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CLASSIFICATION OF FLEXION CREASES ON PALMS OF APES IN DEPENDENCE OF LOCOMOTION TYPE

*ABSTRACT: This paper studied the relationship between the course of flexion creases and different locomotion types, i.e, true brachiation (*Hylobates sp.*), modified brachiation (*Pongo pygmaeus*) and knuckle-walking (*Pan troglodytes, P. paniscus*) based on palm prints and photos of apes. The author created a new terminology and classification of primary flexion creases, based on human flexion creases' classification and distribution of volar pads of primates. The new classification distinguishes 3 groups of primary flexion creases, i.e., transversal, longitudinal and oblique groups. According to morphological analysis of palm prints and photos of apes, the variability in coursing and number of the transversal flexion creases correlate to different locomotion types of apes.*

KEY WORDS: Apes – Gibbons – Orangutans – Chimpanzees – Hands – Palms – Flexion creases – Locomotion type

INTRODUCTION

This work represents a slightly modified English version of the doctoral thesis of the author (Munzarová 2003). The main aim of the presented work is a proof of the relationship between flexion creases coursing on the palms of apes and locomotion types of apes.

Hands of apes, similar to the hands of other primates, have evolved for arboreal and terrestrial locomotion and also as an organ of natural manipulation, i.e., feeding, nest building, grooming, tactile communication etc. Primate hands, unlike hooves and paws of other animals, allow and create a high diversity of locomotor behaviour. Differences in type of locomotion show variability in functional morphology of primates' hands and in coursing of flexion creases on palms.

Primates demonstrate a wide variety of locomotor's patterns. Many fundamental locomotor patterns can be identified within the primate order. These include vertical climbing and leaping, arboreal and terrestrial quadrupedalism, new world semibrachiation, brachiation, knuckle walking and erect bipedalism.

Flexion creases arise on skin near the joints in side of flexion. They run perpendicular to movement (e.g. Borovanský *et al.* 1973, Mazák 1986, Napier 1993). Flexion creases are oblique on the human palms, but are perpendicular to the longitudinal axe of the hand in apes (Mazák 1986, Sarkar 1961, Sperino 1897, Duckworth 1915, Biegert 1971). Creases can be divided into 3 groups, i.e., transversal, longitudinal and oblique. Transversal creases are formed in connection with mutual function of flexors. The longitudinal group is represented by flexion creases which are formed in connection with abduction and adduction of thenar and hypothenar. Oblique creases are formed in connection with opposition of the thumb.

MATERIAL AND METHODS

Material has been provided by different primate facilities and the author's own photos from Zoological gardens from the Czech Republic (see *Tables 1* and *2*). It includes palm prints and photos of 25 chimpanzees (*Pan troglodytes*) and 1 bonobo (*Pan paniscus*), 5 orangutans (*Pongo pygmaeus*) and 3 gibbons (*Hylobates* sp.). The classification of the study material was carried out on the basis of the simple visual comparison of palm prints and palm photos of individuals and on the basis of the computer superprojection in Adobe Photoshop 6.0. Selected palm prints of chimpanzees (5 individuals for right palm and 8 individuals for left palm) and gibbons (3 individuals for left and right palm) were stratified to show summary coursing of individual flexion creases. Simplified line drawings were based on the superprojection, particular palm prints and photos (see *Table 2*). The original material has been retained by the author and a copy was housed in the library of the Department of Anthropology, Faculty of Science, Masaryk University, Brno.

TABLE 1. Overview of individuals included into the study. Symbols: C – Chimpanzee, B – Bonobo, O – Orangutan, G – Gibbon.

No.	Sex	Name	Birth	Organization
				Pan troglodytes
C 1	Female	Majoránka	15. 10. 1996	ZOO Liberec, Czech Republic
C 2	Male	Jimmy	28. 8. 1994	ZOO Liberec, Czech Republic
C 3	Male	Hendrik	1952	ZOO Antwerp, Belgium
C 4	Female	?	?	Japan Monkey Center, Japan
C 5	Male	?	?	Japan Monkey Center, Japan
C 6	Female	?	?	Japan Monkey Center, Japan
C 7	Female	Rodney (1012)	March 1964	Primate Foundation of Arizona, USA
C 8	Female	Sabrina (1015)	November 1968	Primate Foundation of Arizona, USA
C 9	Female	Harriet (1016)		Primate Foundation of Arizona, USA
C 10	Female	Tody (1025)	October 1971	Primate Foundation of Arizona, USA
C 11	Female	Jayme (1036)	May 1979	Primate Foundation of Arizona, USA
C 12	Female	Bernadette (1038)	February 1978	Primate Foundation of Arizona, USA
C 13	Female	Ma¨Ishpa (1043)	February 1982	Primate Foundation of Arizona, USA
C 14	Female	Nahagio (1044)	March 1982	Primate Foundation of Arizona, USA
C 15	Female	Chechekul (1045)	May 1982	Primate Foundation of Arizona, USA
C 16	Female	Doda (1050)	January 1983	Primate Foundation of Arizona, USA
C 17	Male	Bam Bam1 (2019)	June 1970	Primate Foundation of Arizona, USA
C 18	Male	Bahn (2039)	March 1982	Primate Foundation of Arizona, USA
C 19	Male	Kehg (2040)	April 1982	Primate Foundation of Arizona, USA
C 20	Male	Jo Mendi (2045)	March 1979	Primate Foundation of Arizona, USA
C 21	Male	Huhkalig (2046)	March 1983	Primate Foundation of Arizona, USA
C 22	Male	Nowi (2047)	May 1983	Primate Foundation of Arizona, USA
C 23	Female	?	1994	Little Rock ZOO, Arkansas, USA
C 24	Male	Richard	?	Little Rock ZOO, Arkansas, USA
C 25	Male	Viki	22. 12. 1982	ZOO-Safari Dvůr Králové n.L., Czech Republic
				Pan paniscus
B 1	Female	Hannemieke	1951	ZOO Antwerp, Belgium
				Pongo pygmaeus
O 1	Female	Dwang (Ňuninka)	1987 ?	ZOO Ústí nad Labem, Czech Republic
O 2	Male	Kwen (Ňuňák)	1987 ?	ZOO Ústí nad Labem, Czech Republic
O 3	Male	Dahi	1998	ZOO-Safari Dvůr Králové n.L., Czech Republic
O 4	Male	?	1983	The Orangutan Foundation, Great Britain
O 5	Male	?	?	Japan Monkey Centre, Japan
				Hylobates sp.
G 1	?	?	?	Japan Monkey Centre, Japan
G 2	?	?	?	Japan Monkey Centre, Japan
G 3	?	?	?	Japan Monkey Centre, Japan

Primate classification based on locomotion types

Napier (1967, 1968) defined 4 basic types of primate locomotion, i.e. vertical climbing and leaping, quadrupedalism, brachiation and bipedalism. Vančata (1981, 2003) enlarged these basic locomotion groups and divided them on the basis of different factors, e.g. type of environments (arboreal or terrestrial), activity of locomotion (static or dynamic), and position of trunk (pronograde or antipronograde). Generally, it can be defined as five primate locomotion types, i.e. arboreal quadrupedalism, terrestrial quadrupedialism, vertical climbing and leaping, arboreal antipronograde locomotion (brachiation), bipedalism. According to limited studied material, Vančata's classification was reduced to three locomotion groups. The first type of locomotion is true brachiation, which is common in gibbons (*Hylobates* sp.), the second one is modified brachiation, which is typical for orangutans (*Pongo pygmaeus*) and the last one is knuckle-walking, which is the type of movement typical for chimpanzees (*Pan paniscus, P. troglodytes*).

TABLE 2. Overview of methods used for certain individuals. Symbols: Print – copy of the palm print made by printer's ink, Photo – photo of palm or its computer image, C – Chimpanzee, B – Bonobo, O – Orangutan, G – Gibbon.

No.	Species	Right hand	Left hand	Age in time of printing (years)
C 1	*Pan troglodytes troglodytes*	photo	–	3
C 2	*Pan troglodytes troglodytes*	photo	photo	5
C 3	*Pan troglodytes schweinfurthii*	print	print	3
C 4	*Pan troglodytes*	print	print	?
C 5	*Pan troglodytes*	print	print	?
C 6	*Pan troglodytes*	print	print	?
C 7	*Pan troglodytes*	print	print	26
C 8	*Pan troglodytes*	print	print	22
C 9	*Pan troglodytes*	–	print	?
C 10	*Pan troglodytes*	print	print	19
C 11	*Pan troglodytes*	print	print	11
C 12	*Pan troglodytes*	print	print	12
C 13	*Pan troglodytes*	print	print	8
C 14	*Pan troglodytes*	print	print	8
C 15	*Pan troglodytes*	print	print	8
C 16	*Pan troglodytes*	print	print	7
C 17	*Pan troglodytes*	print	print	20
C 18	*Pan troglodytes*	print	print	8
C 19	*Pan troglodytes*	print	print	8
C 20	*Pan troglodytes*	print	print	11
C 21	*Pan troglodytes*	print	print	7
C 22	*Pan troglodytes*	print	print	7
C 23	*Pan troglodytes*	–	photo	6
C 24	*Pan troglodytes*	photo	–	? adult
C 25	*Pan troglodytes*	–	photo	? adult
B 1	*Pan paniscus*	–	print	4
O 1	*Pongo pygmaeus*	photo	photo	12 ?
O 2	*Pongo pygmaeus*	photo	–	12 ?
O 3	*Pongo pygmaeus*	photo	photo	0.5
O 4	*Pongo pygmaeus*	–	print	16
O 5	*Pongo pygmaeus*	print	print	?
G 1	*Hylobates* sp.	print	print	?
G 2	*Hylobates* sp.	print	print	?
G 3	*Hylobates* sp	print	print	?

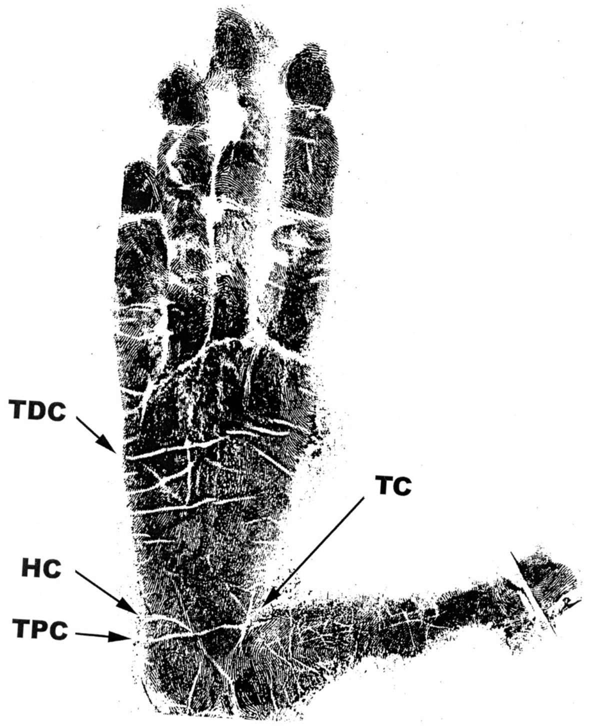

FIGURE 1. Flexion creases on palm of gibbon.

Flexion creases on primate palms

Morphological terminology of flexion creases on primate palms is not available in the current primatological literature. Therefore this study tries to create new classification and terminology of flexion creases on apes' palms. This new concept and terminology are based on similarity with coursing of flexion creases by humans (Weninger, Navratil 1957) and distribution of volar pads by primates (Biegert 1971). A great quantity of flexion creases on palms of primates have been recognized, which can be divided into two main groups, i.e. primary and secondary flexion creases. The primary creases that occur on the palms of juvenile and adult individuals are probably genetic in origin and show similarity with humans. The secondary flexion creases form during the life of individuals and show high intraspecific variability. Therefore this article does not deal with this type of flexion creases.

Three groups of primate flexion creases can be described, i.e. transversal, longitudinal and oblique groups. The transversal group includes a transversal distal crease, which course from ulnar margin of palm to radial margin, perpendicularly to the longitudinal axis of the hand; a transversal medial crease, which course under transversal distal crease from the ulnar to radial margin, perpendicularly to the longitudinal axis of the hand; and a transversal proximal crease, which is distinct and concave and running from the ulnar to radial margin, perpendicularly to longitudinal axis of the hand. A transversal proximal crease rarely creates a hypothenar-thenar bridge, which connects the hypothenar and thenar creases (see below oblique creases). The second group is the group of longitudinal creases, which contains two different creases. A longitudinal ulnar crease running from the middle of the wrist towards between the third and the fourth interdigital volar pads and a longitudinal radial crease, which runs from the middle of the wrist towards between the second and the third interdigital volar pads. The last group is the oblique creases group, which includes thenar and hypothenar creases. The thenar crease is running around the thenar muscles and similarly hypothenar crease girdling the hypothenar muscles.

Variability of primate locomotion is often associated with different functional hand morphology and various coursing of flexion creases on palms of primates. Different locomotion groups show variability in distribution and number of primary flexion creases. Therefore, it figures that flexion creases follow locomotion type of primates for which they have been adapted.

Gibbons

Gibbons have typically long and narrow hands, palms and fingers. The palm is the broadest in distal margin and is narrowed in proximally to thumb. The position of the thumb is the most proximal and the longest of all primates. The thumb has no function in locomotion, because it is incurved into palm during gripping, i.e. hook grip. Gibbon hands are prehensile, the thumb is opposable (e.g. Napier 1963, Napier 1967, Midlo 1934, Erikson 1963, Oxnard 1963, Van Horn 1972).

Classification of gibbon flexion creases is based on a set of only three individuals. However, the quantity of specimens is not as important due to supposed genetic dependence of coursing of flexion creases as suggested by the human literature.

Results of this morphological analysis suggest that gibbons' palms lack one transversal crease and both longitudinal creases (see *Figure 1*). The transversal distal crease (TDC) runs in first (distal) third of palm. The thenar crease (TC) and hypothenar crease (HC) are barely obvious in the proximal third of the palms of all studied individuals. The transversal proximal crease (TPC) is straight. Longitudinal creases are not developed, probably due to markedly proximal position of thumb and limited mobility of palms. Frequency of secondary flexion creases is rare and copy coursing observed in other primates.

Orangutans

Orangutan hands are relatively longer and narrower than hands of other apes. Fingers are long and proximally narrowed like those of gibbons. Hands have reduced thumb in proximal position and relatively long fingers. Hands are prehensile, the thumb is short and opposable. Power grip is very strong and is adapted to gripping of thin branches. Main type of gripping is hook grip, which is improved with double-locking mechanism by orangutans (Napier 1963, 1967, 1993, Midlo 1934, Schultz 1942, Oxnard 1963, Boestani a Smits 1994).

Similarly to gibbons, classification of orangutan flexion creases is not based on relatively numerous materials. The orangutan collection includes only 2 palm prints and 3 photos.

Generally, it is possible to describe all types of above-mentioned primary flexion creases on palms of orangutans (see *Figure 2*). The transversal distal crease (TDC) runs in first (distal) third of palm. The transversal medial crease (TMC) runs under TDC approximately also in the first third of palm. Both creases, i.e. TDC and TMC, run distinctly close each other. The thenar crease (TC) and hypothenar crease (HC) are obvious on proximal third of the palm for all studied individuals. Both of these creases are often connected together by hypothenar-thenar bridge (HTB). The transversal proximal crease (TPC) is distinct, but not so concave due to relatively proximal position of thumb and its reduction. The longitudinal ulnar crease (LUC) runs distally from middle part of wrist and ends between the third and fourth interdigital pads. Similarly, the longitudinal radial crease (LRC) runs distally from the middle part of wrist, but it ends between the second and third interdigital pads. Coursing of secondary flexion creases is unclear, due to poor quality of study material.

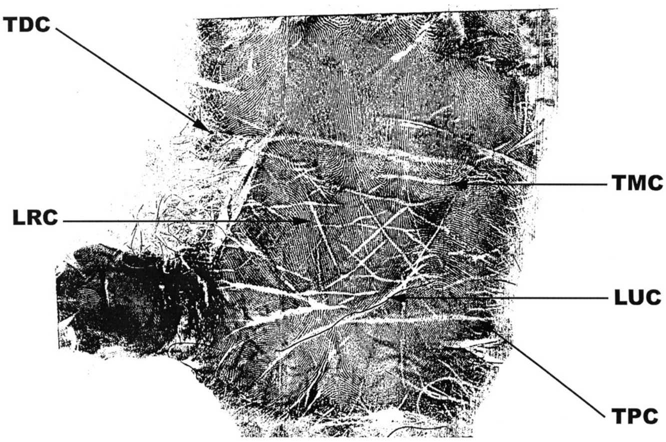

FIGURE 2. Flexion creases on palm of orangutan.

Chimpanzees

The knuckle-walking is a specific type of movement, which is typical for chimpanzees and gorillas (Napier 1963, 1967, 1993). The hand contacts the ground only by the dorsal side of middle segments of the 2nd to 5th fingers (*phalangus medialis*). The body has a semi-upright posture and upper limbs are longer than lower ones. The thumb is relatively short and does not contact the ground. Sometimes, animals use modified brachiation for moving in treetops, but this type of locomotion is rare (e.g. Napier 1967, Cartmill 1974, Doran 1993a, 1993b, 1996). The chimpanzee hand is relatively broad contrary to hand of orangutans, but not so broad as in gorillas. Fingers are relatively shorter than fingers of orangutans and gibbons. Chimpanzee hands are prehensile, the thumb is reduced and is opposable. On the other side the chimpanzee hand is not able to make precision grip due to different length of thumb and fingers. Hook grip is basic type of gripping during brachiation in treetops.

A classification of chimpanzee flexion creases is based on collection of 26 individuals, i.e., 25 of *Pan troglodytes* and 1 of *Pan paniscus*. The collection was divided into three groups according to age of animals. The first group contains individuals less than 10 years old (13), the second one more than 10 years old (9) and the third group includes animals of unknown age (4). The age boundary more or less corresponds to age of sexual maturity by chimpanzees (Rowe 1996). It is possible to describe all types of above-mentioned primary flexion creases on palms of chimpanzees (see *Figure 3*). The transversal distal crease (TDC) runs in first fourth of palm. The transversal medial crease (TMC) runs under TDC approximately in the second fourth of palm. The thenar crease (TC) and hypothenar crease (HC) are relatively distinct on proximal part of palm by all studied individuals. Sometimes, both these creases are connected together by hypothenar-thenar bridge (HTB). The transversal proximal crease (TPC) is concave towards wrist and evident in most individuals. The occurrence of this crease does not correlate with the age of individuals. The longitudinal ulnar crease (LUC) runs distally from middle part of wrist and ends between the third and fourth interdigital poles. Similarly, the longitudinal radial crease (LRC) runs distally from the middle part of wrist, but it ends between the second and third interdigital poles.

The secondary flexion creases are similar in coursing primaries and a transversal direction dominates. The chimpanzee collection shows positive increasing frequency of secondary flexion creases in connection with age of individuals (see *Table 3*).

Primate locomotion versus coursing of flexion creases on palms

Differences among locomotion types, i.e. true and modified brachiation, knuckle-walking, are apparent in coursing, number and position of transversal creases on palms of primates.

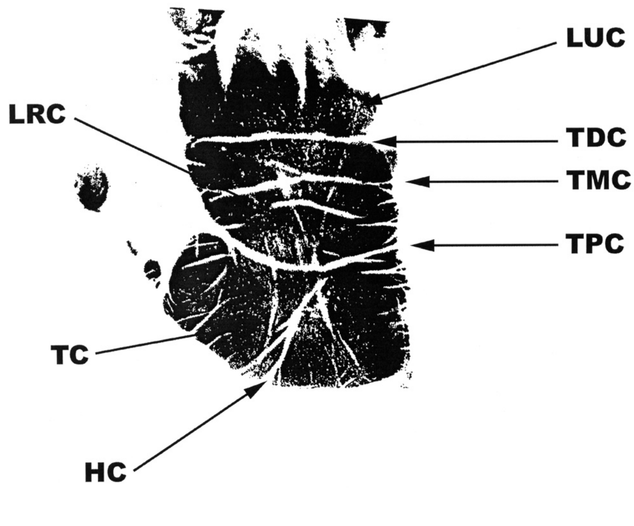

FIGURE 3. Flexion creases on palm of chimpanzee.

TABLE 3. Frequency of the secondary flexion creases on palms of chimpanzees in connection with age of individuals.

Age (number of individuals)	Secondary flexion creases		
	rare	common	dominant
Less than 10 years (13)	5	7	1
	38.46%	53.85%	7.69%
More than 10 years (9)	1	4	4
	12.50%	37.50%	50%
Unknown (4)	1	2	1
	25%	50%	25%

Only 2 transversal flexion creases (i.e. TDC, TPC) are obvious on palms of true brachiators (*Hylobates* sp.). The transversal distal creases occur in first (distal) third of palm and are formed by flexion and extension in metacarpophalangeal joints. Only fingers are used during movement, which are formed in hook grip. The proximal transversal crease is well distinct and runs proximally, which is induced by proximal position of thumb.

Besides, 3 transversal flexion creases (i.e. TDC, TMC, TPC) are present on palms of modified brachiators (*Pongo pygmaeus*). Transversal distal and medial creases run parallel and close to each other in first (distal) third of palm. They are formed by flexion and extension in metacarpophalangeal joints and by double-locking mechanism. The transversal proximal crease is slightly concave, which is induced by proximal position of the thumb.

Similarly, three transversal flexion creases (i.e. TDC, TMC, TPC) are obvious on palms of knuckle-walkers (*Pan paniscus*, *P. troglodytes*). Transversal distal and medial creases are parallel and further than by modified brachiators. They are also formed by flexion and extension in metacarpophalangeal joints. The transversal proximal crease is distinctly concave or a hypothenar-thenar bridge (HTB) is obvious.

CONCLUSIONS

According to analysis of studied palm prints and photos from different locomotion groups, it is possible to confirm the hypothesis that the coursing of primary flexion creases on palms of apes depends on locomotion type of primates.

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