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The Palmar Dermatoglyphics of Macaca Fascicularis: Compared with Data on Macaca Fuscata

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THE PALMAR DERMATOGLYPHICS OF Macaca fascicularis: COMPARED WITH DATA ON Macaca fuscata

By
Ronald G. Cauble

A Thesis Submitted to the Faculty of the Graduate College in partial fulfillment of the Degree of Master of Arts

Western Michigan University Kalamazoo, Michigan August, 1971
ACKNOWLEDGEMENTS

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I would like to thank all those persons in the Department of Anthropology at Western Michigan University who have contributed their time and resources to further my education.

Thanks are also due to the Department of Anthropology, University of Toronto, especially Dr. Frances Burton, for furnishing the Macaque specimens analyzed in this study. I am indebted to Dr. Jamshed Mavalwala, Richard Doble, and Pat Winnicki, all of the University of Toronto, for their technical advice on dermatoglyphics and help in printing procedures.

Ronald G. Cauble
Masters Thesis M-3008

CAUBLE, Ronald Gayle

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Western Michigan University, M.A.,
1971
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MAP 1 - LOCATIONS OF MACAQUE SPECIES CONSIDERED IN THIS STUDY

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THE PALMAR DERMATOGLYPHICS OF Macaca fascicularis:
COMPARSED WITH DATA ON Macaca fuscata

Introduction

At the present time there are few detailed dermatoglyphic studies of different non-human primate species. Besides the pioneering work by Cummins and Midlo (1943), a possible exception to this is the dermatoglyphic work on the Japanese monkey, M. fuscata, by Fukuoka (1941) and Iwamoto (1964a; 1964b, 1966, 1967). Other contributions have been made by such investigators as Hill (1953, 1955, 1957, 1960, 1962, 1966); Biegert (1961, 1963); Tips, Shininger and Perkins (1963); Tips, Picker-ing and Ushijima (1964); and Buettner-Janusch (1966).

Materials

The materials used in this study consisted of the dermatoglyphic prints of 70 Cynomolgus monkeys, Macaca fascicularis, purchased from the Connaught Labs in Toronto, Ontario, after they were sacrificed for medical purposes. These animals were received from the Philippines (Map 1), their place of origin, by the Connaught Labs between November 4, and December 2, 1969.

Printing Procedure

The printing procedure consisted of three (3) main steps:

1. With the onset of rigormortis the animal's hands became completely flexed and to facilitate printing, it was necessary to sever the flexor muscles of each wrist.
2. The hands were thoroughly cleaned with an alcohol and water solution.

3. After drying, the palmar and finger patterns (dermatoglyphics) were taken using the inkless Faurot fingerprint technique.

It was discovered that the printing of non-human primates is much more difficult than printing people for three (3) important reasons:

1. The small size of the Macaque hand.

2. The very uneven terrain of the palmar surface due to raised volar pads.

3. The integument of the hand is slightly rigid when cadaver specimens are used.

Classification of Dermatoglyphics

For comparative purposes it was decided to use the classification proposed by Mitsuo Iwamoto for *Macaca fuscata* (1964b). His classification is based on the following:

I. Fingerprint patterns

II. Palmar patterns

A. Thenar pattern (Th)

B. The first interdigital pattern (I)

C. The second interdigital pattern (II)

D. The third interdigital pattern (III)

E. The fourth interdigital pattern (IV)

F. Distal hypothenar pattern (Hd)

G. Proximal hypothenar pattern (HP)
III. Directions of the palmar ridges

A. Direction of the ridge starting at the second interdigital pattern (R.D.II)

B. Direction of the ridge starting at the third interdigital pattern (R.D.III)

C. Direction of the ridge starting at the distal hypothenar pattern (R.D.Hd)

I. Fingerprint Patterns

All fingerprints of *M. fascicularis* consisted of whorl-type patterns (Fig. 1a) which show no marked variations by fingers or sex. Iwamoto found the same thing to be true for *M. fuscata*. No further analysis of the fingerprints has been attempted in this study.

Fig. 1a Finger Pattern (Iwamoto 1964b)

II. Palmar Patterns

In the following classification of *Macaca fascicularis* dermatoglyphics, the classificatory results for each of the seven (7) palmar areas is set forth by pattern type, sex, and hand side. For comparative purposes the major pattern types for each palmar area of the Toronto group is listed along with the corresponding results obtained by Iwamoto for the Takasakiyama
and Yakushima groups, *M. fuscata fuscata* and *M. fuscata yakui* respectively (Map 1).

The position of each palmar pattern area is illustrated in Figure 1b.

Fig. 1b Positions of Palmar Patterns (Iwamoto 1964b)

A. Thenar pattern (Th)

Following Iwamoto's classification, the thenar patterns were first grouped into two main types: open field (0) and loop (L). Each of these types was then subdivided into two types: \( O_1, O_2 \) and \( L_1, L_2 \) as shown in Figure 2.

Fig. 2 Classification of Thenar Patterns (Th) (Iwamoto 1964b)

In the Toronto group, \( O_2 \) is the most frequent type (43%). The \( O_1 \) type was next (40.7%), followed by
L1 (16.3%), and the L2 type was not represented. A significant sex difference was discovered when the O1, O2 and L1 types were tested by chi-square; however, bimanual differences were not found to be significant (Tables 1a and 12).

The major thenar pattern frequencies for the Toronto group as well as Iwamoto's two subspecies of *M. fuscata* are given in Table 1b.

**TABLE 1**

**a. Frequency of Occurrence of Each Type of Thenar Pattern (Th)**

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Right Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O1</td>
<td>O2</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>24</td>
<td>29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Total of Left and Right Hands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O1</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>55</td>
</tr>
</tbody>
</table>

**b. Frequency of Occurrence of O and L of Thenar Pattern (Th)**

<table>
<thead>
<tr>
<th>Group</th>
<th>O1 (O1 + O2)</th>
<th>O2 (O1 + O2)</th>
<th>L1 (L1 + L2)</th>
<th>L2 (L1 + L2)</th>
<th>Total (O1 + O2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>113 (83.7%)</td>
<td>22 (16.3%)</td>
<td>135 (100.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>74 (66.7%)</td>
<td>37 (33.3%)</td>
<td>111 (100.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yakushima</td>
<td>14 (16.9%)</td>
<td>69 (83.1%)</td>
<td>83 (100.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**B. The first interdigital pattern**

The first interdigital pattern is classified as illustrated in Fig. 3, where type O indicates open field, type Lo single loop, type Ll loop with an
accessory loop, and type D double loop and type W whorl.

Fig. 3 Classification of the First Interdigital Pattern (I)
(Iwamoto 1964b)

The most frequent type of first interdigital pattern is the single loop (57.7%) and next is the whorl (33.6%). The 0, L1, and D types only occurred in low frequencies (2.9%, 2.2%, 3.6%, respectively). There were no significant sex or bimanual differences noted in the first interdigital patterns (Tables 2a and 12).

The major patterns and their frequencies for the three taxonomic groups are given in Table 2b.

**TABLE 2**

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Right Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O Lo L1 D W Total</td>
<td>O Lo L1 D W Total</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>2 28 2 2 14</td>
<td>48 2 27 1 1 17 48</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0 11 0 2 7</td>
<td>20 0 13 0 0 8 21</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>2 39 2 4 21</td>
<td>68 2 40 1 1 25 69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>Group</th>
<th>Sex</th>
<th>Left and Right Hands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>O Lo L1 D W Total</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>4 55 3 3 31</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0 24 0 2 15</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>4 79 3 5 46</td>
<td>137</td>
</tr>
</tbody>
</table>
b. Total Frequencies of O + L and Those of D + W of the First Interdigital Pattern (I)

<table>
<thead>
<tr>
<th>Group</th>
<th>O+L(0+Lo+Ll)</th>
<th>D + W</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>86 (62.8%)</td>
<td>51 (37.2%)</td>
<td>137 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>73 (66.4%)</td>
<td>37 (33.6%)</td>
<td>110 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>56 (83.6%)</td>
<td>11 (16.4%)</td>
<td>67 (100.0%)</td>
</tr>
</tbody>
</table>

C. The second interdigital pattern (II)

The classification of the second interdigital pattern is illustrated in Fig. 4. All second interdigital patterns except two are of the whorl type (W). These non-whorl patterns were proximal loops which occurred on the same animal (H 849 M). It is interesting to note that Iwamoto only has one occurrence of the proximal loop which occurred on a Takasakiyama male (1964b:57). Significant differences by sex and between left and right hands were discovered when the whirling direction of the ridges in the whorl patterns were tested statistically (Tables 3a and 12).

The major patterns and their frequencies for the three different groups are given in Table 3b.

---

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TABLE 3

a. Frequency of Occurrence of Each Type of the Second Interdigital Pattern (II)

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th></th>
<th></th>
<th>Right Hand</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lp</td>
<td>Wr</td>
<td>Wo</td>
<td>Wu</td>
<td>W?</td>
<td>Total</td>
<td>Lp</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>20</td>
<td>12</td>
<td>47</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>1</td>
<td>9</td>
<td>14</td>
<td>28</td>
<td>17</td>
<td>69</td>
<td>1</td>
</tr>
<tr>
<td>Total of</td>
<td>Group</td>
<td>Sex</td>
<td>Left and Right Hands</td>
<td></td>
<td></td>
<td>Right Hands</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lp</td>
<td>Wr</td>
<td>Wo</td>
<td>Wu</td>
<td>W?</td>
<td>Total</td>
<td>Lp</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>64</td>
<td>14</td>
<td>94</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>6</td>
<td>8</td>
<td>22</td>
<td>7</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>2</td>
<td>10</td>
<td>18</td>
<td>86</td>
<td>21</td>
<td>137</td>
<td></td>
</tr>
</tbody>
</table>

b. Frequency of Occurrence of Wr, Wo, and Wu of the Second Interdigital Pattern (II)

<table>
<thead>
<tr>
<th>Group</th>
<th>Wr</th>
<th>Wo</th>
<th>Wu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>10 (8.8%)</td>
<td>18 (15.8%)</td>
<td>86 (75.4%)</td>
<td>114 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>26 (25.5%)</td>
<td>27 (26.5%)</td>
<td>49 (48.0%)</td>
<td>102 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>19 (28.4%)</td>
<td>11 (16.4%)</td>
<td>37 (55.2%)</td>
<td>67 (100.0%)</td>
</tr>
</tbody>
</table>

D. The third interdigital pattern (III)

The same method of classification used for the second interdigital pattern is used for the third interdigital pattern (Fig. 4).

Analysis of the third interdigital patterns revealed that whorl types were the most frequent (132 cases) with only two proximal loops (Lp) and four distal loops (Ld). Significant bimanual differences were discovered when the whirling directions of the whorl patterns were tested; however, no significant sex differences were observed (Tables 4a and 12).

The major patterns and their frequencies for all three groups of macaques are given in Table 4b.
TABLE 4

a. Frequency of Occurrence of Each Type of the Third Interdigital Pattern (III)

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>Lp</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Right Hand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total of Left and Right Hands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

b. Frequency of Occurrence of Wr, Wo, and Wu of the Third Interdigital Pattern (III)

<table>
<thead>
<tr>
<th>Group</th>
<th>Wr (%)</th>
<th>Wo (%)</th>
<th>Wu (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>57 (51.8%)</td>
<td>34 (30.9%)</td>
<td>19 (17.3%)</td>
<td>110 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>50 (66.7%)</td>
<td>19 (25.3%)</td>
<td>6 (8.0%)</td>
<td>75 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>32 (54.2%)</td>
<td>9 (15.3%)</td>
<td>18 (30.5%)</td>
<td>59 (100.0%)</td>
</tr>
</tbody>
</table>

E. The fourth interdigital pattern (IV)

The same classification method used for the second and third interdigital patterns was employed for the fourth interdigital pattern (Fig. 4). The fourth interdigital patterns were mostly whorl types with only seven cases of distal loops (Ld). A significant bimanual difference in the whirling directions of the whorl patterns was discovered; however, no significant sex difference was found (Tables 5a and 12).
Table 5b gives the major patterns and their frequencies for the Toronto and Japanese groups of Macaca.

**TABLE 5**

a. Frequency of Occurrence of Each Type of the Fourth Interdigital Pattern (IV)

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Right Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ld</td>
<td>Wr</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>4</td>
<td>46</td>
</tr>
</tbody>
</table>

Total of Left and Right Hands

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Ld</th>
<th>Wr</th>
<th>Wo</th>
<th>Wu</th>
<th>W?</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>M</td>
<td>0</td>
<td>43</td>
<td>14</td>
<td>15</td>
<td>22</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>7</td>
<td>13</td>
<td>9</td>
<td>7</td>
<td>14</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>7</td>
<td>56</td>
<td>21</td>
<td>24</td>
<td>29</td>
<td>137</td>
</tr>
</tbody>
</table>

b. Frequency of Occurrence of Wr, Wo, and Wu of the Fourth Interdigital Pattern (IV)

<table>
<thead>
<tr>
<th>Group</th>
<th>Wr</th>
<th>Wo</th>
<th>Wu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>56</td>
<td>21</td>
<td>24</td>
<td>101</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>85</td>
<td>12</td>
<td>8</td>
<td>105</td>
</tr>
<tr>
<td>Yakushima</td>
<td>35</td>
<td>8</td>
<td>11</td>
<td>54</td>
</tr>
</tbody>
</table>

F. Distal hypothenar pattern (H<sup>d</sup>)

The classification of this palmar area is illustrated in Fig. 5. No whorl types were discovered in the Toronto group, which was also the case for Iwamoto's Yakushima group (1964b:60).
The distal hypothenar area consisted mainly of the open field type pattern (93.4%) and the remainder (6.6%) was of the loop type (Lr and Lu). No significant sex or bimanual differences were observed (Tables 6a and 12).

The distal hypothenar pattern frequencies for each of the three taxonomic groups is given in Table 6b.

### TABLE 6

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th></th>
<th></th>
<th></th>
<th>Right Hand</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>Lr</td>
<td>Lu</td>
<td>Wr</td>
<td>Total</td>
<td>0</td>
<td>Lr</td>
<td>Lu</td>
<td>Wr</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>42</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>47</td>
<td>43</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>21</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>63</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>69</td>
<td>67</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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TABLE 6

a. Continued

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Total of Left and Right Hands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>85</td>
</tr>
<tr>
<td>F</td>
<td>43</td>
<td>1</td>
</tr>
<tr>
<td>M &amp; F</td>
<td>128</td>
<td>6</td>
</tr>
</tbody>
</table>

b. Frequency of Occurrence of O, L, and W of Distal Hypothenar Pattern (H^d)

<table>
<thead>
<tr>
<th>Group</th>
<th>O</th>
<th>(Lr+Lu)</th>
<th>(Wr+Wo+Wu)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>128 (94.1%)</td>
<td>8 (5.9%)</td>
<td>0 (-%)</td>
<td>136 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>77 (68.8%)</td>
<td>32 (28.6%)</td>
<td>3 (2.7%)</td>
<td>112 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>84 (100.0%)</td>
<td>0 (-%)</td>
<td>0 (-%)</td>
<td>84 (100.0%)</td>
</tr>
</tbody>
</table>

G. Proximal hypothenar pattern (HP)

The classification of this palmar area is illustrated in Fig. 6

![Fig. 6 Classification of Proximal Hypothenar Pattern (HP)](image)

When all proximal hypothenar patterns are pooled, it can be seen in Table 7a that each type (Lo, Ll, D, W) is well represented with a slightly higher frequency of the whorl type (37.0%). Significant sex and bimanual differences were found when the sums of the loop types (Lo and Ll) and whirling types (D and W) were tested (Tables 7a and 12).
The major proximal hypothenar patterns and their frequencies for each of the three groups are given in Table 7b.

**TABLE 7**

a. Frequency of Occurrence of Each Type of Proximal Hypothenar Pattern (HP)

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Right Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lo</td>
<td>L1</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>11</td>
<td>23</td>
</tr>
</tbody>
</table>

Total of Group Sex Left and Right Hands

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Right Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lo</td>
<td>L1</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>23</td>
<td>30</td>
</tr>
</tbody>
</table>

b. Frequency of Occurrence of L Type and Total Frequency of W Type of (HP)

<table>
<thead>
<tr>
<th>Group</th>
<th>Lo+L1</th>
<th>D+W</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>53 (41.7%)</td>
<td>74 (58.3%)</td>
<td>127 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>53 (47.7%)</td>
<td>58 (52.3%)</td>
<td>111 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>83 (98.8%)</td>
<td>1 (1.2%)</td>
<td>84 (100.0%)</td>
</tr>
</tbody>
</table>

III. Directions of the Palmar Ridges

A complete description of palmar dermatoglyphics must include the directions of the ridges which intervene in the palmar patterns. In order to describe the ridge directions and for comparative purposes the method of partitioning and numbering the Macaque hand devised by Iwamoto (1964b) was utilized (Fig. 7).
Fig. 7 Numbering and Partition of the Macaque Palm (left) as Compared with the Partition and Numbering of the Human Hand (Iwamoto 1964b)

A. Direction of the ridge starting from the second interdigital pattern (R.D. II).

"This is the ridge starting from the proximal part of the second interdigital pattern (II) and is called here the ridge direction II (R.D. II)." (Iwamoto 1964b:62)

In the Toronto group (M. fascicularis), most of the R.D. II ridges terminate on part 2 of the palm (76.4%). When the terminals of R.D. II were tested, a significant sex difference was discovered; however, the bimanual difference was less than significant (Tables 8a and 12).

Table 8b gives the frequencies of the major ridge direction II terminals for each of the Macaque groups.
TABLE 8

a. Frequency of the Ending of Ridge Direction II (R.D. II) on Each Terminal

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>1</th>
<th>2</th>
<th>2/4</th>
<th>2/5</th>
<th>2/6</th>
<th>5</th>
<th>6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>M</td>
<td>6</td>
<td>39</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>6</td>
<td>52</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>70</td>
</tr>
</tbody>
</table>

b. Frequency of the Ending of Ridge Direction II (R.D. II) on Parts 2, 5, 6 and Others

<table>
<thead>
<tr>
<th>Group</th>
<th>2</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>107</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>92</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Yakushima</td>
<td>9</td>
<td>35</td>
<td>32</td>
</tr>
</tbody>
</table>

B. Direction of the ridge starting from the third interdigital pattern (R.D. III).

"As to this ridge, the course of the proximal radiant radiating from the triradius which lies in the proximal part of the third interdigital pattern, was pursued. When this triradius is absent, in the case in which
the third interdigital pattern is of the open field type (0), for instance, we must suppose its expected position from which the above-mentioned radiant will arise." (Iwamoto 1964b:64)

In the Toronto group most of the R.D. III terminals are located in part 6 of the palm (87%). No significant sex or bimanual differences were found when the R.D. III terminals were tested (Tables 9a and 12).

The major terminal frequencies for each of the three Macaque groups is given in Table 9b.

TABLE 9

a. Frequency of the Ending of Ridge Direction III (R.D. III) on Each Terminal

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th>Right Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 2/6 5 6 x Total</td>
<td>2 2/6 5 6 x Total</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>5 2 1 39 0 47 4 2 0 42 0</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1 0 1 20 0 22 2 0 0 20 0</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>6 2 2 59 0 69 6 2 0 62 0</td>
<td>70</td>
</tr>
</tbody>
</table>

Total of Group Left and Right Hands

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>2 2/6 5 6 x Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>M</td>
<td>9 4 1 81 0          95</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3 0 1 40 0          44</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>12 4 2 121 0      139</td>
</tr>
</tbody>
</table>

b. Frequency of the Ending of Ridge Direction III (R.D. III) on Parts 2, 5, 6 and Others

<table>
<thead>
<tr>
<th>Group</th>
<th>2</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>12 (8.6%)</td>
<td>2 (1.4%)</td>
<td>121 (87.1%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>15 (13.6%)</td>
<td>0 (-)</td>
<td>94 (85.5%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>3 (3.8%)</td>
<td>3 (3.8%)</td>
<td>72 (91.1%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>4 (2.9%)</td>
<td>139 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>1 (0.9%)</td>
<td>110 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>1 (1.3%)</td>
<td>79 (100.0%)</td>
</tr>
</tbody>
</table>
C. Direction of the ridge starting from the distal hypothenar pattern (R.D. H^d)

The method used to describe this ridge direction is different from those mentioned above because it is rare to find a triradius in this area. The terminal was regarded as that part where more than half of the total ridges terminated. If the ridges in this area branched off toward several different parts, the areas where the largest branches terminated were recorded as the terminal parts.

Most of the R.D. H^d terminals are located in part 2 (65.2%) of the palm area for the Toronto group. When the terminals for this ridge direction were tested there were no marked sex differences, but the bimanual differences were significant (Tables 10a and 12). The terminal frequencies for this area (R.D. H^d) are presented in Table 10b for each Macaque group.

TABLE 10

a. Frequencies of the Ridge Direction H^d Endings for Each Terminal

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Left Hand</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>( \frac{1}{8} )</td>
<td>2/12</td>
<td>10</td>
<td>3</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>24</td>
<td>13</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>36</td>
<td>16</td>
<td>0</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Right Hand</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>( \frac{1}{8} )</td>
<td>2/12</td>
<td>10</td>
<td>3</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>36</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>18</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>54</td>
<td>10</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Total of Left and Right Hands</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>( \frac{1}{8} )</td>
<td>2/12</td>
<td>10</td>
<td>3</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Toronto</td>
<td>M</td>
<td>60</td>
<td>20</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>30</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>M &amp; F</td>
<td>90</td>
<td>26</td>
<td>0</td>
<td>17</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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TABLE 10

b. Frequencies of the Terminal Endings for Ridge Direction $H^d$ on Parts 2, $1\sim2/8\sim12$, $10\sim12$, and Others

<table>
<thead>
<tr>
<th>Group</th>
<th>2</th>
<th>$1\sim2/8\sim12$</th>
<th>$10\sim12$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>90 (65.2%)</td>
<td>26 (18.8%)</td>
<td>18 (13.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>105 (94.6%)</td>
<td>0 (-%)</td>
<td>6 (5.4%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>18 (22.0%)</td>
<td>35 (42.7%)</td>
<td>29 (35.4%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>4 (2.9%)</td>
<td>138 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>0 (-%)</td>
<td>111 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>0 (-%)</td>
<td>82 (100.0%)</td>
</tr>
</tbody>
</table>

Table 11 presents the major palmar patterns and their frequencies for the II, III, and IV interdigital areas combined, whereas the previous data on these three areas only presented the whirling directions of all whorls found. The data on the two subspecies of the Japanese monkey is also presented.

TABLE 11

Frequency of Occurrence of O, L and W Patterns on the II, III, and IV Interdigital

<table>
<thead>
<tr>
<th>Group</th>
<th>O</th>
<th>L</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>0 (-%)</td>
<td>15 (3.6%)</td>
<td>397 (96.4%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>5 (1.5%)</td>
<td>27 (8.1%)</td>
<td>301 (90.4%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>1 (0.4%)</td>
<td>8 (3.2%)</td>
<td>242 (96.4%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>412 (100.0%)</td>
</tr>
<tr>
<td>Takasakiyama</td>
<td>333 (100.0%)</td>
</tr>
<tr>
<td>Yakushima</td>
<td>251 (100.0%)</td>
</tr>
</tbody>
</table>
RESULTS OF CLASSIFICATION

The classification of all Cynomolgus monkeys (M. fascicularis) revealed a number of interesting discoveries which are as follows:

(1) Of the 70 individuals of M. fascicularis printed, all except one (H 899 M) could be classified in Iwamoto's scheme for the Japanese monkey (M. fuscata). The palmar patterns of this one animal were quite aberrant, and he may represent an outsider of a different type or a genetic anomaly.

(2) It was discovered that all fingerprints exhibit a uniform whorl-type pattern, and they show no marked variations by fingers or sex (Fig. 1a). This same condition was also discovered by Iwamoto for the Japanese monkey, and therefore he was unable to incorporate them into his classification (Iwamoto 1964b:65).

(3) Significant sex differences and bimanual differences were found for several of the palmar pattern areas of M. fascicularis after testing by chi-square (Table 12).

<table>
<thead>
<tr>
<th>Palmar Areas and Ridge Directions</th>
<th>Significantly Different</th>
<th>Not Significantly Different</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sex</td>
<td>Bimanual</td>
</tr>
<tr>
<td>Th</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>III</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>R.D. II</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>R.D. III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.D. Hd</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Probability level of 0.05 was used as the dividing line for significance.
These significant sex and bimanual differences in the dermatoglyphics of certain palmar areas cannot be explained and have never been thoroughly dealt with before. While M. fascicularis reveals significant sex differences in four (4) palmar areas, the Japanese monkeys analyzed by Iwamoto only exhibited a significant sex difference for the first interdigital area (Iwamoto 1964b:65). The bimanual differences are similar between the two different species and consist mainly of differences in the whirling direction of whorl ridges for interdigital areas II, III, and IV. A good example of the bimanual differences observed is illustrated in Table 13 for the third and fourth interdigital areas.

**TABLE 13**

Example of Bimanual Differences and Similarities Observed in Macaque Species

**Third Interdigital**

<table>
<thead>
<tr>
<th>Left Hand</th>
<th>Toronto</th>
<th>Takasakiyama</th>
<th>Yakushima</th>
<th>Takasakiyama &amp; Yakushima</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wr</td>
<td>45 (69.2%)</td>
<td>36 (83.7%)</td>
<td>27 (71.1%)</td>
<td>63 (77.8%)</td>
</tr>
<tr>
<td>Wo</td>
<td>8 (12.3%)</td>
<td>6 (14.0%)</td>
<td>2 (5.3%)</td>
<td>8 (9.9%)</td>
</tr>
<tr>
<td>Wu</td>
<td>2 (3.1%)</td>
<td>0 ( -%)</td>
<td>0 ( -%)</td>
<td>0 ( -%)</td>
</tr>
<tr>
<td>W?</td>
<td>10 (15.4%)</td>
<td>1 (2.3%)</td>
<td>9 (23.7%)</td>
<td>10 (12.3%)</td>
</tr>
<tr>
<td>Total</td>
<td>65 (100%)</td>
<td>43 (100%)</td>
<td>38 (100%)</td>
<td>81 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Right Hand</th>
<th>Toronto</th>
<th>Takasakiyama</th>
<th>Yakushima</th>
<th>Takasakiyama &amp; Yakushima</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wr</td>
<td>12 (17.9%)</td>
<td>14 (37.8%)</td>
<td>5 (13.5%)</td>
<td>19 (25.7%)</td>
</tr>
<tr>
<td>Wo</td>
<td>26 (38.8%)</td>
<td>13 (35.1%)</td>
<td>7 (18.9%)</td>
<td>20 (27.0%)</td>
</tr>
<tr>
<td>Wu</td>
<td>17 (25.4%)</td>
<td>6 (16.2%)</td>
<td>18 (48.6%)</td>
<td>24 (32.4%)</td>
</tr>
<tr>
<td>W?</td>
<td>12 (17.9%)</td>
<td>4 (10.8%)</td>
<td>7 (18.9%)</td>
<td>11 (14.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>67 (100%)</td>
<td>37 (100%)</td>
<td>37 (100%)</td>
<td>74 (100%)</td>
</tr>
</tbody>
</table>
TABLE 13 (Cont.)

Fourth Interdigital

<table>
<thead>
<tr>
<th>Left Hand</th>
<th>Toronto</th>
<th>Takasakiyama</th>
<th>Yakushima</th>
<th>Takasakiyama &amp; Yakushima</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wr</td>
<td>46 (71.9%)</td>
<td>55 (98.2%)</td>
<td>27 (65.9%)</td>
<td>82 (84.5%)</td>
</tr>
<tr>
<td>Wo</td>
<td>7 (10.9%)</td>
<td>0 (0.0%)</td>
<td>1 (2.4%)</td>
<td>1 (1.0%)</td>
</tr>
<tr>
<td>Wu</td>
<td>3 (4.7%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>W?</td>
<td>8 (12.5%)</td>
<td>1 (1.8%)</td>
<td>13 (31.7%)</td>
<td>14 (14.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>64 (100%)</td>
<td>56 (100%)</td>
<td>41 (100%)</td>
<td>97 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Right Hand</th>
<th>Toronto</th>
<th>Takasakiyama</th>
<th>Yakushima</th>
<th>Takasakiyama &amp; Yakushima</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wr</td>
<td>10 (15.2%)</td>
<td>30 (54.5%)</td>
<td>8 (19.0%)</td>
<td>38 (39.2%)</td>
</tr>
<tr>
<td>Wo</td>
<td>14 (21.2%)</td>
<td>12 (21.8%)</td>
<td>7 (16.7%)</td>
<td>19 (19.6%)</td>
</tr>
<tr>
<td>Wu</td>
<td>21 (31.8%)</td>
<td>8 (14.5%)</td>
<td>11 (26.2%)</td>
<td>19 (19.6%)</td>
</tr>
<tr>
<td>W?</td>
<td>21 (31.8%)</td>
<td>5 (9.1%)</td>
<td>16 (38.1%)</td>
<td>21 (21.6%)</td>
</tr>
<tr>
<td>Total</td>
<td>66 (100%)</td>
<td>55 (100%)</td>
<td>42 (100%)</td>
<td>97 (100%)</td>
</tr>
</tbody>
</table>

It can be seen that the whirling direction for the left hand in each taxa and for both areas is "significantly" to the radial side; however, the whirling directions are rather evenly divided for the right hand in each group. It appears to this investigator that the very low frequency of ulnar whorls on the left hand for Interdigital Areas III and IV could be a distinctive generic trait for Macaca, and it may even have a wider taxonomic significance.

(4) Although the bimanual differences are great, and this certainly helps to justify using both left and right hands to increase the sample size, it must be noted that there are some similarities between hands. For example, the number of couplets (homologous areas exhibiting the same patterns) in the Toronto group gives a percentage of approximately 60%. It is interesting to observe that the Takasakiyama and Yakushima groups have couplet percentages of around 55% and 66% respectively. All three couplet percentages are similar enough to suggest that they may represent yet another dermatoglyphic trait which shows little variability within the genus Macaca. Naturally the percentages of couplets only include those pairs of palmar areas where both patterns were legible.
COMPARATIVE ANALYSIS

Through first-hand contact with several genera in the superfamily Cercopithecoidae, and research on various others, it has become apparent that as a group they are quite generalized and similar in many ways. However, this observation is by no means new or unique, for example, Chiarelli has noted that the species in the genera Papio, Macaca, Theropithecus and Cercocebus have many chromosomes which are morphologically similar. He also suggests that the chromosome contents must be quite similar and cites evidence of interspecific and inter-generic hybrids which have excellent viability to elucidate this point (1965:271-281). Another example of the similarities between the different taxa of the Cercopithecoidae, and specifically the Cercopithecinae, has been made possible by the separation of serum proteins into different components by two-dimensional starch-gel electrophoresis. Using this technique Morris Goodman has noted that the resulting patterns differ much more among various hominoid types (e.g. man, gorilla, chimpanzee, gibbon and orangutan) than between macaques, baboons, and vervets. He goes on to state that, "Indeed the various species of the subfamily Cercopithecinae examined by two-dimensional starch-gel electrophoresis (five species of Macaca, one of Papio, and one of Cercopithecus) show a high degree of similarity" (1964:220).

In his discussion of taxonomic relationships among the primates as determined by different structural conditions of the skull, hands, and feet, Josef Biegert, cites further evidence pertaining to the phylogenetic similarities of the Cercopithecoidae.
Structurally the chiridia of the Cercopithecoidae are more generalized and much more uniform than those of the Hominoidea. In the Cercopithecinae in particular because of interspecific variability a sharp delimitation of the species on the basis of dermatoglyphic pattern is hardly possible. In this sense the dermatoglyphic pattern is mainly group specific. In the Colobinae the species differences are more marked (e.g. Nasalis and Colobus). However, Pygathrix and Presbytis are not clearly differentiated from the Cercopithecinae. This relative uniformity of the chiridia is an outstanding trait of the Cercopithecoidae, as compared with the Ceboidae and the Hominoidea (1964:139).

The dermatoglyphic data in the present study offer a unique opportunity to test Biegert's statement that dermatoglyphic patterns of the Cercopithecinae are not useful as species-specific indicators and indirectly other evidence presented illustrating the more uniform and generalized biological nature of the Cercopithecinae.

In order to test Biegert's statement the data on Macaca fascicularis was compared with that presented by Iwamoto on the two subspecies of M. fuscata from Takasakiyama and Yakushima. More specifically the major dermatoglyphic patterns for each palmar area of the Toronto group (M. fascicularis) were compared statistically (chi-square test) with each of the corresponding patterns in the two subspecies of the Japanese monkey (Table 14).

To determine if the palmar dermatoglyphics are in fact a species-specific indicator, it was assumed that since the Takasakiyama (M. fuscata fuscata) and Yakushima (M. fuscata yakui) groups only differ as subspecies of M. fuscata then their dermatoglyphic patterns should be substantially more alike than either one is to an entirely different species of Macaque (in this case M. fascicularis). This assumption would be validated of course if the dermatoglyphic patterns actually reflect species' boundaries.
### TABLE 14
Chi-square Comparisons Between Macaque Groups

<table>
<thead>
<tr>
<th>Palmar Areas and Ridge Directions</th>
<th>Degrees of Freedom</th>
<th>Toronto-Takasakiyama $\chi^2$</th>
<th>P</th>
<th>Toronto-Yakushima $\chi^2$</th>
<th>P</th>
<th>Takasakiyama-Yakushima $\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Th</td>
<td>1</td>
<td>9.74</td>
<td>0.003</td>
<td>94.69</td>
<td>(.001)</td>
<td>47.32</td>
<td>(.001)</td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>0.34</td>
<td>0.577</td>
<td>9.28</td>
<td>0.004</td>
<td>6.30</td>
<td>0.013</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>18.42</td>
<td>(.001)</td>
<td>12.73</td>
<td>0.003</td>
<td>2.38</td>
<td>0.306</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>4.96</td>
<td>0.087</td>
<td>6.83</td>
<td>0.036</td>
<td>11.68</td>
<td>0.005</td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
<td>16.28</td>
<td>(.001)</td>
<td>1.37</td>
<td>0.506</td>
<td>6.30</td>
<td>0.045</td>
</tr>
<tr>
<td>Hd</td>
<td>2</td>
<td>27.72</td>
<td>(.001)</td>
<td>5.25</td>
<td>0.077</td>
<td>31.96</td>
<td>(.001)</td>
</tr>
<tr>
<td>Hp</td>
<td>1</td>
<td>0.88</td>
<td>0.362</td>
<td>72.09</td>
<td>(.001)</td>
<td>59.01</td>
<td>(.001)</td>
</tr>
<tr>
<td>R.D. II</td>
<td>3</td>
<td>23.66</td>
<td>(.001)</td>
<td>123.12</td>
<td>(.001)</td>
<td>40.95</td>
<td>(.001)</td>
</tr>
<tr>
<td>R.D. III</td>
<td>3</td>
<td>4.27</td>
<td>0.238</td>
<td>3.58</td>
<td>0.312</td>
<td>8.80</td>
<td>0.035</td>
</tr>
<tr>
<td>R.D. Hd</td>
<td>3</td>
<td>34.73</td>
<td>(.001)</td>
<td>44.74</td>
<td>(.001)</td>
<td>109.58</td>
<td>(.001)</td>
</tr>
<tr>
<td>II, III &amp; IV</td>
<td>2</td>
<td>13.54</td>
<td>0.002</td>
<td>1.59</td>
<td>0.464</td>
<td>8.01</td>
<td>0.019</td>
</tr>
</tbody>
</table>

P = Probability of coming from the same population.

(.001) = Less than the decimal .001

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FIG. 8
RESULTS OF BETWEEN-GROUP CHI-SQUARE COMPARISONS

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The results of the chi-square comparisons between the patterns of the three groups (Toronto, Takasakiyama and Yakushima) are listed in Table 14 and further illustrated in Figure 8. By using the probability level of 0.05 as the dividing line for biological significance the following results can be observed:

1. **Toronto-Takasakiyama (M. fascicularis-M. fuscata fuscata)**
   
The chi-square comparisons of these two groups shows that four (4) of the palmar areas tested are not significantly different (I, III, HP, and R.D. III).

2. **Toronto-Yakushima (M. fascicularis-M. fuscata yakui)**
   
The statistical comparisons of the two groups also reveals four (4) palmar areas which are not significantly different (IV, h^d, R.D. III, and II+III+IV).

3. **Takasakiyama-Yakushima (M. fuscata fuscata-M. fuscata yakui)**
   
The chi-square comparisons of these two subspecies only revealed one (1) palmar area which is not significantly different.

4. **The testing of all palmar areas revealed that the Th, R.D. II, and R.D. H^d areas are the most sensitive indicators of between-group differences.**

**SUMMARY AND CONCLUSIONS**

The objectives of this dermatoglyphic study were twofold and consisted of (1) printing and recording the palmar dermatoglyphics for a sizeable population of *Macaca fascicularis*, and (2) a comprehensive test to try to determine if dermatoglyphics of the Cercopithecinae are reliable as species-specific indicators. The latter objective was made possible by comparing the dermatoglyphic results for
M. *fascicularis* with the results obtained by Iwamoto for two subspecies of the Japanese monkey (1964b:53-73).

When the palmar dermatoglyphics of *M. fascicularis* were classified a number of interesting results --- such as the absence of variation in the fingerprints, the percentages of couplets, sex differences and bimanual differences, and possible distinctive generic traits for *Macaca* (e.g., low frequency of ulnar whorls on the left hand for areas III and IV) --- were forthcoming.

Biochemical, chromosomal, and structural evidence was cited by Goodman, Chiarelli and Biegert respectively to illustrate the uniform and similar biological nature of the Cercopithecoida and especially the Cercopithecinae. Biegert also stated that the dermatoglyphics of the Cercopithecinae are not reliable as a species-specific indicator.

As a result of Biegert's statement and the other evidence illustrating the biological uniformity of the Cercopithecinae, the above-mentioned test (objective No. 2) was undertaken to try to determine if dermatoglyphics are useful as species-specific indicators. The results of the chi-square comparisons between *M. fascicularis* and the two subspecies of the Japanese monkey, illustrated in Table 14 and Figure 8, clearly showed that intraspecific variability obscures interspecific variability and can certainly be viewed as reinforcing Biegert's statement that dermatoglyphics are not reliable as a species-specific indicator for the Cercopithecinae. The assumption made earlier that the two subspecies of *M. fuscata* should be more alike in their palmar dermatoglyphics than either one is to a different species of Macaque was not upheld and therefore it was rejected. The interspecific chi-square tests also revealed that three (3) of the palmar
areas tested (Th, R.D. II, and R. D. Hd) are the most sensitive indicators of group, but not necessarily species-specific, differences. The group in this case may be in the form of a deme or population isolate.

Finally, it is believed by this investigator that these dermatoglyphic results, dealing with several members of the subfamily Cercopithecinae, are quite consistent with the biochemical and chromosomal uniformity of the group, and certainly lend support to the view held by many students of cercopithecoid evolution (e.g., Jolly 1965) that the radiation of the Cercopithecinae was not a very ancient event.
## APPENDIX

Raw Data for *Macaca fascicularis* Specimens

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Sex</th>
<th>Th</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Hd</th>
<th>HP</th>
<th>Left Hand</th>
<th>Right Hand</th>
<th>R. D. Formula</th>
<th>Th</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Hd</th>
<th>HP</th>
<th>R. D. Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 53</td>
<td>F</td>
<td>L1</td>
<td>Lo</td>
<td>W?</td>
<td>Wr</td>
<td>Ld</td>
<td>O</td>
<td>Wr</td>
<td>2/4:6:10</td>
<td>L1</td>
<td>Lo</td>
<td>-</td>
<td>Wo</td>
<td>Ld</td>
<td>0</td>
<td>Wr</td>
<td>5:6:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I 24</td>
<td>M</td>
<td>L1</td>
<td>Lo</td>
<td>W?</td>
<td>Wr</td>
<td>Lld</td>
<td>O</td>
<td>L1</td>
<td>1:6:1/10</td>
<td>L1</td>
<td>Lo</td>
<td>Wu</td>
<td>Wu</td>
<td>W?</td>
<td>O</td>
<td>L1</td>
<td>1:6:1/10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I 90</td>
<td>F</td>
<td>O1</td>
<td>Lo</td>
<td>W?</td>
<td>Ld</td>
<td>Lld</td>
<td>O</td>
<td>Ld</td>
<td>2:5:2/8</td>
<td>O1</td>
<td>Lo</td>
<td>Wu</td>
<td>Ld</td>
<td>Lu</td>
<td>O</td>
<td>Lu</td>
<td>2:5:2/8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H 935</td>
<td>M</td>
<td>O1</td>
<td>Lo</td>
<td>W?</td>
<td>Wr</td>
<td>Wr</td>
<td>O</td>
<td>Lo</td>
<td>2:6:2/10</td>
<td>O1</td>
<td>Lo</td>
<td>Wu</td>
<td>Wr</td>
<td>W?</td>
<td>O</td>
<td>W</td>
<td>2:6:2/10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H 964</td>
<td>F</td>
<td>O1</td>
<td>Lo</td>
<td>Wr</td>
<td>Wr</td>
<td>-</td>
<td>O</td>
<td>L1</td>
<td>2:6:10</td>
<td>O1</td>
<td>Lo</td>
<td>Wu</td>
<td>W?</td>
<td>W?</td>
<td>O</td>
<td>D</td>
<td>2:6:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H 940</td>
<td>M</td>
<td>O2</td>
<td>W</td>
<td>Wo</td>
<td>Wr</td>
<td>Lu</td>
<td>Ld</td>
<td>L1</td>
<td>1:2:3</td>
<td>O2</td>
<td>W</td>
<td>Wu</td>
<td>Wu</td>
<td>Wo</td>
<td>O</td>
<td>Lu</td>
<td>1:2:3</td>
<td></td>
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</tr>
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<td>H 989</td>
<td>M</td>
<td>O1</td>
<td>W</td>
<td>Wu</td>
<td>Wr</td>
<td>Lu</td>
<td>Ld</td>
<td>L1</td>
<td>2:3:8</td>
<td>O1</td>
<td>W</td>
<td>Wu</td>
<td>Wu</td>
<td>W?</td>
<td>O</td>
<td>Lu</td>
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### Appendix (Continued)

| Animal Number | Sex | Left Hand | Right Hand | R. D. Formula | Th | I | II | III | IV | hd | HP | Th | I | II | III | IV | HD | HP | R. D. Formula |
|---------------|-----|-----------|------------|---------------|----|---|----|-----|----|----|----|----|----|-----|----|----|----|----|----|----|---------------|
| H 949         | M   | L1        | Wr         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wr | 0   | Wu | 0   | L1 | Wr | Wu | 0   | Lo | 2:6:2 |               |
| H 957         | M   | L1        | Wu         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2:6:2 |               |
| H 945         | M   | L1        | Wu         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2:6:2 |               |
| H 958         | M   | L1        | Wu         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wr | 0   | Wu | 0   | L1 | Wr | Wu | 0   | Lo | 2:6:2 |               |
| H 902         | M   | L1        | Wr         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wr | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2:6:2 |               |
| H 965         | F   | L1        | Wu         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2/5:6:2 |               |
| H 951         | F   | L1        | Wu         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2:6:2 |               |
| RC 2          | M   | L1        | Wu         | 0             | L1 | 2:6:2 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2:6:2 |               |
| H 900         | M   | L1        | Wu         | 0             | L1 | 2:6:2/10 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 2:6:2/10 |               |
| I 190         | M   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wu | 0   | Wu | 0   | L1 | Wu | Wu | 0   | Lo | 5:6:10 |               |
| I 192         | M   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wu | 0   | Wu | 0   | L1 | Wu | Wu | 0   | Lo | 5:6:10 |               |
| H 832         | M   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 5:6:10 |               |
| I 189         | M   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 5:6:10 |               |
| I 193         | F   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 5:6:10 |               |
| H 848         | M   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 5:6:10 |               |
| H 849         | M   | L1        | Wu         | 0             | L1 | 5:6:10 | 0   | L1 | Wu | Wo | 0   | Wu | 0   | L1 | Wu | Wo | 0   | Lo | 5:6:10 |               |
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