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Gross Anatomy and Nerve Distribution of the Brachial Plexus in the Flippers of a Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

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Abstract We dissected a Pacific white-sided dolphin and observed the brachial plexus morphology and nerve distribution of the flippers. The brachial plexus was formed by the union of the ventral rami of the lower six cervical nerves and the first thoracic nerve. These seven roots of the brachial plexus joined or continued alone to form four trunks on the right side and three trunks on the left side. All the trunks united to form a flattened nerve cord, which gave off many branches in the axilla and continued as the common fascicle of the median and ulnar nerves.

The phrenic and pectoral nerves gave a branch to the costo-coracoid muscle. Intrinsic muscles distal to the shoulder joint were not identified except for the long head of the triceps brachii. Therefore, it is conceivable that the median and ulnar nerves contained no motor nerve fibers. The median and ulnar nerves and the radial and ulnar nerves supplied the skin on the palmar and dorsal surfaces of the flipper, respectively. The spinal segmental constitution of branches of the brachial plexus of the dolphin were clarified for the first time.

Key words: Cetacea, costo-coracoid muscle, forelimb, spinal nerve, spinal segment.

Introduction

Cetaceans have evolved to live secondarily in an aquatic habitat. Their general appearance and body shape have undergone some very remarkable changes with regards to morphological adaptations to an aquatic environment. In particular, the most conspicuous among such locomotive adaptations are the virtual absence of the hind limbs, and transformation of the forelimbs into a pair of paddle-shaped flippers. Thus, the anatomical features of the forelimb musculoskeletal elements are altered from those of terrestrial mammals.

Although the musculoskeletal system of cetaceans is well documented, there have been few detailed studies of the peripheral nervous system that control the muscular system. Cunningham (1877) stated that the brachial plexuses of some porpoises and a dolphin are formed by the union of two or three cords, which are composed of the ventral rami of the last five cervical and the first thoracic nerves (C4–T1). Schulte (1916) described that the brachial plexus of a *Balaenoptera borealis* fetus is composed of C5–T1. In *Kogia*, Schulte and Smith (1918) reported that the plexus consists of two trunks, which they termed the lesser and greater brachial trunks. Strickler (1978) also described two trunks constituting the plexus and the cranial and caudal trunks in *Pontoporia*, which were made up of ventral rami from C4–C6 and C6–C8, respectively. Kodama *et al.* (1991) dissected the brachial plexus of *Mesoplodon* and discussed the stratigraphic relationship of the ventral and dorsal divisions of the plexus. We also carried out a similar study on a Pacific white-sided dolphin and reported preliminary findings (Sekiya *et al.*, 2011). Kunze (1912) and Cooper *et al.* (2007) reported the distribution of the peripheral nerves in the flipper but did not reference the brachial plexus and spinal segmental innervations. Despite many studies of the dermatome of the skin and the segmental innervation of the skeletal muscles in terrestrial mammals (including humans), such studies have not yet been carried out on cetaceans. Here, we demonstrate the anatomical features of the brachial plexus and spinal segmental constitution of the nerves in the flipper of a Pacific white-sided dolphin, *Lagenorhynchus obliquidens.*

Materials and Methods

We used an adult female Pacific white-sided dolphin that had been stranded and died on the beach of Toyama Bay in Japan on May 16, 2003 (Nambu *et al.*, 2004). The cervicothoracic portion, including the first cervical to the second thoracic vertebrae and both flippers, were cut off from the carcass and preserved in 50% ethanol solution (Specimen ID: M33458, National Museum of Nature and Science). The specimen was dissected to expose the brachial plexuses and nerves arising from the plexuses. Subsequently, they were separated from the skeletal and muscular elements. To clarify the spinal segmental constitution of each branch, the epineuria surrounding the branches were first exhaustively removed using fine-tip tweezers under a surgical stereomicroscope (Koizumi and Sakai [1995] termed this method the nerve fascicle analysis). Nerve fibers contained in each branch were then traced back to the spinal roots by cutting off the perineurium (termed the nerve fiber analysis).

The terms used to describe the orientation of flippers are “palmar” (or ventral) and “dorsal”, “cranial” and “caudal”, and “proximal” and “distal”, similar to the terminology of terrestrial tetrapod animals. Regarding the terminology of the proper digital nerves, we numbered them in order from the radial side to the ulnar side (see the list of abbreviations). For other terminologies, we followed the Nomina Anatomica Veterinaria terminology (International Committee on Veterinary Gross Anatomical Nomenclature, 2005).

Results

Constitution of the brachial plexus

The right and left brachial plexuses were formed from the ventral rami of the caudal five cervical nerves (C4–C8) with two great branches of the ventral rami of the third cervical nerve (C3) and the first thoracic nerve (T1) (Fig. 1). These seven roots emerged from their respective intervertebral foramina and ran ventrolaterally between the scalenus dorsalis and scalenus ventralis muscles. On the right side, the two cranial roots (C3, C4) united as the cranial trunk, the third root (C5) became the cranial middle trunk, the caudal cervical three roots (C6, C7 and C8) merged as the other caudal middle trunk, and the last caudal root (T1) became the caudal trunk (Fig. 1A–B). On the left side, the C3 became the cranial trunk; the C4, C5, and C6 joined as the middle trunk; and the C7, C8, and T1 united as the caudal trunk (Fig. 1C–D). Subsequently, these trunks merged to form a flattened nerve cord (Fnc) approximately 1 cm in width. The Fnc then passed in front of the subscapularis muscle and entered the axilla. When the Fnc reached the axilla, it ended as ramifications of many nerve branches (Figs. 2A–B, 3A–B).

Branches of the brachial plexus

Branches of the brachial plexus can be classified into ventral and dorsal branches, which arise from the ventral and dorsal surfaces of the Fnc,

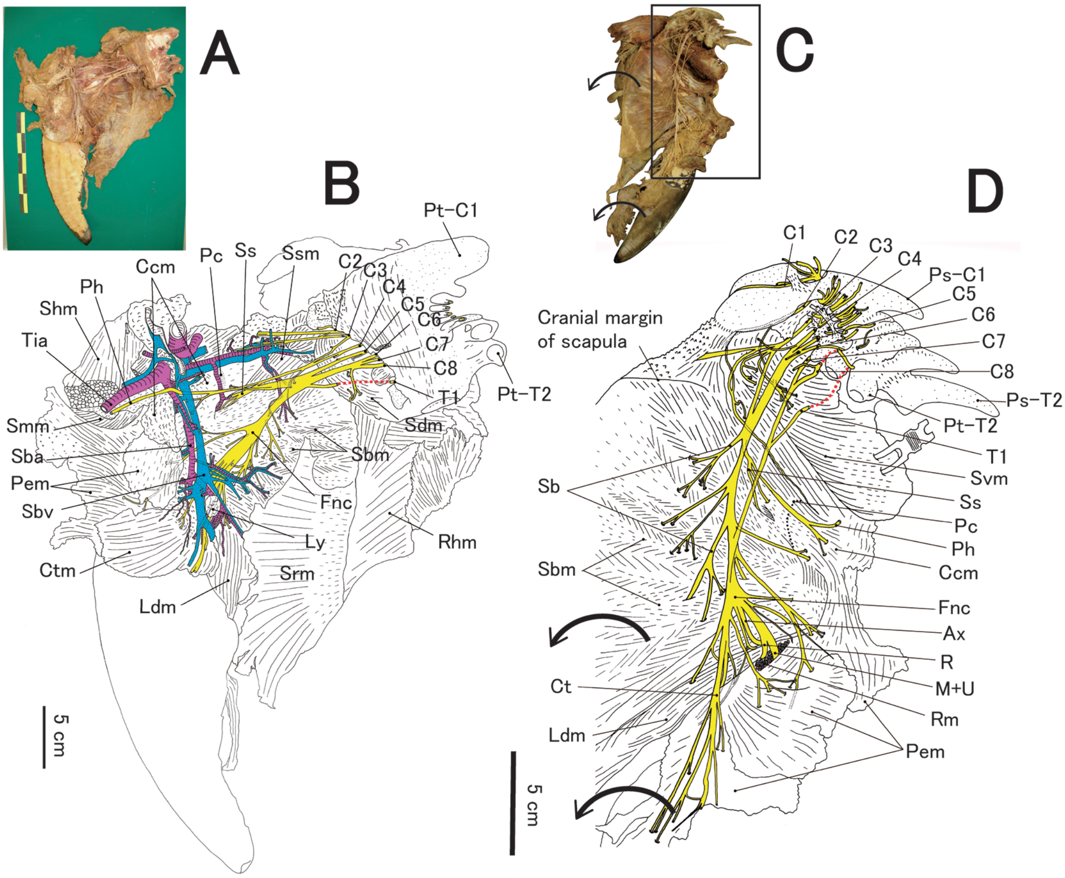

Fig. 1. Brachial plexus of the Pacific white-sided dolphin. The right brachial plexus (A and B) is viewed from the medial side with the scapula and the scalenus ventralis muscle removed. The left brachial plexus (C and D) is viewed from the lateral side with the scalenus dorsalis muscle removed. D is a line drawing of the box in C. Note that the left scapula and flipper have been reflected to the lateral direction (curved arrows) to observe the medial surface of the distal part of the brachial plexus. The severed parts of nerves during the dissection are shown by red-colored broken lines.

respectively. In principle, the former supplies the flexor while the latter supplies the extensor.

1. Ventral branches

The phrenic nerve and suprascapular nerve arose as a common stem from the extreme cranial region of the brachial plexus (Figs. 1, 3A–B). The phrenic nerve gave rise to a branch supplying the costo-coracoid muscle (as termed by Murie, 1870) before it entered the thorax. This muscle ran from the sternal end of the first sternal rib to the coracoid process of the scapula. The suprascapular nerve was a large nerve that passed through the suprascapular notch on the superior border of the scapula and supplied the supraspinatus and infraspinatus (Fig. 1). The pectoral nerve arose from the intermediate region of the Fnc. The right pectoral nerve innervated the pectoralis major, the costo-coracoid muscle, and the coracobrachialis. The branch to the left coracobrachialis arose directly from the Fnc (Fig. 4E–H). Several branches to the cutaneous trunci muscle (Ct) arose from the end of the Fnc, one of which was the thickest branch in the axilla (Figs. 2A–B, 3A–B).

In the right flipper, the median and ulnar nerves arose from a common stem (Fig. 4A–D). In the left flipper, not only the median and ulnar

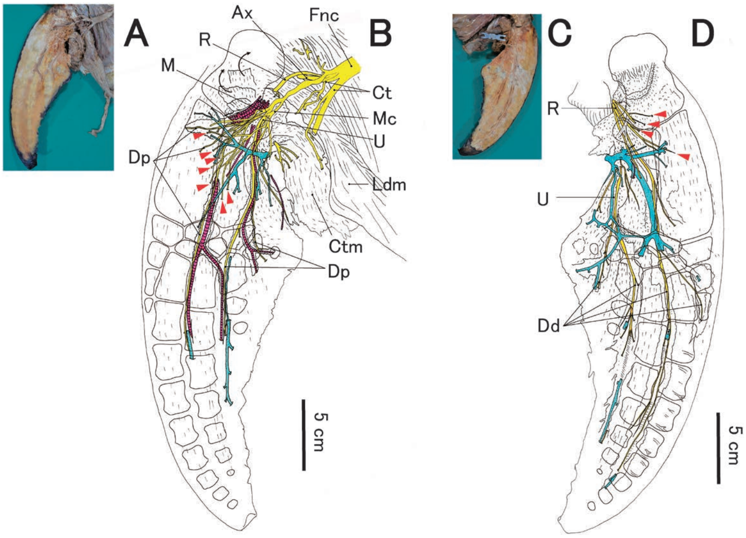

Fig. 2. The right brachial plexus and its branches showing the distribution of nerves (yellow), arteries (red), and cutaneous veins (sky blue). A and B: palmar view; C and D: dorsal view. Arrowheads indicate the branches of the musculocutaneous (Mc), median (M), and radial (R) nerves that supplied the dense connective tissue, and were then distributed into the subcutaneous tissue of the flipper. The severed parts of nerves during the dissection are shown by red-colored broken lines. The deep veins surrounding the arteries has been removed. The outlines of bones of the flipper obtained from X-ray photographs are superimposed on the drawing.

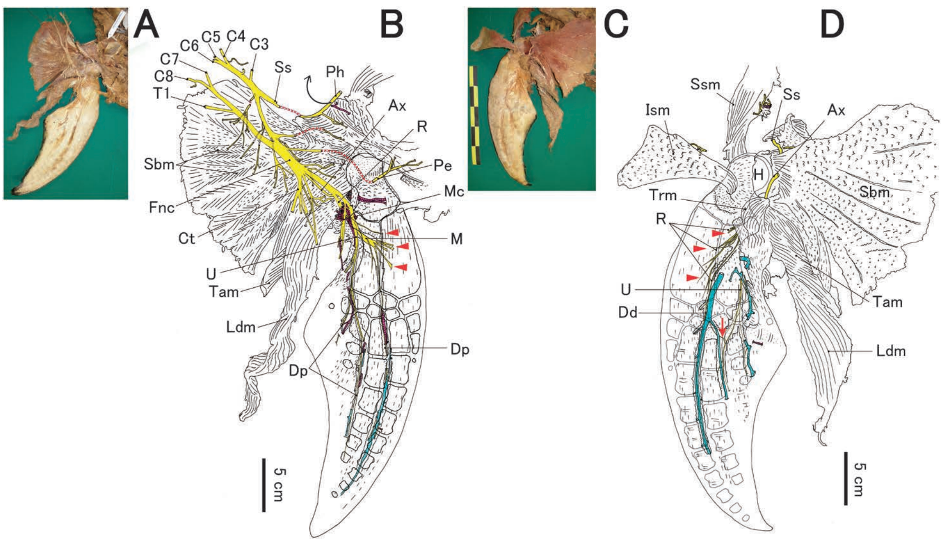

Fig. 3. Left flipper showing the distribution of nerves (yellow), arteries (red), and cutaneous veins (sky blue). A and B: palmar view; C and D: dorsal view. The scapula has been removed, and the supraspinatus (Ssm) and infraspinatus (Ism) muscles are reflected laterally. The phrenic nerve (Ph) is turned over to the cranial direction (curved arrow) from the original location. Arrowheads indicate similar branches to those in Fig. 2. The arrow indicates the connection between the radial and the ulnar nerves in the cleft between the medius and the annularis. The severed parts of nerves during the dissection are shown by red-colored broken lines.

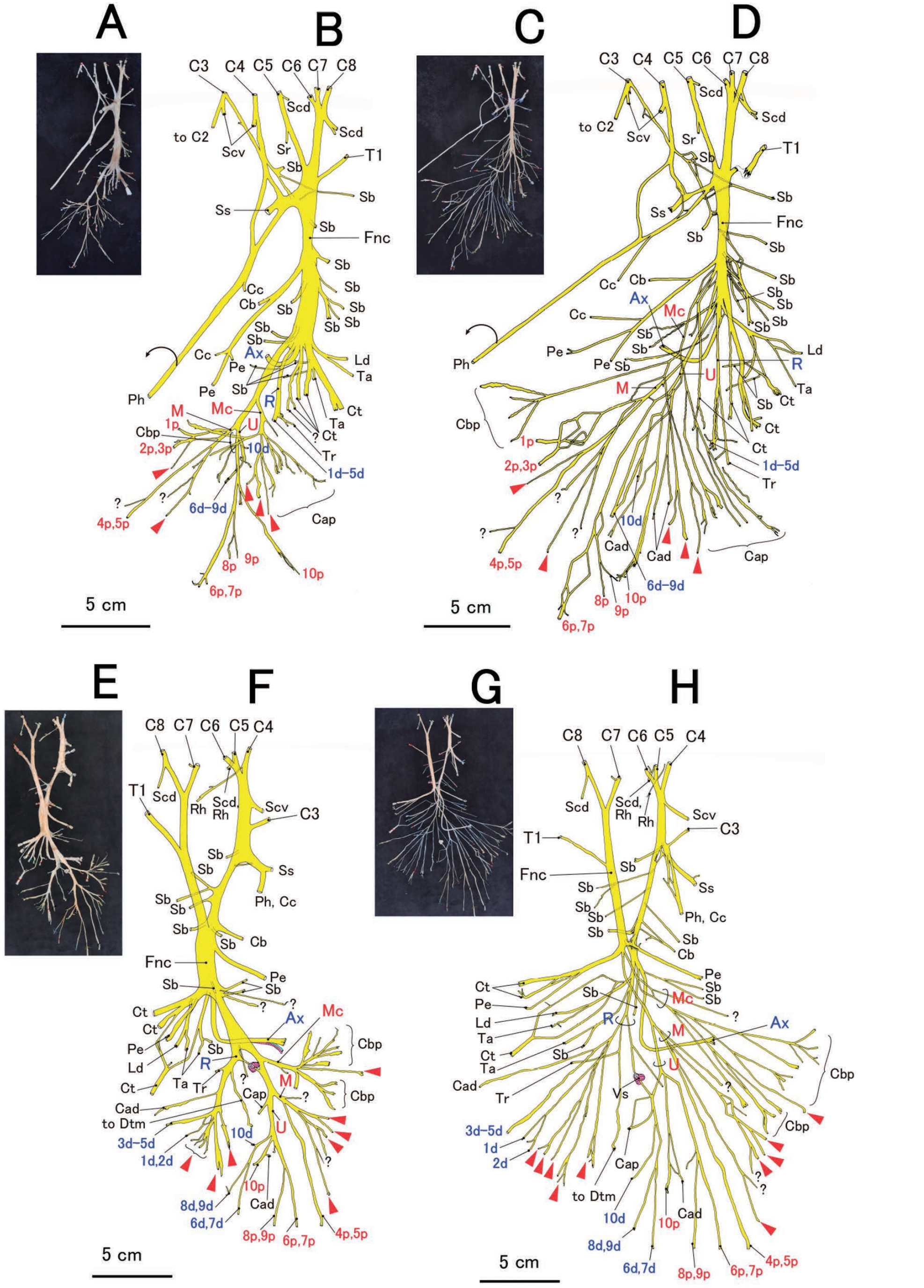

Fig. 4. A and B: the right brachial plexus as removed from the carcass. C and D: the same plexus as A and B without the epineurium (the fascicle analysis). E–H: the left brachial plexus treated the same as A–D. 1p–10p (red) and 1d–10d (blue) indicate the proper palmar digital nerves and the proper dorsal digital nerves, respectively. Arrowheads indicate cutaneous branches passing under the layers of dense connective tissue, which are considered as the degenerated flexor or extensor muscles. The phrenic nerve (Ph) in A–D has been displaced at the cranial position from the original caudal position on processing of the fascicle analysis (curved arrows). A–H: medial view.

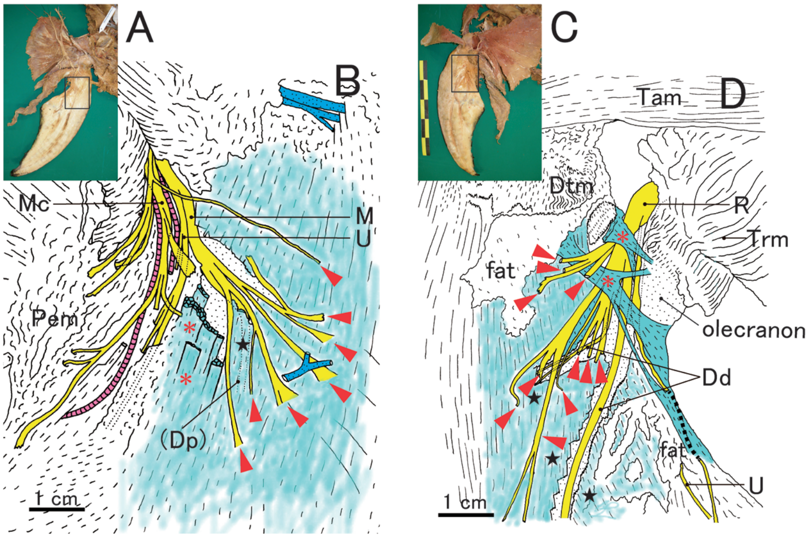

Fig. 5. Distribution of branches of the median nerve, musculocutaneous nerve (A and B: palmar view), and radial nerve (C and D: dorsal view) in the left flipper. B and D are line drawings of the boxes in A and C, respectively. Note that many branches (arrowheads) distributed under the dense connective tissues (asterisks), which are considered as the degenerated flexor and extensor muscles. The palmar digital nerve (Dp indicated by dotted lines) and dorsal digital nerves (Dd) pass within the dense periosteum (solid stars) of the ulna and radius, respectively.

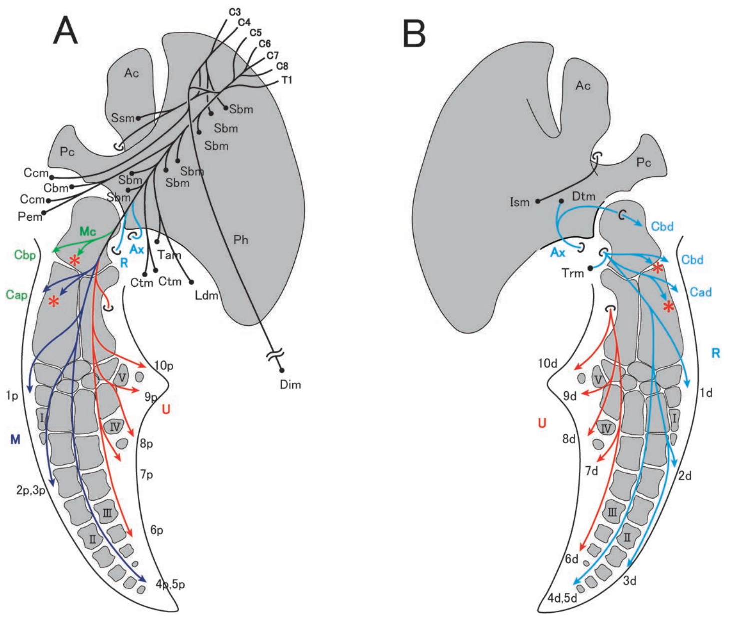

Fig. 6. Diagram of the course and distribution of the nerves of forelimb of the Pacific white-sided dolphin. A: palmar view; B: dorsal view. 1p–10p and 1d–10d indicate each the proper palmar digital nerves and the proper dorsal digital nerves, respectively, which supply the sides of the fingers in turn from the radial side of the pollex to the ulnar side of the minimus. Solid circles indicate innervations of the muscular nerves, and arrows are cutaneous branches. Asterisks indicate that cutaneous nerves (Cbp, Cap, Cbd, and Cad) are considered to contain remnants of the muscular branches. Roman numerals indicate each finger from the pollex to the minimus.

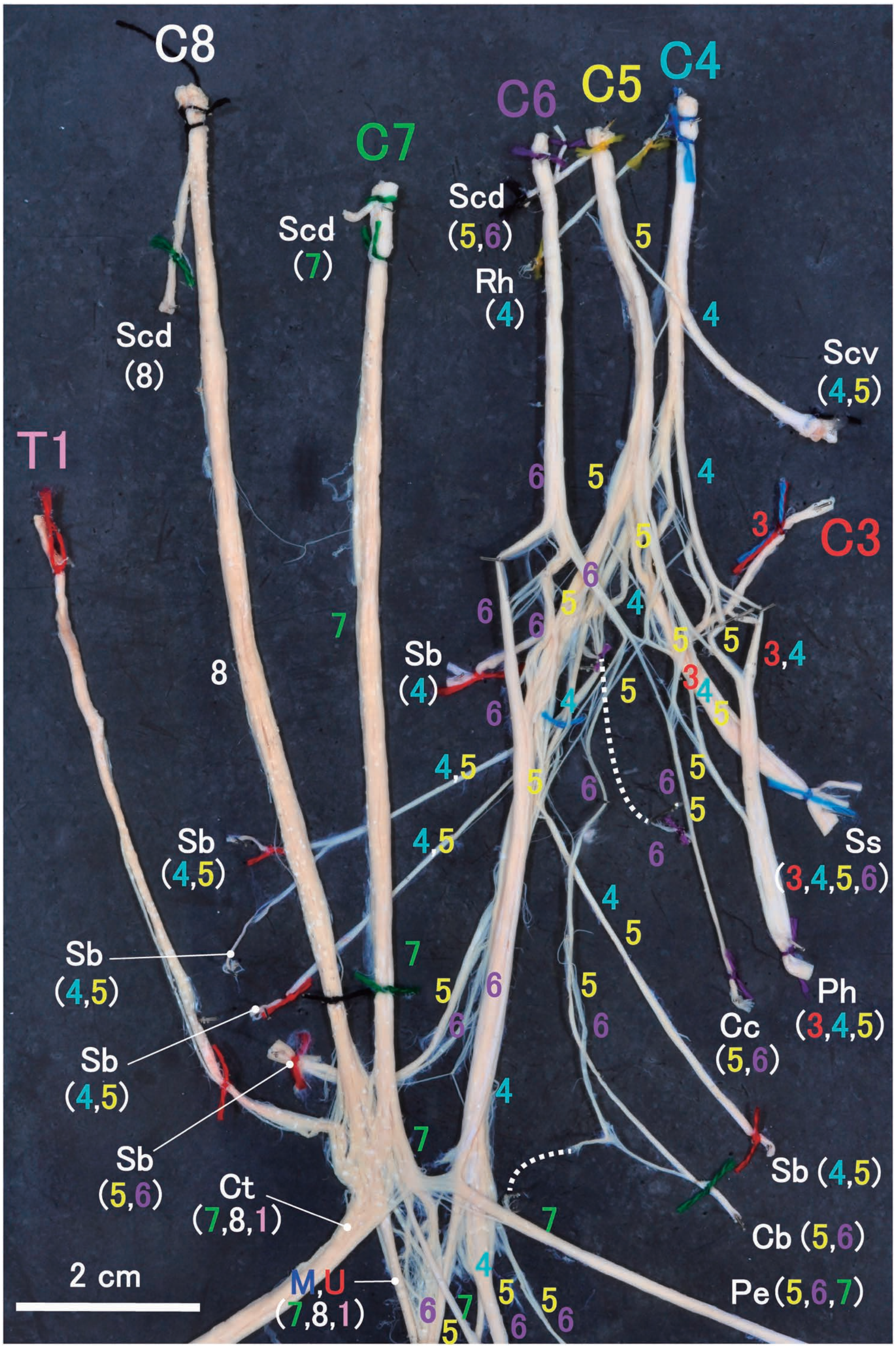

Fig. 7. Photograph of the fiber analysis performed in the left brachial plexus. Medial view. The method of incising the perineurium permit for the individual nerve fibers to be traced back to the spinal roots.

Table 1. Spinal segmental constitution of branches of the brachial plexus in the Pacific white-sided dolphin.

	Branches (Abbreviations)		Left forelimb							Right forelimb						
			C3	C4	C5	C6	C7	C8	T1	C3	C4	C5	C6	C7	C8	T1
Ventral branches	Branches to M. scalenus ventralis	(Scv)		●	•					●	●	●				
	N. suprascapularis	(Ss)	•	●	●	•				●	●	●	•			
	N. phrenicus	(Ph)	•	●	•					●	●	•				
	Branches to M. coracobrachialis	(Cb)			●	●						●	●			
	Branches to the costo-coracoid muscle	(Cc)			●	●						●	●	●		
	Branches to M. pectoralis major	(Pe)			●	●	●						●	●		
	Branches to M. cutaneus trunci	(Ct)					●	●	●				●	●	●	●
	N. musculocutaneus	(Mc)					●	●					•	●	•	
	N. medianus	(M)					●	●					•	●	●	
	N. ulnaris	(U)					●	●	•				•	●	●	
Dorsal branches	N. subscapularis	(Sb)		●	●	●					●	●	●	●		
	Branches to M. scalenus dorsalis	(Scd)			●	●	●	●				●	●	●	●	
	N. axillaris	(Ax)		•	●	●						●	●	•		
	N. radialis	(R)			●	●	●	●				•	●	●	●	
	Branches to M. triceps brachii	(Tr)					●	●							●	
	Branches to M. latissimus dorsi	(Ld)			•	•	●	•					●	●	●	
	Branches to M. teres major	(Ta)			●	●							●	●	●	

The size of circles indicates relative amount of nerve fibers.

nerves, but also the radial nerve, appeared to arise from this large common stem (Fig. 4E–F). However, when the epineurium was removed (fascicle analysis), it was clarified that the median and ulnar nerves arose from the common fascicle, while the radial nerve arose from another fascicle (Fig. 4G–H). In addition, a thick cutaneous branch arose from the median–ulnar common stem and supplied the palmar skin of the proximal part of the flipper. In this study, we termed this branch the musculocutaneous nerve (Mc), as some branches from the Mc entered the fibrous dense connective tissue, which appeared to be degenerated tissue of the brachial flexors (Fig. 5A–B). The common stem of the median and ulnar nerves divided into each nerve as soon as it reached the forearm. There was no gross evidence of antebrachial muscle fibers in this dolphin (Figs. 2A–B, 3A–B). Instead of muscle fibers, only a few layers of dense connective tissue with longitudinally oriented fibers were found. They connected the humerus to the radius and ulna or covered these antebrachial bones. Several branches of the median nerve passed under these layers of dense connective tissue and were then distributed to the subcutaneous tissue of the flipper (Fig. 5A–B). In addition to these branches, the abaxial palmar digital nerve I (1p) and the palmar common digital nerves I and II ran within the thick periosteum covering the radius. The ulnar nerve passed over the olecranon and reached the palmar skin of the web lying between the olecranon and minimus. It then bifurcated into the abaxial palmar digital nerve V (10p) and the palmar common digital nerves III and IV (Fig. 2A–B). Another branch of the ulnar nerve penetrated the web to supply the dorsal skin (Figs. 2–3).

2. Dorsal branches

The dorsal scapular, subscapular, axillar, and radial nerves arose from the dorsal surface of the

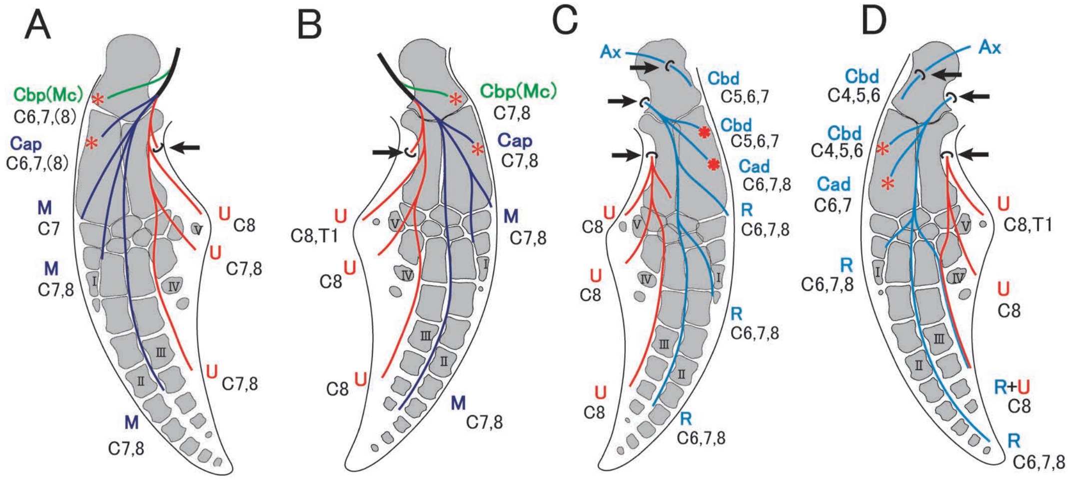

Fig. 8. Diagrams of the course and distribution of the nerves in flippers, showing the segmental cutaneous distribution of the spinal nerves (C4–T1) in the right flipper (A and C), and in the left flipper (B and D). A and B: palmar view; C and D: dorsal view. The arrows indicate the sites where the nerves pierce the deep fascia (intermuscular septum) in the palmodorsal direction. In the axillary nerve (Ax), the arrows indicate the sites where the branches of the axillary nerve pass through the deltoid muscle, continuing as the cutaneous nerves to the arm (Cbd). Asterisks indicate that cutaneous nerves (Cbp, Cap, Cbd, and Cad) are considered to contain remnants of the muscular branches.

brachial plexus. The left dorsal scapular nerve arose from the fourth and fifth cervical nerves and supplied the rhomboideus. We failed to find the right dorsal scapular nerve and right and left long thoracic nerves. The subscapular nerves arose from the dorsal surface of the brachial plexus as 11 branches on the right side, and as nine branches on the left side (Fig. 4A–B, E–F). The axillary nerve also arose from the distal end of the Fnc and passed dorsally through the space between the subscapularis and teres major; it supplied only the deltoid. The axillary nerve gave rise to a few slender cutaneous branches, which penetrated the deltoid supplying the skin of the dorsal proximal portion of the flipper. As mentioned above, the right radial nerve arose as a common branch with the median and ulnar nerves from the Fnc. However, fascicle analysis indicated that the radial and axillary nerves arose from a common fascicle, while the median and ulnar nerves arose from another fascicle (Fig. 4G–H). The first branch of the radial nerve supplied the long head of the triceps brachii. The radial nerve passed through the space between the triceps brachii and the humerus. On reaching the dorsal surface of the flipper, the nerve gave rise to several branches that passed under the dense connective tissue with longitudinally oriented fibers and were distributed to the dorsal skin of the flipper (Fig. 5C–D). All extensor muscles in the antebrachium were not completely identified. The radial nerve then ran along the midline of the forearm, between the radius and ulna, and reached the carpus (Figs. 2C–D, 3C–D). It then divided into two dorsal common digital nerves which passed into the cleft between the pollex and index finger, and between the index and medius. In the left flipper, the radial nerve gave rise to a branch that ran to the cleft between the medius and annularis and joined with the branch of the ulnar nerve to form the dorsal common digital nerve III (Fig. 3C–D). The dorsal common digital nerve often communicated with the palmar common digital nerve.

Thus, we have herein clarified the constitution of the brachial plexus, its branches, and the distribution of these branches in the flipper. A conceptual diagram summarizing these results is shown in Fig. 6.

Segmental innervation of muscles and skin

The fiber analysis was performed as shown in Fig. 7, and the results shown in Table 1. In seven out of 10 ventral branches, those on the right side arose from the spinal nerves that were one or half a level higher (more cranial) than those on the left side, e.g., the right ulnar nerve consisted of fibers from C6–C8, while the left ulnar nerve consisted of those from C7–T1. In contrast, in the dorsal branches, those on the right side arose from the spinal nerves that were half a level lower (more caudal) than those on the left side. The branches that constituted of fibers from over four spinal segments were the subscapular nerves (C4–C8), radial nerve (C5–C8), suprascapular nerve (C3–C6), thoracodorsal nerve (C5–C8), and branches to the cutaneous trunci muscle (C6–T1). The course and distribution of the cutaneous nerves of the flipper and their segmental origins are shown in Fig. 8.

Discussion

Constitution of the brachial plexus

A major observation in this study was that the brachial plexus of the Pacific white-sided dolphin was composed from C3–T1. In comparison with the brachial plexus in other mammals, the number of the cervical spinal roots composing the brachial plexus of the dolphin is exceptionally large. Similar numerous segmental constitutions have been reported in *Mesoplodon* (Kodama *et al.*, 1991) and *Kogia breviceps* (Schulte and Smith, 1918). In *Mesoplodon*, the fibers from C3 contributed to only the phrenic nerve, but in the Pacific white-sided dolphin they contributed to the suprascapular and phrenic nerves. In *Kogia breviceps*, the second cervical nerves might innervate the pectoralis major muscle and the panniculus carnosus (synonymous with the cutaneus trunci) (Schulte and Smith, 1918). The brachial plexus comprised C5–T1 in rat (Greene, 1935), human (Williams *et al.*, 1989), rhesus monkey (Howell and Straus, 1933), and common hippopotamus (Yoshitomi, *et al.*, 2012). In canine (Evans and Christensen, 1979), horse (Budras *et al.*, 2003), and okapi (Endo *et al.*, 2009), it comprised C6–T1 and C7–T2 in giraffe (Solounias, 1999). The spinal roots comprising the camel brachial plexus (Smuts and Bezuidenhout, 1987) are C7–T1, which to the best of our knowledge, is the fewest. The data in these various mammalian species show that the spinal roots comprising the brachial plexus tend to increase in number with a decrease in the length of the neck. Therefore, such tendency suggests that the number of spinal segments forming the brachial plexus depends on the vertebral morphology.

Each of these ventral rami joins to form the trunks or the cords, but the manner in which the trunks are formed appears to be different depending on the species, or even on the right and left sides of the same individual, as shown in our study. In porpoise, C4–T1 forms three cords, and in *Delphinus albirostris*, it forms two cords (Cunningham, 1877).

Another feature of the brachial plexus of dolphins is that even though it is composed of many segments, it eventually converges into the single cord, called the Fnc in this study. The Fnc has been thought to correspond to the trunk, which Schulte and Smith (1918) called the greater brachial trunk in *Kogia breviceps*. In contrast, the lesser brachial trunk—as termed by them—which mainly gave rise to the suprascapular nerve and phrenic nerve, corresponded to the extreme cranial or second trunk in this study. The figure in Cunningham (1877) suggests that the brachial plexus of the porpoise converge as a single cord, in a fashion similar to the result of our study. Despite these studies, little attention has hitherto been given to the fact that the brachial plexus in dolphins has a simple structure that converges on a single cord. However, such a formation of the brachial plexus in dolphins is unparalleled within the Mammalia. Miller (1934) stated "An increase in the complexity of the musculature, accompanied by more coordination of action, results in more complexity of the nerves supplying the muscles, which produces more complicated plexus-formation." Therefore, it is conceivable that the disappearance of many intrinsic muscles of the forelimb that occurred during the evolution of dolphins was associated with formation of the Fnc.

Branches of the brachial plexus

Although the nerves diverging from the brachial plexus of the Pacific white-sided dolphin were mostly not different from those of other terrestrial mammals, there were some characteristics: (1) the branches to the cutaneous trunci muscle were the most well-developed nerves; (2) the muscular branch of the radial nerve was the only branch to the long head of the triceps brachii; (3) it was conceivable that the median and ulnar nerves contained no motor nerve fibers; (4) the axillary nerve supplied only the deltoid; (5) the subscapular nerve comprised approximately 10 branches; and (6) on the palmar and dorsal surfaces of the flipper, the median, ulnar, and radial nerves supplied the skin of each half of the flipper.

Of these features, one of particular interest is that the muscular branch was the branch to the long head of the triceps brachii only. That means that all nerve fibers included in the musculocutaneous, median and ulnar nerves, and most fibers in the radial nerve are sensory nerve fibers. Furthermore, the distribution of these nerves in the flipper was similar to the distribution pattern in the forelimbs of terrestrial mammals. These findings support the suggestion of Cooper *et al.* (2007) that cetacean forelimb sensory innervation retains the basic mammalian pattern of distribution. However, since gross anatomical methods have their limitations, more detailed further studies are needed to clarify the function of these peripheral nerves in the flipper.

The pectoral nerve innervated the pectoralis major, as well as the costo-coracoid muscle and coracobrachialis. In *Kogia breviceps*, the pectoralis minor was supplied by a twig from the phrenic nerve (Schulte and Smith, 1918). Howell (1930) called this muscle the pectoralis profundus in *Monodon monoceros* but did not reference its innervation. Strickler (1978) reported that the pectoralis minor of *Pontoporia blainvillei* was innervated only by a branch from the nerve to the pectoralis major. The costo-scapular muscle (perhaps synonymous with the costo-coracoid muscle) in porpoise and *Delphinus albirostris* was supplied by a branch from the phrenic nerve (Cunningham, 1877). Therefore, the muscles innervated by the pectoral nerve vary from species to species or among researchers, similar to how the pectoralis minor and costo-coracoid muscles are referred to by various names. These results have shown the need for a more detailed study of the pectoral and costo-coracoid muscles. Separate from this study, we have been investigating the morphology of the costo-coracoid muscle and the issue of dual innervation of this muscle using Sihler's stain technique. This will be described more fully in a report to be published in future.

We did not find the subdeltoideus that was described by Schulte and Smith (1918) in *Kogia breviceps.* They stated that the subdeltoideus was innervated by branches of the axillary nerve. Therefore, this muscle may correspond to the teres minor or to a slip separated from the deltoideus. This missing teres minor in the dolphin will be clarified in future by comparative anatomical studies on various cetacean species.

Segmental innervation of the muscles and skin

The spinal segmental constitution of the nerves of the flipper was slightly different in the right and left sides and in the ventral and dorsal branches. In the ventral branches of the brachial plexus, the spinal segmental constitution of the right flipper was about one segment higher (more cranial) than that of the left flipper, and was the opposite in the dorsal branches. The cause of these differences in the right and left sides is unknown.

The suprascapular, subscapular, and radial nerves and the branches to the cutaneus trunci were composed of more spinal roots than in other nerves. In contrast, the median nerve was composed of only two and three roots, which was fewer than that of humans (C5–T1) (Romanes, 1981; Williams *et al*., 1995). In cetaceans, the muscles in association with the movement of the scapulo-humeral joint have been conserved, while there are no muscle bellies in the forearm and hand (Thewissen, 2009). The number of spinal segments that comprise the innervating nerve may be correlated with the degree of muscle development.

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Abbreviations

1d–10d : proper dorsal digital nerves from the radial side of the pollex (1d) to the ulnar side of the minimus (10d)
1p–10p : proper palmar digital nerves from the radial side of the pollex (1p) to the ulnar side of the minimus (10p)
Ac : acromion
Ax : axillary nerve
C1–C8 : ventral rami of the 1st–9th cervical nerves
Cad : cutaneous nerves to the dorsal surface of the antebrachium
Cap : cutaneous nerves to the palmar surface of the antebrachium
Cb : branch to the coracobrachialis muscle
Cbd : cutaneous nerves to the dorsal surface of the brachium
Cbm : coracobrachialis muscle
Cbp : cutaneous nerves to the palmar surface of the brachium
Cc : branch to the costo-coracoid muscle
Ccm : costo-coracoid muscle
Ct : branch to the cutaneous trunci muscle
Ctm : cutaneous trunci muscle
Dd : dorsal digital nerve
Dim : diaphragm
Dp : palmar digital nerve
Dtm : deltoid muscle
Fnc : flattened nerve cord
H : head of the humerus
Ism : infraspinatus muscle
Ld : branch to the latissimus dorsi muscle
Ldm : latissimus dorsi muscle
Ly : lymph node
M : median nerve
Mc : musculocutaneus nerve
Pc : coracoid process
Pe : branch to the pectoralis major muscle
Pem : pectoralis major muscle
Ph : phrenic nerve
Ps : spinous process
Pt : transvers process
R : radial nerve
Rh : branch to the rhomboideus muscle
Rhm : rhomboideus muscle
Rm : rete mirabile
Sb : subscapular nerve
Sba : subclavian artery
Sbm : subscapularis muscle
Sbv : subclavian vein
Scd : branch to the scalenus dorsalis muscle
Scv : branch to the scalenus ventaralis muscle
Sdm : scalenus dorsalis muscle
Shm : sternohyoid muscle
Smm : sternomastoid muscle
Sr : branch to the serratus ventralis muscle
Srm : serratus ventralis muscle
Ss : suprascapular nerve
Ssm : supraspinatus muscle
Svm : scalenus ventaralis muscle
T1 : ventral ramus of the 1st thoracic nerve
Ta : branch to the teres major muscle
Tam : teres major muscle
Tia : internal thoracic artery
Tr : branch to the long head of the triceps brachii muscle
Trm : long head of the triceps brachii muscle
U : ulnar nerve
Vs : blood vessels