ABSTRACT

Studi morfometrik telah dilakukan dengan mengukur 32 karakter dari 176 spesimen Dobsonia dari Papua. Spesimen-spesimen Dobsonia diwakili oleh enam OTU, yaitu G, B, R, E, SP1, dan SP2. Analisis univariat menghitung seluruh spesimen dewasa yang terdiri dari 171 karakter badan dan sayap dan 176 karakter tengkorak dan gigi pada enam OTU tersebut. Selanjutnya digunakan uji-t dan PCA untuk menghitung G, B, dan R, sedangkan tiga OTU lain (E, SP1 dan SP2) tidak dihitung tetapi ikut diproyeksikan ke dalam scatter plot. Hasil uji-t (p<0.05) menunjukkan ada seksual dimorfisme pada D. minor dan D. beauforti. Pemisahan D. magna, D. minor, dan D. beauforti nyata pada karakter badan, sayap, dan gigi berdasarkan PCA. D. emersa terpisah dari spesies lainnya pada karakter badan dan tengkorak. Hasil scatter plot pada SP1 dan SP2 mengelompok dengan D. beauforti pada semua karakter (badan, sayap, tengkorak, dan gigi). Sebanyak 32 karakter yang diukur didapatkan karakter taksonomi yaitu WT, HB, dan TV untuk karakter badan; FA, TIB, dan DIG1P untuk karakter sayap; ONL, POW, PL, dan MH untuk karakter tengkorak; $I^2$, $M^2$, $WM^1$, dan $LM^1$ untuk karakter gigi. D. minor yang telah ditemukan di Pulau Waigeo tahun 2007 merupakan catatan baru penyebaran spesies ini, sebelumnya hanya tercatat di daratan utama Papua dan Pulau Yapen.

Kata kunci: Dobsonia, morfometrik, variasi, penyebaran, Papua

INTRODUCTION

Dobsonia is a fruit bat group that is characterized by a pair of incisors; short rostrum (often considerably shortened); sub linear premaxilla; second finger without claw; wings attached at spinal line, with back looked bold (Andersen, 1912; Flannery, 1995a, 1995b).

In Papua, morphological characters of Dobsonia have been studied based on limited specimens and number of characters (Andersen, 1912; Tate, 1942; Bergmans, 1975; Bergmans & Sarbini, 1985; Flannery, 1995a, 1995b). Andersen (1912) described the size of D. magna and D. minor based on 23 external characters and 18 skull characters of nine specimens of D. magna and two specimens of D. minor. Whereas, Flannery (1995b) described seven external characters of nine D. magna and seven D. minor. Bergmans (1975) proposed D. beauforti as a new species based on five external characters and 12 skull characters of ten specimens. D. emersa was proposed as a new species by Bergmans & Sarbini (1985), based on two external characters and 19 skulls and dental characters of one specimen.

So far the studies on morphometric variation of Dobsonia sp. were based on limited specimen, morphometric characters and using univariate analysis. Present study uses more characters and samples from more localities and using multivariate analysis. This study aims to discover taxonomically
important characters and updates the geographical distribution of *Dobsonia* in Papua.

**MATERIALS AND METHODS**

**Materials**

Specimens of *Dobsonia* used in this study are represented in Table 1, and map of the location in

| Location                  | Species          | House of Collection | N  | Material        |
|---------------------------|------------------|---------------------|----|-----------------|
|                           |                  | UNIPA | MZB |                |
| Jayapura                  | *D. magna*      | 10    | 10  | Skin & skull    |
|                           | *D. minor*      | 14    | 14  | Skin & skull    |
| Kerom                     | *D. magna*      | 1     | 1   | Skin & skull    |
| Sarmi                     | *D. minor*      | 5     | 5   | Skin & skull    |
| Mamberamo                 | *D. minor*      | 18    | 6   | Skin & skull    |
| Waropen                   | *D. minor*      | 8     | 8   | Skin & skull    |
| Yapen Island              | *D. magna*      | 6     | 6   | Skin & skull    |
|                           | *D. minor*      | 4     | 4   | Skin & skull    |
| Supiori Island            | *D. beauforti*  | 10    | 10  | Skin & skull    |
|                           | *D. emersa*     | 4     | 4   | Skin & skull    |
| Nabire                    | *D. minor*      | 2     | 2   | Skin & skull    |
| Bintuni                   | *D. magna*      | 6     | 6   | Skin & skull    |
|                           | *D. minor*      | 2     | 2   | Skin & skull    |
| Wasior                    | *D. magna*      | 1     | 1   | Skin & skull    |
| Manokwari                 | *D. magna*      | 10    | 10  | Skin & skull    |
| Mimika                    | *D. minor*      | 4     | 4   | Skin & skull    |
| Wamena                    | *D. magna*      | 13    | 13  | Skin & skull    |
| Merauke                   | *D. minor*      | 4     | 4   | Skin & skull    |
| Mappi (Idenburg River)    | *D. magna*      | 1     | 1   | Skin & skull    |
| Raja Ampat Islands:       |                  |       |     |                 |
| - Waigeo Island           | *D. magna*      | 2     | 2   | Skin & skull    |
|                           | *D. beauforti*  | 9     | 9   | Skin & skull    |
| - Batanta Island          | *D. beauforti*  | 10    | 10  | Skin & skull    |
|                           | *D. magna*      | 1     | 1   | Skin & skull    |
| - Gag Island              | *D. beauforti*  | 16    | 16  | Skin & skull    |
|                           | *D. sp*         | 3     | 3   | 1 Skin & skull  |
|                           | *D. sp2*        | 6     | 6   | 2 Skull         |
|                           |                 |       |     | 3 Skin & skull  |
| Total                     |                  | 176   |     |                 |

UNIPA: Universitas Negeri Papua (The state University of Papua) Manokwari.
MZB: deposited in Museum Zoologicum Bogoriense, Cibinong.
Methods

*Dobsonia* from Mamberamo, Waropen, Supiori, and Manokwari were collected by using mist nets; data on sex, age and standard measurements were recorded. Specimens were fixed in 10% formalin and preserved in 70% ethanol. They are housed in Museum Zoologicum Bogoriense (MZB) and Laboratory of Biology, The State University of Papua (UNIPA). The specimens were measured in millimeter by using digital caliper with resolution of 0.05 mm, and weight in gram. Specimens in MZB are identified as *D. magna*, *D. minor*, *D. beauforti*, and *D. emersa*. Two species, designated as SP1 and SP2, are not yet described. According to Maryanto (pers.comm) SP1 and SP2 could be new species which closely related to *D. beauforti* in size, but different in shape. Because of incomplete identification, suspected new species, and statistical analysis which treated different taxa into one sample, we used Operational Taxonomic Unit (OTU) as the basis for analysis (Rohlf & Sokal 1962). Therefore, the study used six OTUs (Table 2).

![Map of materials studied from Papua](image)

**Figure 1.** Map of materials studied from Papua

| Species         | References                     | OTU | Number of adult |
|-----------------|--------------------------------|-----|-----------------|
| *D. magna*      | Flannery 1995a, 1995b          | G   | 51              |
| *D. beauforti*  | Flannery 1995a                 | B   | 48              |
| *D. minor*      | Flannery 1995a, 1995b          | R   | 71              |
| *D. emersa*     | Flannery 1995a                 | E   | 4               |
|                 | Maryanto (pers. comm)          | S1  | 3               |
|                 | Maryanto (pers. comm)          | S2  | 6               |

**Table 2.** Six OTUs and references

Morphometric Characters

The morphometric measurements are the standard ones on the body, wings, skull and teeth (Freeman 1981). There are thirty two characters illustrated in Figure 2. Explanation of figure 2 is given in Table 3.
Table 3. List of Characters used in the study

| No | Characters                          | Abbreviation | Figure |
|----|------------------------------------|--------------|--------|
| 1  | Head and body length               | HB           | 1A     |
| 2  | Tail vertebrae length              | TV           | 1A     |
| 3  | Ear length                         | E            | 1A     |
| 4  | Hindfoot length (su)               | HF           | 1A     |
| 5  | Forearm length                     | FA           | 1A     |
| 6  | Tibia length                       | TIB          | 1A     |
| 7  | Digit1 phalanx length              | DIG1P        | 1A     |
| 8  | Digit2 metacarpal length           | DIG2M        | 1A     |
| 9  | Digit3 metacarpal length           | DIG3M        | 1A     |
| 10 | Digit4 metacarpal length           | DIG4M        | 1A     |
| 11 | Digit5 metacarpal length           | DIG5M        | 1A     |
| 12 | Greatest skull length              | GSL          | 1B     |
| 13 | Condylobasal length                | CBL          | 1B     |
| 14 | Condylocanine length               | CCL          | 1C     |
| 15 | Orbit to nasal                     | ONL          | 1B     |
| 16 | Interorbital width                 | IOW          | 1B     |
| 17 | Postorbital width                  | POW          | 1B     |
| 18 | Zygomatic width                    | ZW           | 1B     |
| 19 | Braincase width                    | BW           | 1B     |
| 20 | Palatum length                     | PL           | 1C     |
| 21 | Mandible length                    | ML           | 1D     |
| 22 | Mandible height                    | MH           | 1D     |
| 23 | Mesopterygoid fossa width          | MFW          | 1C     |
| 24 | Upper toothrow                     | 1\(^{M2}\)   | 1C     |
| 25 | Outside upper canines width        | C\(^{C1}\)   | 1C     |
| 26 | Outside upper molar2 width         | M\(^{M2}\)   | 1C     |
| 27 | Lower toothrow                     | I\(^{M3}\)   | 1D     |
| 28 | Outside upper molar1 width         | M\(^{M1}\)   | 1C     |
| 29 | Upper molar1 length                | LM\(^{1}\)   | 1C     |
| 30 | Upper molar1 width                 | WM\(^{1}\)   | 1C     |
| 31 | Mandible teeth length              | C\(_{M3}\)   | 1D     |
| 32 | Weight                             | WT           |        |

Figure 2. Characters on the body and wing (A), skull (B).

Figure 2b. Characters on the skull (C, D).
Data Analysis

Before analysis, non-normality of values was examined by residual analysis. Data processing used R software on logarithm - converted measurement for generalize of scale. Missing data was surrogated by their means. E, SP1, and SP2 did not included in computation because of very few samples, but they were projected post analytically. Univariate analysis is used to describe statistics of characters on G, B, R, E, SP1 and SP2. T test (p<0.05) is used to recognize sexual dimorphism on the character of G, B, and R OTUs. Multivariate analysis used principal components analysis (PCA) method (Venables & Ripley 1999; Everrit & Hothorn 2006). The principal component analysis is a multivariate information extraction and ordination technique to reveal clusters of phenetically similar taxa. In analysis PCA, 32 characters were grouped into four group, they are body, wing, skull, and teeth characters.

RESULTS

Univariate Analysis
specimens for body and wing characters and 176 adult specimens for skull and teeth characters. Means and sexual dimorphism are found from T test analysis (p<0.05) on G is not significant difference, 15% from 32 characters difference on B, and 50% from 32 characters difference on R. Table 4a and 4b demonstrated that HF (su), DIG3M, CiC1, WM1 and C1M3 were sexual dimorphism on B: only one characters (CiC1) was sexual dimorphism on G; WT, HB, FA, TIB, DIG1P, DIG2M, DIG3M, DIG4M, DIG5M, GSL, CBL, CCL, ONL, ZW, ML and PL were sexual dimorphism on R.

Univariate data of the specimens are given in Table 5a and 5b. The size of Dobsonia from large to small is D. magna; D. emersa, D. beauforti, and D. minor, respectively. Size of SP1 and SP2 are not difference with D. beauforti.
Table 4b. Means and Sexual Dimorphism of B, G, and R OTUs on skull and teeth characters

| Characters | B |   |   | G |   |   | R |   |   |   |
|------------|---|---|---|---|---|---|---|---|---|---|
|            | ♂ | ♀ |   | ♂ | ♀ |   | ♂ | ♀ |   |   |
|            | Means | Means | Sexual dimorphism | Means | Means | Sexual dimorphism | Means | Means | Sexual dimorphism |
| GSL        | 42.92 | 42.62 | No | 58.47 | 58.54 | No | 36.87 | 37.45 | Yes |
| CBL        | 40.97 | 40.42 | No | 56.83 | 56.90 | No | 35.25 | 35.90 | Yes |
| CCL        | 40.78 | 40.04 | No | 56.71 | 56.42 | No | 35.08 | 35.65 | Yes |
| ONL        | 10.60 | 10.25 | No | 15.89 | 16.05 | No | 9.55  | 9.49  | Yes |
| IOW        | 7.94  | 7.96  | No | 10.84 | 10.65 | No | 7.30  | 7.44  | No  |
| POW        | 7.37  | 7.30  | No | 9.75  | 9.60  | No | 7.05  | 7.25  | No  |
| ZW         | 25.85 | 25.92 | No | 35.09 | 35.13 | No | 23.27 | 23.68 | Yes |
| BW         | 17.18 | 17.30 | No | 22.20 | 22.44 | No | 15.38 | 15.49 | No  |
| ML         | 31.12 | 30.67 | No | 45.45 | 45.18 | No | 27.76 | 28.24 | Yes |
| MH         | 15.92 | 16.07 | No | 22.13 | 22.14 | No | 13.02 | 13.20 | No  |
| PL         | 21.82 | 21.51 | No | 31.69 | 31.59 | No | 18.40 | 18.78 | Yes |
| MFW        | 5.21  | 5.12  | No | 7.62  | 7.67  | No | 4.76  | 4.86  | No  |
| FM′        | 17.28 | 16.83 | No | 25.40 | 25.05 | No | 13.67 | 13.96 | No  |
| C′C′       | 8.74  | 8.19  | Yes| 11.74 | 11.21 | Yes| 7.47  | 7.49  | No  |
| M′M′       | 11.38 | 11.35 | No | 16.69 | 16.88 | No | 10.35 | 10.49 | No  |
| IJM1       | 18.44 | 17.87 | No | 27.25 | 26.83 | No | 15.30 | 15.37 | No  |
| M′M′       | 13.01 | 12.74 | No | 18.36 | 18.33 | No | 11.03 | 11.05 | No  |
| LM′        | 4.31  | 4.25  | No | 6.10  | 6.01  | No | 3.00  | 3.01  | No  |
| WM′        | 2.41  | 2.31  | Yes| 3.40  | 3.55  | No | 1.71  | 1.69  | No  |
| C′M1       | 18.55 | 17.90 | Yes| 27.08 | 26.68 | No | 15.13 | 15.31 | No  |
Table 5a. Body and wing measurements of *Dobsonia*

| CHARACTERS TAXON | WT | HB | E | TV | HF (su) | FA | TIB | DIG1P | DIG2M | DIG3M | DIG4M | DIG5M |
|------------------|----|----|---|----|---------|----|-----|-------|-------|-------|-------|-------|
| *D. beauforti* ♀ | N  | 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | X  | 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | SD | 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | Min| 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | Max| 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
| *D. beauforti* ♂ | N  | 17 | 17 | 17 | 17     | 17 | 17  | 17    | 17    | 17    | 17    | 17    |
|                  | X  | 17 | 17 | 17 | 17     | 17 | 17  | 17    | 17    | 17    | 17    | 17    |
|                  | SD | 17 | 17 | 17 | 17     | 17 | 17  | 17    | 17    | 17    | 17    | 17    |
|                  | Min| 17 | 17 | 17 | 17     | 17 | 17  | 17    | 17    | 17    | 17    | 17    |
|                  | Max| 17 | 17 | 17 | 17     | 17 | 17  | 17    | 17    | 17    | 17    | 17    |
| *D. magna* ♀    | N  | 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | X  | 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | SD | 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | Min| 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
|                  | Max| 28 | 28 | 28 | 28     | 28 | 28  | 28    | 28    | 28    | 28    | 28    |
| *D. magna* ♂    | N  | 23 | 23 | 23 | 23     | 23 | 23  | 23    | 23    | 23    | 23    | 23    |
|                  | X  | 23 | 23 | 23 | 23     | 23 | 23  | 23    | 23    | 23    | 23    | 23    |
|                  | SD | 23 | 23 | 23 | 23     | 23 | 23  | 23    | 23    | 23    | 23    | 23    |
|                  | Min| 23 | 23 | 23 | 23     | 23 | 23  | 23    | 23    | 23    | 23    | 23    |
|                  | Max| 23 | 23 | 23 | 23     | 23 | 23  | 23    | 23    | 23    | 23    | 23    |
| *D. minor* ♀    | N  | 33 | 33 | 33 | 33     | 33 | 33  | 33    | 33    | 33    | 33    | 33    |
|                  | X  | 33 | 33 | 33 | 33     | 33 | 33  | 33    | 33    | 33    | 33    | 33    |
|                  | SD | 33 | 33 | 33 | 33     | 33 | 33  | 33    | 33    | 33    | 33    | 33    |
|                  | Min| 33 | 33 | 33 | 33     | 33 | 33  | 33    | 33    | 33    | 33    | 33    |
|                  | Max| 33 | 33 | 33 | 33     | 33 | 33  | 33    | 33    | 33    | 33    | 33    |
| *D. minor* ♂    | N  | 34 | 34 | 34 | 34     | 34 | 34  | 34    | 34    | 34    | 34    | 34    |
|                  | X  | 34 | 34 | 34 | 34     | 34 | 34  | 34    | 34    | 34    | 34    | 34    |
|                  | SD | 34 | 34 | 34 | 34     | 34 | 34  | 34    | 34    | 34    | 34    | 34    |
|                  | Min| 34 | 34 | 34 | 34     | 34 | 34  | 34    | 34    | 34    | 34    | 34    |
|                  | Max| 34 | 34 | 34 | 34     | 34 | 34  | 34    | 34    | 34    | 34    | 34    |
Table 5b. Skull and dental measurements of *Dobsonia*

|          | X    | 63.73 | 113.14 | 20.68 | 13.02 | 16.04 | 77.45 | 28.91 | 26.98 | 36.72 | 50.62 | 45.80 | 49.35 |
|----------|------|-------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | SD   | 4.36  | 10.53  | 1.44  | 2.36  | 1.52  | 1.52  | 0.10  | 2.39  | 1.78  | 1.83  | 1.87  | 1.95  |
|          | Min  | 55.00 | 100.5  | 15.96 | 9.03  | 12.98 | 73.70 | 26.67 | 22.34 | 32.81 | 45.47 | 40.55 | 43.47 |
|          | Max  | 76.39 | 135.0  | 23.18 | 20.00 | 20.32 | 80.25 | 31.78 | 31.58 | 40.14 | 53.60 | 49.26 | 53.33 |
| *D. emersa* ♂ | N    | 4     | 4      | 4      | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     |
|          | X    | 195.25| 166.20 | 28.75 | 23.50 | 24.75 | 115.50| 49.25 | 36.94 | 49.39 | 72.58 | 64.79 | 66.07 |
|          | SD   | 14.64 | 7.50   | 1.50  | 1.00  | 1.25  | 1.73  | 1.50  | 1.51  | 0.82  | 1.54  | 1.81  | 1.30  |
|          | Min  | 174.0 | 155.0  | 27.00 | 22.00 | 23.00 | 114.0 | 47.00 | 34.83 | 48.46 | 70.43 | 63.06 | 64.17 |
|          | Max  | 207.0 | 170.0  | 30.00 | 24.00 | 26.00 | 118.0 | 50.00 | 38.41 | 50.21 | 73.89 | 66.81 | 67.07 |
| SP1 ♂   | N    | 1     | 1      | 1      | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
|          | X    | 126   | 120.73 | 25.67 | 20.61 | 21.17 | 103.53| 44.91 | 31.49 | 44.12 | 65.17 | 56.40 | 58.11 |
| SP2 ♂   | N    | 1     | 1      | 1      | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
|          | X    | 122   | 140.1  | 28.81 | 22.24 | 24.22 | 111.05| 46.97 | 35.00 | 47.88 | 68.93 | 61.71 | 64.07 |
| SP2 ♂   | N    | 2     | 2      | 2      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
|          | X    | 162.0 | 152.8  | 26.57 | 20.35 | 21.00 | 106.8 | 46.75 | 36.21 | 49.50 | 67.52 | 61.56 | 63.14 |

| CHARAC  | GS | CB | CC | ON | IO | PO | ZW | B | I'M | C'I | M'M | ML | M'H | I'M | M'M | PL | L | M'1 | W | MF | C1 | M1 |
| TAXON   |    |    |    |    |    |    |    |   |    |     |     |    |    |    |    |    |    |    |    |    |    |
| D.     | N  | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Beaufo  | X  | 42 | 40 | 40 | 40 | 10 | 25 | 7.9 | 7.3 | 25.92 | 17.30 | 16.83 | 11.35 | 30.67 | 16.07 | 17.87 | 12.74 | 21.51 | 4.25 | 2.35 | 5.14 |
| riti    |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Min     | S  | 21 | 23 | 23 | 23 | 0.7 | 0.6 | 0.6 | 0.4 | 1.6 | 0.5 | 0.9 | 0.3 | 0.6 | 2.1 | 1.6 | 1.0 | 1.0 | 0.6 | 1.0 | 0.6 | 0.1 |
|         | D  | 37 | 35 | 35 | 35 | 9.1 | 6.9 | 6.4 | 6.2 | 6.4 | 15.30 | 10.02 | 25.77 | 11.49 | 16.41 | 16.18 | 16.66 | 3.87 | 2.08 | 2.64 | 1.64 |
| Max     | M  | 47 | 30 | 45 | 94 | 45.36 | 12.56 | 9.1 | 8.3 | 8.3 | 29.21 | 18.66 | 20.05 | 35.35 | 35.61 | 35.18 | 23.39 | 25.48 | 5.22 | 2.61 | 5.94 | 21.38 |

*SP1♂*: 100% male, *SP2♂*: 100% female, *SP3♂*: 100% male, *SP4♂*: 100% female.

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| Beaufort | X | 42.92 | 40.97 | 40.78 | 10.60 | 7.94 | 7.37 | 25.85 | 17.18 | 17.28 | 8.74 | 11.38 | 31.12 | 15.92 | 18.44 | 13.01 | 21.82 | 4.31 | 2.41 | 5.21 | 18.55 |
|----------|---|-------|-------|-------|-------|------|------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|
| S        | 1.60 | 1.61 | 1.63 | 0.59 | 0.35 | 0.45 | 1.67 | 0.48 | 0.83 | 0.37 | 0.57 | 1.30 | 1.32 | 0.97 | 0.98 | 0.91 | 0.89 | 0.82 | 0.83 | 0.87 | 0.87 |
| D        | 38.1 | 38.1 | 38.1 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 | 9.32 |
| M        | 45.0 | 45.0 | 45.0 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 |

| D. magna | X | 58.54 | 56.90 | 56.42 | 16.05 | 10.65 | 9.60 | 35.13 | 22.44 | 25.05 | 11.21 | 16.88 | 45.18 | 22.14 | 26.83 | 18.33 | 31.59 | 6.00 | 3.50 | 7.64 | 26.68 |
|----------|---|-------|-------|-------|-------|------|------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|
| S        | 2.48 | 2.65 | 2.70 | 1.04 | 0.64 | 0.65 | 1.06 | 0.69 | 0.68 | 1.01 | 1.03 | 1.06 | 1.06 | 1.06 | 1.07 | 1.04 | 1.02 | 1.02 | 1.04 | 1.04 | 1.08 |
| D        | 52.1 | 50.1 | 50.1 | 13.49 | 15.15 | 25.13 | 9.50 | 8.70 | 30.11 | 21.12 | 32.13 | 19.14 | 15.12 | 39.15 | 17.16 | 24.12 | 26.15 | 49.14 | 26.15 | 65.14 |
| M        | 61.37 | 60.36 | 59.68 | 17.11 | 52.10 | 14.06 | 43.38 | 23.34 | 26.43 | 13.17 | 18.14 | 48.18 | 25.29 | 23.24 | 20.31 | 24.32 | 31.32 | 8.62 | 9.34 | 16.29 |

| D. minor | X | 58.47 | 56.71 | 56.42 | 15.89 | 10.45 | 9.60 | 35.13 | 22.44 | 25.05 | 11.21 | 16.88 | 45.18 | 22.14 | 26.83 | 18.33 | 31.59 | 6.00 | 3.50 | 7.64 | 27.08 |
|----------|---|-------|-------|-------|-------|------|------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|
| S        | 3.22 | 3.30 | 3.55 | 1.33 | 0.70 | 0.66 | 1.06 | 0.68 | 0.42 | 0.10 | 0.68 | 15.06 | 15.17 | 15.06 | 15.06 | 15.06 | 15.06 | 15.06 | 15.06 | 15.06 |
| D        | 51.92 | 49.26 | 48.10 | 11.75 | 8.48 | 30.12 | 10.93 | 8.10 | 23.40 | 12.13 | 20.93 | 16.12 | 30.10 | 16.13 | 24.13 | 17.32 | 25.32 | 5.43 | 4.26 | 23.65 |
| M        | 64.96 | 62.68 | 62.68 | 16.00 | 57.12 | 40.10 | 63.23 | 47.27 | 51.27 | 33.13 | 33.01 | 15.50 | 52.49 | 14.92 | 53.49 | 14.50 | 65.49 | 14.50 | 53.49 | 14.50 |

| D. minor | X | 37.54 | 36.74 | 35.95 | 5.74 | 7.72 | 23.71 | 15.53 | 14.02 | 7.50 | 10.49 | 27.76 | 13.42 | 15.10 | 18.85 | 3.00 | 1.70 | 4.80 | 15.12 |
|----------|---|-------|-------|-------|------|------|-------|-------|-------|------|------|-------|-------|-------|-------|------|------|------|------|------|
| S        | 0.80 | 0.90 | 0.80 | 0.45 | 0.50 | 0.46 | 0.48 | 0.35 | 0.30 | 0.32 | 0.35 | 0.21 | 0.15 | 0.17 | 0.15 | 0.45 | 0.15 | 0.50 | 0.15 | 0.35 | 0.08 |
| D        | 35.94 | 33.30 | 33.30 | 8.51 | 6.11 | 6.11 | 22.00 | 14.02 | 10.92 | 6.45 | 9.75 | 26.11 | 14.11 | 11.14 | 14.03 | 10.07 | 1.45 | 1.45 | 1.45 |
| M        | 39.31 | 37.37 | 37.37 | 10.10 | 50.83 | 14.84 | 24.68 | 16.26 | 14.76 | 8.25 | 11.13 | 29.11 | 15.15 | 16.15 | 11.84 | 3.18 | 1.54 | 1.54 | 1.54 |

| D. minor | X | 36.87 | 35.35 | 35.95 | 7.30 | 7.03 | 23.37 | 15.38 | 13.67 | 7.40 | 10.35 | 27.32 | 13.30 | 11.03 | 18.40 | 3.01 | 1.76 | 4.76 | 15.36 |
|----------|---|-------|-------|-------|------|------|-------|-------|-------|------|------|-------|-------|-------|-------|------|------|------|------|------|
| S        | 0.70 | 0.80 | 0.70 | 0.50 | 0.60 | 0.60 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| D        | 35.50 | 34.11 | 34.09 | 8.65 | 0.65 | 0.62 | 22.01 | 14.03 | 13.00 | 6.83 | 9.60 | 26.11 | 14.50 | 14.21 | 17.40 | 2.60 | 1.40 | 1.40 | 1.40 |
| M        | 38.38 | 38.38 | 10.79 | 8.22 | 24.16 | 14.78 | 11.88 | 30.14 | 18.14 | 13.19 | 19.32 | 19.19 | 19.32 | 19.19 | 19.32 | 19.19 | 19.32 | 19.19 | 19.32 |
DISCUSSION

Morphometric study

*D. magna* was described by Andersen (1912) based on nine specimens of external characters (FA, TV, E, TIB, HF (cu), DIG1P to DIG5M) and six specimens of 18 skull characters. He did not separate the specimen between female and male, and it is only describe of morphology. Flannery (1995b) separated male and female in describe on seven external characters (WT, HB, E, FA, TV, TIB, HF) of nine specimens of *D. magna*, but he did not analyze sexual dimorphism. This study analyzed of *D. magna* based on 32 characters and separated into 28 females and 23 males. T test analysis (p<0.05) on 32 characters of *D. magna* resulted sexual dimorphism on C1C1 (male larger than female). The PCA demonstrated that *D. magna* separated from other species on body, wing, skull, and teeth characters.

*D. minor* was described based on two specimens (one specimen is immature) of external characters (FA, TV, E, TIB, HF (cu), DIG1P to DIG5M) and six specimens of 18 skull characters (Andersen 1912). Whereas, Flannery (1995b) separated male and female in describe on seven external characters (WT, HB, E, FA, TV, TIB, HF) of seven specimens of *D. minor*, but he did not analyze sexual dimorphism. Description of *D. minor* by Boeadi & Bergmans (1987) based on 39 characters and separated male and female, but they did not sexual dimorphism. This study analyzed of *D. minor* based on 32 characters and separated into 33 females and 34 males. T test analysis (p<0.05) on 32 characters of *D. minor* resulted sexual dimorphism in body, wing, and skull characters (WT, HB, FA, TIB, DIG1P, DIG2M, DIG3M, DIG4M, DIG5M, GSL, CBL, CCL, ONL, ZW, ML and PL). Its size of female larger than male. The PCA demonstrated that *D. minor* separated from other species on wing, and teeth characters are significant, whereas body and skull characters reach *D. beauforti*.

According to Bonaccorso* et al.* (2002), females *D. minor* had significantly larger mean core-use areas than males (1.43 ± 0.61 and 0.65 ± 0.16 ha, respectively). Also, females have larger long-axes across the home range than males that indicating longer commuting flights between day roosts and foraging areas. The longer commuting flights of female are a possible cause of their external body and wing characters larger than male.

*D. beauforti* was proposed as a new species based on five body characters (HB, TV, E, FA, HF su) and 12 skull characters of ten specimens (Bergmans 1975). He separated male and female and use univariate analysis, but he did not analyze sexual dimorphism. According to Flannery (1995a), *D. beauforti* is sexually dimorphic in body size (WT and HB) that male larger than female; but he did not measure wing, skull and teeth characters. He measured five males and four males of specimens. This study examined a total of 32 characters on *D. beauforti* (28 females and 17 males) and use univariate and multivariate analysis. T test analysis (p<0.05) resulted sexual dimorphism on HF su, DIG3M, C1C1, WM3, C3M3 of *D. beauforti*. HF su and DIG3M on female is larger than male, on the contrary C1C1, WM1, C3M3 on male is larger than female. The PCA demonstrated that *D. beauforti* separated from other species on wing and teeth characters, whereas body and skull characters of small size to reach large size of *D. minor*.

*D. emersa* was proposed as a new species by Bergmans & Sarbini (1985), based on two body characters (FA and WT) and 19 skull and teeth characters of one specimen. This study examined a total of 32 characters on *D. emersa* (four males) and use univariate analysis, but it is not analyze sexual dimorphism. When *D. emersa* are projected in scatter plot, its position separate from other species on body and teeth characters. SP1 and SP2 however can not be diagnosed separately from *D. beauforti*.

This is the first study that used PCA to analyze morphometric characters on *Dobsonia*. Formerly, PCA was used in morphometric study on *Cynopterus nusatenggara* (Kitchener and Maharadatunkamsi, 1996). The study of *Cynopterus nusatenggara* to group characters into two variables, they are external variable (11 characters) and skull variable (16 characters). The PCA demonstrated that FA, TIB, DIG1P to DIG5M lengths (external), GSL, PL, C3M1, C1M2, CPL, ONL, and MFB (skull) are characters used as taxonomic character for *Cynopterus nusatenggara* (Kitchener 1996).
CONCLUSION AND FUTURE STUDIES

*D. magna*, *D. minor*, *D. beauforti*, and *D. emersa* are distinct in body, wing, skull, and teeth characters. SP1 and SP2 are projected into domain of *D. beauforti* in external body, wing, skull, and teeth. There are sexual dimorphisms in *D. beauforti* and *D. minor*. The characters that sexually dimorphic on *D. beauforti* are HF su, DIG3M, C1C1, WM1, and C1M1; whereas on *D. minor* are WT, HB, FA, TIB, DIG1P, DIG2M, DIG3M, DIG4M, DIG5M, GSL, CBL, CCL, ONL, ZW, ML, and PL. The characters that can be used as taxonomical characters of *Dobsonia* are WT, HB and TV for body characters; FA, TIB, and DIG1P for wing characters; ONL, POW, PL, and MH for skull characters; F2M2, M2M2, WM1 and LM1 for teeth characters. The presence of *D. minor* from Waigeo Island is a new record.

Further study is needed to investigate SP1 and SP2 which have been grouped in *D. beauforti*.

REFERENCES

Andersen, K. 1912. *Catalogue of The Chiroptera in The Collection of British Museum*, 2nd ed. Vol I. Megachiroptera. London: Printed by Order of the Trustees.

Bergmans, W. 1975. A new species of *Dobsonia* Palmer, 1898 (Mammalia, Megachiroptera) from Waigeo, with notes on other members of the genus. *Beaufortia* 23:3-7.

Bergmans, W. and S. Sarbini. 1985. Fruit bats of the genus *Dobsonia* Palmer, 1898 from the islands of Biak, Oiiw, Numfoor and Yapen, Irian Jaya (Mammalia, Megachiroptera). *Beaufortia* 34:181-189.

Boeadi and W. Bergmans. 1987. First record of *Dobsonia minor* (Dobson, 1879) from Sulawesi, Indonesia (Mamalia, Megachiroptera). *Bulletin Zoologisch Museum* 11(8):69-76.

Bonaccorso, F.J. 1998. *Bats of Papua New Guinea*. Papua New Guinea: Conservation International.

Bonaccorso, F.J., J.R.Winkelmann, E.R.Dumont, K. Thibault. 2002. Home range of *Dobsonia minor* (Pteropodidae): A solitary, foliage-roosting fruit bat in Papua New Guinea. *Biotropica* 34(1):127-135.

Everitt, B.S. and T. Hothorn. 2006. *A Handbook of Statistical Analyses Using R*. USA: Chapman & Hall/CRC.

Flannery, T. 1995a. *Mammals of the South-West Pacific & Mollucan Islands* (1st ed). Australia: Reed Books.

Flannery, T. 1995b. *Mammals of New Guinea* (2nd ed). Australia: Reed Books.

Freeman, P.W. 1981. A multivariate study of the family Molossidae (Mammalia, Chiroptera): morphology, ecology, evolution. *Fieldiana Zoology* 7:1-173.

Kitchener, D.J. and Maharadatunkamsi. 1996. Geographic variation in morphology of *Cynopterus nusatenggara* (Chiroptera, Pteropodidae) in Southeastern Indonesia, and description of two new subspecies. *Mammalia* 60:255-276.

Rohlf, F.J. and R.R. Sokal. 1962. The comparison of dendrograms by objective method. *Taxon* (Abstract).

Tate, G.H.H. 1942. Pteropodidae (Chiroptera) of the Archbold collections. *Bulletin of The American museum of Natural history* 80(48):331-347.

Venables, W.N. and B.D. Ripley. 1999. *Modern Applied Statistics with S-PLUS* (3st ed). New York: Springer.