

MORPHOLOGICAL OBSERVATION OF THE *Wohlfahrtia magnifica* IN MONGOLIA PLATEAU

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ABSTRACT

The *Wohlfahrtia magnifica* living in Mongolia plateau was the only pathogen of Bactrian camel vaginal myiasis. In this paper, the head, thorax, abdomen, wing, leg and male and female identification of *W. magnifica* were observed and described by ultra depth imager. The *W. magnifica* was a kind of medium and large flies and covered with silver-gray pollen. The head had compound eyes, mouthparts, antenna, and a large amount of bristles. The dorsal of thorax was covered with silver-gray pollen and the mesothorax was developed, the legs, wings and halter were attached to thorax. The abdomen was divided into five abdominal segments, its dorsal had symmetrical black patch and the ventral was gray-black. The wings were composed of veins and cells. The leg was divided into propodium, mesopodium and metapodium. The structure of terminalia was difference between male and female, the female flies had serration end edges in the caudal end of abdominal segment and its terminalia was concave and the anal papilla was grayish white. To the male flies, its end edges of the caudal end of abdominal segment was smooth and its terminalia was convex, the dark yellow saccular process was shaped like a spoon swollen. This results would enrich people's understanding of the biological characteristics of *W. magnifica* in the Mongolia Plateau.

Key words: Morphology, ultra depth imager, *Wohlfahrtia magnifica*

Bactrian camels usually suffer from *W. magnifica* in summer and autumn. *W. magnifica* belongs to the order Diptera, family Sarcophagidae, genus *Wohlfahrtia Brauer*. The larvae of *W. magnifica* mature in the vaginal tissues of Bactrian camels, also known as the Mediterranean spiral worm, which is specialised parasite of warm blooded vertebrates (Tóth *et al*, 2006; Piralí *et al*, 2014; Wangchao, 2019). After mating, when the eggs develop until the 1st instar larvae in the female flies, the female fly looks for the host to deposit larvae, thus the healthy Bactrian camel becomes infected with vagina myiasis or the diseased camel to be re-infected (Xiwen *et al*, 2019). The 3rd instar larvae automatically falls off from its host, quickly burrows into the soil and metamorphosis into pupae, the pupae becomes imagoes in the dry season after about 20 days (Xiwen, 2018). Mongolia Plateau has little rain falls and hot in summer which is beneficial to the metamorphosis and development of *W. magnifica*, hence Bactrian camels are more predisposed.

There are few reports on morphological characteristics of *W. magnifica* but its occurrence in

Mongolia Plateau has not been reported. In this study, we describe the morphological characteristics of *W. magnifica* in the Mongolia Plateau.

Materials and Methods

Sample collection

The wild *W. magnifica* were caught in the field and others were those hatched in laboratory.

Ultra depth imager sample preparation

The samples with structural integrity were placed in the room for observation and photographed using a KEYENCE-1000 Ultra Depth Imager.

Results

Observation on the dorsal, ventral and lateral of *W. magnifica*

Observation on the head of *W. magnifica*

The compound eyes of *W. magnifica* were red and yellow, naked, and the size of ommatidium was equal. There were 3 ocellus on the ocellar triangle

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and red coloured, the bristles on the ocellar triangle was divided into two pairs, the one pair of which was called ocellar bristles, leaned forward and bifurcated left and right, and the another pair of which was called postocellar bristles, leaned backward and parallel. The parafrontalia and parafacialia were covered by the silver gray pollen and under the parafrontalia had small black hairs, silver gray pollen of interfrontalia was slightly thin and small black hairs on its both sides. The face was composed of lunule, mid-facial plate, epistoma and a pair of facialia, the lower end of facialia has small black hair and developed vibrissae. The frontal bristles in the both side of interfrontalia were arranged in parallel and symmetrically, 8 bristles on each side. The vertex had prevertical bristles, inner vertical bristles, outer vertical bristles and post vertical bristles, the outer vertical bristles and post-compound eyes bristles were differentiated obviously. The gena was located under the compound eyes, parafacialia and intermedian triangle, the bottom colour of single gena was black and covered with black hair, it has a small amount of silver gray pollen. The mouthparts, namely proboscis was located under distal of head and brown coloured, a pair of maxillary palpi were located on the basiproboscis, brownish black and expansion of its distal end was not obviously. The peristoma bristles was one row and developed, the oral disc was composed of a pair of semicircular labellum. The antennae has three segments, the 1st and 2nd segments were short and small, the 3rd segment was significantly longer than the other two segments, the 2nd segment was dull yellow, the 3rd segment was brown, naked and with aristate, the antennae was also covered with a large number of bristle (Fig 2).

Observation on the lateral of the thorax and abdomen of *W. magnifica*

Bottom colour of the thorax was black, the notopleural bristles, front-mesopleura bristles and post-mesopleura bristles were developed, and there was clearance bristles between the post-mesopleura bristles. There were pteropleura, pteropleural bristles and the coxa of front, middle and hind legs in the thorax. Two pairs of sternopleural bristles were located in sternopleura. The halter was a small rod-like structure and it's a vestigial structure of rear wing. There were prostigma and post-stigma in the thorax and which were covered with bristles (Fig 3).

Observation on the dorsal of the thorax of *W. magnifica*

The dorsal of the thorax was covered with silver gray pollen and the mesothorax was well

developed. The mesonotum consist of scutum, scutellum, postscutellum and mesophragma. The scutum was divided into prescutum and postscutum by the scutal sulcus. The scutum had three light black longitudinal grooves and two ridges. There were acrostichal bristles, dorsocentral bristles, intra-alar bristles, presulcal bristles, supra-alar bristles, prealar bristles in the scutum. The bristles on the scutellum was well developed and including discal scutellar bristles and margin scutellar bristles (Fig 4).

Observation on the abdomen of *W. magnifica*

Abdomen of *W. magnifica* was gray pollen and divided into five abdominal segments. On the dorsal, there were symmetrical black patch distributed in sagittal median line. The 3rd and 5th tergites has middle marginal bristles, respectively. Black patch in the 1st and 2nd abdominal segments were shaped like "m". There were three black patch in the 3rd to 5th abdominal segments, respectively. Middle black patch in the 3rd and 4th abdominal segments were large and they were connected with each other from 1st to 4th abdominal segments, black patch in the 5th abdominal segments were relatively small. On the ventral, each pair of abdominal segments was bilateral symmetry and separated by six sternite in the middle, the stigma were distributed in each segment, and the anus was located in terminalia (Fig 5).

Observation on the wings of *W. magnifica*

The wing was transparent, and there were two types of veins including longitudinal vein and cross-vein. The radial stem vein was thick and it was divided into the 1st radial vein and radius sector. The radial node which was located in the distal end of the radius sector divided into the 2nd and 3rd radial vein and the 4th and 5th radial vein. The medial vein was divided into the 1st and 2nd medial vein and the 3rd and 4th medial vein. The 1st cubital vein had a right angle bend at the wing base and was combined with the 1st anal vein to form the 1st cubital and 1st anal vein. The 2nd cubital vein was degenerated to form a shallow vestige, the 1st and 2nd medial vein (m1 + 2) had a right-angle bend and the 4th and 5th radial vein (r4 + 5) was open cell. The cross-veins included humeral cross vein, radio medial cross-vein, inter-medial cross- vein, and medial-cubital cross- vein, while the radio medial cross-vein lost its dark halo. The veins divided the wing membrane into form cells (Szpila *et al*, 2010), there were mainly basal costal cell, distal costal cell, subcostal cell, 1st radial cell, 3rd radial cell, basal 5th radial cell, distal 5th radial cell, basal 2nd medial cell, distal 2nd medial cell, basal

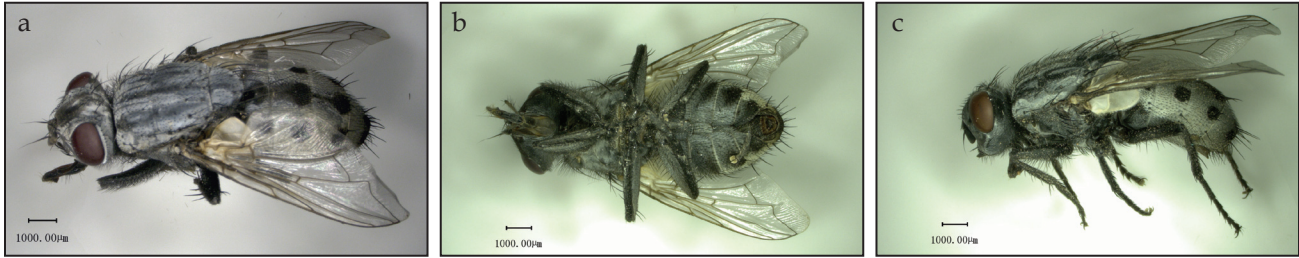


Fig 1. Observation on the whole body of *Wohlfahrtia magnifica* a: dorsal view; b: ventral view; c: lateral view

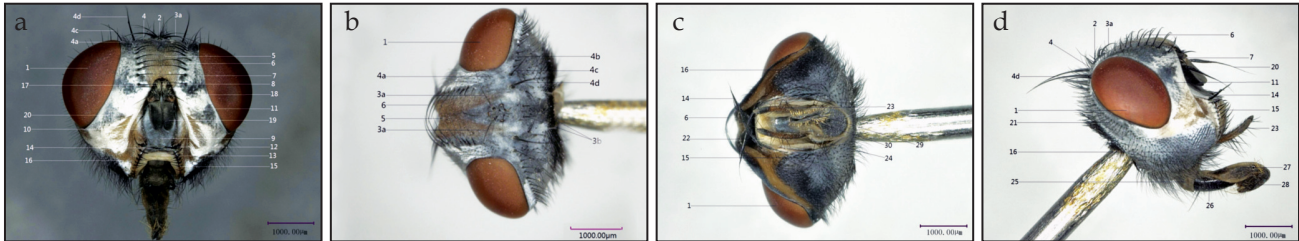


Fig 2. The observation of *Wohlfahrtia magnifica's* head a: anterior view; b: dorsal view; c: ventral view; d: lateral view

1 - compound eyes; 2-ocellar triangle; 3a - ocellar bristles; 3b - post ocellar bristles; 4 - vertex; 4a - prevertical bristles; 4b - outer vertical bristles; 4c - inner vertical bristles; 4d - postvertical bristles; 5 - interfrontalia; 6 - frontal bristles; 7 - lateral bristles; 8 - lunule; 9 - mid-facial plate; 10 - facialia; 11 - parafacialia; 12 - facies bristles; 13 - epistoma; 14 - vibrissae; 15 - peristoma bristles; 16 - gena; 17 - the first segments of antenna; 18 - the second segments of antenna; 19 - the third segments of antenna; 20 - arista; 21 - post-compound eyes bristles; 22 - peristoma; 23- maxillary palpus; 24 - mouthparts fossa ; 25 -baisproboscis; 26 - haustellum; 27 - prementum; 28 - oral disc; 29 - labellum; 30 - labellum port



Fig 3. Lateral view of *Wohlfahrtia magnifica's* thorax and abdomen

1 - notopleura; 2 - notopleural bristles; 3 - humeral callus; 4 - mesopleura; 5 - front- mesopleura bristles; 6 - post-mesopleura bristles; 7 - clearance bristles; 8 - prostigma; 9 - prostigmal bristles; 10 - auxillary prostigmal seta; 11 - propleuron; 12 - episternum bristles; 13 - sternopleura; 14 - sternopleural bristles; 15 - pteropleura; 16 - pteropleural bristles; 17 - postscutellum; 18 - postnotum of mesothorax; 19 - superior pleurotergite; 20 - inferior pleurotergite; 21 - halter; 22 - post-stigma; 23 - beret; 24 - hypopleura; 25 - hypopleural bristles; 26 - front legs coxa; 27 - middle legs coxa; 28 - hind legs coxa

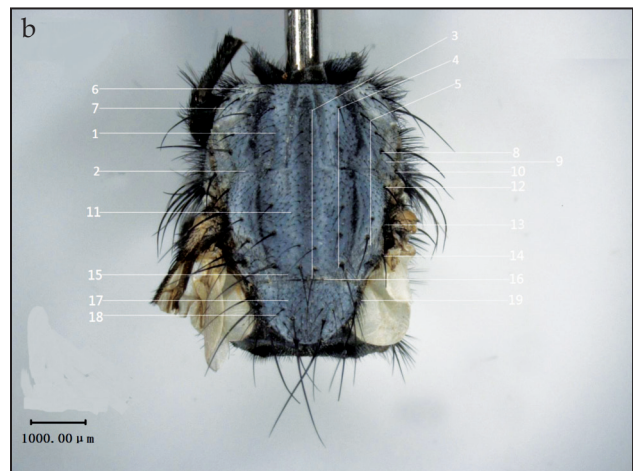


Fig 4. Dorsal view of *Wohlfahrtia magnifica's* thorax

1 - mesothorax prescutum; 2 - scutal sulcus; 3 - acrostichal bristles; 4 - dorsocentral bristles; 5 - intra-alar bristles; 6 - humeral callus; 7 - humeral bristles; 8 - presulcal bristle; 9 - notopleura; 10 - notopleural bristles; 11 - mesothorax postscutum; 12 - prealar bristles; 13 - supra-alar bristles; 14 - postalar bristles; 15 - postsulcal dorsocentral bristles; 16 - scutellar suture; 17 - scutellum; 18 - discal scutellar bristles; 19 - margin scutellar bristles

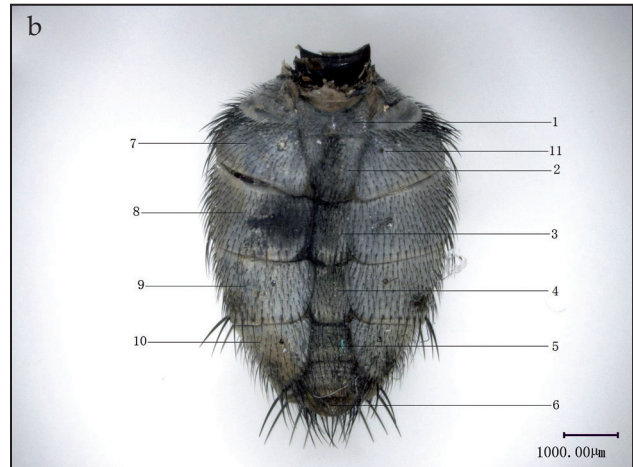
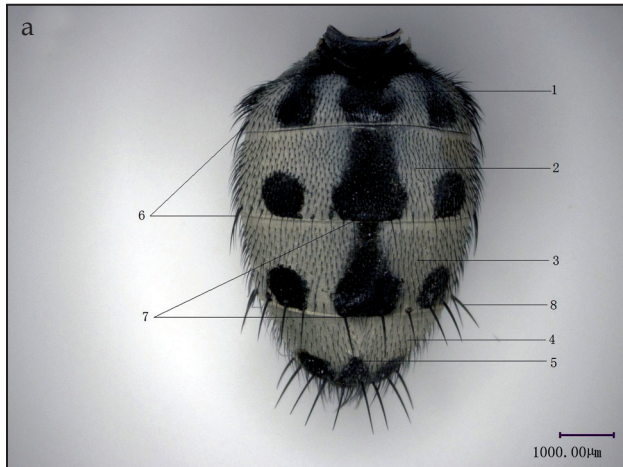


Fig 5. The observation of *Wohlfahrtia magnifica's* abdomen

a: 1 - 1st and 2nd abdominal segment; 2 - 3rd abdominal segment; 3 - 4th abdominal segment; 4 - 5th abdominal segment; 5 - discal bristles; 6 - lateral bristles; 7 - middle marginal bristles; 8 - lateral marginal bristles

b: 1 - 1st sternite; 2 - 2nd sternite; 3 - 3rd sternite; 4 - 4th sternite; 5 - 5th sternite; 6 - anus; 7 - 1st and 2nd abdominal segment; 8 - 3rd abdominal segment; 9 - 4th abdominal segment; 10 - 5th abdominal segment; 11 - stigma

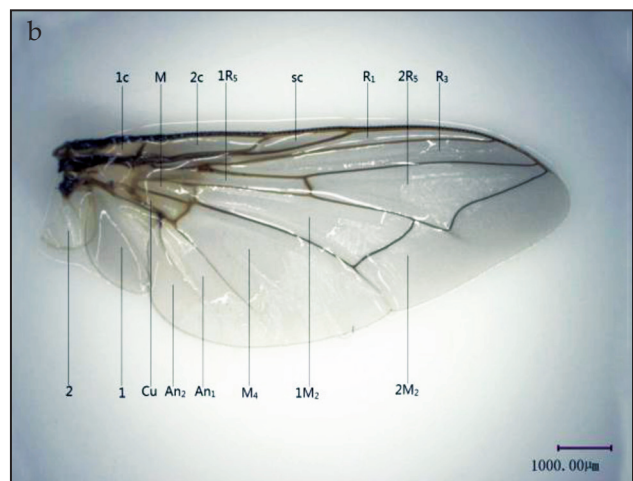
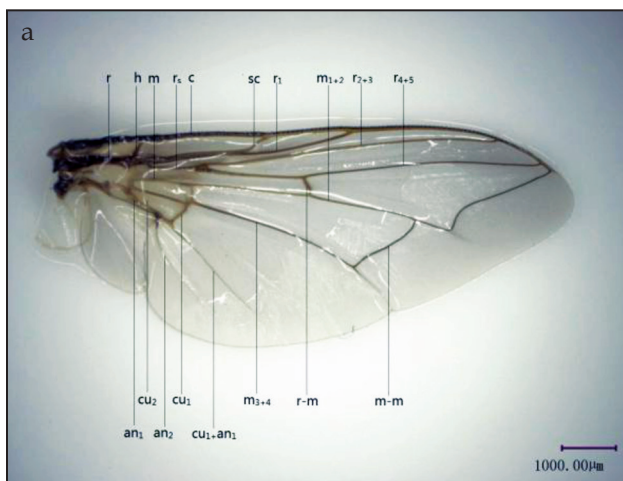


Fig 6. The observation of *Wohlfahrtia magnifica's* wing

a: veins of wing membrane c - costa; sc - subcosta; r - radial stem vein; r1 - 1st radial vein; rs - radius sector; r2+3 - 2nd and 3rd radial vein; r4+5 - 4th and 5th radial vein; m - medial vein; m1+2 - 1st and 2nd medial vein; m3+4 - 3rd and 4th medial vein; cu1 - 1st cubital vein; cu2 - 2nd cubital vein; an1 - 1st anal vein; an2 - 2nd anal vein; h - humeral cross-vein; r-m - radio-medial cross-vein; m-m - inter-medial cross-vein; cu1+an1 - 1st cubital and 1st anal vein

b: cells of wing membrane 1c - basal costal cell; 2c - distal costal cell; sc - subcostal cell; R1 - 1st radial cell; R3 - 3rd radial cell; 1R5 - basal 5th radial cell; 2R5 - distal 5th radial cell; M - basal 4th medial cell; 1M2 - basal 2nd medial cell; 2M2 - distal 2nd medial cell; M4 - distal 4th medial cell; cu - cubital cell; An1 - 1st anal cell; An2 - 2nd anal cell; 1 - upper squama; 2 - lower squama

4th medial cell, distal 4th medial cell, cubital cell, 1st anal cell, 2nd anal cell. The squamae were white and attached with thorax, they were connected in the front of upper squama and lower squama, the lower squama was about twice the size of the upper squama (Fig 6).

Observation on the leg of *W. magnifica*

The *W. magnifica* leg consisted of a pair of propodium, a pair of mesopodium, and a pair of

metapodium, each of which was divided into coxa, trochanter, femur, tibia and tarsus. The tarsus was composed of 5 tarsomeres, the 1st tarsomere was the longest, and the pretarsus had the claw and pulvilli, a large amount of bristles were covered around the legs (Fig 7).

Comparison of male and female flies

Observing on the male and female of *Wohlfahrtia magnifica*, the male abdomen was long oval and

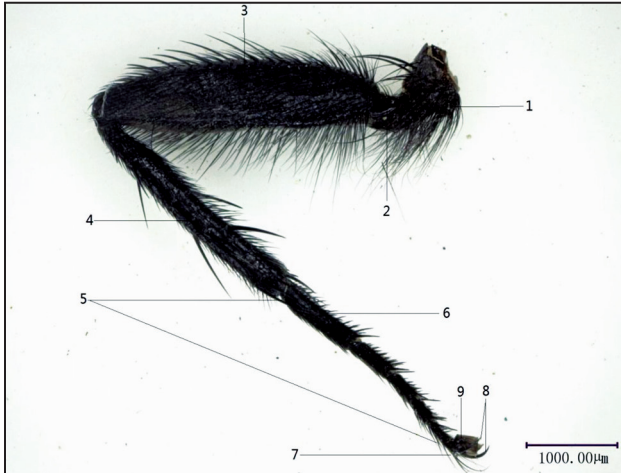


Fig 7. The observation of *Wohlfahrtia Magnifica*'s leg
1 - coxa; 2 - trochanter; 3 - femur; 4 - tibia; 5 - tarsus; 6 - 1st tarsomere; 7 - pretarsus; 8 - claws ; 9 - pulvilli.

female abdomen was oval, abdomen of male flies was longer and narrow than that of female flies. Difference of the terminalia between male and female were the most obviously, caudal end of abdominal segments in male flies was smooth and its terminalia was convex, tergites of the last abdominal segments formed a dark yellow eminentia which extended downward oblique to form saccular process, a spoon-like expansion. Female flies had serration in the caudal end of abdominal segments and its terminalia was concave and anal papilla was grayish white (Fig 8 and Fig 9).

Measurement of *W. magnifica*

20 adult flies were randomly taken to measure each part of body with vernier caliper (Fig 10 and table 1)

According to the data analysis, the adult length of *Wohlfahrtia magnifica* was about 1.423 cm and belong to a medium and large fly. The length of head was about 0.280 cm and its width was about 0.437 cm, the length was about half of width of the head, the length of wing was about 1.005 cm and its width was about 0.401 cm, the width was about half of the length of wing; length of the thorax and abdomen was slightly larger than its width, respectively, the propodium and mesopodium were similar in length and the metapodium was longer than the other two legs.

Table 1. Size measurement of various parts of *Wohlfahrtia magnifica* (unit: cm)

hl	0.280±0.004	tl	0.500±0.009	al	0.641±0.013	wl	1.005±0.018	pl	1.076±0.031	mpl	1.143±0.026
hw	0.437±0.005	tw	0.473±0.010	aw	0.449±0.008	ww	0.401±0.009	ml	1.056±0.057	bl	1.423±0.016

pl - propodium length ; ml - mesopodium length; mpl - metapodium length
Note: the measured data was the average value ± standard error

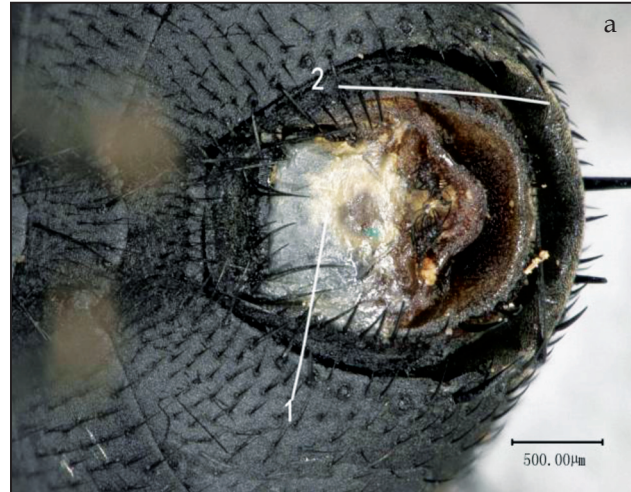


Fig 8. Comparison of terminalia for male and female of *Wohlfahrtia magnifica*
a: Female b: male 1 - anal papilla; 2 - serration; 3 - anus; 4- saccular process

Discussion

The *W. magnifica* is widely distributed in the Mongolia plateau, causing myiasis of many kinds of livestock. Vaginal myiasis occurs from the end of May to the beginning of October in the Bactrian camel.

Lunule in the head of *W. magnifica* were located between the antennae and interfrontalia, and it's extending downward to separate the facial and parafacialia, the gena height was obviously a half high than that of eye, occiput was backward expansion

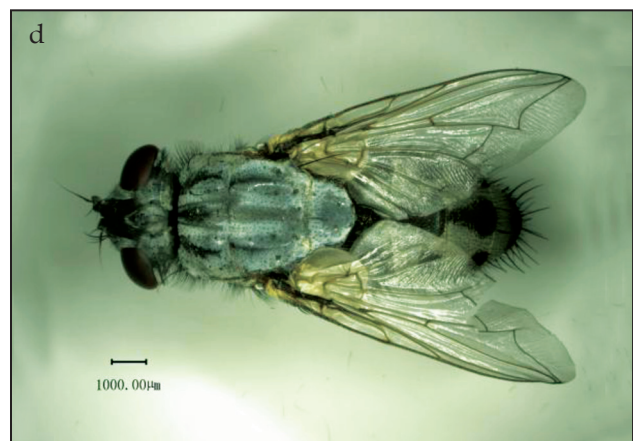
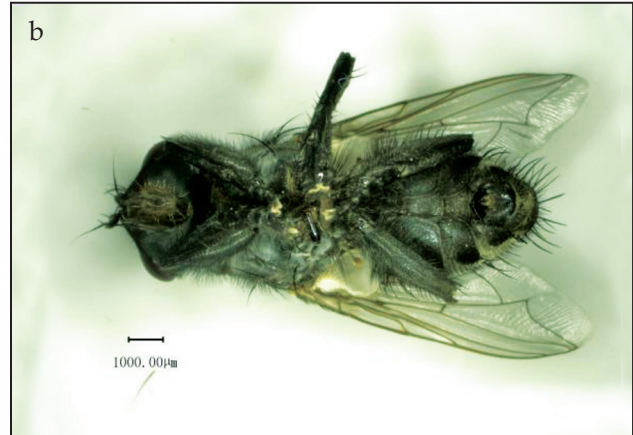
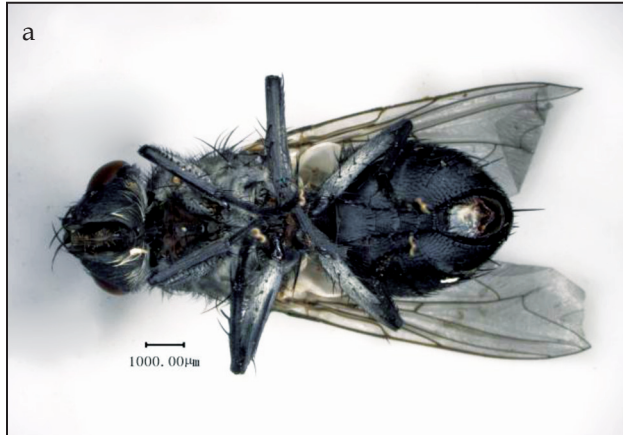


Fig 9. Morphological Comparison between male and female of *Wohlfahrtia magnifica*
 a: female ventral view; b: male ventral view; c: female dorsal view; d: male dorsal view

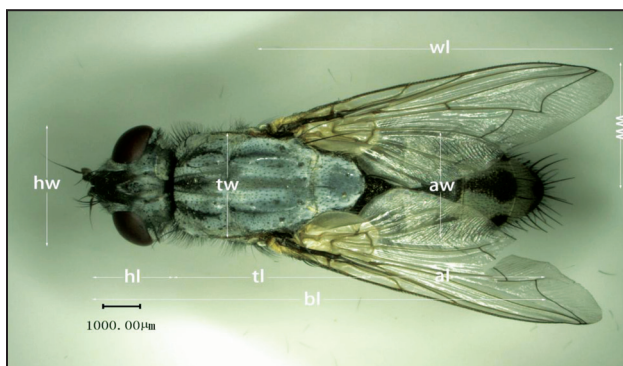


Fig 10. Dimension measurement and marking of various parts of *Wohlfahrtia magnifica*
 hw - head width; hl - head length; tw - thorax width; tl - thorax length; aw - abdomen width; al - abdomen length; ww - wing width; wl - wing length; bl - body length.

(Baohai, 2001). The distal of maxillary palpi were black and maxillary palpi had olfactory and gustatory functions (Zhongcheng, 2005). The antennae of *W. magnifica* had three segments, arista was located in the base of the 3rd segment and covered by feathery

cilia (Mengyu and Xinsheng, 1990). The antennae was slightly short, the length of the 3rd segment was 1.5 times as long as the 2nd segment of antennae (Zhang Ming, 2016). Thousands of olfactory receptors were distributed on the antennae, which was of great significance in host, spawning, mate seeking and other behaviours of insects (Szyszka and Galizia, 2015; Tan Jing *et al*, 2016).

The anal-cell of wing was short and closed away from the wing margin, the squamae and alulae were differentiated obviously. The wings used for flying by insects were made up of membranous and there were crisscross veins on the wing surface, actually veins were formed by thickening parts of the wing surface at the trachea, which acted as a skeleton to support and strengthen the wing surface, and was also related to the twisting movement of the wing during flight. The halter play a balancing role in flight (Jinping, 2017). The wings comprised of nonsmooth microstructures, this kind of structure not only enhanced the hydrophobic performance of wing surface and provided mass stabilisation for flight,

but also effectively reduced the reflectivity of wing surface (Yanling *et al*, 2014).

The base of legs was close to each other, and located in the ventral of thorax, the scutal sulcus of mesothorax was obviously integrity (Whitmore *et al*, 2013). The three longitudinal grooves and two ridges on the dorsal of thorax were obviously and increased the contact area with environment. There were bristles arranged like arc in the hypopleura which located in the under of the anterior of post-stigma. The acrostichal bristles on the dorsal of thorax had five bristle sites, the anterior three were tiny and posterior two were developed. "Vase-like shaped" black patch were on the dorsal of abdomen, and black patch on dorsal of the 5th abdominal segments were clearly, the abdomen was covered with silver gray pollen.

According to observation, the *W. magnifica* was belong to medium and large flies and with darker colour. Morphological difference was obvious in the terminalia between male and female. With the naked eye, the terminalia of male was bulge outward to form convex and the terminalia of female was sunken inward to form concavity. Under anatomical microscope, we can see the dark yellow saccular process in the male flies and the white anal papillae in the female flies; anal papillae were used to hold the maggots and help the maggots adhere to object. The external genitalia of insects play an important role in courtship and mating behaviour (Eberhard, 2010). Through this study, we had a comprehensive understanding of the morphological structure of *W. magnifica* living in the Mongolia Plateau, which would enrich people's knowledge of the biological characteristics of *W. magnifica*.

Acknowledgements

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