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One new peacock spider from Western Australia (Araneae: Salticidae: Euophryini: Australphryni: *Maratus hakea*), with a review of known species in the *M. bubo* and *M. mungaich* groups

Jürgen C. Otto [1] and David E. Hill [2]

[1] 19 Grevillea Avenue, St. Ives, New South Wales 2075, Australia, *email* jurgenotto8@gmail.com
[2] 213 Wild Horse Creek Drive, Simpsonville SC 29680, USA, *email* platycryptus@yahoo.com

Abstract. A new peacock spider with a distinct appearance, *Maratus hakea*, is described from one site on the southwestern coast of Australia, and assigned to the *M. mungaich* group. Courtship display of this spider is also described. The *M. mungaich* group, endemic to southwestern Australia, is reviewed and divided into two hypothetical clades: the *M. bubo* group and the *M. mungaich* group.

Keywords. courtship, jumping spider, new species

Here we first describe one new and distinctive peacock spider collected at a single locality on the southwestern coast of Australia, with a brief description of its courtship behaviour and habitat. We will then review the relationship of this spider to other members of the *Maratus mungaich* group.

Genus *Maratus* Karsch 1878

Type species *Maratus amabilis* Karsch 1878

Maratus hakea, new species

Type specimens. The holotype male (♂ #1), two paratype males (♂ #2-3), and four paratype females (♀ #1-4) were collected above Back Beach, just SE of Arpenteur Nature Reserve, SE of Cheynes, Western Australia (S34.890556°, E118.420694°; 17 SEP 2023; Michelle Peak, collector). Additional collections from the same area were: four paratype males (♂ #4-7) and four paratype females (♀ #5-8) (S34.890583°, E118.420722°; 13 OCT 2023; Flynn Prall, collector); four paratype males (♂ #8-11) and three paratype females (♀ #9-11) (S34.890556°, E118.420694°; 18 OCT 2023; Michelle Peak, collector). Males #1-3 and all females except female #1 were collected as immatures and raised to the adult stage. All types will be deposited in the Western Australian Museum, Perth.

Etymology. The species group name, *hakea* (Latin, noun in apposition) was chosen to reflect the collection of these spiders in association with the low-growing, endemic shrub *Hakea prostrata*.

Diagnosis. *Maratus hakea* can be easily distinguished from all other peacock spiders by the presence of a series of dark blue or violet transverse stripes on a field of iridescent blue-green scales, on either side of a large black median area, on the dorsal surface of the large and wide fan of the adult male (Figure 2). As with other *Maratus*, the detailed structure of the pedipalps is of little use for identification to species.

Description of male (Figures 1-6, 39). Type males (n=11) range from 4.1-4.6 mm in length. Dorsally and laterally the pedipalps are covered with long white or light grey setae. Each paturon is mostly glabrous and dark brown, but has some long white or light grey setae on the front. Light grey setae project forward and medially from the clypeus, above the chelicerae, and these are also found to either side, below each ALE. Unless scraped, the eye region may have a cover of dark red-brown scales, interrupted by as many as six front-to-rear tracts of grey scales, sometimes indistinct. The length of each tract of grey scales varies, from less than 1/2 to 3/4 of the length of the eye region. Behind each PLE, and at the median, indistinct tracts of dark red-brown scales and white to grey scales may extend toward the rear, at the top of the carapace. The PME are closer to the PLE than to the ALE. Toward the rear of the carapace, a small patch of white scales may be present at the median. The sides and rear of the carapace are black and glabrous, with a prominent marginal band comprised of bright white setae.

The fan (Figure 2) is very wide, with a prominent, extensible flap on either side. Shorter white setae can be found at the anteromedian margin of the fan, wheras the large flaps are fringed with very long white to light grey setae. The arrangement of scales on the dorsal surface of the fan is distinctive. At the center is a large dark black figure enclosing three or four pairs of deep blue spots. To either side of this figure, a field of brilliantly iridescent blue-green scales is broken up by 6-7 tracts of deep blue or violet scales, extending toward the margins. At the rear of the fan, several small spots or lines comprised of bright orange-red scales may be present, and the iridescent blue-green scales may take on more of a lighter blue or even green hue. A triangular anal tuft of white setae is present. The ventral opisthosoma has a uniform cover of white to off-white setae.

Legs I and II are shorter, legs III and IV longer, and legs III the longest. Legs I, II and IV are brown, indistinctly banded with white or light grey setae. Legs III, featured prominently in courtship display, have a different pattern of colouration (Figure 3): The femur has white setae and a fringe of longer white setae dorsally, with red-brown setae on the lower distal anterior surface. Each patella is also red-brown. The tibia and metatarsus are dark brown, fringed with black setae, and there is a white or light yellow tuft of setae projecting ventrally at the distal end of each of these leg segments. Bright white setae cover each tarsus, and the tenent setae of each footpad are grey.

As viewed from below (Figure 4), the coxae, sternum, labium and endites are mostly glabrous and translucent brown or grey in colour, except for scattered white or light grey setae extending from the rear of the sternum and the sides of the coxae. From below, the proximal leg segments (from trochanter to femur) are light brown and translucent, with a cover of scattered white setae on the femur.

The male pedipalp (Figure 6), is like that of most *Maratus* from southwestern Australia, with the curved outer loop of the embolus terminating in a stout, pointed apex just above the apex of a shorter inner loop. Just before the apex is a slight projection.

Figure 1 (continued on next page). Living male types for *Maratus hakea*.

Figure 1 (continued from previous page, continued on next page). Living male types for *Maratus hakea*.

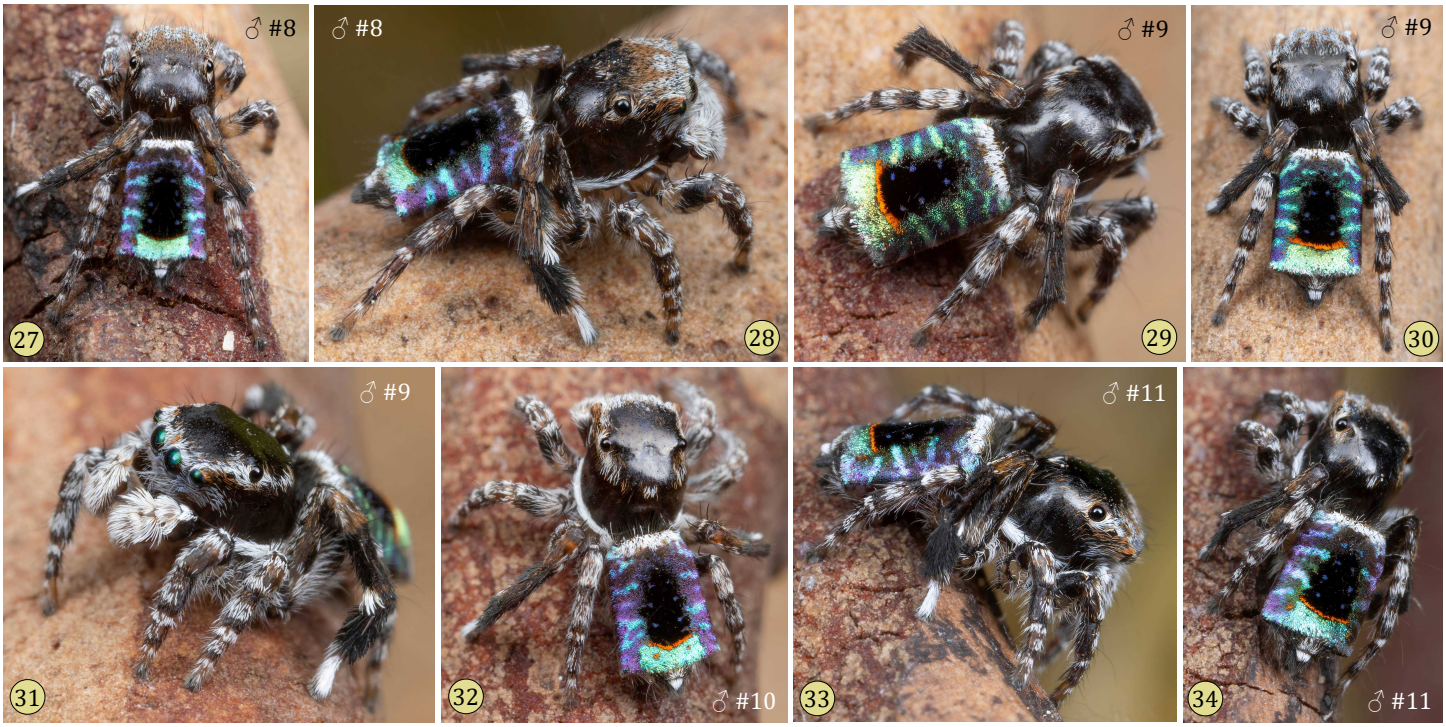

Figure 1 (continued from previous page). Living male types for *Maratus hakea*.

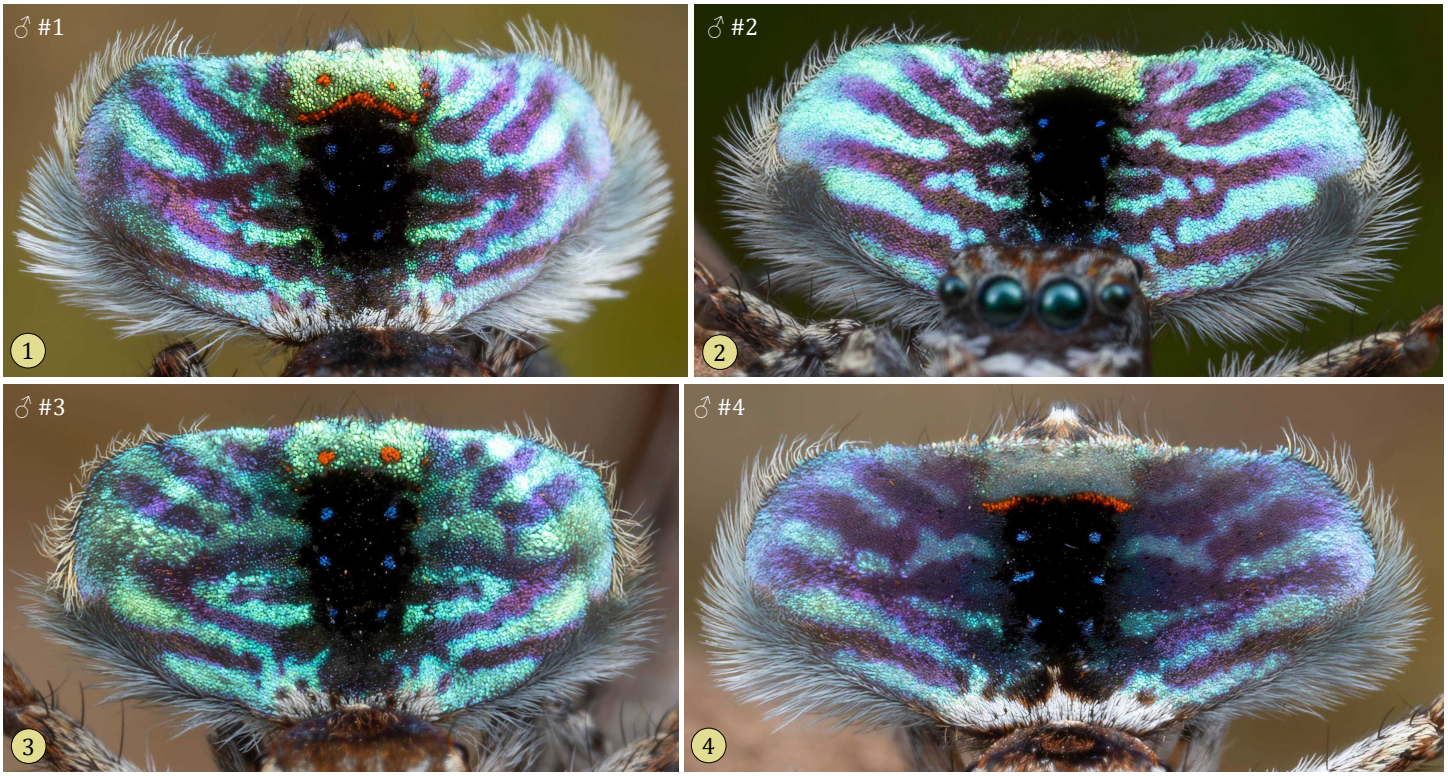

Figure 2 (continued on next page). Fully expanded and elevated fan during courtship display by the living male types for *Maratus hakea*.

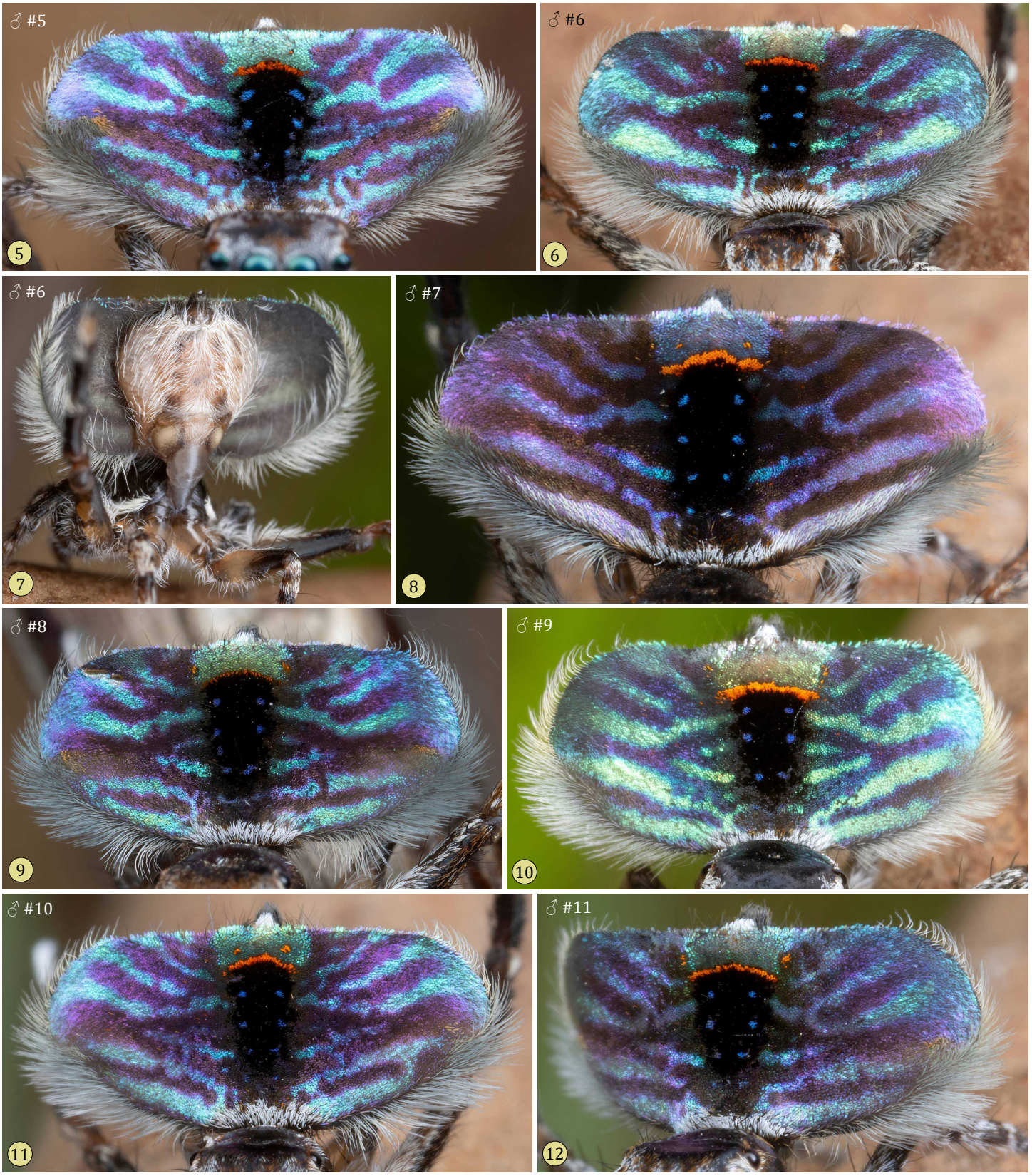

Figure 2 (continued from previous page). Fully expanded and elevated fan during courtship display by the living male types for *Maratus hakea*. **7,** Rear view. The stripes can be seen through the thin flaps of the fan.

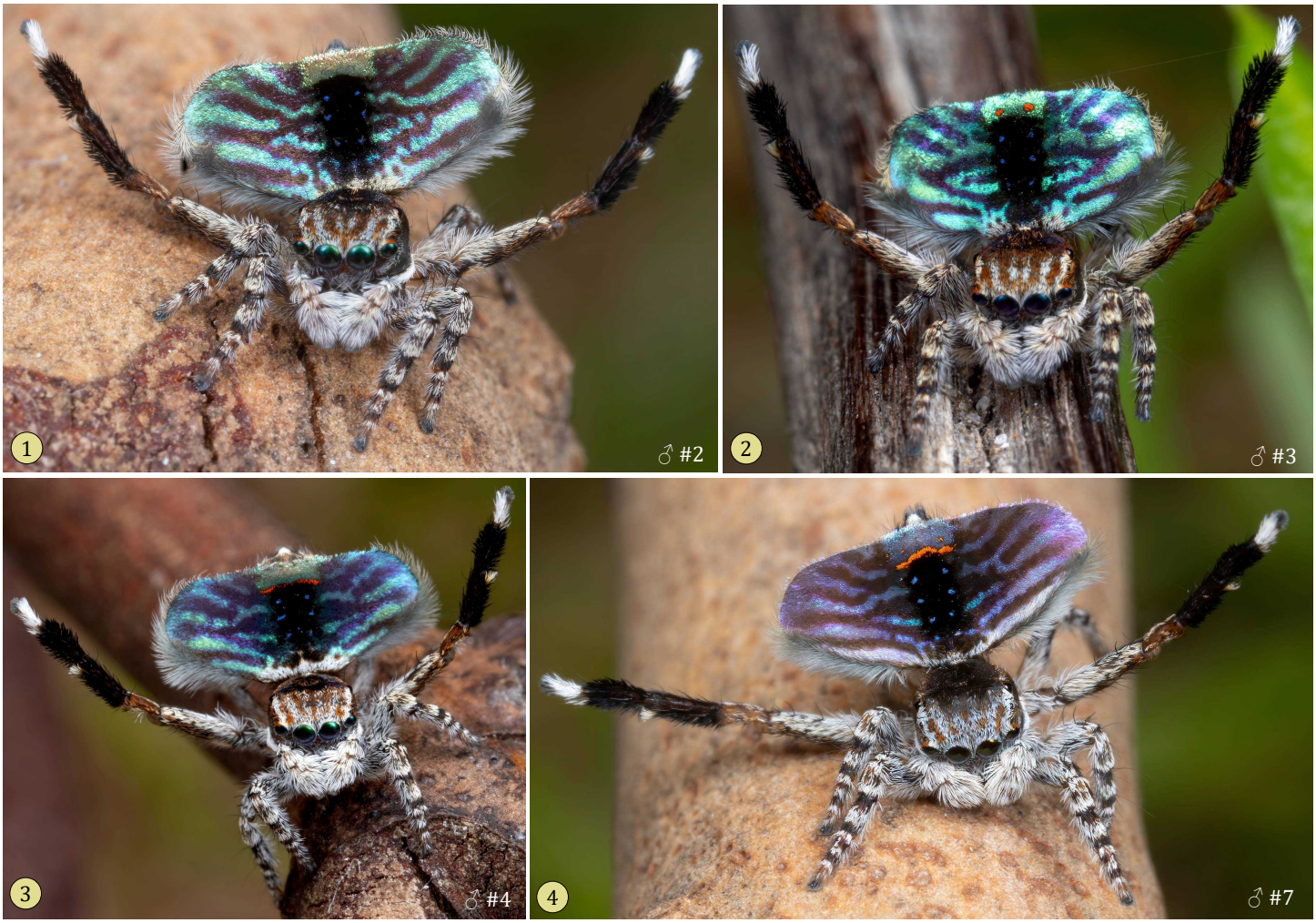

Figure 3. Courtship display by male types for *Maratus hakea*, with fan extended and elevated, and hyperextended (more than 180°) legs III. Hyperextension (evident in 1-3) is supported by extreme flexibility of the patellarmetatarsal joint of these spiders.

Figure 4 (continued on next page). Ventral views of living male types for *Maratus hakea*.

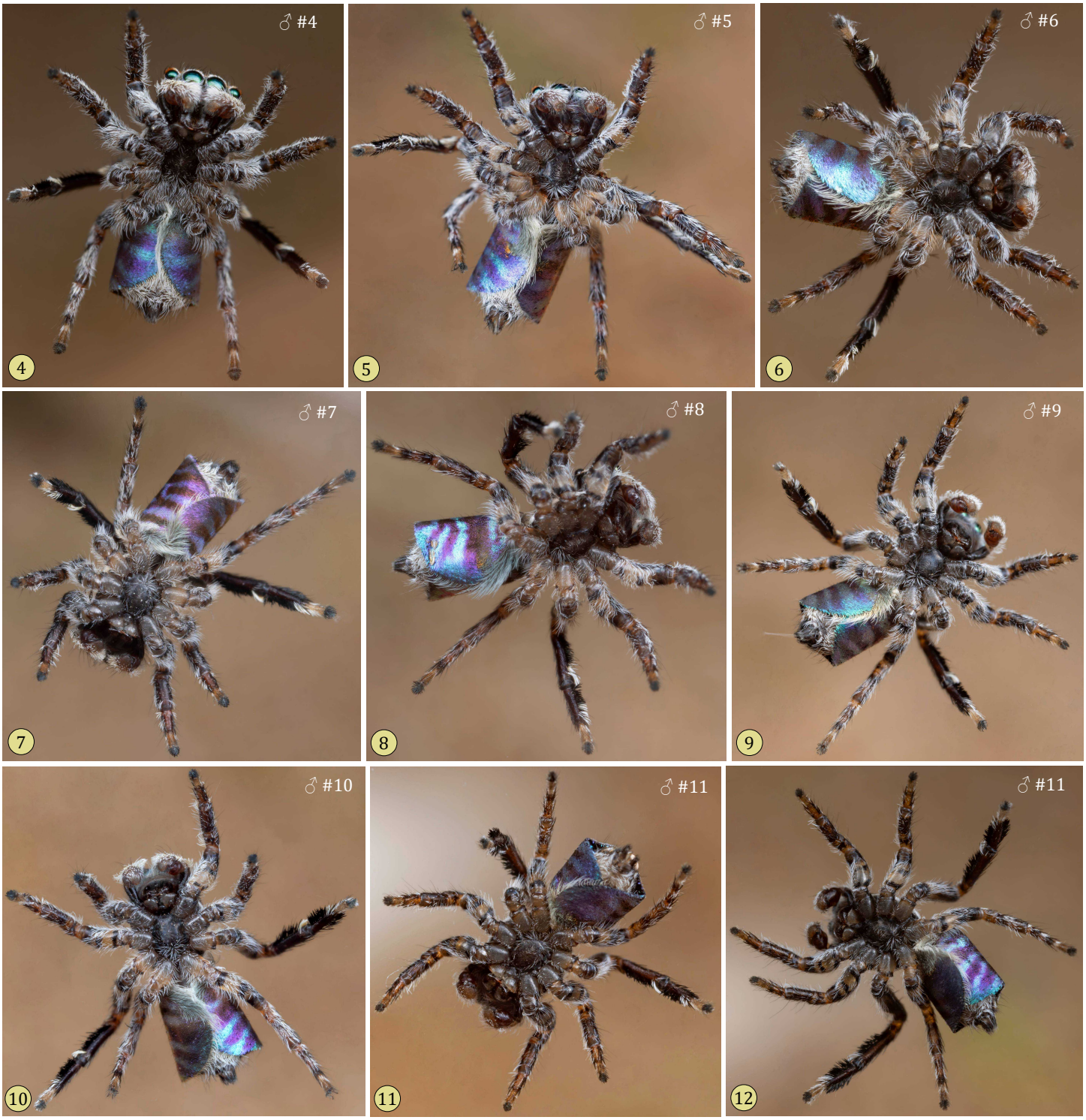

Figure 4 (continued from previous page). Ventral views of living male types for *Maratus hakea*.

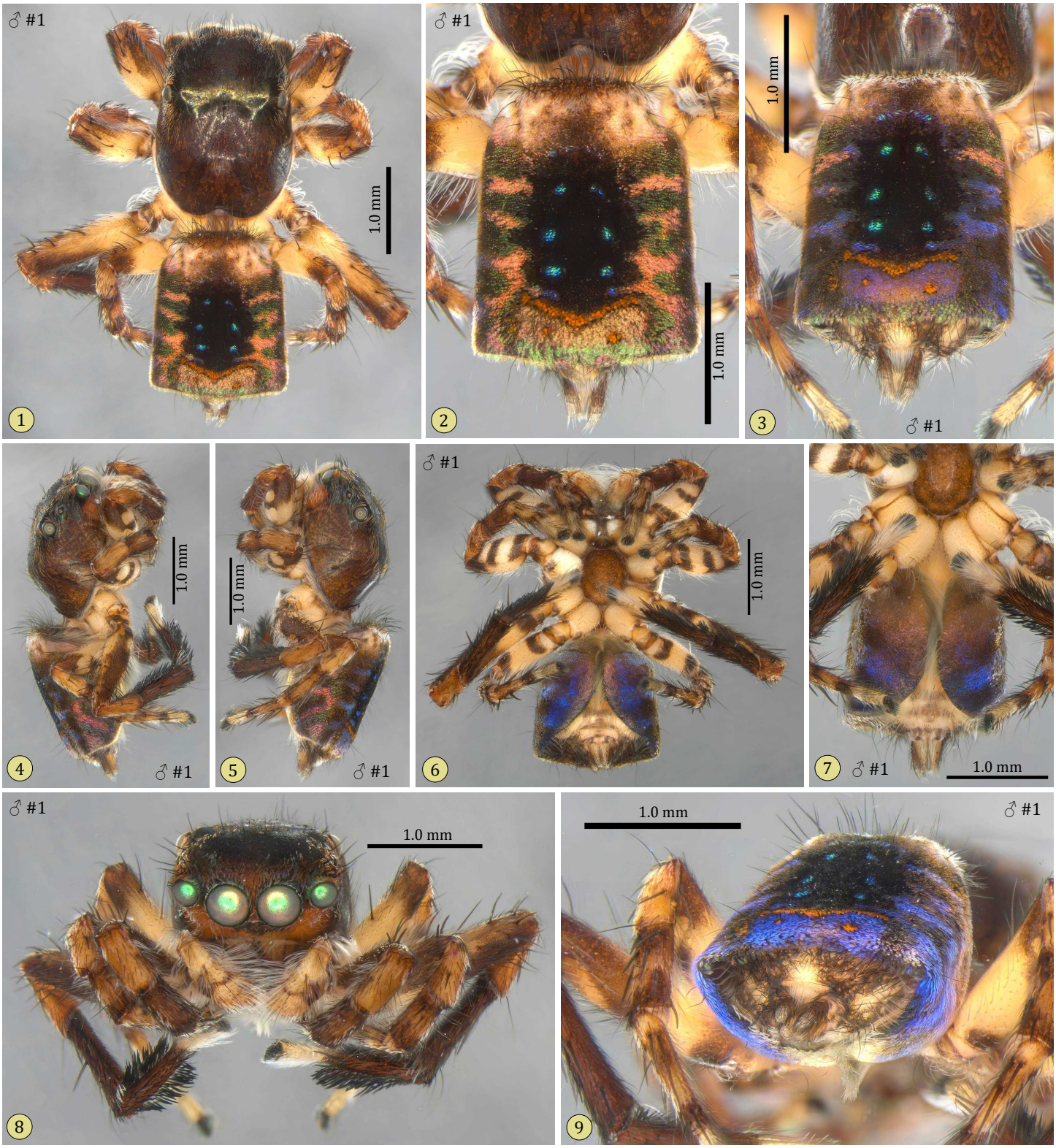

Figure 5 (continued on next page). Male types for *Maratus hakea* in alcohol.

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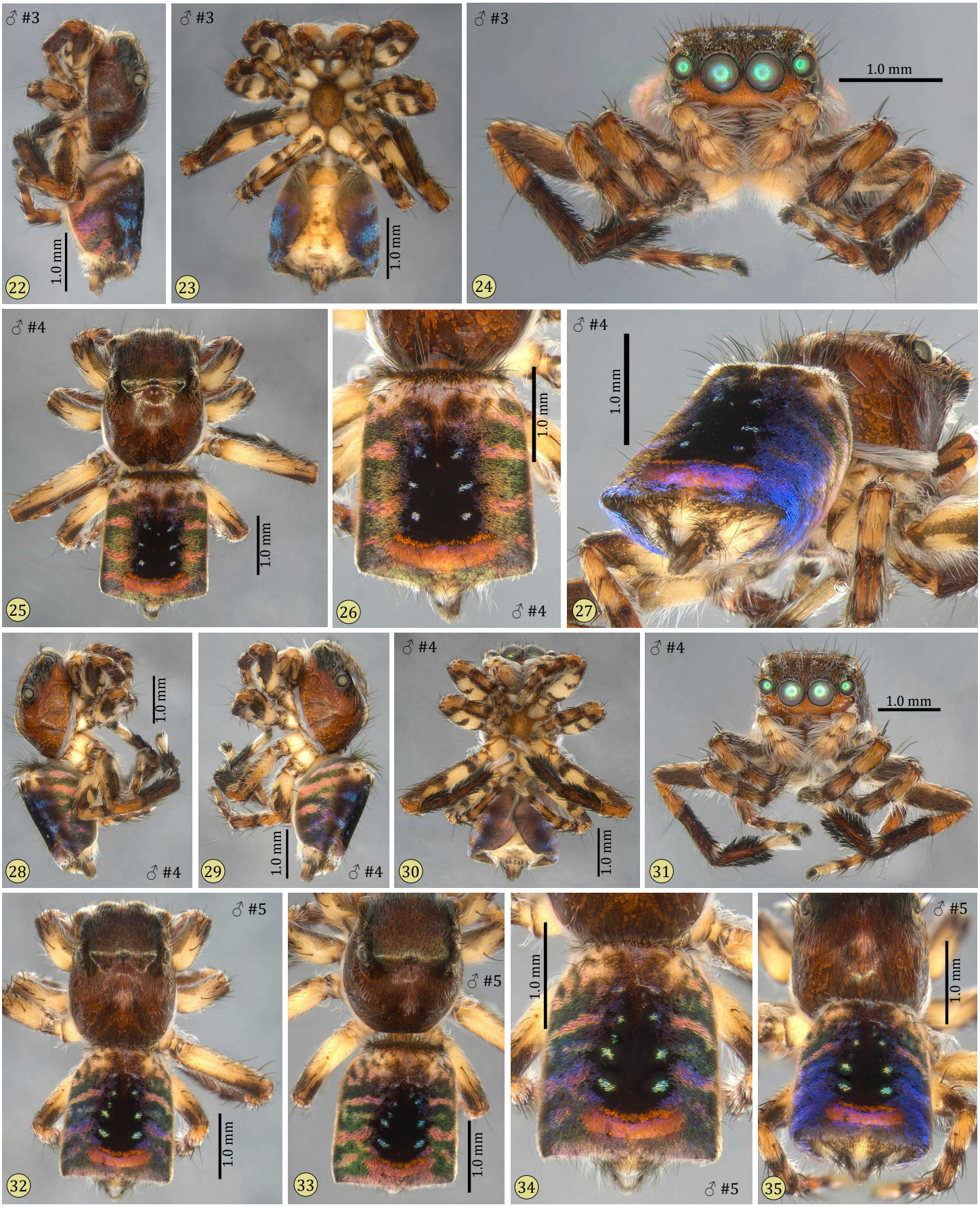

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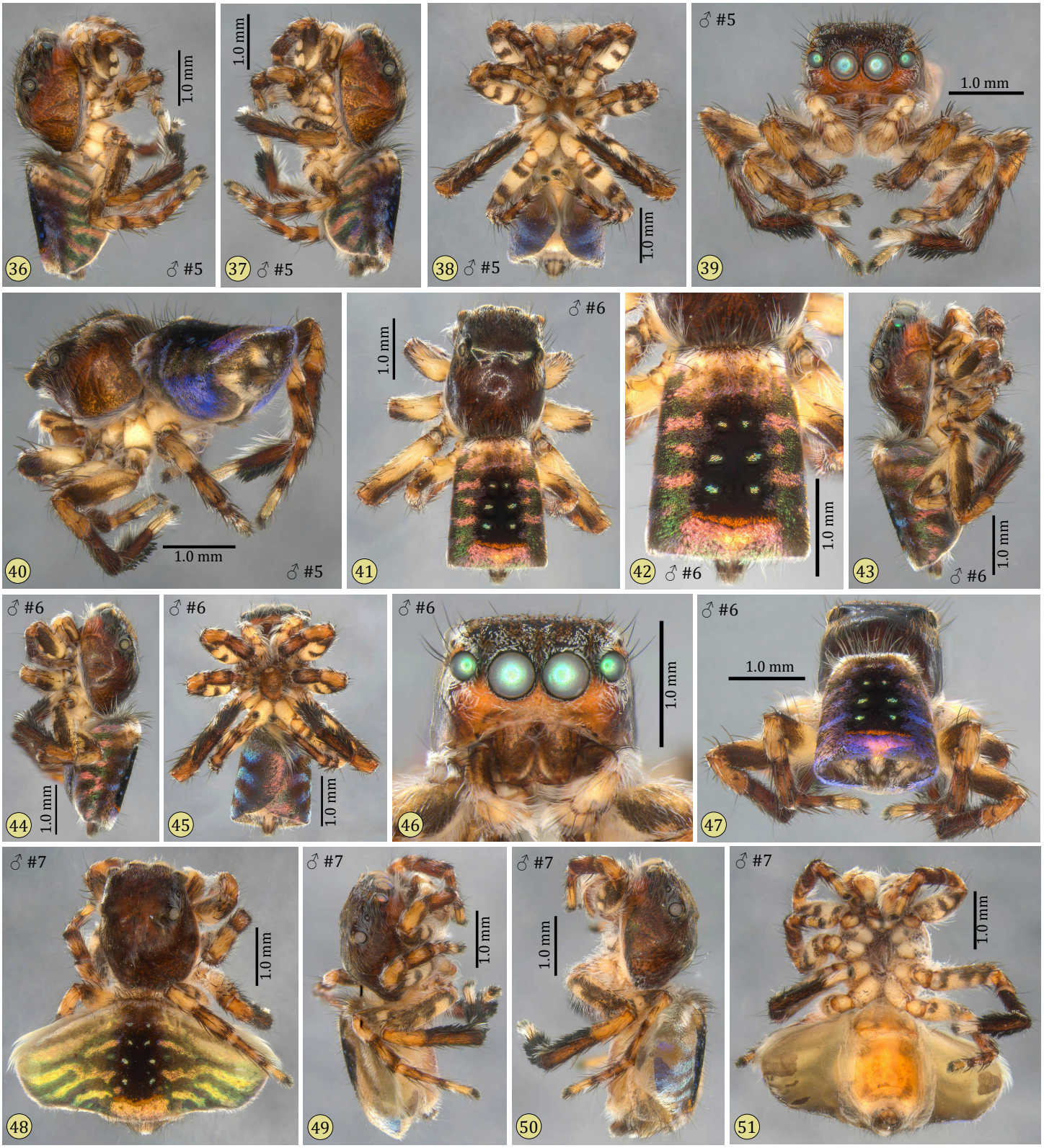

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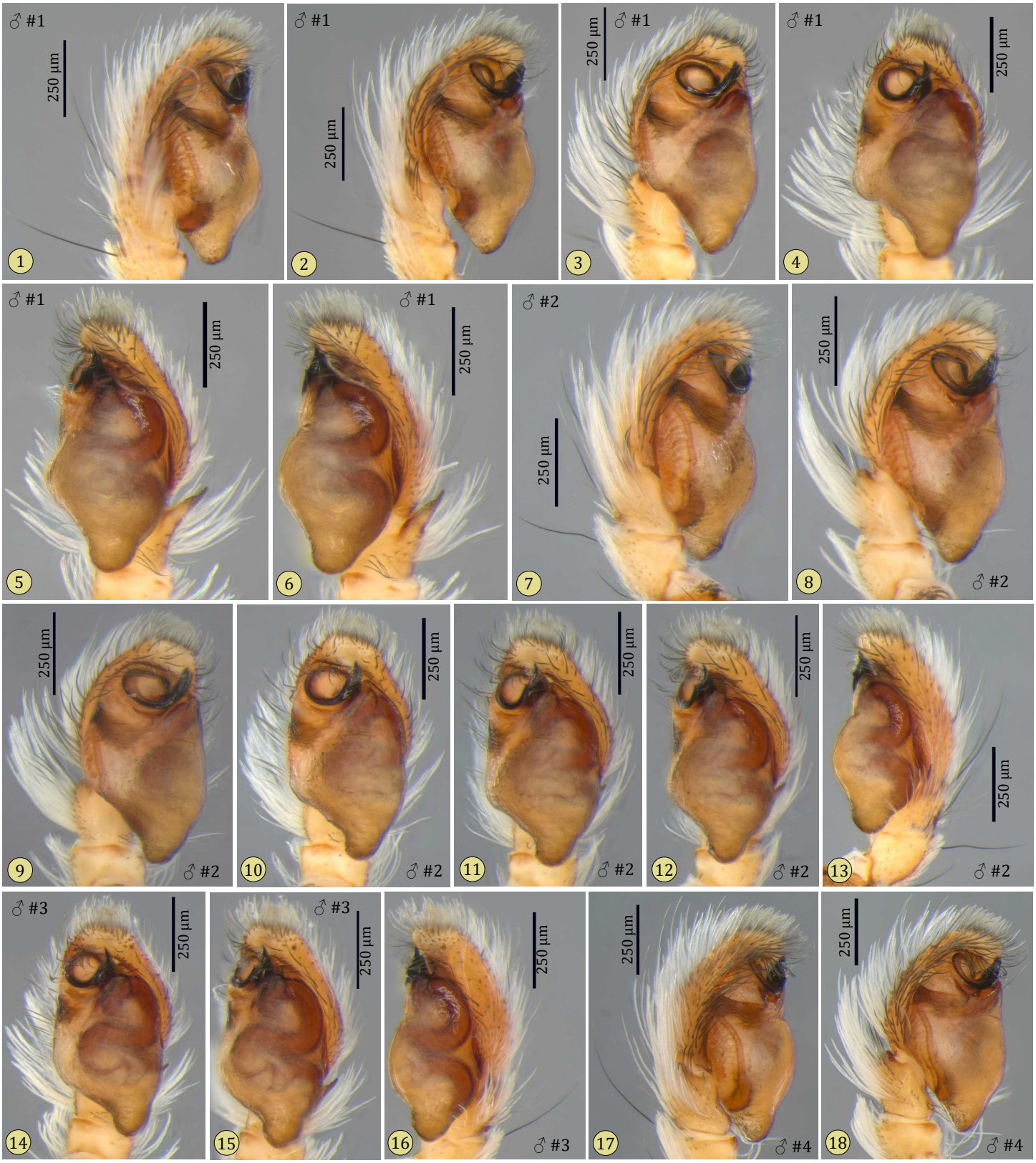


Figure 6 (continued on next page). Medial (prolateral) to lateral (retrolateral) views of the left pedipalp of male types for *Maratus hakea*.

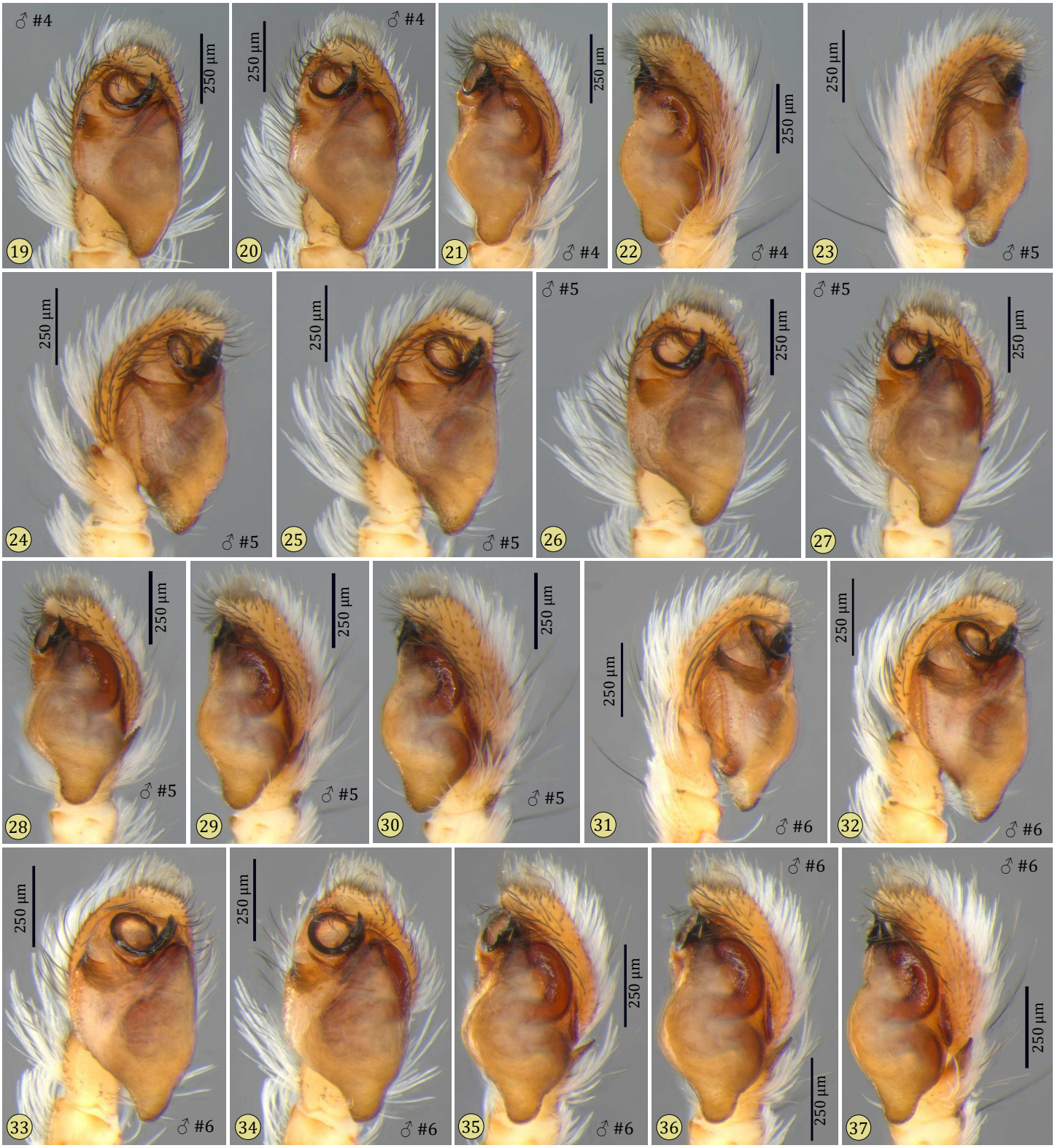
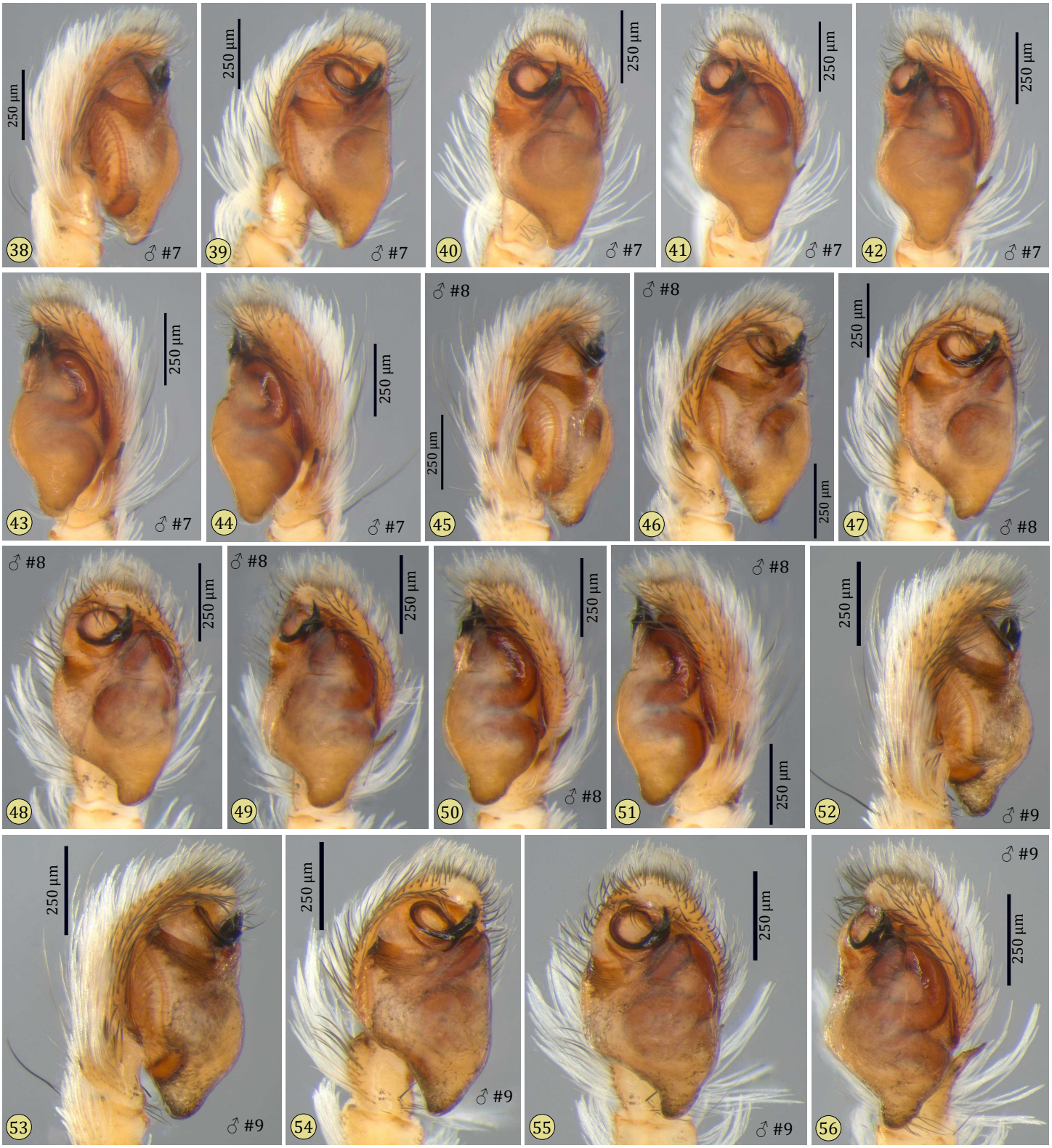


Figure 6 (continued from previous page, continued on next page). Medial (prolateral) to lateral (retrolateral) views of the left pedipalp of male types for *Maratus hakea*.



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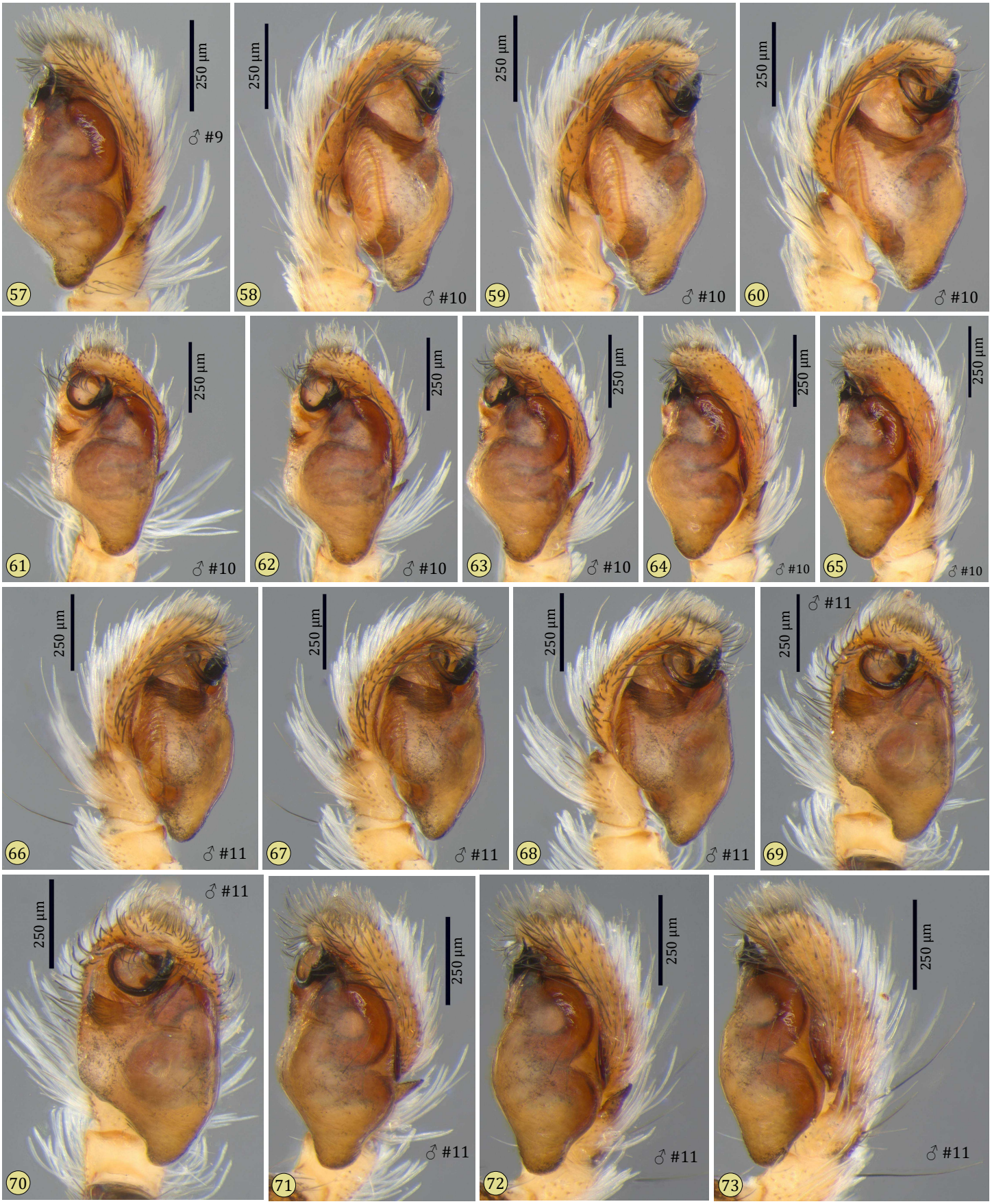

Figure 6 (continued from previous page). Medial (prolateral) to lateral (retrolateral) views of the left pedipalp of male types for *Maratus hakea*.

Description of female (Figures 7-10). Type females (n=11) range from 5.0-5.8 mm in length. Females have cryptic colours and are much like females of other *Maratus* species. The pedipalps are brown, with an incomplete cover of longer white setae. Each paturon is brown and mostly glabrous, with several longer white setae projecting downward on the front. Long white setae on the clypeus extend in a medioventral direction, over the top of the chelicerae. The scale cover of the eye region varies from ivory to brown or red-brown in colour. Scales of the same colours can be found in tracts that extend around the lateral eyes to cover most of the sides of the carapace, and with lighter coloured scales comprising indistinct tracts behind the PLE and at the median behind the eye region. The PME are slightly closer to the PLE than to the ALE. There is no distinct marginal band around the sides of the carapace, but some long setae occupy this position.

Colouration of the dorsal opisthosoma is similar to that of the carapace, mostly dark brown at the center, but with a broad band of off-white or ivory scales comprising a marginal band on each side. An anteromedian tract of lighter scales is usually present. Some individuals are more grey in colour (e.g., Figure 7.19), while others are more brown and darker (Figure 7.10). A small triangular anal tuft of white setae is present, above the grey to light brown spinnerets. Below (Figure 8) the opisthosoma is light or off-white in colour, speckled with many small brown spots.

From below, the trochanters, coxae, sternum, labium and endites are mostly glabrous and grey in colour, with scattered off-white setae projecting from the rear of the sternum. Legs I and II are shorter and about the same length, legs III and IV longer and also about the same length. All legs are brown to dark brown in colour, with indistinct banding and a partial cover of off-white setae.

The epigynum (Figure 10) closely resembles that of other *Maratus*, with a large window (fenestra) on either side though which sclerotized ducts may be seen on the posterior side, in front of a large posterior spermatheca. The width of the midline septum separating the two windows is variable.

Figure 7 (continued on next page). Living female types for *Maratus hakea*.

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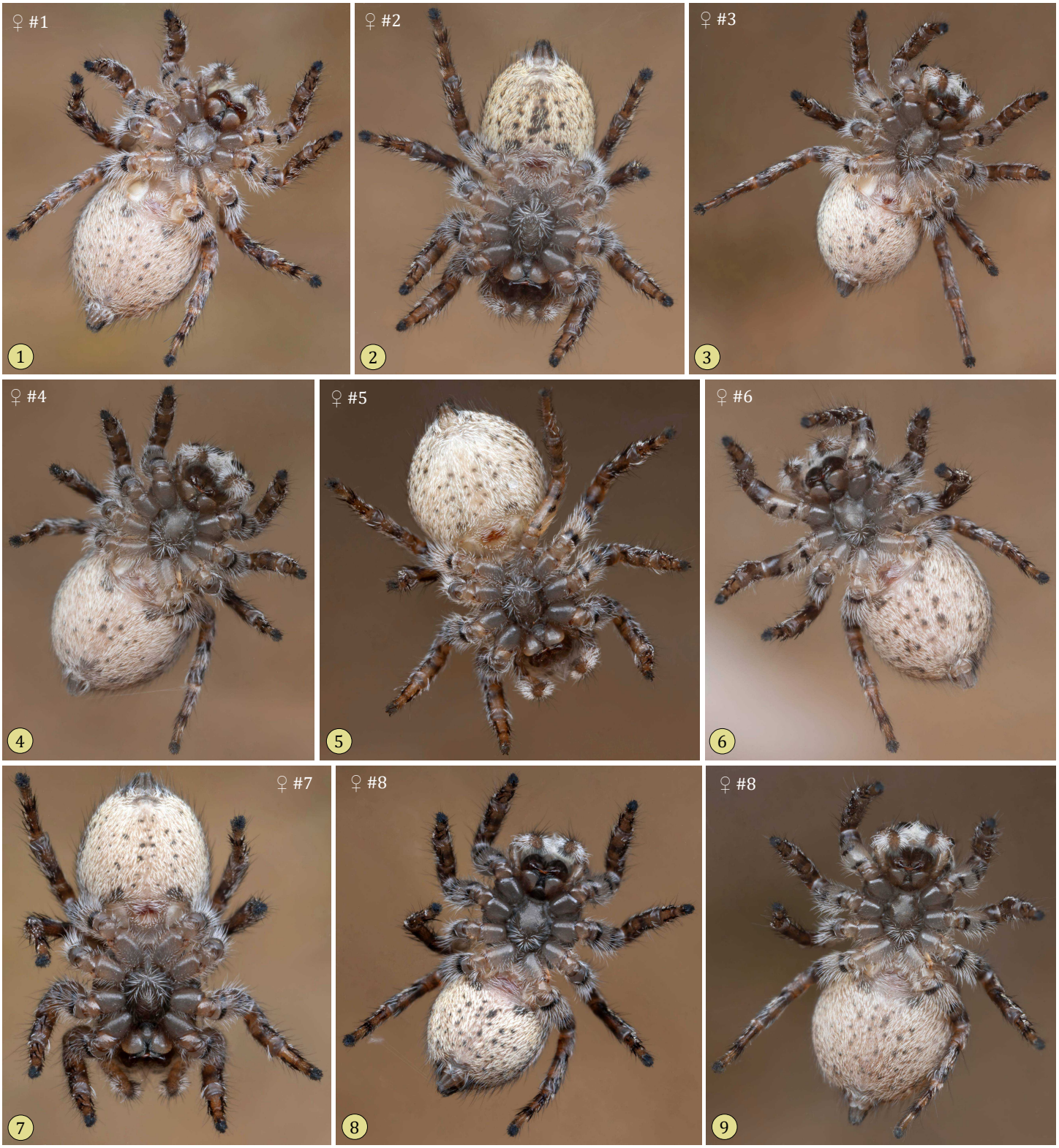

Figure 8 (continued on next page). Ventral views of living female types for *Maratus hakea*.

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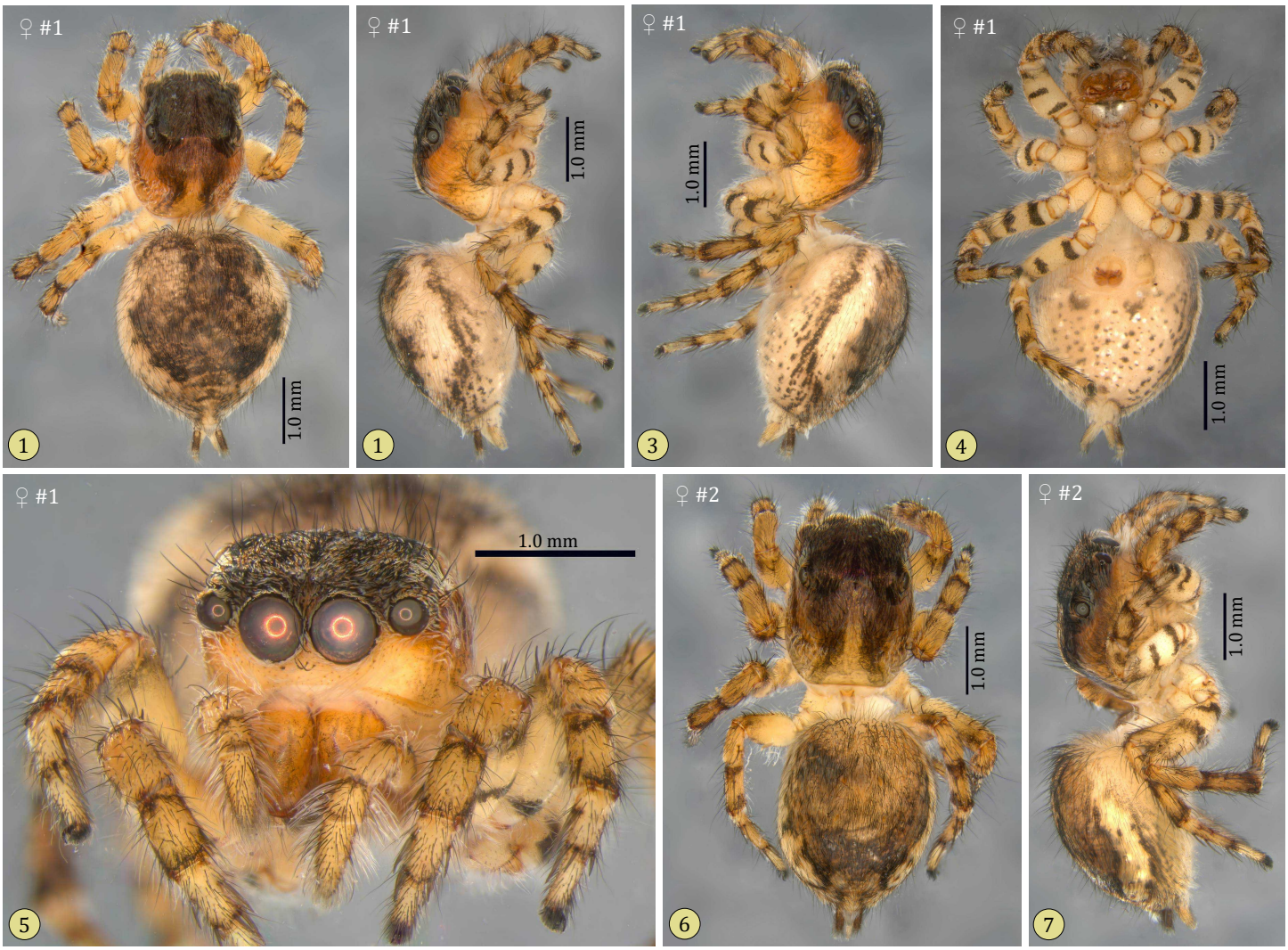


Figure 9 (continued on next page). Female types for *Maratus hakea* in alcohol.

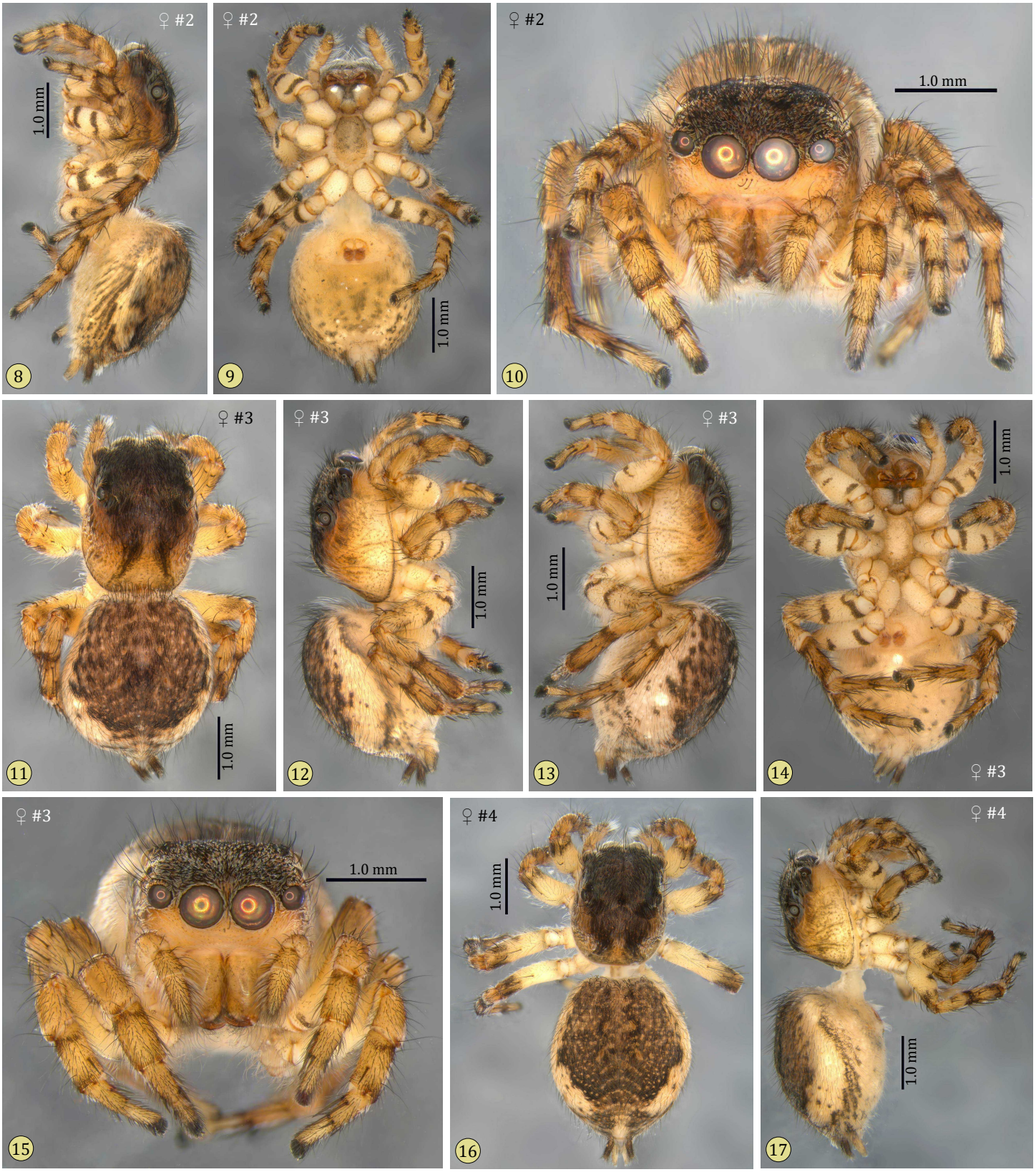
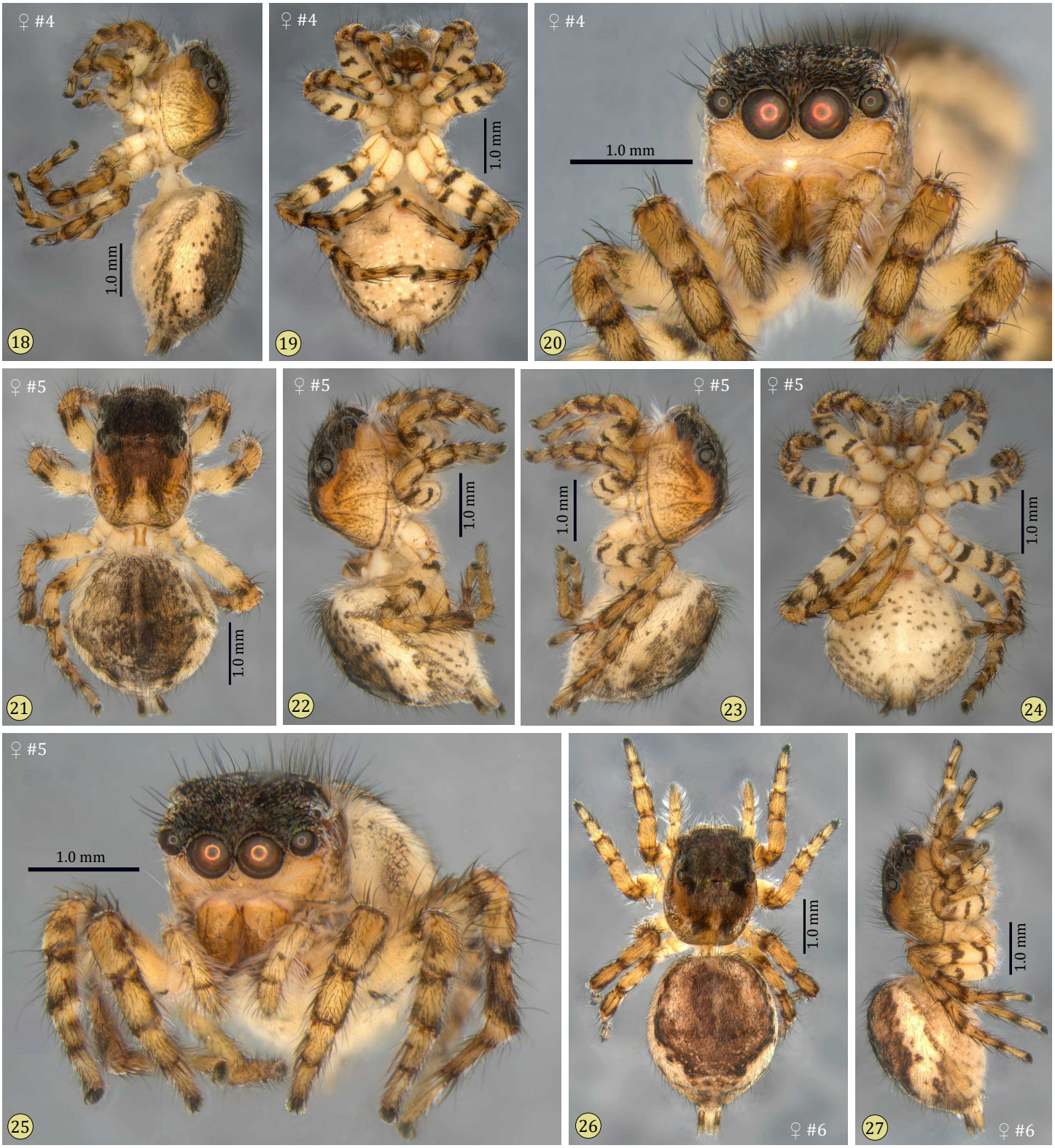


Figure 9 (continued from previous page, continued on next page). Female types for *Maratus hakea* in alcohol.



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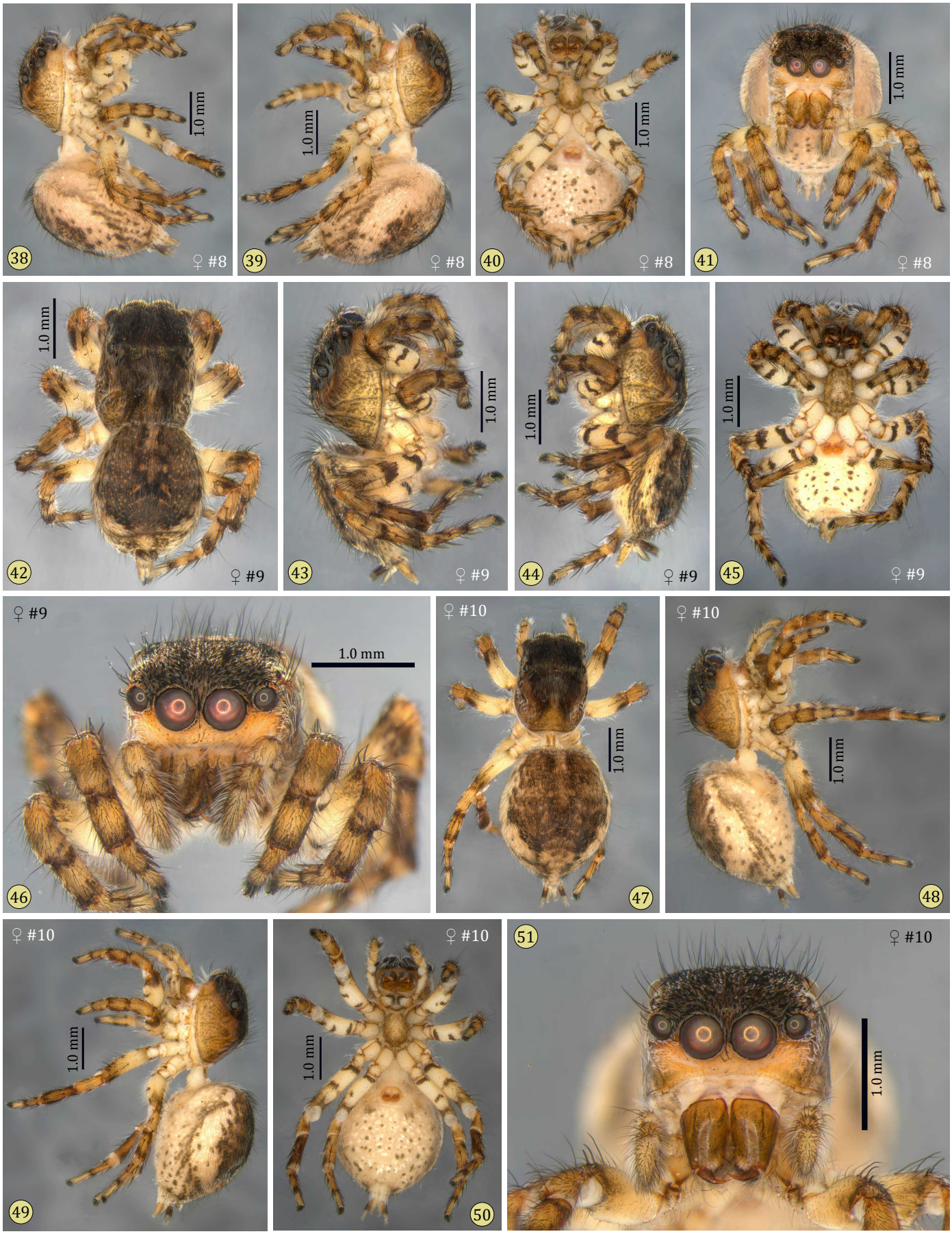

Figure 9 (continued from previous page). Female types for *Maratus hakea* in alcohol.

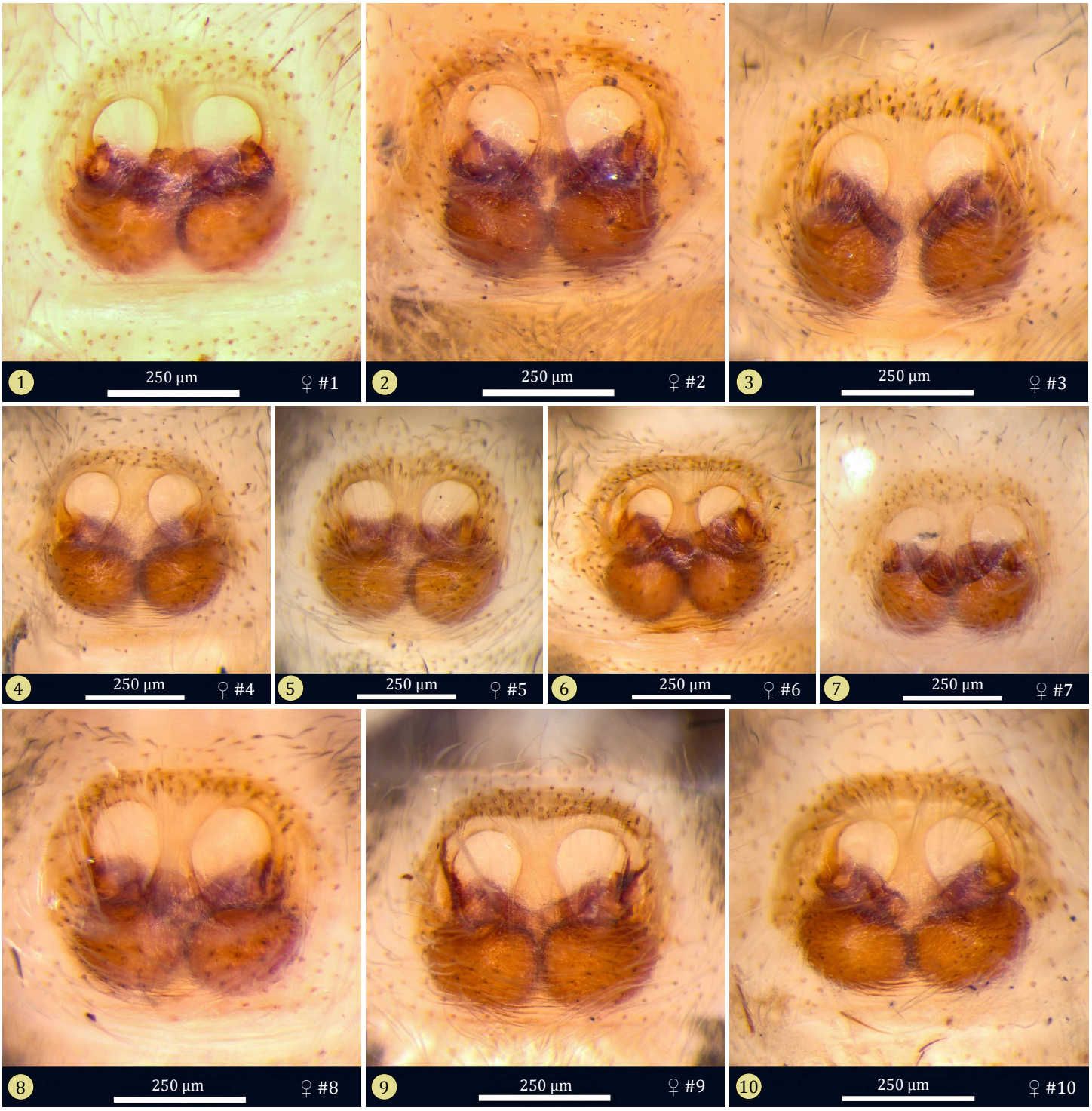

Figure 10. Ventral (external) view of the epigynum of female types for *Maratus hakea* in alcohol. The anterior direction is toward the top of the page.

Immatures. Immatures of both sexes resemble adult females in colouration (Figures 11-13). The opisthosoma of penultimate males (Figure 12) can be quite wide, apparently to accomodate the development of the large lateral flaps found in this species. Opisthosomal scale patterns of penultimate males can also be more complex, reflecting the banded pattern of scales found in the adult.

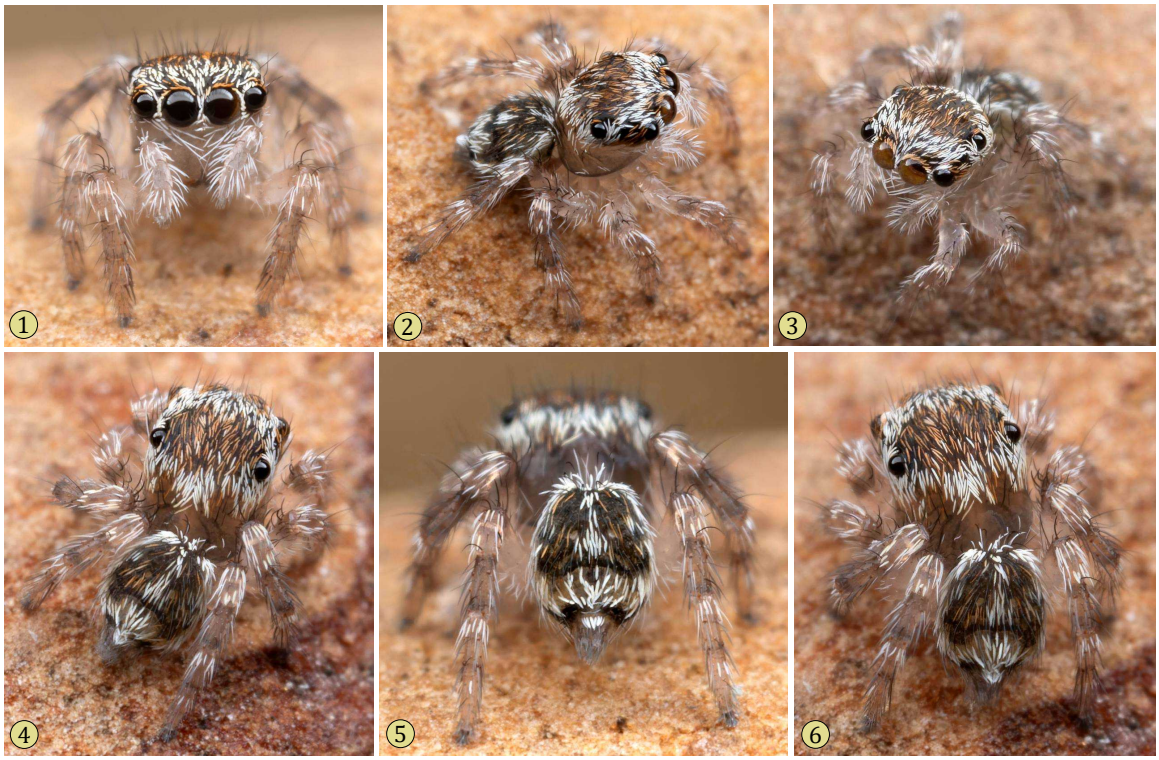

Figure 11. Second (emergent) instars of *Maratus hakea*.

Figure 12. Two male types for *Maratus hakea* in the penultimate instar.

Figure 13. Penultimate female *Maratus hakea*. **1-11,** Paratype females. **12,** One more female (not a type).

Courtship (Figures 14-26). This brief description of courtship is based on the observation of captive spiders in a simulated natural habitat in the laboratory. Like other *Maratus*, *M. hakea* males advertise by raising and lowering one (usually) or both legs III, extended to the side (Figures 14-15). Courtship display in front of a female is primarily associated with exhibition of the fully expanded and elevated fan. This can be divided into three stages (Figure 16): 1) *display at a distance* (~2 cm or more; Figures 16.1-16.3, 17-21), mostly with a stationary fan, but also with intermittent waves to one side or the other, 2) a *close display* (~4-6 mm in front of the female; Figures 16.4, 22) in which the male waves the fan from side to side continuously at ~8 Hz, as he steps from side to side, and 3) a *mounting display* (Figures 16.5, 24-26), in which the male advances to touch the carapace of the female with extended legs I, as legs III are flexed forward around either side of the female. One interesting characteristic of this courtship lies in the fact that it is the male that advances to a close position with the female, and the male frequently retreats from the second to the first, and less active, stage of display, apparently based on the female's receptivity. As in other *Maratus*, the female may also display her rejection of a male by extending her legs III and elevation her opisthosoma (Figure 27).

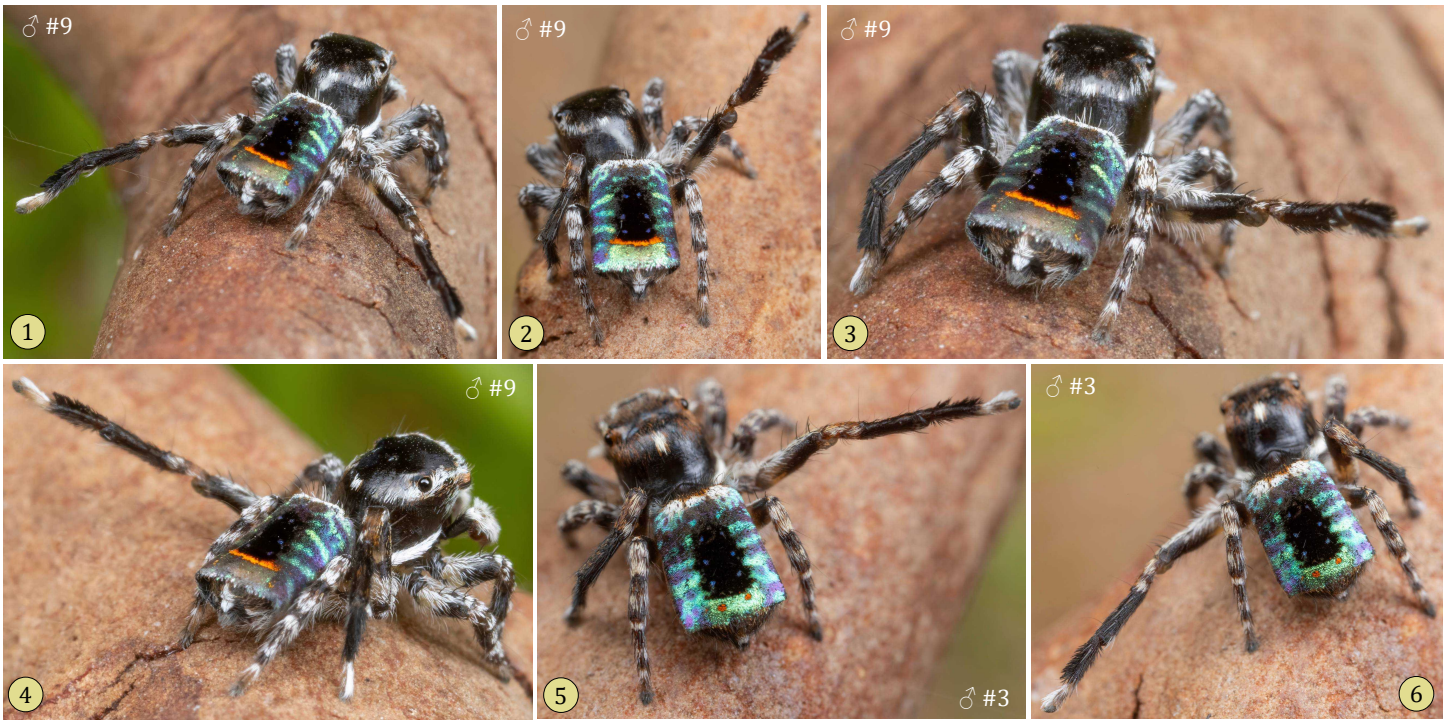

Figure 14. Advertisement with one or two elevated legs III by male *Maratus hakea*.

Figure 15. Three sequential frames from a 25 fps video showing advertisement by a male *Maratus hakea*. Here the extended right leg (RIII) was first raised to a vertical position, then lowered in increments of ~12°.

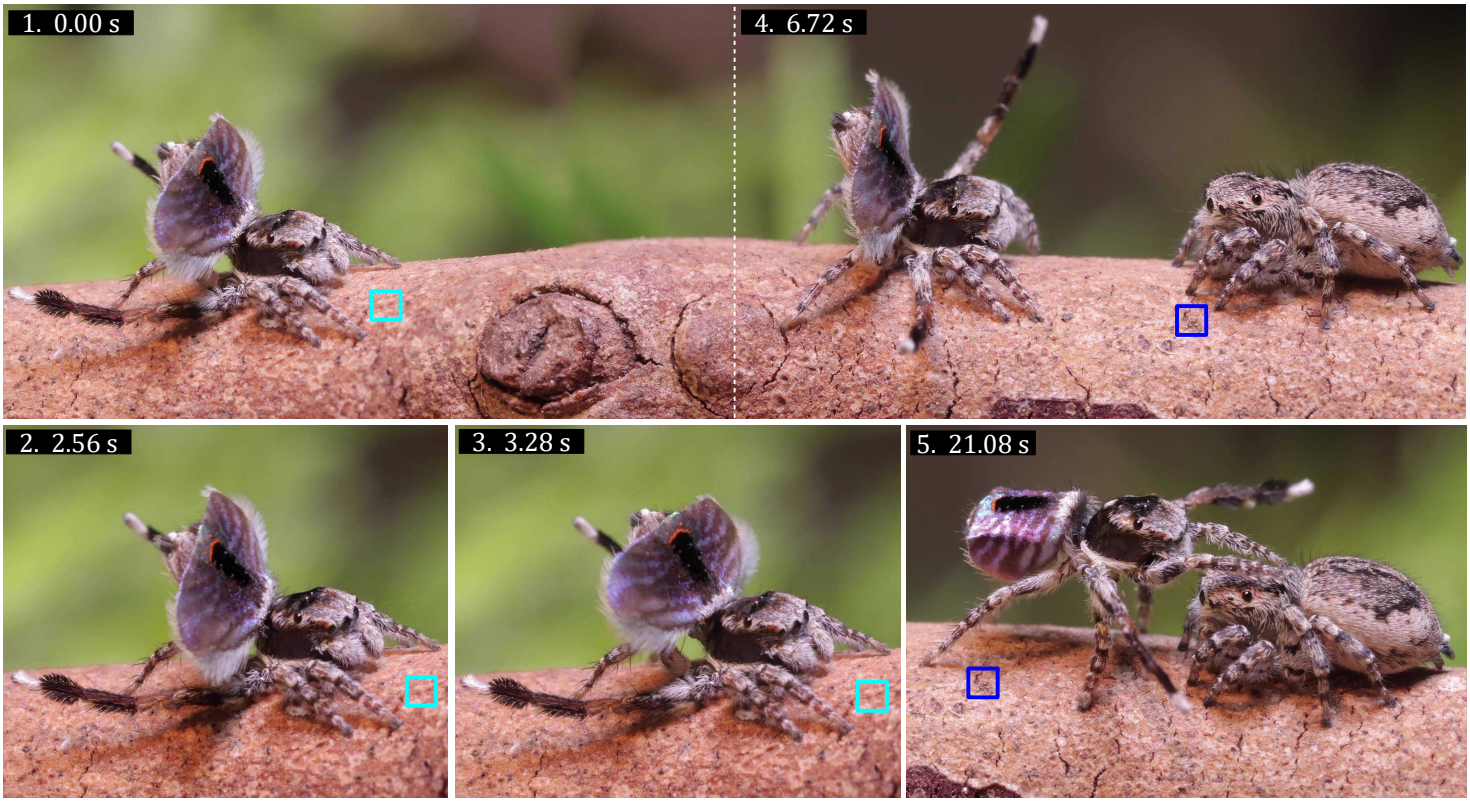

Figure 16. Sequential frames from a 25 fps video showing the three stages of courtship by a male *Maratus hakea*. Frames (1) and (4) are composited to show the distance between the male and female (~2 cm). Small rectangles are reference positions that link respective frames. **1-3,** Display at a *distance* is mostly stationary, with intermittent waves of the fan to the right or left. **4,** For the *close display* (at ~4-6 mm), the male walks quickly up to the female, and actively displays by stepping from side to side while rapidly waving the fan. **5,** During pre-copulatory *mounting*, the male touches the female with extended legs I while extending legs III forward to either side.

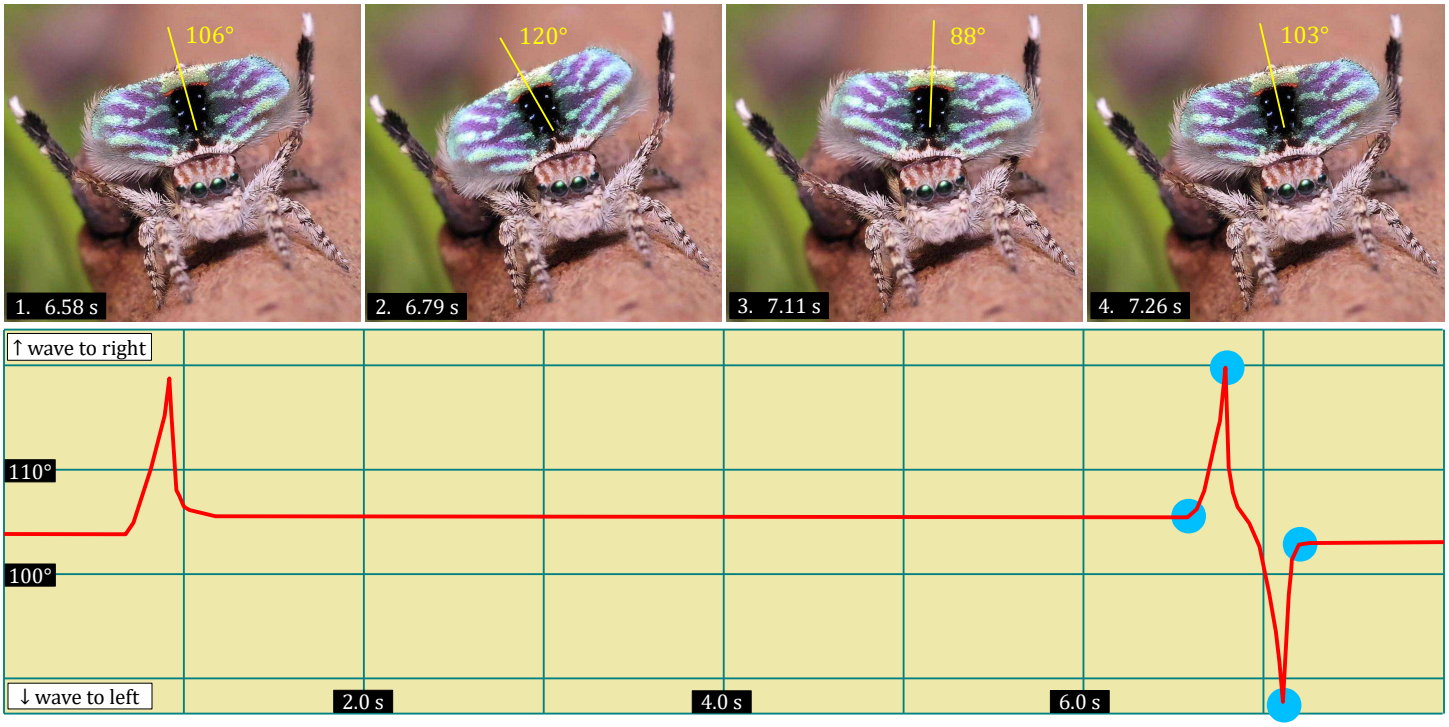

Figure 17. Position of fan during display at a distance by a male *Maratus hakea*. Blue circles correspond to selected frames (1-4) from a 100 fps video. Intermittent waves (lateral rotation of fan) are either unilateral (to one side, then back) or bilateral.

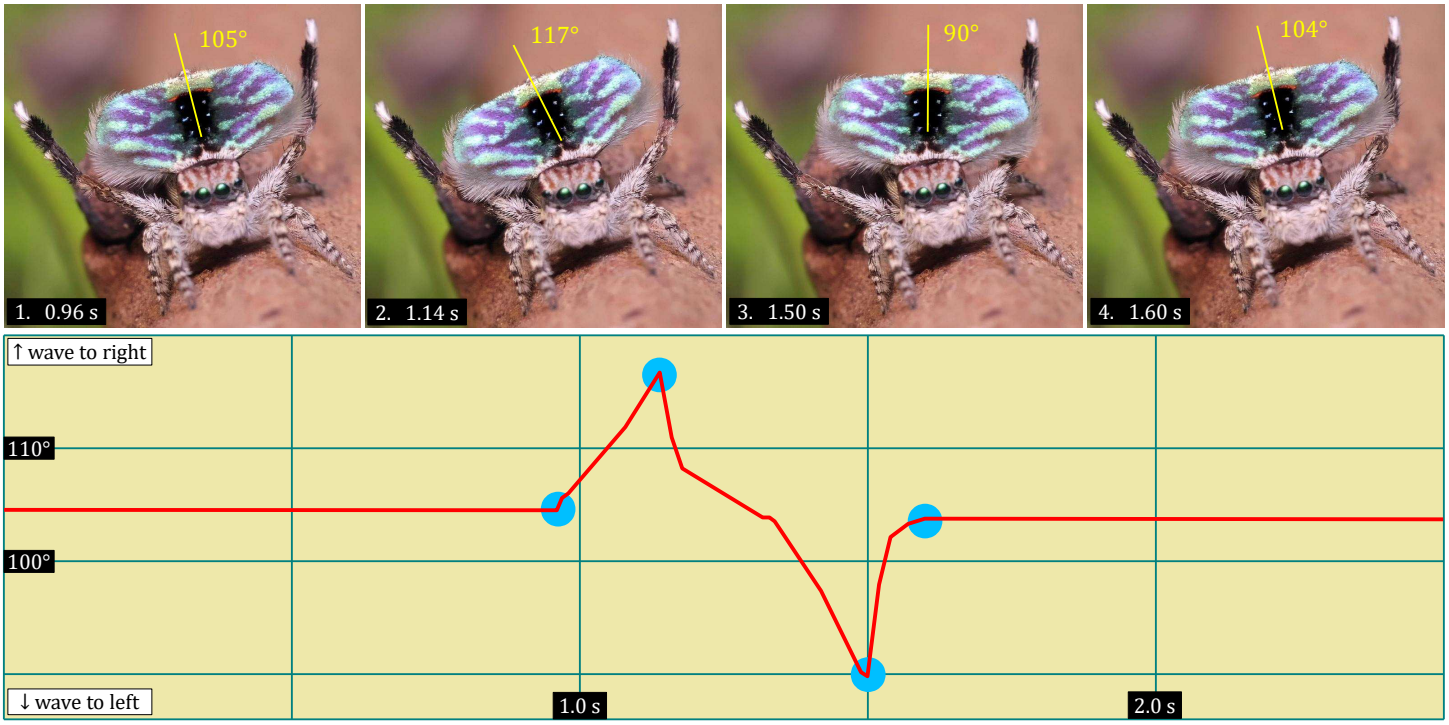

Figure 18. Position of fan during display at a distance by a male *Maratus hakea*. Blue circles correspond to selected frames (1-4) from a 100 fps video. This shows an isolated bilateral wave (~0.6 s), comprised of a unilateral wave to the spider's right side, immediately followed by a unilateral wave to the left (~0.3 s each).

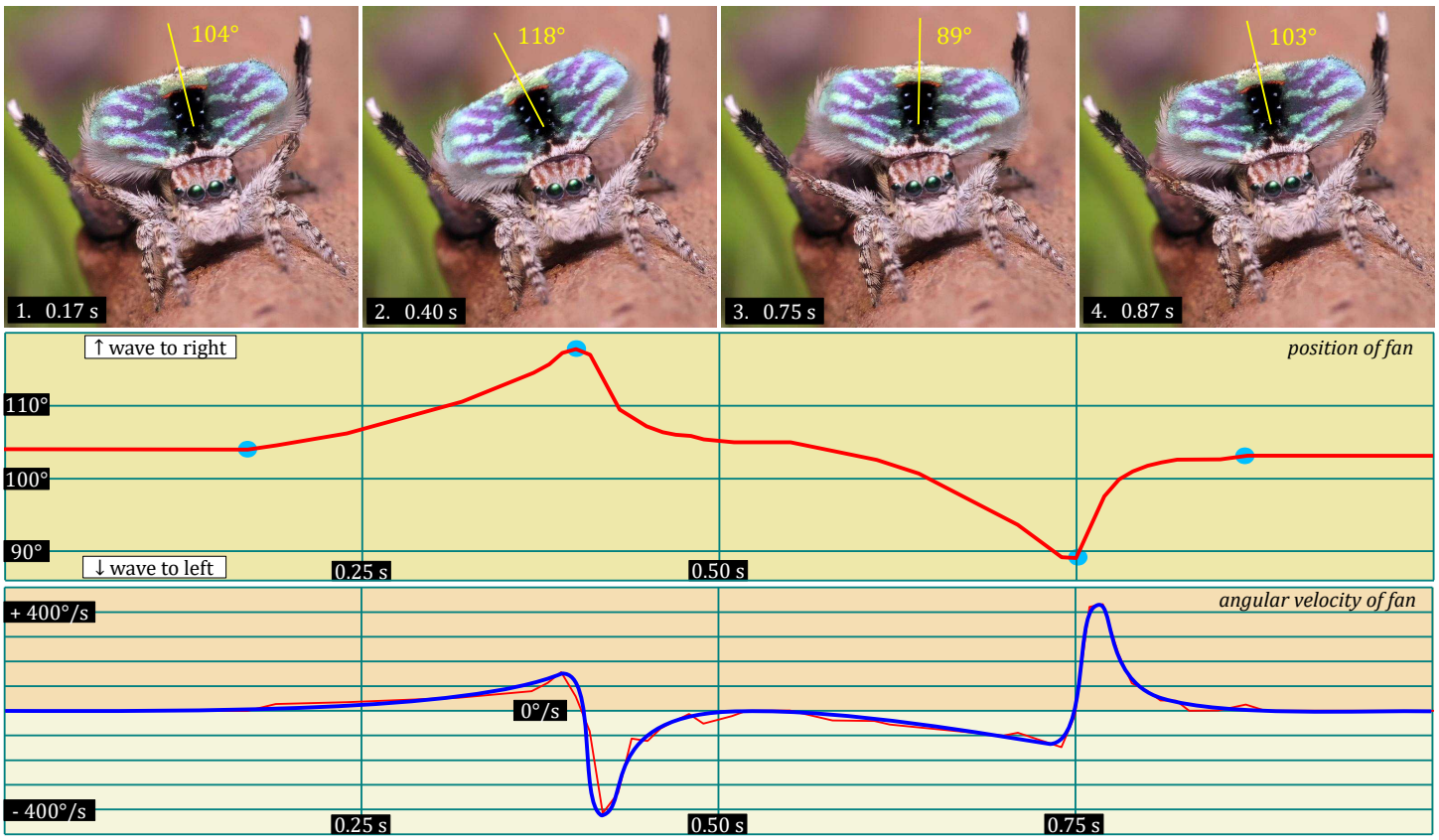

Figure 19. Position (top chart) and angular velocity (lower chart) of fan during display at a distance by a male *Maratus hakea*. Blue circles in the top chart correspond to selected frames (1-4) from a 100 fps video. Detail of an isolated bilateral wave shows that lateral rotation *away from* the midline is slower, and each *return to* the midline is much faster. In the lower chart the thin red line was calculated from measurements, and the heavier blue line represents a smooth curve to approximate this.

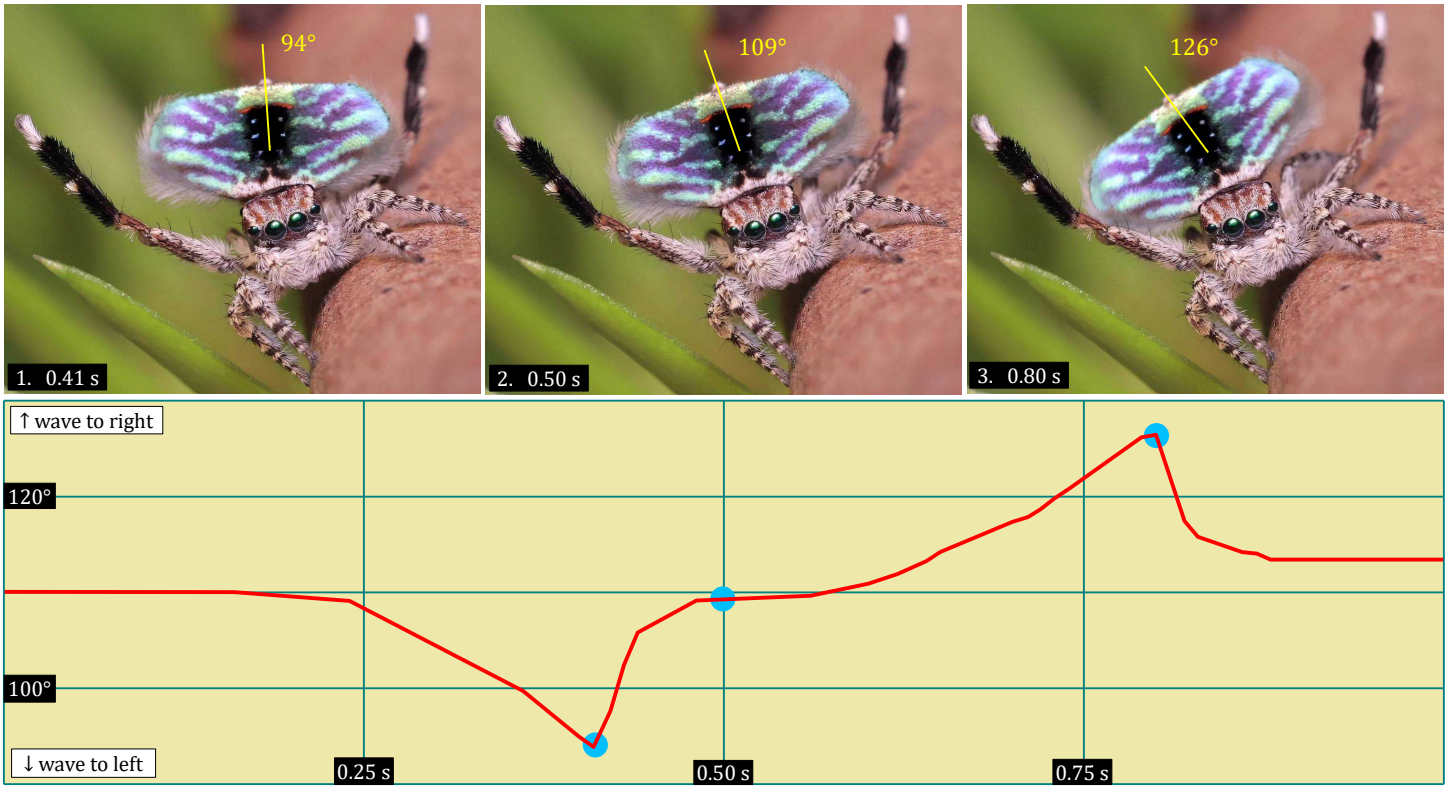

Figure 20. Position of fan during display at a distance by a male *Maratus hakea*. Blue circles correspond to selected frames (1-3) from a 100 fps video. This bilateral wave began with a wave to the left.

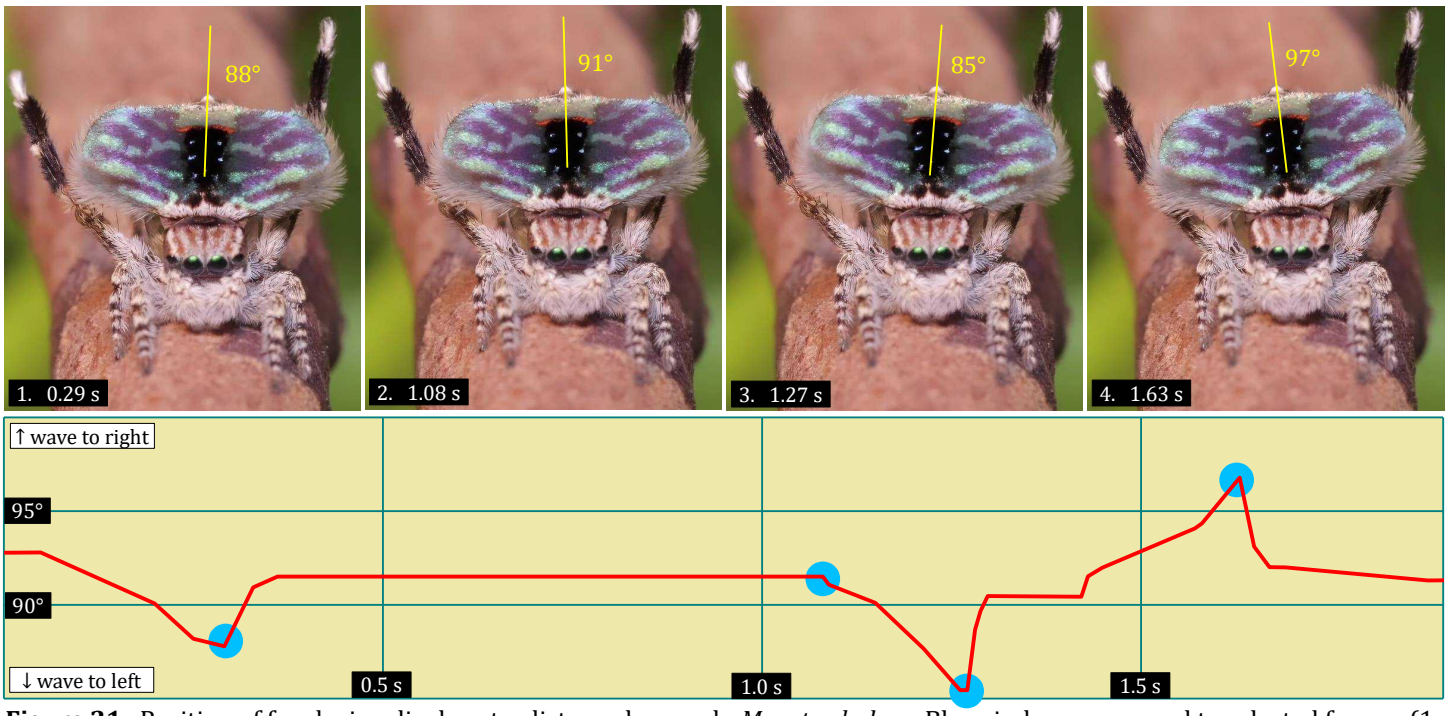

Figure 21. Position of fan during display at a distance by a male *Maratus hakea*. Blue circles correspond to selected frames (1-4) from a 100 fps video. This shows a series of lower amplitude (~5°) waves, two to the left followed by one to the right.

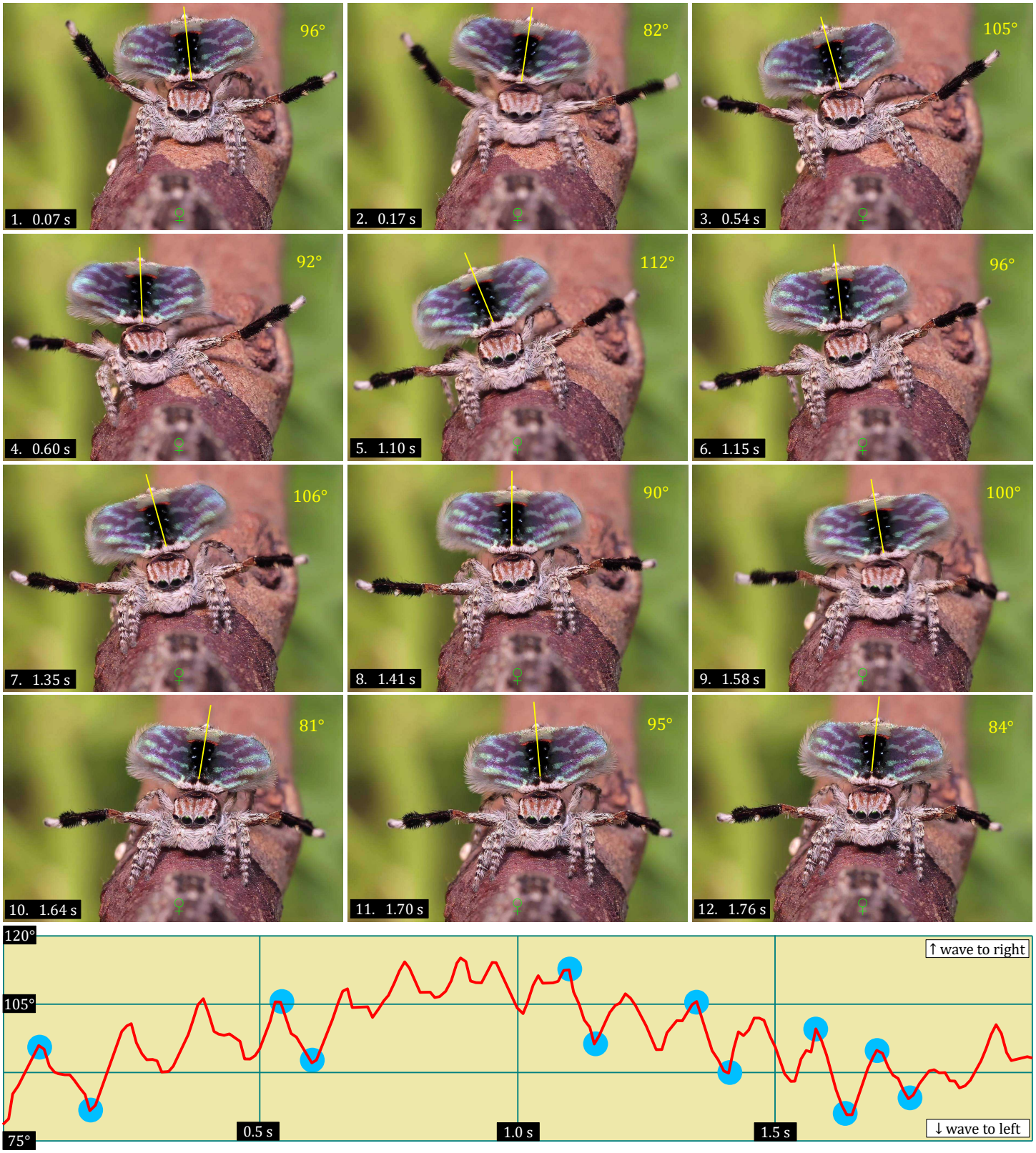

Figure 22. Position of fan during *close display* by a male *Maratus hakea*. Blue circles correspond to selected frames (1-12) from a 100 fps video. This shows a rapid (~8 Hz) series of waves at an amplitude of ~15°, as the male stepped first to the left (frames 1-5, to the right of the female) and then to the right (frames 6-10, to the left of the female).

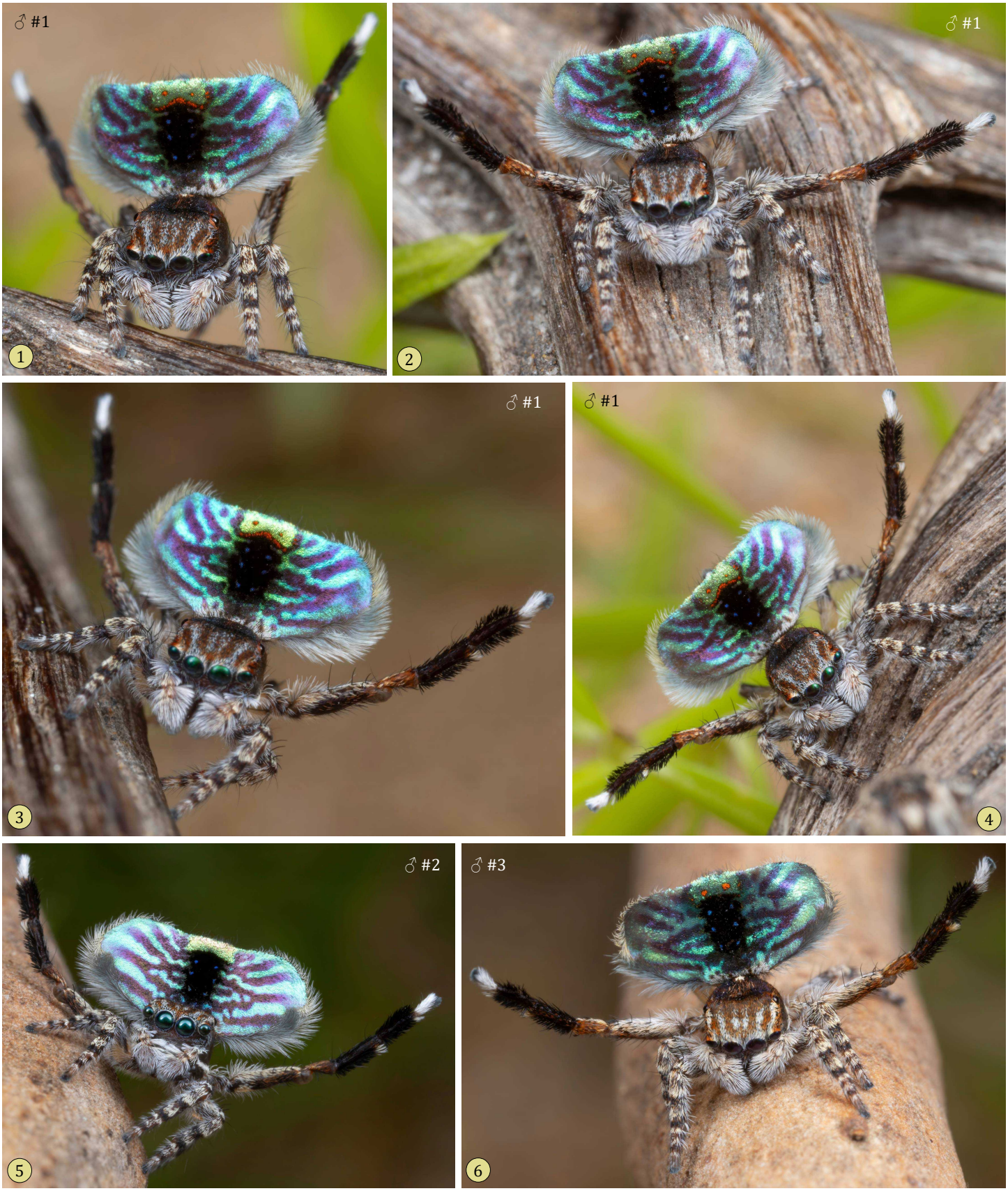

Figure 23 (continued on next page). Photographs showing display of male *Maratus hakea* to females at a variable distance.

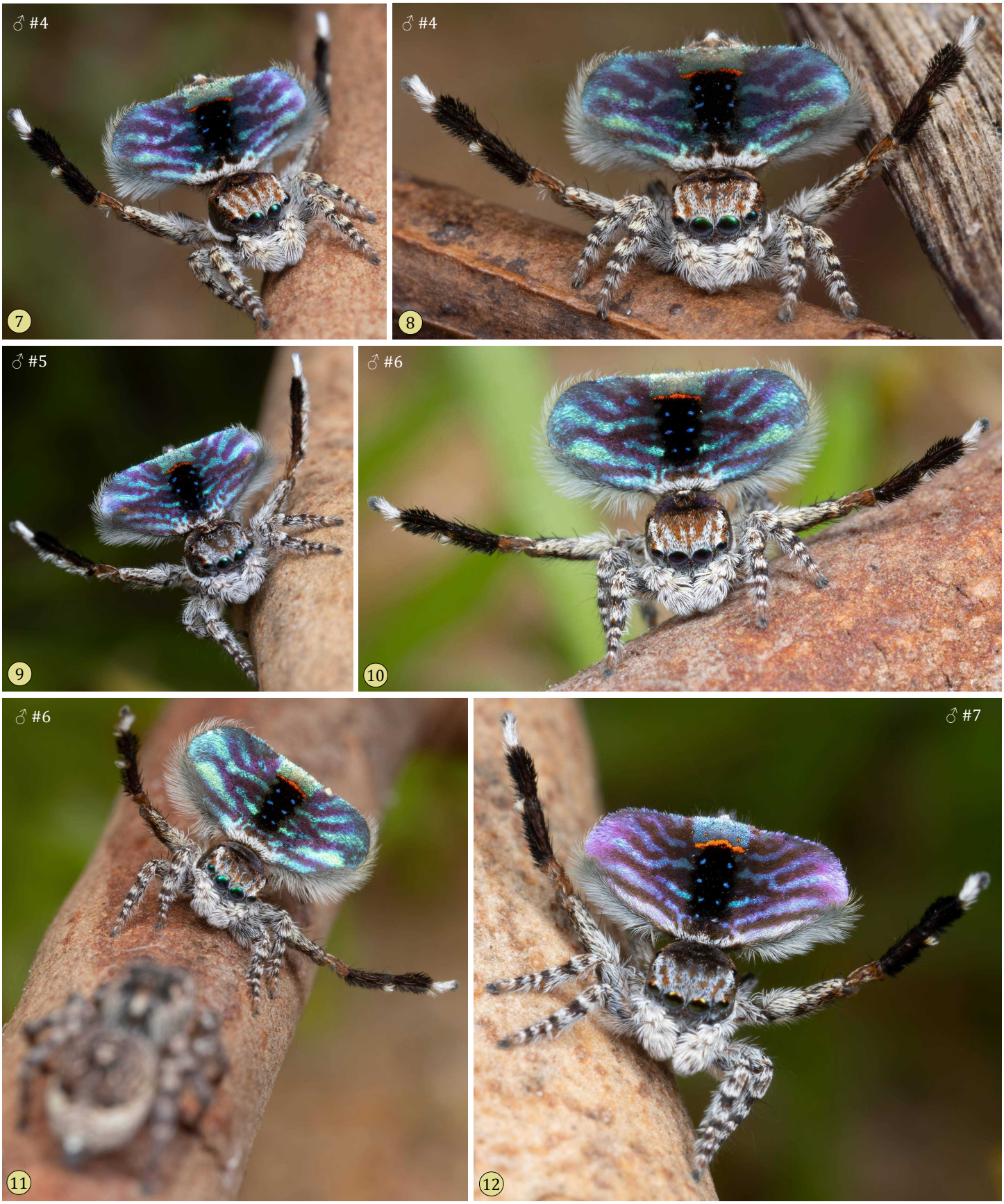

Figure 23 (continued from previous page, continued on next page). Photographs showing display of male *Maratus hakea* to females at a variable distance.

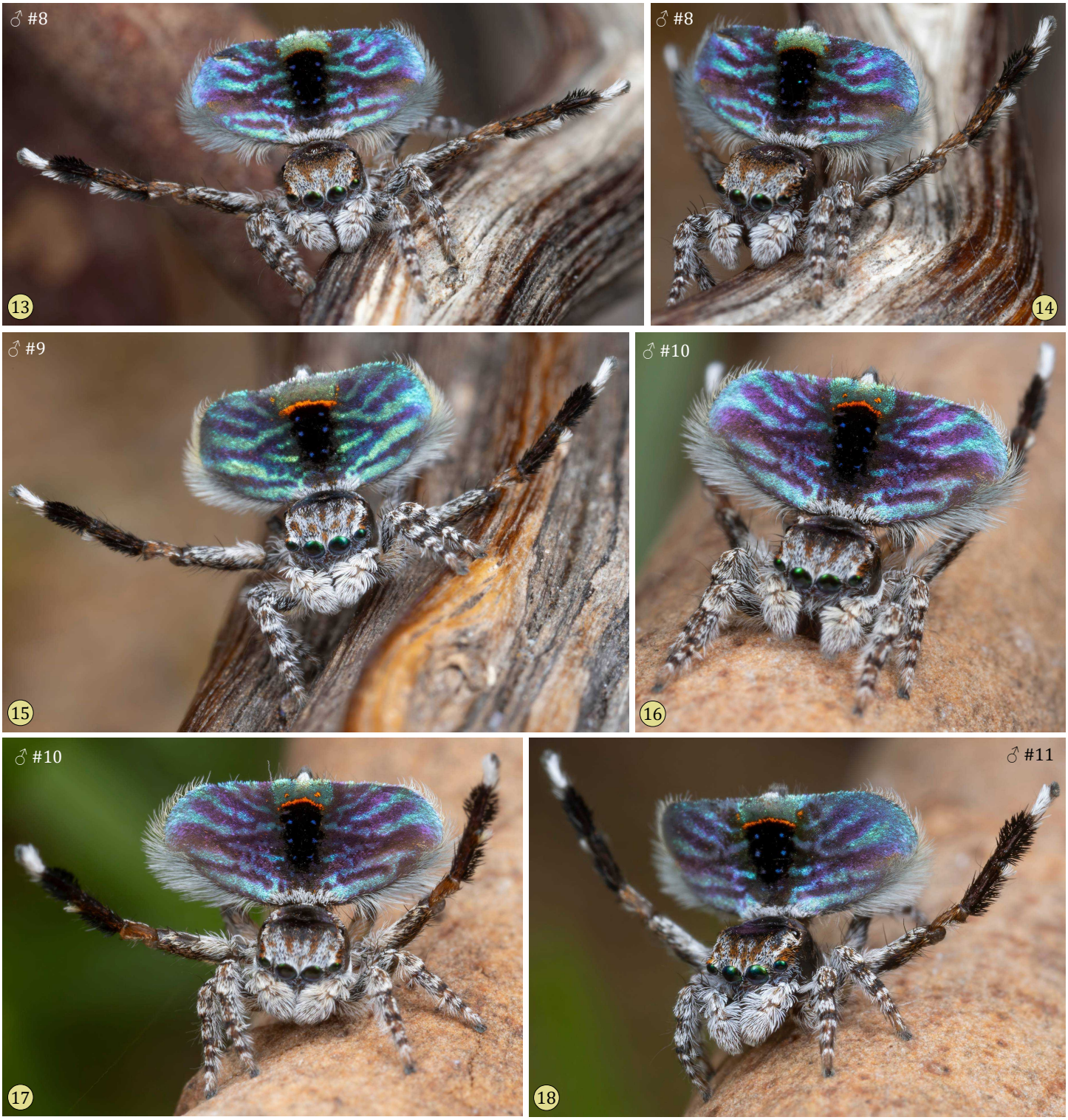

Figure 23 (continued from previous page). Photographs showing display of male *Maratus hakea* to females at a variable distance.

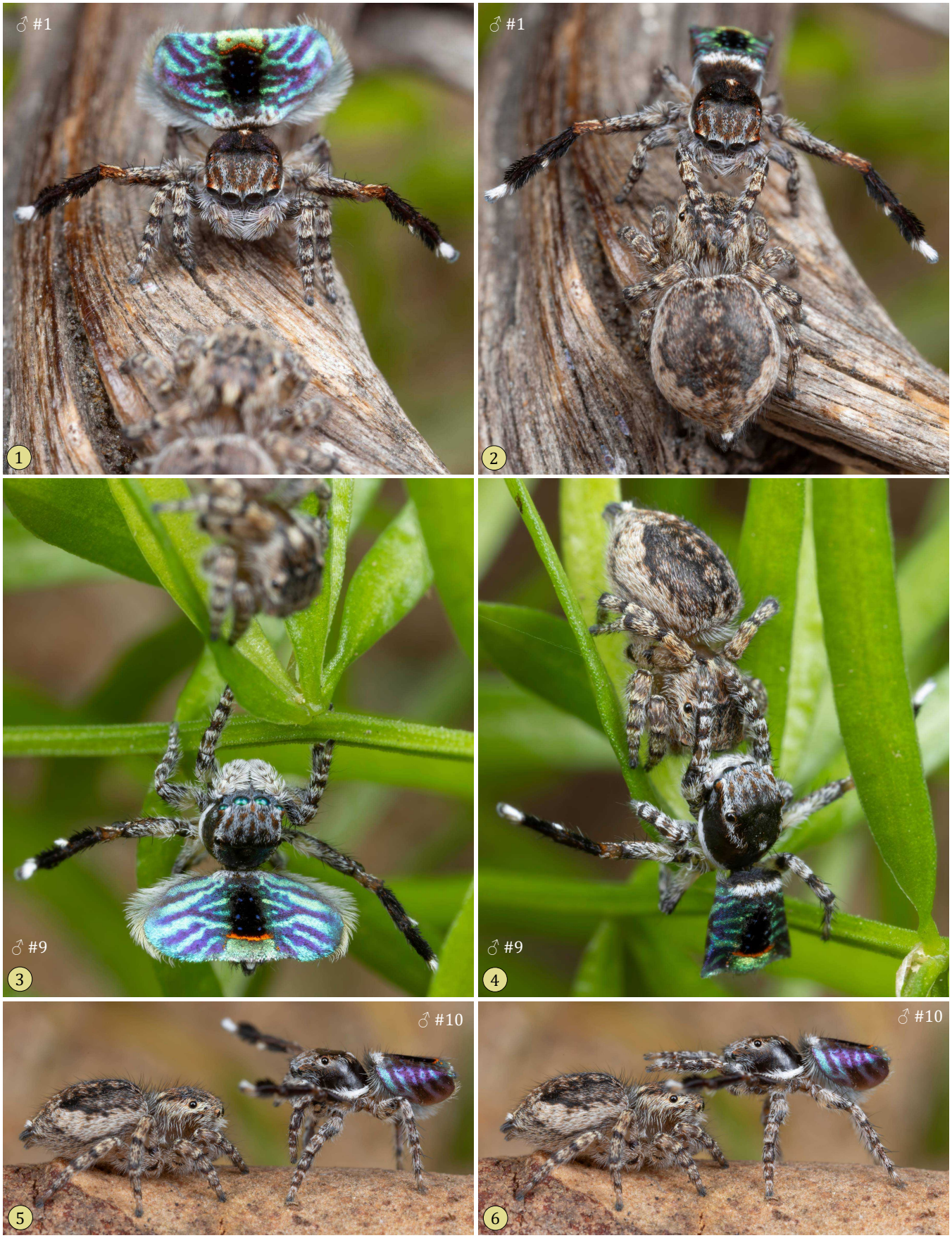

Figure 24. Three sequences (1-2, 3-4, 5-6) showing a male *Maratus hakea* approaching to mount a female.

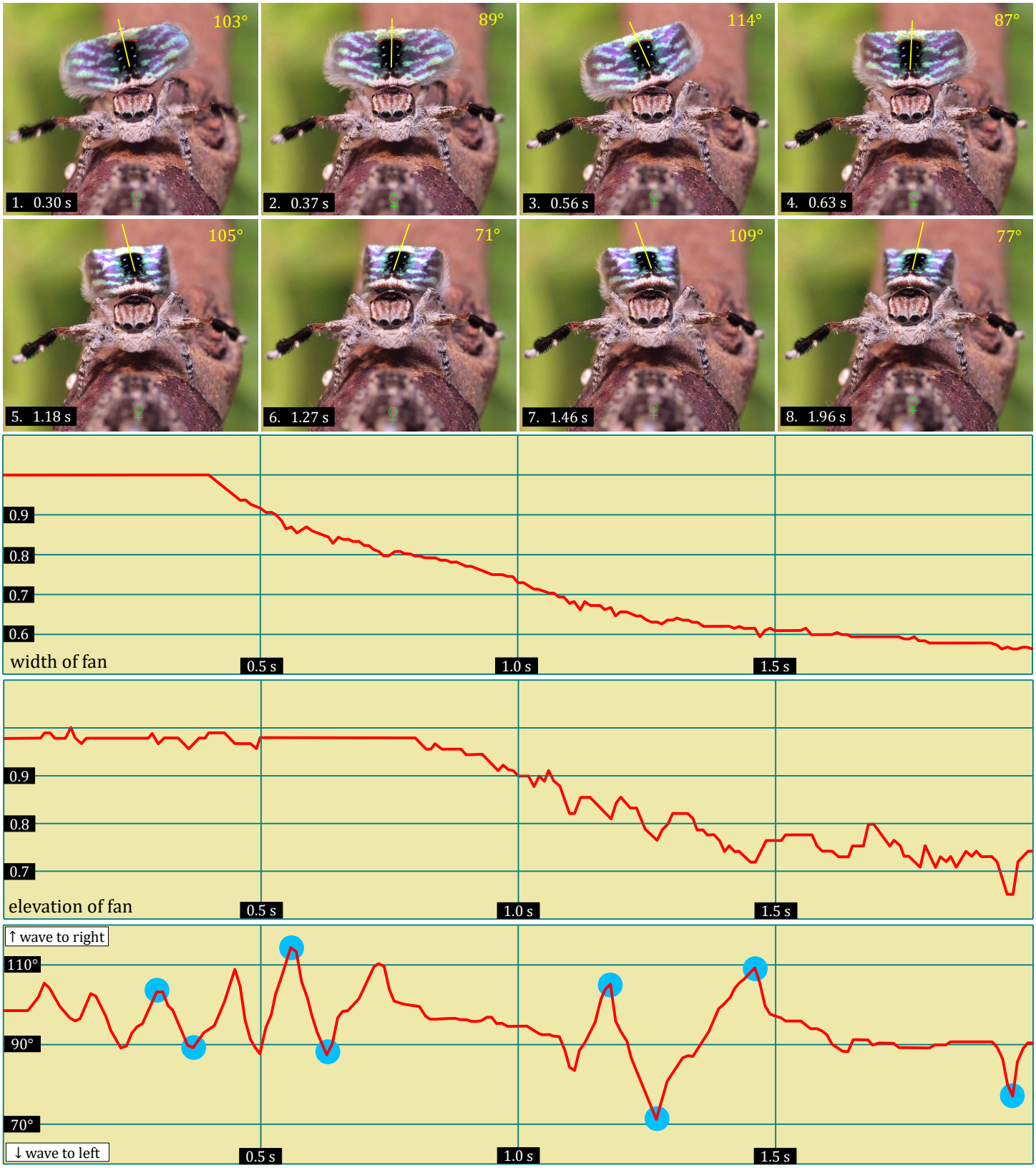

Figure 25. Movement by a male *Maratus hakea* approaching to mount a female. During this sequence legs I were elevated in preparation for contact with the female. **Upper graph (*width of fan*):** At about 0.4 s, the male began to retract the flaps of his fan, and this continued to the end of this interval. The scale at left represents the relative width of the fan. **Middle graph (*elevation of fan*):** After about 0.8 s, this male began to lower the fan (rotation downward in a sagittal plane). The scale at left represents the relative height of the fan. **Lower graph (*lateral position of fan*):** Initially the fan was waved rapidly (~8 Hz), but this movement became more irregular as the male prepared to mount the female. Blue circles correspond to selected frames (1-8) from a 100 fps video.

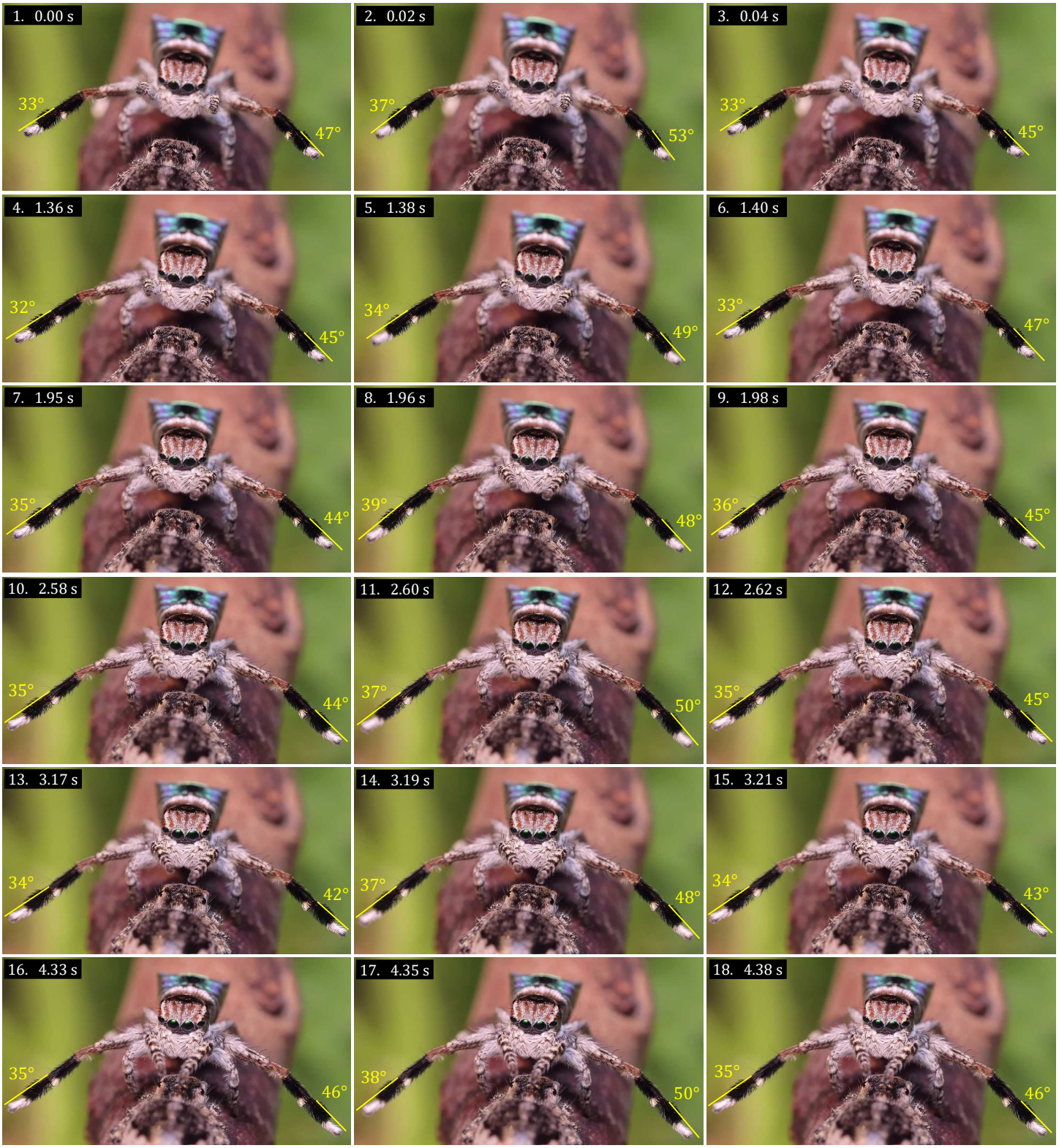

Figure 26. Position of legs III during the final approach of a male *Maratus hakea*. Sequential frames (1-3, 4-6, 7-9, 10-12, 13-15, 16-18) from a 100 fps video show how this male flexed, then extended both legs III at the tibiometatarsal joint (metatarsal flexion, ~1 Hz), as these were extended to either side of the female. In each frame the direction of the metatarsus is shown as degrees below the horizontal. Each cycle of metatarsal flexion may also include up and down movement (bobbing) of the opisthosoma, still in a lower position as shown here. This sequence also shows the first contact of legs I of the male with the carapace of the female, first leg LI (10), then leg RI (16).

Figure 27. Three sequential positions assumed by a female *Maratus hakea* during her display. Characteristic of *Maratus* in general, we consider this display to represent rejection of males in the vicinity.

Mating (Figures 28-29). Mating positions are like those of other *Maratus*, with extreme rotation of the opisthosoma of the female. Copulation is associated with regular pulses (0.5 Hz, or once every 2 s, ~0.25 s duration) that appear to be assoicated with increased pressure in the prosoma. This results in inflation of the tegulum (bulb), and also expansion of the leg bases and inflation of leg setae (Figure 29). Synchronous retraction of the spinnerets suggests that each pulse is associated with the movement of hemolymph from the opisthosoma into at least the lower (sub-endosternite) part of the prosoma.

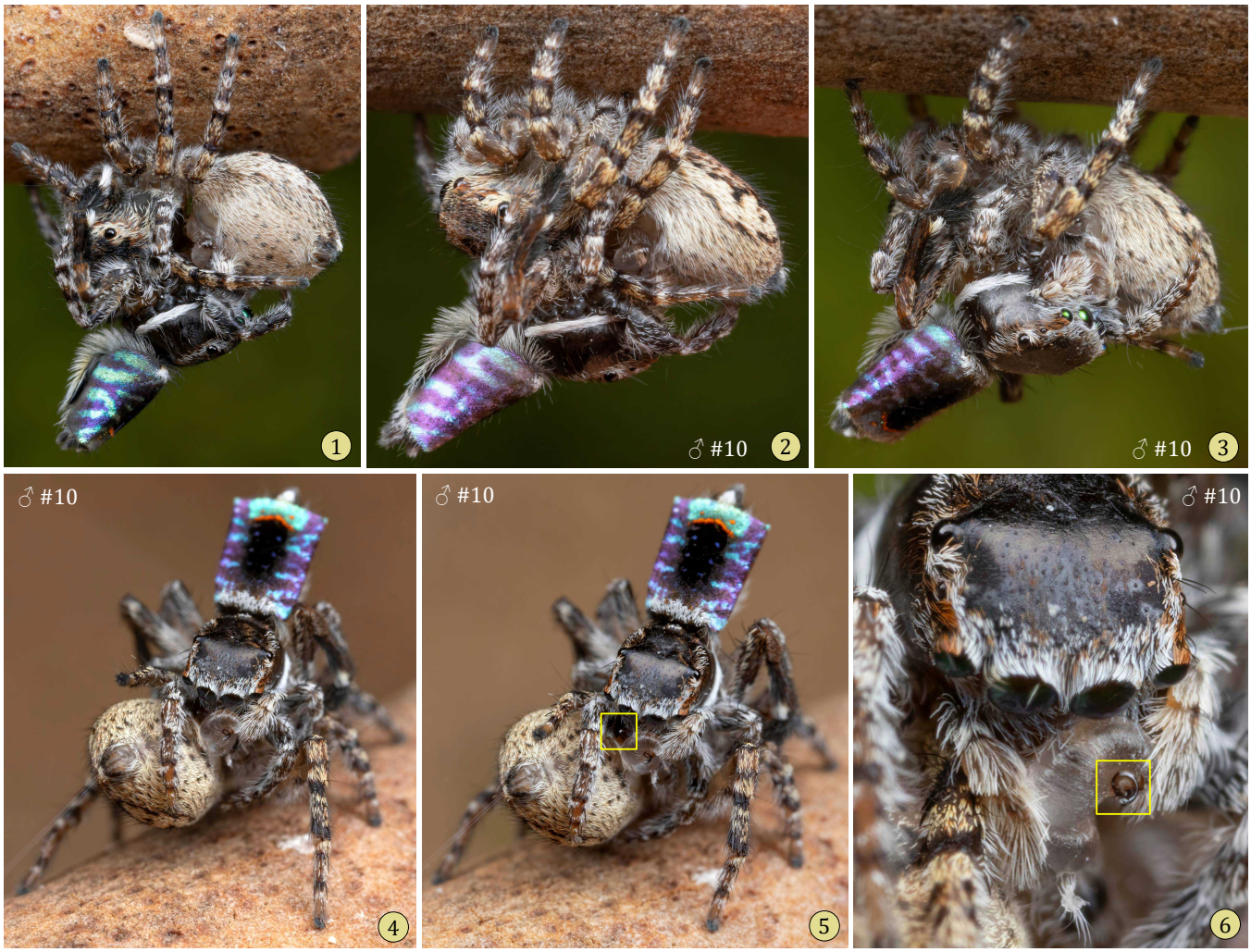

Figure 28. Mating positions of *Maratus hakea*. **4-6,** The position of the embolic disc (6, yellow square) shows that the right pedipalp of this male, still inflated, was disengaged from the right side of the epigynum. After removal of this pedipalp, fluid exuded from the epigynum (5, yellow square).

Figure 29. Sequential frames from a 25 fps video of mating by *Maratus hakea*. For each row of frames, the left frame shows relaxation and retraction of the spines of right leg I (RI), and the right frame shows the subsequent extension of these spines (lasting ~0.25 s, each 2 s). Extension of legs spines was apparently due to a general increase in fluid pressure within the prosoma, or at least in the lower (sub-endosternite) chamber of the prosoma. As these spines were extended, the tegulum (or bulb, T) was inflated, and the legs (L) were pushed away from the carapace. At the same time, the spinnerets (S) were retracted. This suggests that periodic (~0.5 Hz) contraction of the opisthosoma contributed to fluid pressure in the prosoma.

Habitat (Figure 30). *Maratus hakea* were found only on or near the low-growing endemic shrub, *Hakea prostrata* (Proteaceae), on the southern coast of Western Australia. The genus *Hakea* has its greatest diversity in this region.

Figure 30. Type locality for *Maratus hakea* above Back Beach, just SE of Arpenteur Nature Reserve, SE of Cheynes, Western Australia. **1,** View from the type locality, showing dense coastal shrubland and Back Beach in the background. **2,** A sprawling *Hakea prostrata* shrub can be seen at the center. **3,** Detail of flowering *H. prostrata*. **4-7,** Adult male *M. hakea* on the leaves and stem of *H. prostrata*. Photo credits: 1, Reef Coakley; 2-7, James Nicolson.

Review of the *Maratus bubo* and *M. mungaich* groups

The only available DNA study for the genus *Maratus* (Girard 2021; see also Otto & Hill 2021) supports the close relationship between many species of this genus that are endemic to Western Australia. However, it will require additional studies to resolve the relationship between species that we presently associate with the *mungaich* group. Beginning with the scope of that group as depicted by Otto & Hill (2021), we now include *M. hakea*, n. sp., and four species that resemble *M. bubo* in many ways, *M. clupeatus*, *M. nambung*, *M. pardus*, and *M.* cf. *nambung*, in our review (Table 1, Figure 31).

Because of their shared characteristics, we now designate five of these species (*M. bubo*, *M. clupeatus*, *M. nambung*, *M. pardus*, and *M.* cf. *nambung*) as members of a separate clade, the *bubo* group (Figure 32). These characteristics include generally shorter flaps, often prominent fringes on the margin of the fan, front-to-rear or broken stripes comprised of orange to red pigmented scales on a background of blue-green iridescent scales on the fan, solid colour (no stripes) in the eye region, and fringes of (usually) black setae on the tarsus and metatarsus of leg III (Figure 33). In contrast, almost all remaining members of the *mungaich* group (Figures 34-39) have transverse stripes comprised of red or red-orange pigmented scales on a background of blue-green iridescent scales on the fan, a large black area at the center of the fan (usually), and a central black spot on each flap (often). Some also have front-to-rear stripes across the eye region, as well as the fringes of black setae on the tarsus and metatarsus of leg III that we also find in the *bubo* group. We consider both groups to be closely related (as clade 1 in Figure 32).

Maratus gemmifer, *M. hortorum* and *M. mungaich* (Figure 32: clade 8; Figure 34), endemic to a small region to the south and east of Perth) are very similar, with minor distinctions based primarily on scale patterns of the male fan. *M. melindae* (also included in clade 7; Figure 35), found to the north and south of clade 8, is very similar in appearance but has a larger central black mark. *M. avibus* and *M. caeruleus* (clade 10) are very closedly related, and a hybrid male with intermediate characters has been reared in the laboratory (Figure 37). Presently *M. caeruleus*, endemic to Middle Island, is separated by only 10 km from the mainland range of *M. avibus*, but this separation only dates back ~20Ky, to the last glacial maximum. *M. madelineae* (Figure 36) is distinctly different, but shares several characters with both *M. avibus* and *M. caeruleus*, including the setation of legs III and the anteromedian field of green to blue-green iridescent scales on the fan. *M. karrie* and *M. sarahae* (Figure 32: clade 11; Figure 38) are very closely related to each other, and difficult to separate. Clade 11 (Figure 32) may be more closely related to clade 7 than to clade 9. *M. hakea* (Figure 39) has transverse stripes and a dark median area on the fan, but is otherwise quite distinct from all other members of the *mungaich* group.

Table 1. Members of the *bubo* and *mungaich* groups within the genus *Maratus*. Type localities are shown for all described species, collection locality for the other species. Numbers at left correspond to numbers used in Figure 31.

species		reference for description	collectors	type locality/locality
1	*M. avibus*	Otto & Hill 2014a	J. Otto, D. Knowles	S33.97008°, E123.22100°
2	*M. bubo*	Otto & Hill 2016	J. Otto, D. Knowles	S34.86057°, E116.66612°
3	*M. caeruleus*	Waldock 2013	M. S. Harvey et al.	S34.10111°, E123.20222°
4	*M. clupeatus*	Otto & Hill 2014c	D. Knowles	S31.83705°, E115.81638°
5	*M. gemmifer*	Otto & Hill 2017	D. Knowles	S32.37126°, E115.82713°
6	*M. hakea*, new sp.	Otto & Hill 2024 (this paper)	M. Peak	S34.89056°, E118.42069°
			F. Prall	S34.89058°, E118.42072°
7	*M. hortorum*	Waldock 2014	F. Hort, J. Hort	S31.87300°, E116.04439°
			J. M. Waldock, A. Sampey, M. S. Harvey	S31.86806°, E116.05111°
			J. M. Waldock, A. Sampey, M. S. Harvey	S31.87306°, E116.04611°
8	*M. karrie*	Waldock 2013	M. L. Moir, A. Sampey	S34.70583°, E116.80056°
9	*M. madelineae*	Waldock 2014	M. B. Girard, D. O. Elias, J. M. Waldock	S33.41783°, E115.81025°
10	*M. melindae melindae*	Waldock 2013	M. L. Moir	S34.34972°, E118.11083°
			G. Friend, G. Hall. D. Mitchell	S34.48333°, E118.25000°
11	*M. melindae corus*	Otto & Hill 2017	D. Knowles	S30.39398°, E115.18039°
12	*M. mungaich*	Waldock 1995	J. M. Waldock, M. S. Harvey	S32.42100°, E116.30433°
13	*M. nambung*	Otto & Hill 2023	M. Peak, B. Buzatto	S30.56805°, E115.24510°
			F. Prall	S30.55647°, E115.39716°
14	*M. pardus*	Otto & Hill 2014b	J. Otto	S33.96698°, E122.25227°
15	*M. sarahae*	Waldock 2013	M. L. Moir	S34.38083°, E118.30056°
			D. Knowles	S34.38333°, E118.25000°
16	*M.* cf. *nambung*	Otto & Hill 2023 (as cf. *bubo*)	J. Schubert, J. Walker	S31.36083°, E115.79526°

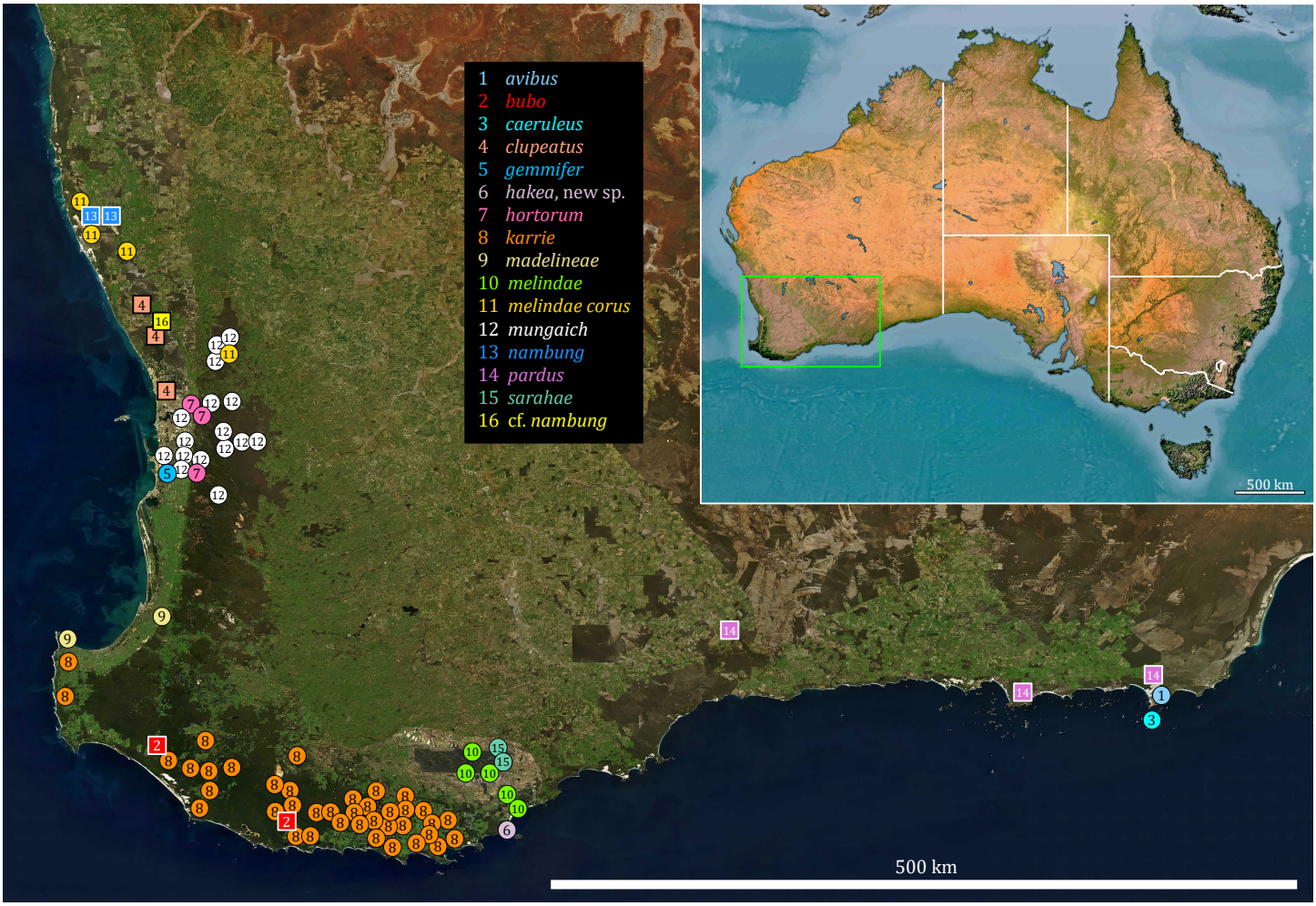

Figure 31. Known distribution of the *bubo* (squares) and *mungaich* (circles) groups within the genus *Maratus*. All are endemic to the southwestern corner of Australia.

<table>
<tr><td rowspan="17">1</td><td colspan="2" rowspan="5">2. bubo group</td><td colspan="2"></td><td>pardus</td></tr>
<tr><td colspan="2"></td><td>clupeatus</td></tr>
<tr><td colspan="2" rowspan="3">3</td><td></td><td>bubo</td></tr>
<tr><td rowspan="2">4</td><td>nambung</td></tr>
<tr><td>cf. nambung</td></tr>
<tr><td rowspan="12">5. mungaich group</td><td rowspan="12">6</td><td rowspan="5">7</td><td rowspan="3">8</td><td>mungaich</td></tr>
<tr><td>hortorum</td></tr>
<tr><td>gemmifer</td></tr>
<tr><td rowspan="2"></td><td>melindae melindae</td></tr>
<tr><td>melindae corus</td></tr>
<tr><td rowspan="3">9</td><td></td><td>madelineae</td></tr>
<tr><td rowspan="2">10</td><td>caeruleus</td></tr>
<tr><td>avibus</td></tr>
<tr><td colspan="2" rowspan="2">11</td><td>karrie</td></tr>
<tr><td>sarahae</td></tr>
<tr><td colspan="3"></td><td>hakea, new sp.</td></tr>
</table>

Figure 32. Hypothetical phylogeny of the *bubo* and *mungaich* groups within the genus *Maratus*. Hypothetical clades are numbered for reference (1-11).

Figure 33. Members of the *bubo* group within the genus *Maratus*.

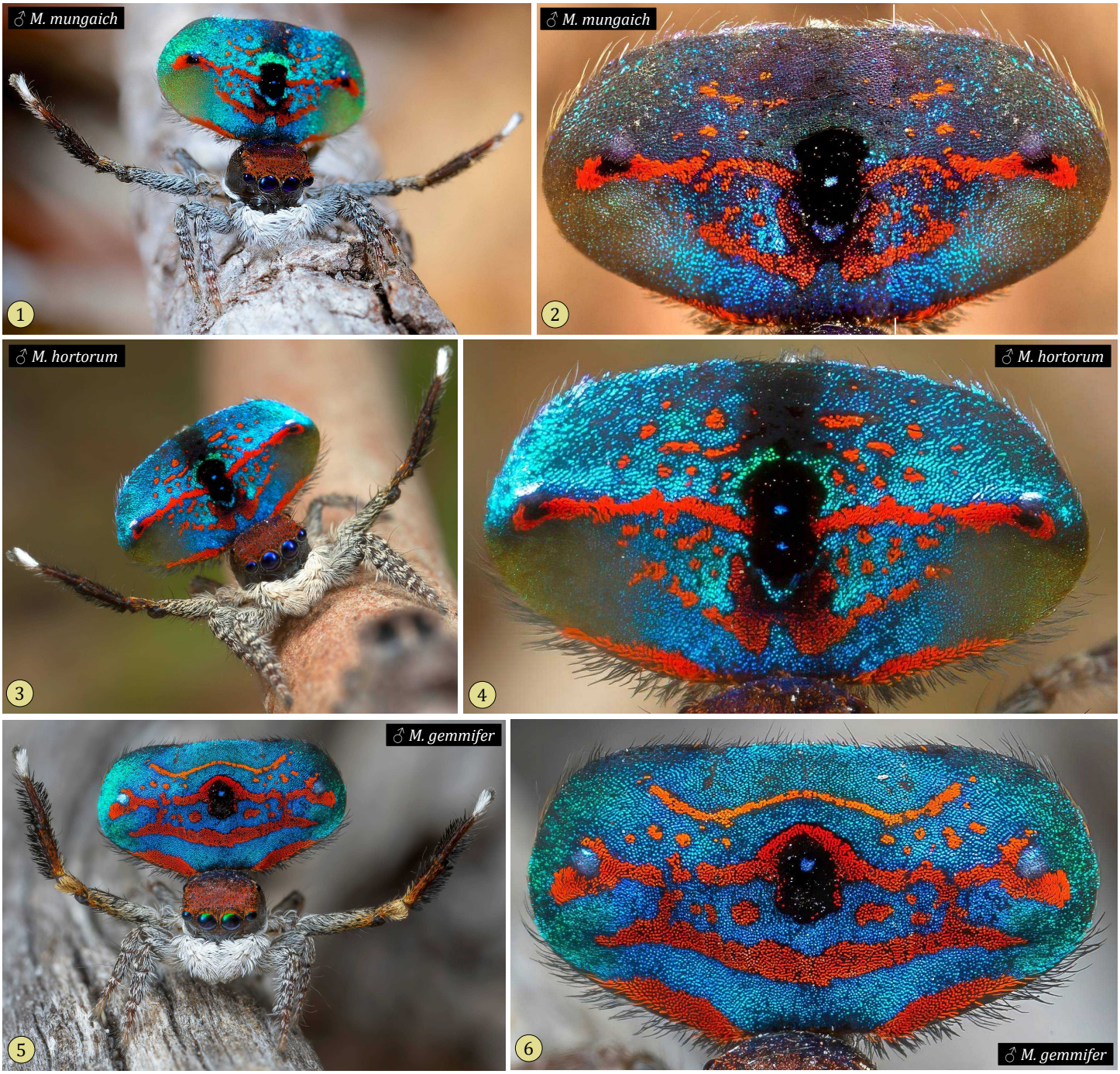

Figure 34. *Maratus mungaich* and its closest relatives.

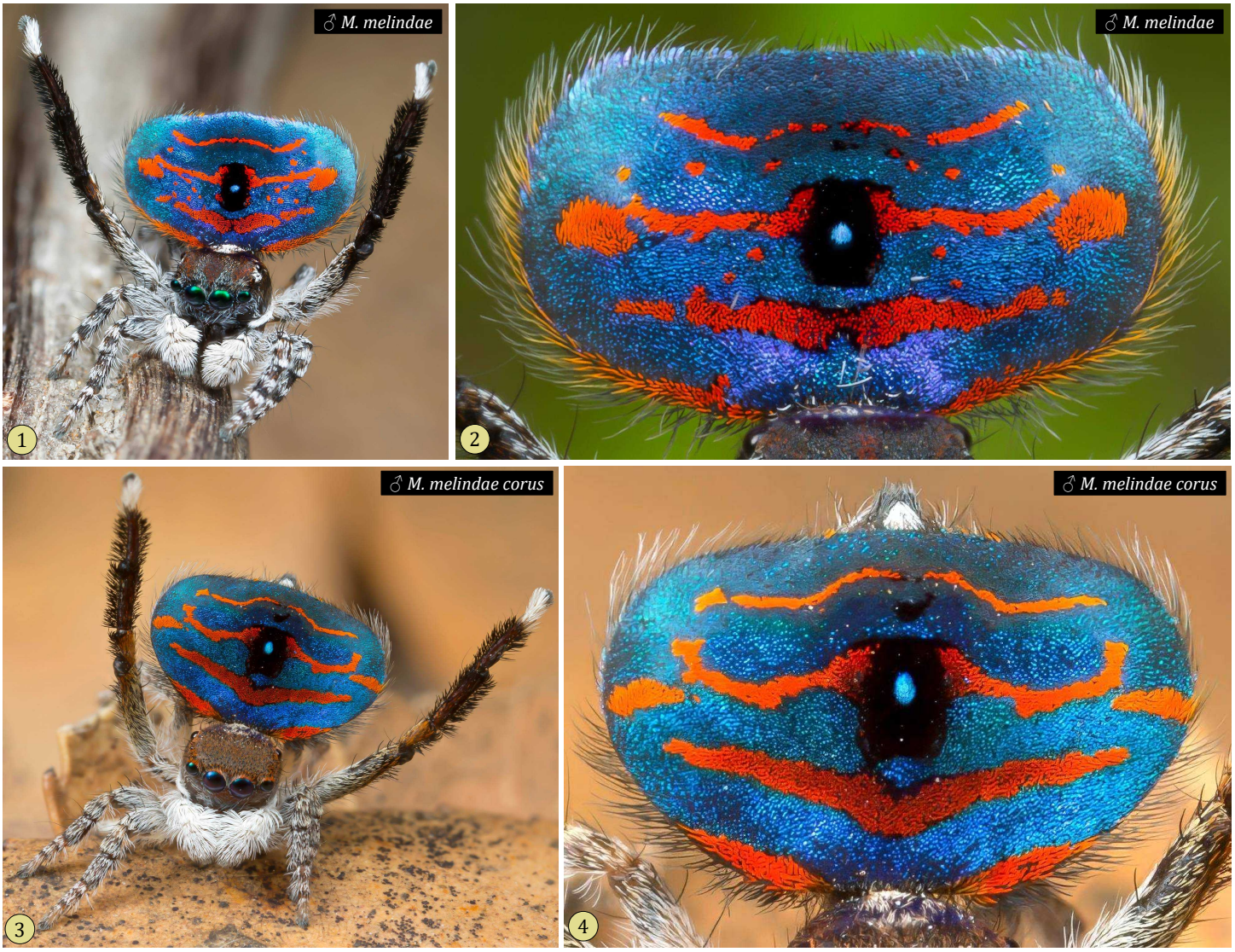

Figure 35. The two designated subspecies of *Maratus melindae*. *M. m. melindae* is a southern form, and *M. m. corus* is found far to the north.

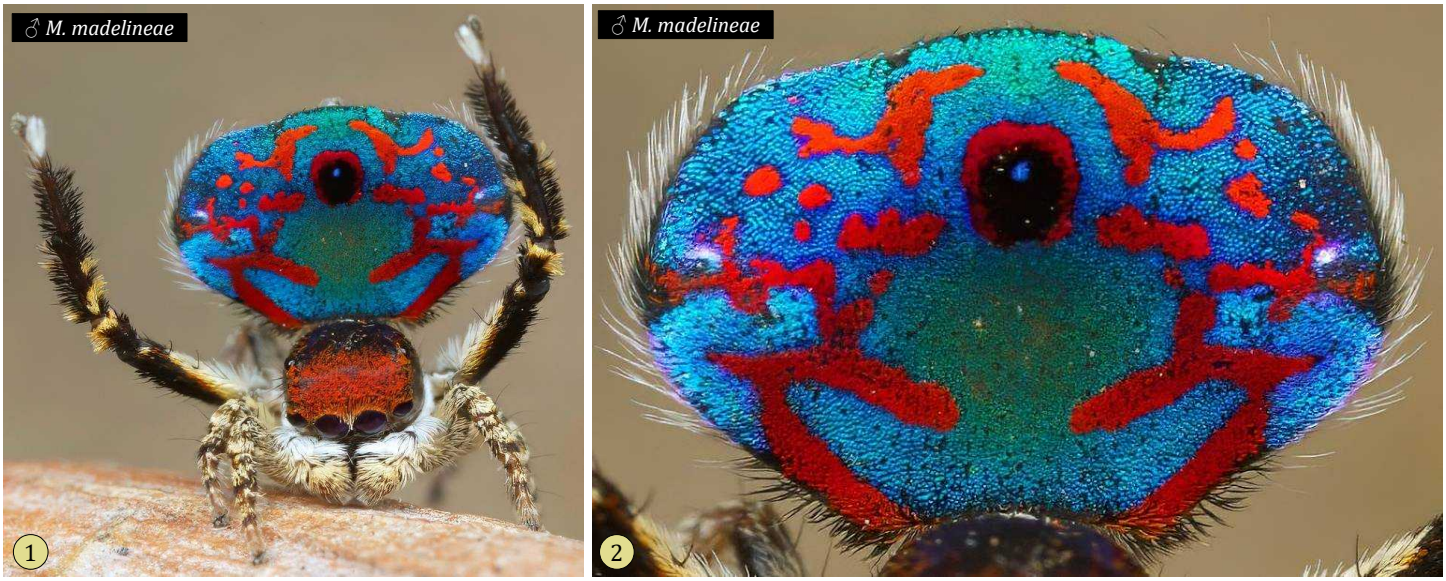

Figure 36. *Maratus madelineae*.

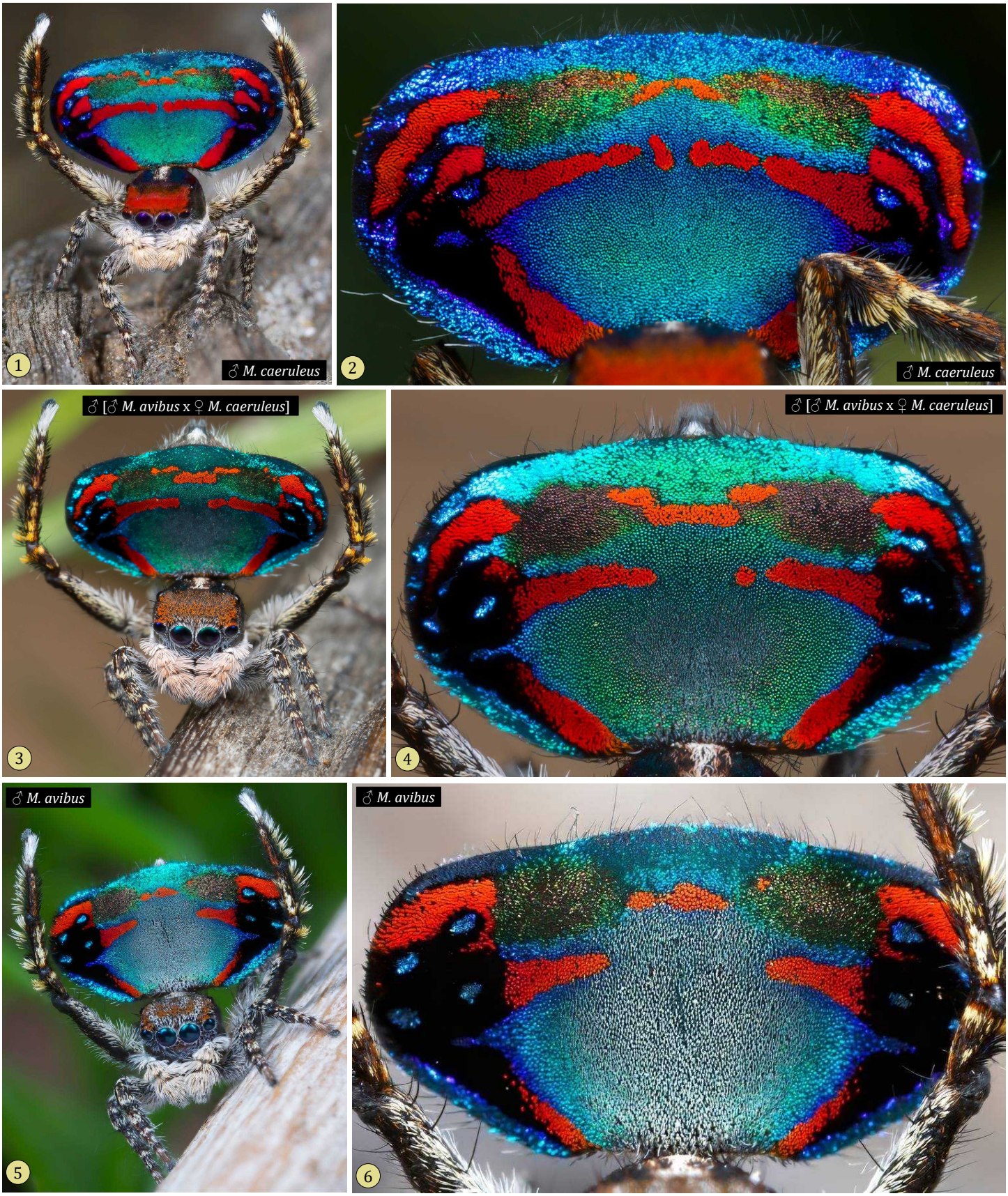

Figure 37. *Maratus avibus*, *M. caerulus*, and a hybrid male reared in the laboratory (3-4).

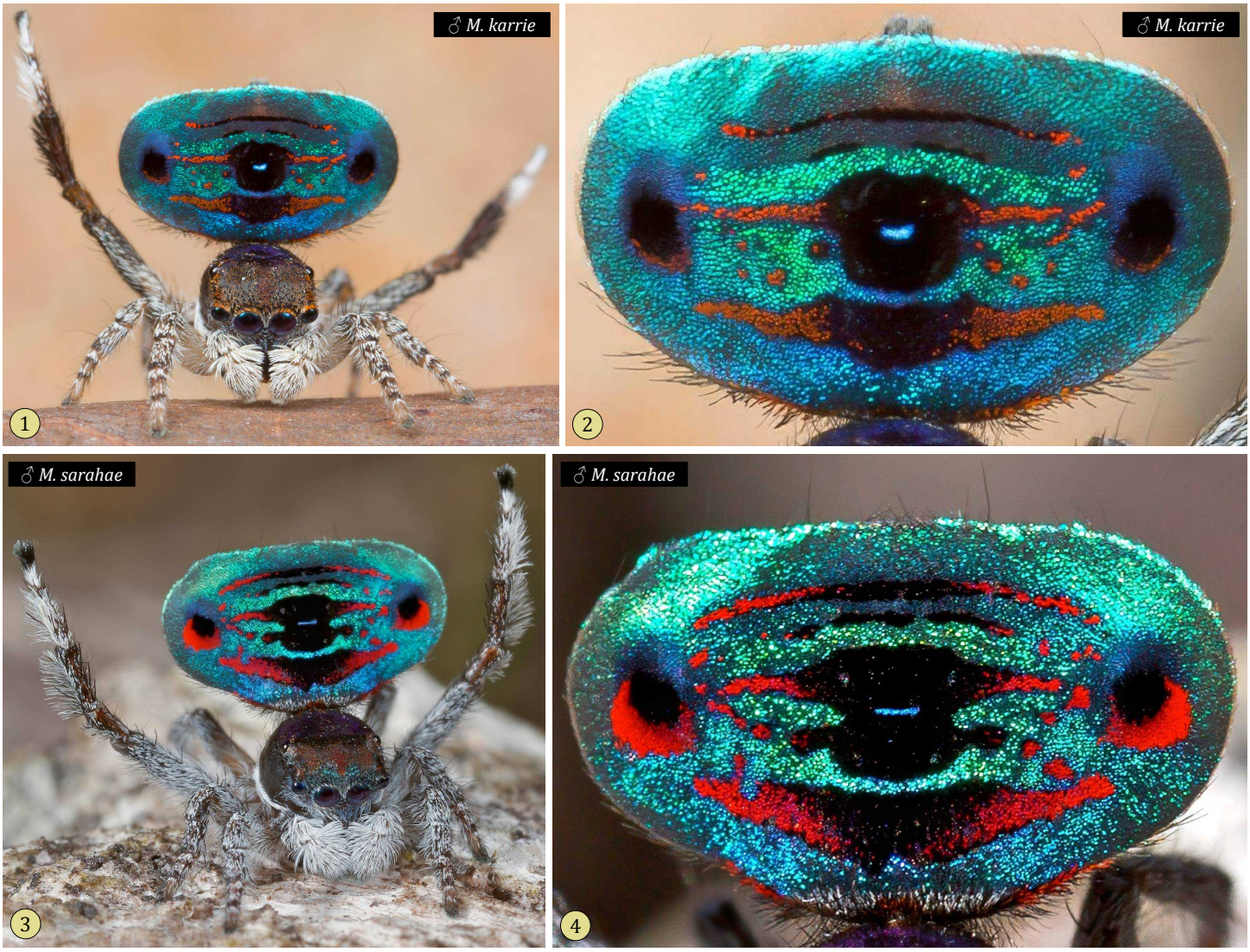

Figure 38. *Maratus karrie* and *M. sarahae*.

Figure 39. *Maratus hakea*.

Acknowledgements

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