

**RE-DESCRIPTION OF THE ADULTS OF INDIAN GYPSY MOTH
LYMANTRIA OBFUSCATA WALKER (LEPIDOPTERA:
LYMANTRIIDAE) IN HIMACHAL PRADESH, INDIA**

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ABSTRACT: *Lymantria obfuscata* Walker is a serious pest of about 200 broad-leaved tree species, including oaks, throughout India. It is a small moth, belonging to family Lymantriidae (class Insecta), which over-winter in egg stage in the form of egg-masses and has six larval instars. Sexual dimorphism was distinct, as the female moths were dull brown having shiny pubescence and sedentary, while the males were dark coloured having well-developed wings. The taxonomic description was not completely available in the past so the present study emphasized on the re-description of the adult stages of *L. obfuscata*.

KEY WORDS: *Lymantria obfuscata*, IGM, genitalia, wing venation, scales.

The forests of Himachal Pradesh are composed of valuable species like deodar, chir, kail, oak and various other conifers and broad-leaved species. In the recent past, these valuable forests have been sufferings a huge loss on the account of diseases and outbreak of insect pests, which constitute a serious problem in the management of forest resources (Baker, 1972; Furniss & Carolin, 1977). The majority of important forest defoliators are Lepidoptera. *Lymantria obfuscata* Walker (1865), commonly known as Indian Gypsy Moth (IGM) is a serious pest of about 200 broad-leaved tree species throughout India, viz. willow (*Salix* spp.), poplar (*Populus* spp.), oak (*Quercus* spp.), walnut (*Jugulans* spp.), apple (*Malus* spp.), apricot (*Prunus* spp.), cherry (*Prunus cerasus*) and almond (*Prunus amygdalis*) (Beeson, 1941; Dharmadhikari et al., 1985; Rishi & Shah, 1985). It is found in the montane and submontane zones of northwestern India and West Pakistan and reported from northern and southern plains of India.

Several outbreaks as well as sporadic attack of this pest have been reported from Himachal Pradesh (Verma et al., 1979). An outbreak was reported in year 2005, from Sarahan and Narag in Sirmour district (H.P.), where massive defoliation of oak trees took place (Singh et al., 2007). Infestations of IGM cause major loss of the fodder trees and cash crops. *L. obfuscata* is one of the most destructive pests of fruit and forest plantations including willows and poplars in Kashmir (Malik et al., 1972; Sheikh, 1975). Fletcher (1919) was the first to focus attention on *L. obfuscata* as a serious pest of apple, apricot, willow and poplar and Rahman (1941) observed it feeding on apple trees at Kotgarh, Shimla. Incidence of *L. obfuscata* on apples, poplars, willows and other plantations in India has also been reported by Pruthi & Batra (1960) and Singh & Singh (1986). Earlier the same species was described under the Genus *Porthetria*. At present the Taxonomy ID for *Lymantria obfuscata* Walker is 78900, which is internationally accepted. It was felt that taxonomic re-description of the adult moth of *Lymantria obfuscata* Walker was necessary because detail account of both the male and female moths was incomplete. All the adult moths studied, were from the laboratory reared stock.

MATERIALS AND METHODS

The biology of *L. obfuscata* was studied under the laboratory conditions for four consecutive years, 2006 to 2009 at HFRI, Shimla, with the average temperature and relative humidity of $19.98 \pm 4.535^\circ\text{C}$ and $58.46 \pm 16.627\%$, respectively [Thermo-Hygro Clock M288CTH, Mextech]. The egg-masses of IGM were collected from the areas of Sarahan and Bhuntar (H.P.). These egg-masses were then placed in the laboratory for over-winter storage. The hatching of eggs took place around mid March and the neonate larvae were placed on fresh tender leaves of *Quercus leucotrichophora* Roxb. (ban oak), in the wire-meshed wooden cages of dimensions, 65 cm \times 68 cm \times 99 cm, having a sliding glass on one side and the bottom resting on the wooden base.

The adult moths, as they emerged from laboratory reared stock, were instantly killed by exposing them to cotton soaked ethyl acetate and were subsequently stretched, pinned and preserved. Morphology of the male and female adult moths was studied by taking observations on different body parts of the moth. The body length and wing span of adult moth were measured with Digital Caliper [Aerospace, Resolution 0.01 mm]. The colour, shape and size, structure of antennae, legs, wings and body segments were studied. The length and wing span of the adult moths were measured by taking the mean of five male and five female moths. Slides of insect body parts, such as head, antennae, fore- and hind-wings and genitalia were prepared. The weight of the adult moths was measured by taking the mean of sixty male and female moths each with the help of electronic balance [Denver Instrument, TB-214, d=0.1 mg].

Mounting of wings

For the preparation of slides of forewing and hindwing of adult moth, the wings were detached from the body of the adult moth with fine pointed forceps by piercing the body cuticle surrounding the wing base and then pulling the wing loose. The wings were bleached by immersing them in sodium hypochlorite solution for 1-3 minutes and after that the surface of the wings was rubbed softly, with a fine brush so as to separate the scales. Unwanted parts of body cuticle and muscles at the base of wing were also removed. Dehydration of the wings was done in 70%, 90% and 100% grades of alcohol, for 5-10 minutes each. Then the wings were mounted in modified Bersale's mounting media.

Preparation of genitalia

For the preparation of genitalia, the posterior segments of the adult were exposed and sliced with the help of scissors. These segments were taken in the test tube and boiled in 10% KOH for 5-10 minutes in water bath. After cooling, the samples were cleared of their respective tergum, sternum, muscles and internal tissues in the cavity block. Dehydration was done in 70%, 90% and 100% grades of alcohol, for 5-10 minutes each. Lastly, drying was done with the help of blotting paper and then warmed gently in chloral phenol solution (clearing agent) and mounted in modified Bersale's mounting media.

Microscopic observations

Morphometric studies were made with the help of compound microscope [Nikon E400] and Radical stereo zoom microscope [RSM-9] with USB Digital Scale 1.1E software in a digital microscopic workstation. Photography was done with the help of Nikon D80 Digital SLR camera.

RESULTS AND DISCUSSION

Lymantria obfuscata

Lymantria obfuscata, Walker (1865)

Lymantria obfuscata, Hampson (1892)

Lymantria obfuscata, Strand (1910)

Lymantria obfuscata, Strand (1923)

Lymantria obfuscata, Schintlmeister (2004)

Lymantria (Porthetria) obfuscata, Pogue & Schaefer (2007)

Liparis obfuscata, Swinhoe (1923)

Morphology

In the present study it was observed that *Lymantria obfuscata* was a small moth, which exhibited sexual dimorphism. The female was dull brown with shiny pubescence on abdomen and possessed vestigial wings, whereas, the male was dark coloured having well developed wings with characteristic designs. Hampson (1892) also made the similar observations regarding the study of *L. obfuscata*.

The male moths were smaller, greyish in appearance and had bipectinate type of antennae (Fig. 1A). They have well developed pairs of wings, and fly actively in a zig-zag course, after their emergence from the puparium. The mean wing expanse, body length and weight of the male moth recorded was 31.80 ± 3.768 mm, 13.60 ± 1.140 mm and 60.14 ± 19.847 mg, respectively (Table 1). Ferguson (1978) has also reported that the male antennae were strongly bipectinate and have a few long, divergent spinules at the end of each pectination.

The female moths were creamy-white with heavy abdomen and serrate type of antennae. The wings were light yellow in appearance with the characteristic marks on them. The wings were not developed to such an extent that they can fly and therefore were sluggish (Fig. 1B). The mean wing expanse, body length and weight of the female moth recorded were 36.80 ± 6.611 mm, 18.40 ± 3.209 mm and 457.25 ± 142.135 mg, respectively (Table 1). Barbosa & Capinera (1978) also studied the adult gypsy moth females and found that they were flightless and dispersal was accomplished primarily by ballooning first instars.

Forewings of IGM were covered with greyish scales, were small sized with light fuscous or greyish brown colouration. The hindwings were trapezoidal and the forewings were oblong. The forewings and hindwings were well fringed. The hindwings have lighter colouration and were smooth without any pattern. Frenulum was characteristically present on the hindwing. Ferguson (1978) considered the resting posture of the adult to be diagnostic, as the wings were held flattened against the substrate, the forewings meeting at their dorsal margins, tending to form a triangle.

The head of male moth was hypognathus, front and vertex light brown, with a pair of light brown bipectinate antennae, and a pair of brown labial palpi, which were ventrally cream-coloured (Fig. 2A). The mean length and width of male head and antennae was recorded as 1.66 ± 0.192 mm and 2.38 ± 0.064 mm; and 6.53 ± 0.302 mm and 0.20 ± 0.019 mm, respectively, and mean length of male palpi measured was 0.99 ± 0.045 mm (Table 1).

Similarly, the head of female moth has front and vertex white, with a pair of black serrate antennae with short pectinations, and a pair of dark grey labial palpi (Fig. 2B). The mean length and width of female head and antennae was recorded as 1.89 ± 0.182 mm and 2.40 ± 0.115 mm; 6.04 ± 0.081 mm and 0.18 ± 0.027 mm, respectively, and mean length of female palpi measured was 0.71 ± 0.258 mm (Table 1).

The total mean length of foreleg of male was recorded as 8.06 ± 0.205 mm, with coxa, trochanter, femur, tibia, tarsus and claw, measuring 1.31 ± 0.027 mm, 0.39 ± 0.044 mm, 2.01 ± 0.050 mm, 1.97 ± 0.116 mm, 2.38 ± 0.074 mm and 0.24 ± 0.034 mm, respectively. The total mean length of midleg of male was recorded as 9.51 ± 0.106 mm, with coxa, trochanter, femur, tibia, tarsus and claw, measuring 1.47 ± 0.070 mm, 0.54 ± 0.033 mm, 2.45 ± 0.032 mm, 2.24 ± 0.104 mm, 2.80 ± 0.138 mm and 0.27 ± 0.057 mm, respectively. The total mean length of hindleg of male was recorded as 9.95 ± 0.124 mm, with coxa, trochanter, femur, tibia, tarsus and claw, measuring 1.48 ± 0.034 mm, 0.55 ± 0.078 mm, 2.55 ± 0.029

mm, 2.29 ± 0.069 mm, 3.09 ± 0.063 mm and 0.26 ± 0.048 mm, respectively. Hence, the foreleg was smaller and hindleg was longer than the midleg in case of male moth (Table 2).

Similarly, the total mean length of foreleg of female was recorded as 9.00 ± 0.427 mm, with coxa, trochanter, femur, tibia, tarsus and claw, measuring 1.52 ± 0.146 mm, 0.56 ± 0.058 mm, 2.21 ± 0.116 mm, 2.06 ± 0.093 mm, 2.64 ± 0.119 mm and 0.35 ± 0.046 mm, respectively. The total mean length of midleg of female was recorded as 10.31 ± 0.904 mm, with coxa, trochanter, femur, tibia, tarsus and claw, measuring 1.93 ± 0.166 mm, 0.76 ± 0.059 mm, 2.40 ± 0.210 mm, 2.45 ± 0.266 mm, 2.78 ± 0.243 mm and 0.34 ± 0.032 mm, respectively. The total mean length of hindleg of female was recorded as 10.42 ± 0.782 mm, with coxa, trochanter, femur, tibia, tarsus and claw, measuring 1.87 ± 0.149 mm, 0.69 ± 0.046 mm, 2.40 ± 0.201 mm, 2.69 ± 0.295 mm, 2.76 ± 0.179 mm and 0.32 ± 0.051 mm, respectively. Hence, in case of female moth also, the foreleg was smaller and hindleg was longer than the midleg (Table 3).

The abdomen of *L. obfuscata* was ten-segmented and in case of male moth, it was slender, tapering towards the hind end, reddish-brown dorsally and cream-coloured ventrally. The abdomen of the female moth was swollen, dark reddish-brown dorsally and ventrally and thickly covered with golden brown hairs. Casey (1980) has considered that in male gypsy moth the thorax is spherical in shape, having a diameter of 4-5 mm. The abdomen is long (11-12 mm), slender (diameter 2-3 mm) in shape, and poorly insulated. The dorsal surface of the first three abdominal segments is loosely covered with long, hair-like scales (1 mm) but they are much less dense than those on the thorax.

Wing venation

Forewing was found with discal cell almost equal to half the length of wing; costa minutely straight; apex obtusely angulate; termen slightly wavy; tornus obtusely angulate; inner margin nearly straight; Sc free from base; R_1 free originated from before upper angle of the discal cell; R_2 - R_5 stalked, very near to upper angle of discal cell. M_1 from upper angle of discal cell; M_2 from near lower angle of discal cell; M_3 from lower angle of discal cell; m_1 - m_2 angulated; m_2 - m_3 straight; CuA_1 from before lower angle of discal cell; Anal 1A free and straight (Figs. 3, 5).

Hindwing was observed with discal cell almost equal to half the length of wing; costa minutely straight; apex obtusely angulate; termen slightly wavy; tornus obtusely angulate; inner margin nearly straight; $Sc+R_1$ originated from base, approximated with discal cell from before middle, then diverging toward apex; R_s and M_1 shortly stalked from upper angle of discal cell; M_2 from near to lower angle of discal cell; M_3 from lower angle of discal cell; CuA_1 from before lower angle of discal cell; CuA_2 from behind middle of discal cell; Anal 1A free and straight; Frenulum present (Figs. 4, 6).

Genitalia

Male genitalia were found with uncus well-developed, curved, adorned with a single highly sclerotized spine-like structure; tegumen broad, partially sclerotized; lateral processes absent from tegumen; gnathus wanting; valva cone-shaped, highly sclerotized, undivided, not fused ventrally; vinculum almost equal to tegument; juxta partially sclerotized, a square plate with dorsal margin slightly concave, ventral margin with broad excavation; sacculus apex broadly rounded; saccus variable, from V-shaped to narrow U-shaped; aedeagus, sclerotized, straight, slightly curved distal to opening for ductus ejaculatorius; vesica ovate, ventrally produced lobe; cornuti absent (Figs. 7A,B, 8).

Female genitalia with ovipositor lobes well developed, setosed, sclerotized; papillae anales quadrate, dorsal margin truncate; anterior and posterior

apophyses short; ventral plate of ostium bursae broad, U-shaped, with vertical indentations or medial pockets, apices of these pockets merge medially; ductus bursae shorter than corpus bursae; corpus bursae oblong (Figs. 9A,B).

Wing scales

The presence of scales on the wings of order Lepidoptera, comprising moths and butterflies, characterizes this order of insects. The colour and pattern of wings was formed due to the scattering of light by scales present on the wings. The scales of *L. obfuscata* were seen under the compound microscope and variable shapes and sizes were observed. Some were small and stout, other long and even long and stout, with variable number of dentations (one, two, three or four). The body of a typical scale consisted of an upper and lower lamina and scales were attached on the wing by a stalk or pedicel (Fig. 10).

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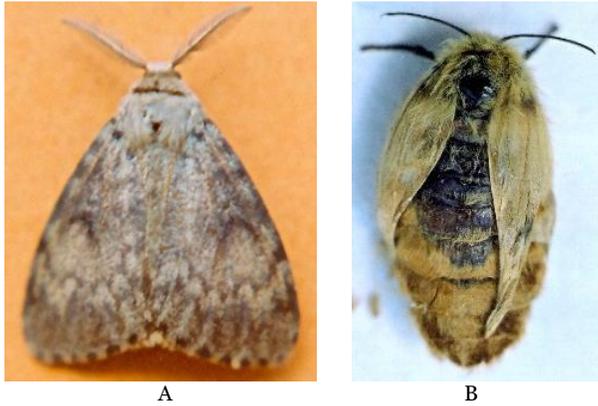


Figure 1. A) Adult male of *Lymantria obfuscata*. B) Adult female of *Lymantria obfuscata*.

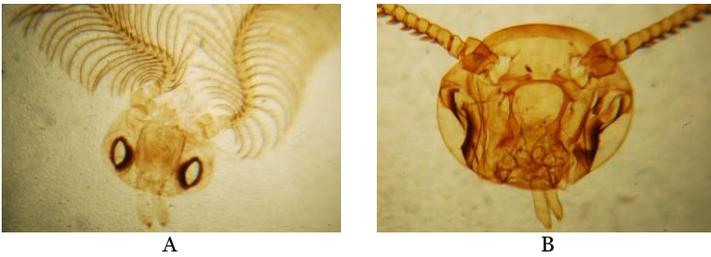


Figure 2. A) Dorsal view of head of adult male moth (x20). B) Dorsal view of head of adult female moth (x40).

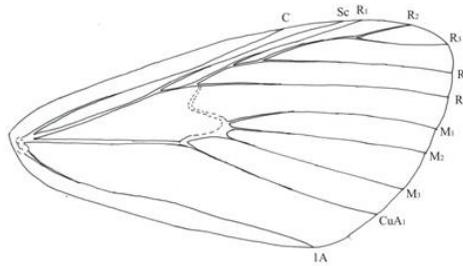


Figure 3. Forewing of adult male moth (x35). (C= Costa, Sc= Subcosta, R= Radial, Rs= Radial Sector, M= Medial, Cu= Cubital, A= Anal).

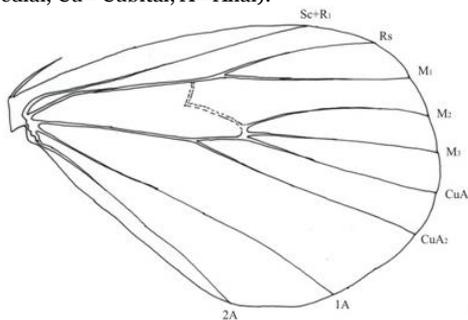


Figure 4. Hindwing of adult male moth (x35). (C= Costa, Sc= Subcosta, R= Radial, Rs= Radial Sector, M= Medial, Cu= Cubital, A= Anal).

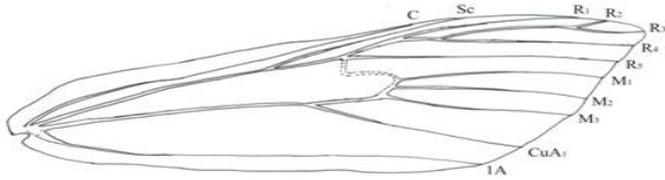


Figure 5. Forewing of adult female moth (x35). (C= Costa, Sc= Subcosta, R= Radial, Rs= Radial Sector, M= Medial, Cu= Cubital, A= Anal).

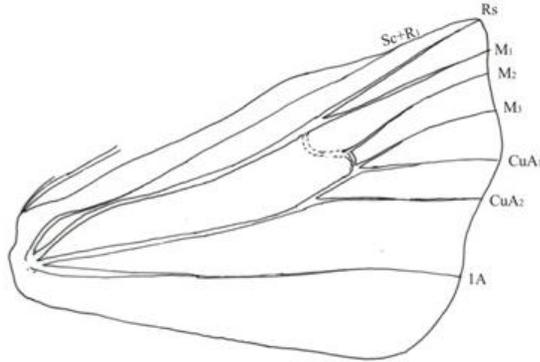


Figure 6. Hindwing of adult female moth (x35). (C= Costa, Sc= Subcosta, R= Radial, Rs= Radial Sector, M= Medial, Cu= Cubital, A= Anal).

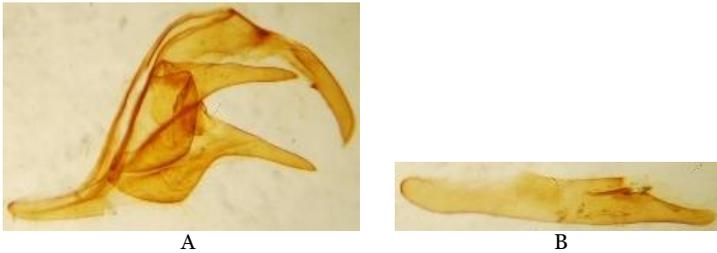


Figure 7. A) Genitalia of adult male moth without aedeagus (x30). B) Aedeagus of adult male moth (x30).

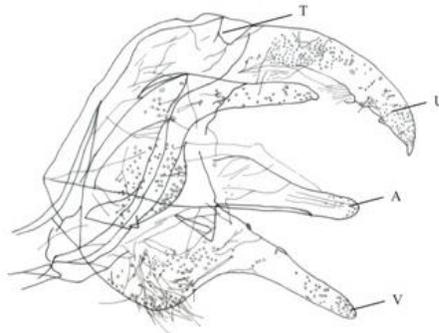


Figure 8. Genitalia of adult male moth (x100). (A= Aedeagus, S= Saccus, T= Tegumen, U= Uncus, V= Valva).

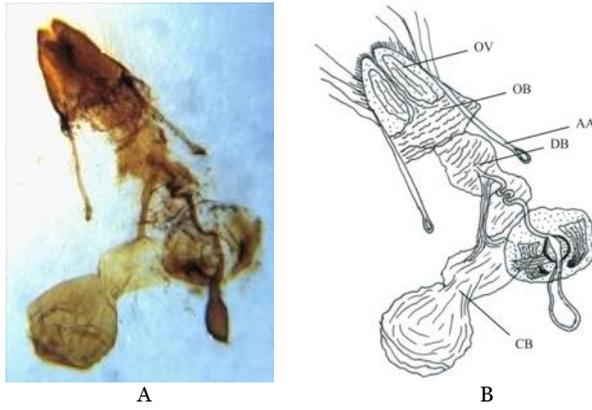


Figure 9. A) Genitalia of adult female moth (x75). B) Genitalia of adult female moth (x15). (AA= Anterior Apophyses, CB= Corpus Bursae, DB= Ductus Bursae, OB= Ostium Bursae, OV= Ovipositor Lobe, PA= Posterior Apophyses).



Figure 10. Different types of scales of wing of adult moth (x400).

Table 1. Morphometric observations of adults of *Lymantria obfuscata*.

Parameters	R.V.	Mean±S.D.
Adult male length (mm)	12-15	13.60±1.140
Adult male wing expanse (mm)	28-38	31.80±3.768
Male head length (mm)	1.35-1.83	1.66±0.192
Male head width (mm)	2.27-2.42	2.38±0.064
Male palpi length (mm)	0.96-1.07	0.99±0.045
Male antenna length (mm)	6.08-6.86	6.53±0.302
Male antenna width (mm)	0.18-0.23	0.20±0.019
Adult female length (mm)	15-23	18.40±3.209
Adult female wing expanse (mm)	30-46	36.80±6.611
Female head length (mm)	1.68-2.18	1.89±0.182
Female head width (mm)	2.26-2.53	2.40±0.115
Female palpi length (mm)	0.38-1.01	0.71±0.258
Female antenna length (mm)	5.94-6.15	6.04±0.081
Female antenna width (mm)	0.16-0.21	0.18±0.027

Table 2. Mean length of different leg segments of foreleg, midleg and hindleg of adult male of *Lymantria obfuscata*.

Male Leg Parts	Foreleg (mm)		Midleg (mm)		Hindleg (mm)	
	R.V.	Mean±S.D.	R.V.	Mean±S.D.	R.V.	Mean±S.D.
Coxa	1.27-1.34	1.31±0.027	1.37-1.54	1.47±0.070	1.44-1.53	1.48±0.034
Trochanter	0.36-0.47	0.39±0.044	0.52-0.60	0.54±0.033	0.45-0.66	0.55±0.078
Femur	1.96-2.07	2.01±0.050	2.42-2.50	2.45±0.032	2.51-2.59	2.55±0.029
Tibia	1.88-2.17	1.97±0.116	2.12-2.36	2.24±0.104	2.22-2.39	2.29±0.069
Tarsus	2.27-2.47	2.38±0.074	2.67-2.98	2.80±0.138	2.98-3.15	3.09±0.063
Claw	0.19-0.27	0.24±0.034	0.22-0.34	0.27±0.057	0.22-0.33	0.26±0.048
Total	7.75-8.23	8.06±0.205	9.41-9.67	9.51±0.106	9.77-10.08	9.95±0.124

Table 3. Mean length of different leg segments of foreleg, midleg and hindleg of adult female of *Lymantria obfuscata*.

Female Leg Parts	Foreleg (mm)		Midleg (mm)		Hindleg (mm)	
	R.V.	Mean±S.D.	R.V.	Mean±S.D.	R.V.	Mean±S.D.
Coxa	1.38-1.77	1.52±0.146	1.65-2.07	1.93±0.166	1.73-2.09	1.87±0.149
Trochanter	0.50-0.64	0.56±0.058	0.66-0.82	0.76±0.059	0.62-0.74	0.69±0.046
Femur	2.09-2.36	2.21±0.116	2.04-2.57	2.40±0.210	2.04-2.50	2.40±0.201
Tibia	1.96-2.15	2.06±0.093	2.00-2.71	2.45±0.266	2.18-2.93	2.69±0.295
Tarsus	2.48-2.77	2.64±0.119	2.40-3.04	2.78±0.243	2.54-2.91	2.76±0.179
Claw	0.31-0.41	0.35±0.046	0.31-0.39	0.34±0.032	0.26-0.37	0.32±0.051
Total	8.51-9.52	9.00±0.427	8.75-11.09	10.31±0.904	9.12-11.07	10.42±0.782