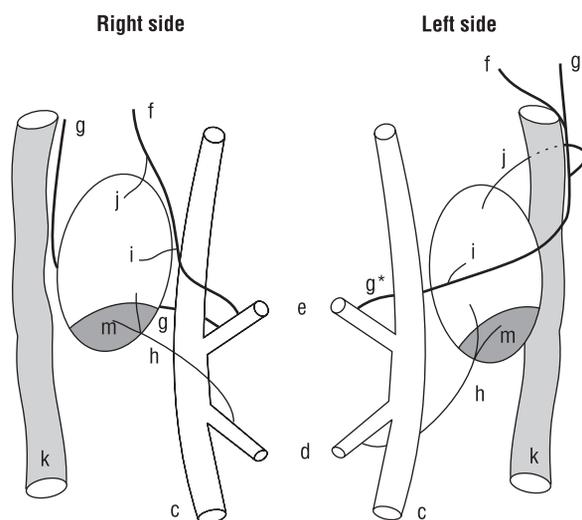
**Left side**



**Figure 2.** Variations in the topographical relationships between the thyroid and parathyroid glands and the large arteries which separate from the common carotid artery in the region of these glands on the left and right sides of the body; I–VII — topographical variants, number and frequency of their occurrence indicated as a percentage; 1 — medial surface of thyroid gland, 2 — parathyroid glands; a — *Truncus brachiocephalicus*, b — *A. subclavia*, c — *A. carotis communis*, d — *A. esophagotracheobronchialis*, e — *Truncus vertebralis*, f — *A. esophagalis ascendens*, g — *A. comes nervi vagi*, g\* — common trunk of the *comes nervi vagi* and ascending oesophageal arteries.

**Table 1.** Total and averages for the frequency of occurrence of the thyroid arteries in relation to the side of the body (a — right, b — left) and the sex of the bird

	Left arteries			Right arteries		
	Females (n = 11)	Males (n = 19)	Birds (n = 30)	Females (n = 11)	Males (n = 19)	Birds (n = 30)
<b>Cranial artery thyroid</b>						
One artery	5	15	20	4	9	13
Two arteries	2	2	4	3	2	5
Three arteries	0	0	0	—	2	2
Absent	4	2	6	4	6	10
<b>Caudal Artery thyroid</b>						
One artery	9	14	23	5	10	15
Two arteries	2	4	6	6	8	14
Three arteries	0	1	1	0	0	0
Four arteries	0	0	0	0	1	1
<b>Middle artery thyroid</b>						
One artery	5	5	10	9	10	19
Two arteries	1	1	2	1	2	3
Absent	5	13	18	1	7	8

**Figure 3.** Thyroid and parathyroid glands (medial surface of “cluster”) against the background of the most commonly observed arterial pattern in budgerigar on the right and left-hand sides of the body; c — *A. carotis communis*, d — *A. esophagotracheobronchialis*, e — *Truncus vertebralis*, f — *A. esophagalis ascendens*, g — *A. comes nervi vagi*, g\* — common trunk of the *comes nervi vagi* and ascending oesophageal arteries, h — *A. thyroidea caudalis*, i — *A. thyroidea media*, j — *A. thyroidea cranialis*, k — *V. jugularis*, m — *A. parathyroidea*.

The right-hand *comes nervi vagi* artery gave off the suprascapular artery, the ascending cutaneal colli artery and also the ascending oesophageal artery (Fig. 2-I-g\*, f).

In 12 specimens, the right-hand arteries — the *comes nervi vagi* and the ascending oesophageal — arose separately from the common carotid or verte-

bral trunk (Fig. 2-II, III-f, g). In these specimens, exclusively, the ascending oesophageal artery sent out the thyroid arteries (Fig. 3f, i, j; Table 1). This is possibly due to the topography of the course of the vessel, the first part of which passed, in these cases, along the medial surface of the thyroid gland. The *comes nervi vagi* artery, separating individually from

**Table 2.** Number of the single and multiples thyroid arteries; acc — *A. carotis communis*, otb — *A. esophagotracheobronchialis*, v — *Truncus vertebralis*, cnv — *A. comes nervi vagi*, oea — *A. esophagalis ascendens*)

Arteries	Number of vessels (number of birds)						Number of vessels		
	Acc	Otb	V	Cnv + Oea	Cnv	Oea	Females	Males	Birds
<b>Right side</b>									
Cranial thyroid	4 (4)	0 (0)	4 (4)	0 (0)	2 (1)	19 (11)	10	19	29
Caudal thyroid	7 (5)	33 (22)	1 (1)	0 (0)	0 (0)	6 (4)	17	30	47
Middle thyroid	3 (3)	3 (3)	4 (4)	0 (0)	2 (2)	13 (12)	11	14	25
Total							<b>38</b>	<b>63</b>	<b>101</b>
Average number							<b>3.37</b>	<b>3.45</b>	<b>3.31</b>
<b>Left side</b>									
Cranial thyroid	3 (3)	0 (0)	0 (0)	24 (20)	0 (0)	1 (1)	9	19	28
Caudal thyroid	8 (7)	26 (24)	4 (4)	0 (0)	0 (0)	0 (0)	13	25	38
Middle thyroid	1 (1)	0 (0)	4 (4)	9 (8)	0 (0)	0 (0)	7	7	14
Total							<b>29</b>	<b>51</b>	<b>80</b>
Average number							<b>2.63</b>	<b>2.68</b>	<b>2.67</b>

the vertebral trunk, passed along the medial aspect of the jugular vein (Fig. 3g). Occasionally this artery also sent out the thyroid arteries (Table 1).

The left *comes nervi vagi* artery passed craniolaterally, in general on the medial surface of the thyroid initially and then dorsolaterally to the gland and the jugular vein (Fig. 3g\*, g). In its course, it gave off, in caudocranial order, the following: the suprascapular artery, the thyroid arteries (Table 1), the ascending oesophageal artery and the ascending cutaneous colli artery. On the left side the *comes nervi vagi* artery and the ascending oesophageal artery always arose from the vertebral trunk by one stem (Fig. 2-IV, V, VI-g\*). In one case this common stem originated from the brachiocephalic trunk together with the oesophagotracheobronchial artery (Fig. 2-VII-d, g\*).

The thyroid glands were found to have their blood supplied through: 1–3 cranial thyroid arteries, 1–4 caudal thyroid arteries and 1–2 middle thyroid arteries.

At least one cranial thyroid artery (*A. thyroidea cranialis*) was found in 20 (66.7% ± 16.8%) birds on the right side of the body and in 24 (80.0% ± 14.3%) birds on the left (Table 2). In 8 specimens, two cranial thyroid arteries were found on one (Fig. 4j) or on both sides of the body (one female). In 2 male specimens, there were 3 cranial thyroid arteries on the right side. These multiple arteries branched off separately from the same main vessel.

The bilateral cranial thyroid arteries differed from each other in their separation site from the larger vessels and, in consequence, in the topography of their course.

The right cranial thyroid artery (or arteries) can originate from the ascending oesophageal artery (11 birds — 36.7% ± 17.2%, with 19 vessels), from the common carotid artery (Fig. 5j), from the vertebral trunk (Fig. 6j) and from the *comes nervi vagi* artery (Table 1). It most commonly originated near the cranial extremity of the thyroid gland, so that in the vicinity of this site it penetrated under the fibrous capsule of the gland (“short vessels”; Fig. 5j).

The left cranial thyroid artery in general arose from the common trunk of the *comes nervi vagi* artery and the ascending oesophageal artery (20 birds — 66.7% ± 16.8%, with 24 vessels; Fig. 3g\*, j; 4g\*, j). It rarely branched off from other main vessels (Table 1).

The left cranial thyroid artery could be a “long” (53.3% ± 17.8%) or “short” vessel (26.6% ± 15.7%). The “long” artery originated dorsally and laterally to the cranial extremity of the thyroid gland. It initially ran caudomedially, crossing in its course the dorsal aspect of the jugular vein (Fig. 3j). The behaviour of the “short” vessel is similar to the aforementioned behaviour of the right cranial thyroid artery (Fig. 4j).

Irrespective of side of the body, the cranial thyroid artery (or arteries), under the fibrous capsule, gave off two or several subcapsular vessels. Occasionally the division into these two glandular *rami* took place cranially to the thyroid gland (Fig. 5j). The final twigs of the subcapsular vessels penetrated the thyroid parenchyma, entering through the lateral and medial surfaces into the cranial 1/3 or the middle 1/3 of the gland.



**Figure 4.** Isolated left thyroid and parathyroid glands and the arteries supplying blood to the glands (male). View of the lateral surface of the glands. The vertebral trunk, and the oesophago-tracheobronchial artery put aside laterally.



**Figure 5.** Ventral view of the right area of the thoracic inlet (female) after putting aside cranially the ingluviens. Among 30 birds investigated only one female had this artery pattern.



**Figure 6.** Ventral view of right-side area of the thoracic inlet (male). The ingluviens, the oesophagus and jugular vein were excised; 1 — thyroid gland (Fig. 5 medial surface, Fig. 6 lateral view), 2 — parathyroid glands; a — *Truncus brachiocephalicus*, b — *A. subclavia*, c — *A. carotis communis*, d — *A. esophagotracheobronchialis*, e — *Truncus vertebralis* and its divisions into *Aa. vertebrales ascendens et descendens*, f — *A. esophagalis ascendens*, g\* — common trunk of the *comes nervi vagi* and ascending oesophageal arteries, h — *A. thyroidea caudalis*, i — *Aa. thyroideae medie*, j — *Aa. thyroideae craniales* (Fig. 5, 6 *A. thyroidea cranialis*), k — *V. jugularis*, l — *N. vagus sinister*; running at the medial surface of the "cluster" (Fig. 5, 6 *N. vagus*), m — *A. parathyroidea*, n — *A. suprascapularis*, 3,3' — crop and oesophagus, 4 — trachea, 5 — syrinx, 6 — heart.

At least one caudal thyroid artery (*A. thyroidea caudalis*) occurred on both sides of the body in all the budgerigars examined. In 16 (53.3%  $\pm$  17.8%) specimens we found two caudal thyroid arteries on one side or on both sides (2 females, 2 males). One male bird had 4 arteries on its right-hand side, and one male bird had 3 arteries on the left side (Table 2).

The single or multiple caudal thyroid arteries in most cases were the branch or the branches of the respective oesophago-tracheobronchial artery (right — 22 birds — 73.3%  $\pm$  13.3%, with 33 vessels; left — 24 birds — 80.0%  $\pm$  14.3% with 26 vessels; Fig. 4h, 6h). They seldom separated directly from the common carotid (Fig. 5h) or the vertebral trunk (Table 1).

Unlike the cranial thyroid artery, the multiple caudal thyroid arteries could arise from different, larger arteries. In 3 cases on the right and 3 on the left (including in one specimen on both sides), one of the two thyroid caudal arteries originated from the oesophago-tracheobronchial artery, whereas the other took its origin from the common carotid or from the vertebral trunk. In one male bird with 3 left caudal thyroid arteries, each of them originated from different arteries.

Originating from the first part of the oesophago-tracheobronchial artery, the caudal thyroid artery ran cranio-laterally, crossing the common carotid artery, the right one on the ventral aspect of this artery and the left one on its dorsal aspect (Fig. 3h, 6h). Irrespective of the side of the body, before the caudal thyroid arteries penetrated the glands they sent branches to the ultimobranchial gland and the carotid body, while the right thyroid vessels gave off the oesophageal *ramus*. Under the fibrous capsule of the "cluster", on the attachment line of the thyroid and the parathyroid glands, the caudal thyroid artery gave out the laterally-running parathyroid artery (Fig. 3m, 6m). It then penetrated the caudal 1/3 and middle part of the thyroid. The very well-developed caudal thyroid artery also entered the cranial part of the gland with its final twigs (in 3 birds on the right side and in 3 birds on the left side).

At least one middle thyroid artery (*A. thyroidea media*) was found on the right side in 22 specimens (73.3%  $\pm$  15.9%) and on the left side in 12 birds (40.0%  $\pm$  17.4%; Table 1). The right artery commonly arose from the ascending oesophageal artery (12 cases: 30.0%  $\pm$  16.4%), whereas the left arose from the common stem of the *comes nervi vagi* and the ascending oesophageal arteries (8 cases: 23.3%  $\pm$  7.7%; Fig. 3g\*, i, 4g\*, i). In 5 speci-

mens there were two middle thyroid arteries (Fig. 4i). In 3 specimens, each of the two arteries originated from a different larger vessel. On the right, (two cases) one originated from the ascending oesophageal and the other from the vertebral trunk or the common carotid. On the left, one of them originated from the common stem of the *comes nervi vagi* and the ascending oesophageal arteries, the other from the vertebral trunk.

The site of origin of the middle thyroid artery (or arteries) was found near the glands. Thus, generally, a short trunk of it penetrated the thyroid at the level of the middle 1/3 of the "cluster". In 5 birds on the right side and in 3 on the left side the final twigs of the middle thyroid artery also penetrated the cranial part of the thyroid, assuming the role of the missing cranial thyroid artery.

On one side the thyroid gland most commonly received blood through two arteries or groups of arteries (caudal thyroid and cranial thyroid or caudal thyroid and middle thyroid) — this was found in 13 specimens on the right-hand side (43.3%  $\pm$  17.6%) and in 17 specimens (56.7%  $\pm$  17.6%) on the left — or through 3 arteries or groups of arteries (cranial, caudal and middle thyroid), as evidenced in 14 (46.7%  $\pm$  17.8%) specimens on the right and 10 (33.3%  $\pm$  16.8%) on the left. It was rare for one type of vessel to supply blood to the gland (caudal thyroid artery or arteries — 3 cases on the right and 3 cases on the left).

The total number of vessels supplying the right thyroid with blood ranged from 2–6 vessels, whereas there were 1–6 vessels for the left thyroid.

A significance test was conducted of the difference between the average number of left and right vessels (Table 1). The empirical value of the statistics  $t$  assumed a greater value than the critical value  $t_c$  from the tables of Student's-t distribution. This gives grounds for rejecting the hypothesis about the lack of a statistically significant difference between the average number of thyroid arteries on the right and on the left-hand sides.

The number of vessels was similar in females and males (Table 1). On the basis of the bilateral tests conducted for the hypothesis that the average arithmetical numbers of the arteries in males and females on each part of the body did not differ significantly, there are no grounds for rejecting the hypothesis adopted.

The parathyroid artery (*A. parathyroidea*) was present as a single vessel or 2–3 parathyroid branches (37.7%  $\pm$  17.1% on the right, 33.3%  $\pm$  12.7% on the left). A single parathyroid artery most often arose

from the caudal thyroid artery (Fig. 3m, 6m) separating itself inside the "cluster". In one case, the right parathyroid artery arose from the oesophagotracheobronchial artery. Multiple parathyroid branches may take their origin from two different vessels: on the right side — from the caudal thyroid artery and from the oesophago-tracheobronchial artery (5 birds), and on the left — from the caudal and middle thyroid arteries (one bird).

A parathyroid artery or branch which originates from a vessel other than the caudal thyroid artery originates caudal to the glands.

A parathyroid artery which is the branch of the caudal thyroid artery enters the parathyroid under the capsule of the „cluster" on the line of attachment of these glands with the thyroid gland (Fig. 3m, 6m).

## DISCUSSION

The examination of the topography and arterial supply of the thyroid and parathyroid glands of the budgerigar was conducted using 30 birds. The glands, situated in proximity to each other, were surrounded by a common connective tissue capsule [6, 7] so that a characteristic "cluster" of the thyroid and parathyroid glands was formed on each side of the body. The bilateral "clusters" were of very similar dimensions. In each the thyroid gland took up 2/3 of the cranial part, whereas the parathyroid glands occupied the remaining caudal part.

According to Ringer [12], in the avian female the size and mass of the thyroid glands are usually bigger than in the males.

In case of budgerigars, if there were sexual dimorphism in the thyroid gland dimension, it would involve the same dimorphism in the dimensions of the whole "cluster".

In this investigation no statistically significant differences were found between the dimensions of the "clusters" in females and males.

Bilateral glands are situated asymmetrically with regard to each other. The right ones are most commonly placed more cranially and ventrally than those on the left. Such a position corresponds to the one described by Raether [11] in *Columba*, *Anser* and *Anas*. Breit et al. [4] also described the asymmetry of the bilateral glands in chicken and Raether [11] in adult *Gallus*. However, in these domestic birds, the left glands were located more cranially. Abdel-Magied and King [1], working on adult domestic fowls (*Gallus gallus domesticus*), and Hess et al. [9], working on chicken, drew attention to the asymmetry of the

bilateral parathyroid localisation. The right ones were located in the direct vicinity of the caudal pole of the thyroid gland, while the left ones were usually caudal to this extremity.

On the basis of the results of the morphological analysis of the gland arteries, it can be stated that 3 single arteries or 3 groups of multiple thyroid arteries supply blood to the budgerigar thyroid. These vessels are the caudal thyroid, cranial thyroid and middle thyroid arteries. In a single specimen the absolute number of arteries for the right or left side ranged from 2–6 and 1–6 arteries, respectively. The average number of vessels for the right-hand glands was statistically significantly higher than the number for the left-hand ones. Other researchers also observed multiple thyroid arteries (instead of a single arterial trunk) in domestic birds, such as *Gallus*, *Anas*, and *Anser* [5, 11], although they did not give the absolute number of arteries supplying a single thyroid of a given species of bird. In this context, it seems appropriate to distinguish either 3 thyroid arteries or 3 groups of thyroid arteries in these birds, classifying the latter ones according to the site where they enter the thyroid.

On one side of the budgerigar's body, the thyroid can be supplied with blood by one, two or 3 (single or multiple) thyroid arteries. One thyroid artery (or group of arteries), which in this arterial pattern was always the caudal thyroid artery (one to four), was found in 6 budgerigars (3 on the right, 3 on the left). This pattern of blood supply of the thyroid is regarded as being the most common among avian species [2]. According to our observations, in budgerigars the blood is supplied to the thyroid on either side of the body, most commonly by two or three groups of thyroid arteries. According to Baumel [2], birds with two thyroid arteries include several species of *Columbidae*, galliform species, seagulls and flamingos. Birds with 3 thyroid arteries include ducks (*Anatidae*). The examination results of other researchers [5, 11] show that 3 thyroid arteries occur in the domestic birds *Gallus*, *Anas*, *Anser* and *Columba*. However, Bhaduri et al. [3] distinguish only one artery in the domestic pigeon, this being a caudal thyroid artery. The differences presented in the results of the researchers cited when referring to the number of arteries supplying blood to the thyroid of *Columba* are probably the result of individual variations in this avian species. Variations in the arterial supply in the budgerigars examined result from the same individual variation.

In budgerigars, as in other avian species [2, 5, 11], thyroid arteries may originate from the common carotid artery, the oesophago-tracheobronchial artery, the vertebral trunk, the ascending oesophageal artery, the *comes nervi vagi* artery or from the common trunk of the last two. The significant asymmetry observed in the sites of origin of the right thyroid arteries with regard to the left arteries, as well as the different courses of these vessels, are most probably connected with the position of the oesophagus on the right-hand side of the neck. Specialist publications lack information about the aforementioned differences. We agree with Raether [11] that the arterial supply of the thyroid glands in different avian species is determined by species-characteristic topographical relationships inside the thoracic inlet between these glands and the large vessels which separate from the common carotid artery (directly or indirectly) such as the oesophago-tracheobronchial artery, the *comes nervi vagi* and the vertebral trunk. As far as this problem is concerned, Raether [11] drew attention to individual variance in the birds examined but did not refer to the parts of the body in his observations.

Our reports on the arterial supply of the thyroid gland in budgerigars, similarly to the results of the aforementioned authors, make it possible to state that the blood supply of the thyroid by means of these two thyroid arteries originating from the common carotid artery is only one of the variants of the blood supply of these glands in this species of bird. Among the 30 specimens investigated only one female had this particular arterial pattern, this being found on the right-hand side of the body (Fig. 5).

The right and left parathyroid artery (1–2) usually originated from the caudal thyroid artery, arising from this artery under the external lamina of the fibrous capsule of the “cluster”. Occasionally the parathyroid artery could originate from the oesophago-tracheobronchial or middle thyroid arteries. This applied mainly to those individuals in which these two parathyroid arteries occurred on one side of the body. If so, one of them originated caudal to the caudal extremity of the “cluster”. In these cases the

parathyroid artery passed cranio-laterally and entered the caudal parathyroid gland through the caudal extremity of the “cluster”, having supplied blood to the carotid body. The separation variant presented and the course of the parathyroid artery are similar to the description of these arteries in domestic birds as described by other researchers [1, 5, 11].

## REFERENCES

1. Abdel-Magied EM, King AS (1978) The topographical anatomy and blood supply of the carotid body region of domestic fowl. *J Anat*, 126: 535–546.
2. Baumel JJ (1993) *Systema cardiovasculare*. In: Baumel JJ (ed.). *Handbook of avian anatomy. Nomina Anatomica Avium*. Ornithological Club, Cambridge, Massachusetts.
3. Bhaduri JL, Biswas B, Das SK (1957) The arterial system of the domestic pigeon (*Columba livia* Gmelin). *Anat Anz*, 104: 1–13.
4. Breit S, König HE, Stöger E (1998) Morphological studies on the thyroid gland of chicken in addition to seasonal changes. *Anat Histol Embryol*, 27: 271–276.
5. Cotofan N, Cotofan O, Cozariuc L (1970) Cercelari privind vascularizatia tiroidei si paratiroidei la pasari. *Ins Ionescu Brad Iasi Lucr Sti II Zooteh Med Vet*, 11: 145–152.
6. Feder FH (1971) Zur Topographie und mikroskopischen Anatomie der endokrinen Organe beim Wellensittich (*Melopsittacus undulatus*). *Anat Anz*, 128: 338–353.
7. Golob Z, Bavdek S, Pogacnik A, Lorger J, Mrzel I (1991) The budgerigar (*Melopsittacus undulatus*) thyroid gland structure. 1 Conf Euro Commit AAV Wien Proceedings European Assoc Avian Vets, pp. 450–452.
8. Golob Z, Mrzel I, Bavdek S, Dovc A (1991) Hyperplasia of the thyroid gland (*Melopsittacus undulatus*). 1 Conf Euro Commit AAV Wien Proceedings European Assoc Avian Vets, pp. 447–449.
9. Hess JB, Fletcher DL, Buhr RJ, Britton WM (1990) Localization of chicken parathyroid glands through vital staining. *Poultry Science*, 69: 133–137.
10. Platt Cz (1978) *Problemy rachunku prawdopodobieństwa i statystyki matematycznej*. PWN Warszawa.
11. Raether W (1964) Schilddrüse, Epithelkörperchen, Ultimobranchialer Körper und Paraganglion caroticum ihre Topographie, Blutversorgung und Morphologie bei Huhn, Taube, Gans und Ente. *Inaug Diss Veterinär Anatomischen Institut, Gießen*, pp. 5–31.
12. Ringer RK (1976) Thyroids. In: Sturkie PD (ed.). *Avian Physiology*. Springer Verlag, New York, pp. 349–350.