

## *Maratus pinniger*, a new peacock spider in the *vespa* group from southwestern Australia (Araneae: Salticidae: Euophryini)

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**Abstract.** Male and female *Maratus pinniger*, new species, are described and placed in the *vespa* group of the genus *Maratus*. Courtship behavior of the male is also described. This species appears to be most closely related to *M. fletcheri*, a nearby species also known from a single locality. The *vespa* group, now containing 12 members, appears to represent one more example of narrow endemism in the Southwest Australian Floristic Region, perhaps associated with low dispersal and a rapid rate of evolution associated with sexual selection. Based on the limited number of localities sampled to date, many more related species should be found in this area in the future.

**Key words.** biodiversity, biogeography, courtship display, narrow endemism

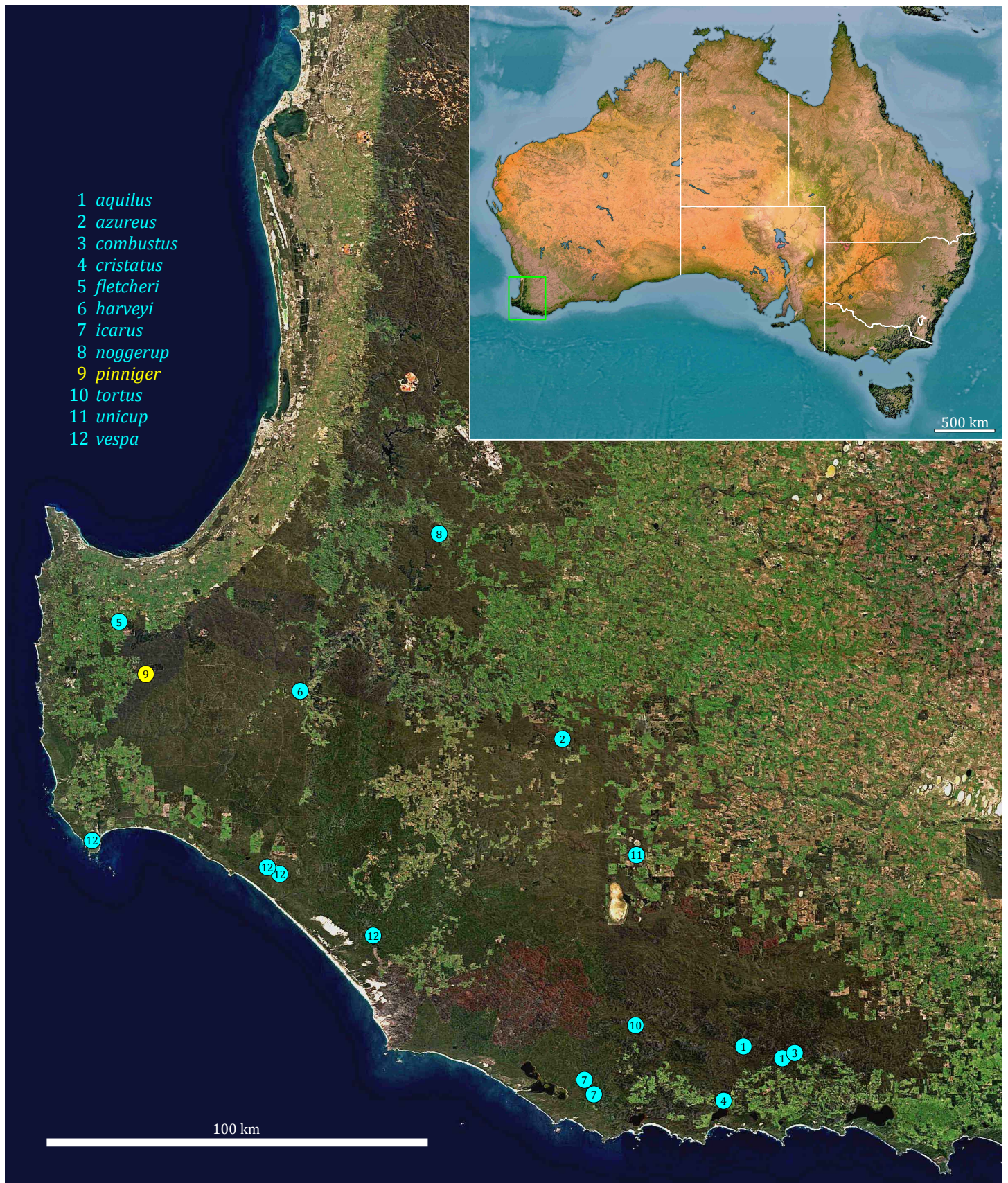
With the recent addition of *Maratus nemo* Schubert 2021, there are now at least 92 species assigned to the genus group *Maratus* Karsch 1878, all endemic to Australia (Otto & Hill 2021; Schubert 2021). Within this large genus, 11 species, all endemic to the southwestern corner of Australia, have been assigned to the *vespa* group (Table 1, Figures 1-2), unknown prior to 2016. Here we describe one more species in this group, *M. pinniger*, new species, known from a single locality near the site where the closely-related *M. fletcheri* was found. All members of this group have a distinctive pattern of courtship that includes close female following of the male as he rotates the fan to either side, behind the heavily-fringed legs III.

**Table 1.** Members of the *Maratus vespa* group.

map#	species	reference	type collectors	type locality
1	<i>M. aquilus</i>	Schubert 2019	M. Duncan	34.85167S, 117.14833E
2	<i>M. azureus</i>	Schubert 2020	D. Harley, J. Schubert	34.09981S, 116.50479E
3	<i>M. combustus</i>	Schubert 2019	M. Duncan	34.85306S, 117.18667E
4	<i>M. cristatus</i>	Otto & Hill 2017	J. Otto	34.96797S, 116.97943E
5	<i>M. fletcheri</i>	Waldock 2020, in Waldock et al. 2020	A. Fletcher, M. Doe, M. Duncan	33.80972S, 115.21528E
6	<i>M. harveyi</i>	Waldock 2020, in Waldock et al. 2020	M. E. Blosfelds, M. S. Harvey, P. Irvine, C. O'Toole	33.98128S, 115.74944E
7	<i>M. icarus</i>	Otto & Hill 2019	J. Otto	34.91230S, 116.56745E
8	<i>M. noggerup</i>	Schubert 2020	D. Harley, J. Schubert	33.59623S, 116.15118E
9	<i>M. pinniger</i> , new species	Otto & Hill 2022	P. Winthrop	33.94517S, 115.30256E
10	<i>M. tortus</i>	Otto & Hill 2018	J. Otto	34.78413S, 116.72002E
11	<i>M. unicum</i>	Otto & Hill 2018	J. Otto	34.37563S, 116.73133E
12	<i>M. vespa</i>	Otto & Hill 2016	D. Knowles, J. Otto	34.42018S, 115.69467E



**Figure 1.** Adult males representing eight species in the *vespa* group. 2-3, Both white and tan versions of *M. cristatus* were found at the same locality. 4, *M. fletcheri* most closely resembles *M. pinniger*, new species (6). 7, *M. tortus* is the only species in this group that twists the fan to display each "feathered" flap between legs III, as shown here. 8-9, Note the similar pattern on the fan of these two distinct species. *M. vespa* is the type species for the group. Photo credit: 4, © Adam Fletcher, used with permission.



**Figure 2.** Known distribution of members of the *Maratus vespa* group, all endemic to forested areas with relatively high rainfall in southwestern Australia. To date these species appear to be parapatric, i.e., without any overlap in distribution. Note the proximity of *M. fletcheri* (5) and *M. pinniger* (9, highlighted in yellow) type localities. Records for these narrowly endemic species are scarce. For most of this area, no records exist for the group.

### ***Maratus pinniger*, new species**

*Type specimens.* The holotype male (♂ #1), six paratype males (♂ #2-7), and one paratype female (♀ #1) were collected in coastal sword-sedge (*Lepidosperma gladiatum*) in a damp swale area surrounded by Jarrah/Marri forest, in Blackwood State Forest, Western Australia (Figure 2; S33.945174°, E 115.302561°, 16 OCT-10 NOV 2021, coll. Paul Winthrop). All types will be deposited in the Western Australian Museum, Perth.

*Etymology.* The species group name, *pinniger* (Latin, adjective, m.), means *pinnate* or *feather-bearing*, an apt description for the fan flaps displayed by the male of this species, bearing specialized setae that resemble long "feathers." *Pinnager* (or *pennager*) is also a medieval English occupational surname for a pennant or ensign-bearer.

*Diagnosis.* Females resemble other females in the *vespa* group, and related groups in southwestern Australia, and examination of the male is necessary for identification. The male pedipalp also resembles that of other members of the *vespa* group and related groups. The male is closest to *M. fletcheri* in appearance (Figure 1), but can be reliably separated from that species by the presence of larger areas of iridescent scales at the rear of the fan, and the presence of multiple, long, feather-like setae (*pinnae*) extending beyond the margin of each lateral flap of the fan. The colour of scales that cover much of the body and legs (brown in *M. fletcheri*, white in *M. pinniger*) may not be a reliable indicator, as the related *M. cristatus* (Figure 1:2-3) has both colour forms.

*Description of male* (Figures 3-9). Males (n=7) ranged from 3.3-3.8 mm in length. The chelicerae are black, glabrous. The clypeus is covered with many long white-grey setae, directed toward the front above the chelicerae. The carapace is black, mostly glabrous, with a cover of grey scales in the eye region, where three interrupted bands of brown or dark red-brown scales can be seen, one at the median and one on either side of this. Another irregular or interrupted band of brown or dark red-brown scales runs on either side of the carapace, through the lateral eyes. Small spots comprised of white-grey scales are present just behind each PLE, and in a median thoracic position. The margin of the carapace is lined with white-grey scales or setae. Each PME is distinctly closer to the ipsilateral PLE than to the ipsilateral ALE.

Long, stout or erect black and white setae project from the anterodorsal opisthosoma. The fan bears a distinctive pattern (Figures 4, 6) comprised of iridescent blue-green and pigmented red to brown scales, with long feather-like setae (*pinnae*), some >0.5 mm in length, extending beyond the curved posterior margin of each flap. The anterior margin of each flap also has a fringe of white-grey setae. Behind the fan, the posterodorsal opisthosoma is black, with a median group of mostly white, scattered scales and, behind this, the anal tuft of white setae (Figure 4) that is typically found in *Maratus* species. The spinnerets are black. Below (Figure 9), the opisthosoma is brown, with a covering of white setae, and the coxae, sternum, endites, chelicerae and pedipalps are mostly dark-grey or black.

The legs are generally black to brown in colour, legs I and II of about the same length and shortest, legs III longest. Legs I-II and IV are distinctly to indistinctly banded with white scales or setae. Legs III are heavily fringed with long white setae, dorsally on the femur, and mostly ventrally from the patella to metatarsus. Tarsus III is covered with bright white setae. Femora I and II are thicker, each with several black spots on glabrous, light brown cuticle when viewed from below.

The pedipalp, with a single tooth below the apex of the outer ring of the embolus (Figure 8), is typical for the *vespa* group, as well as the related *flavus*, *linnaei*, and *mungaich* groups of southwestern Australia (Otto & Hill 2021), and appears to be of no use for identification to species.

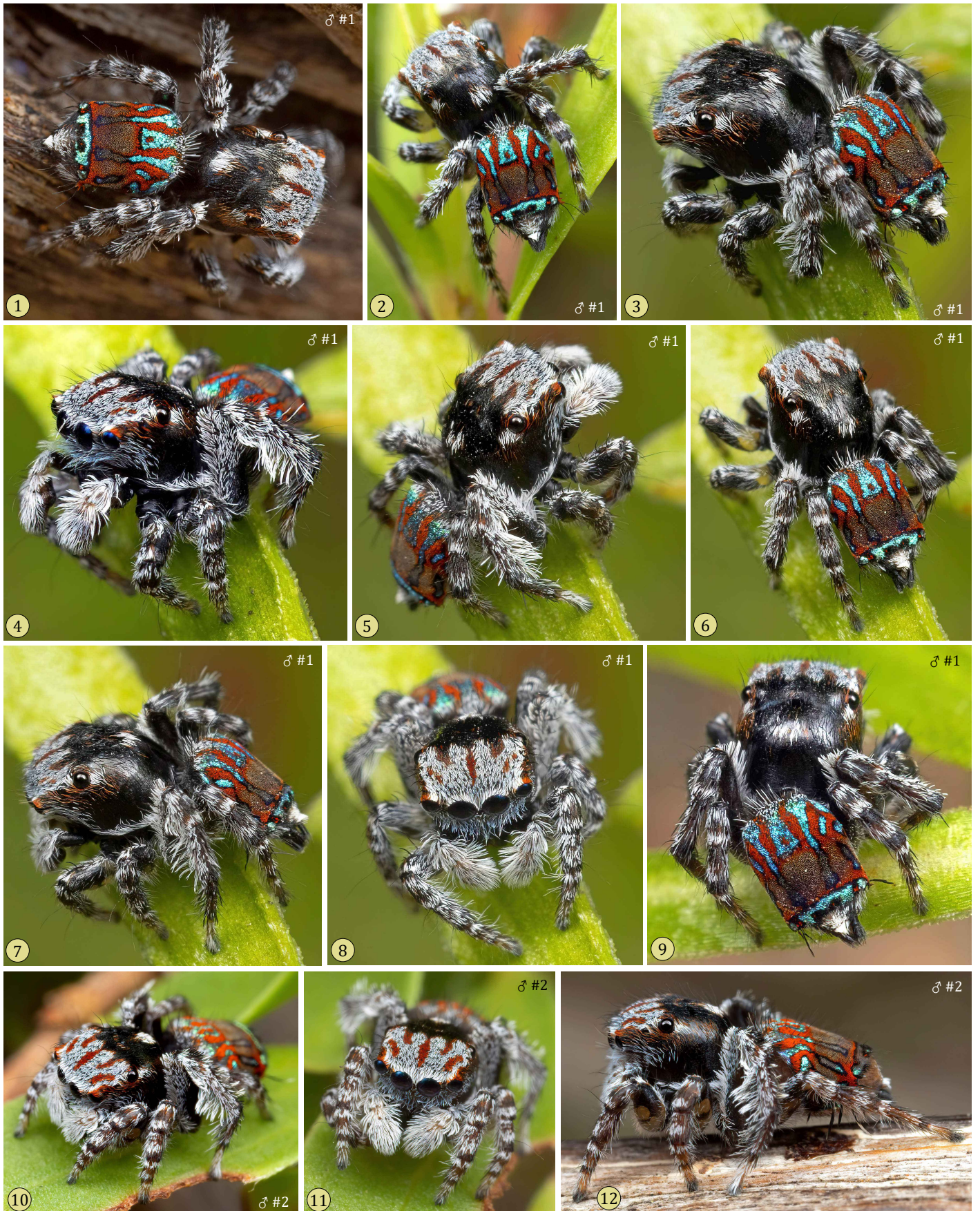
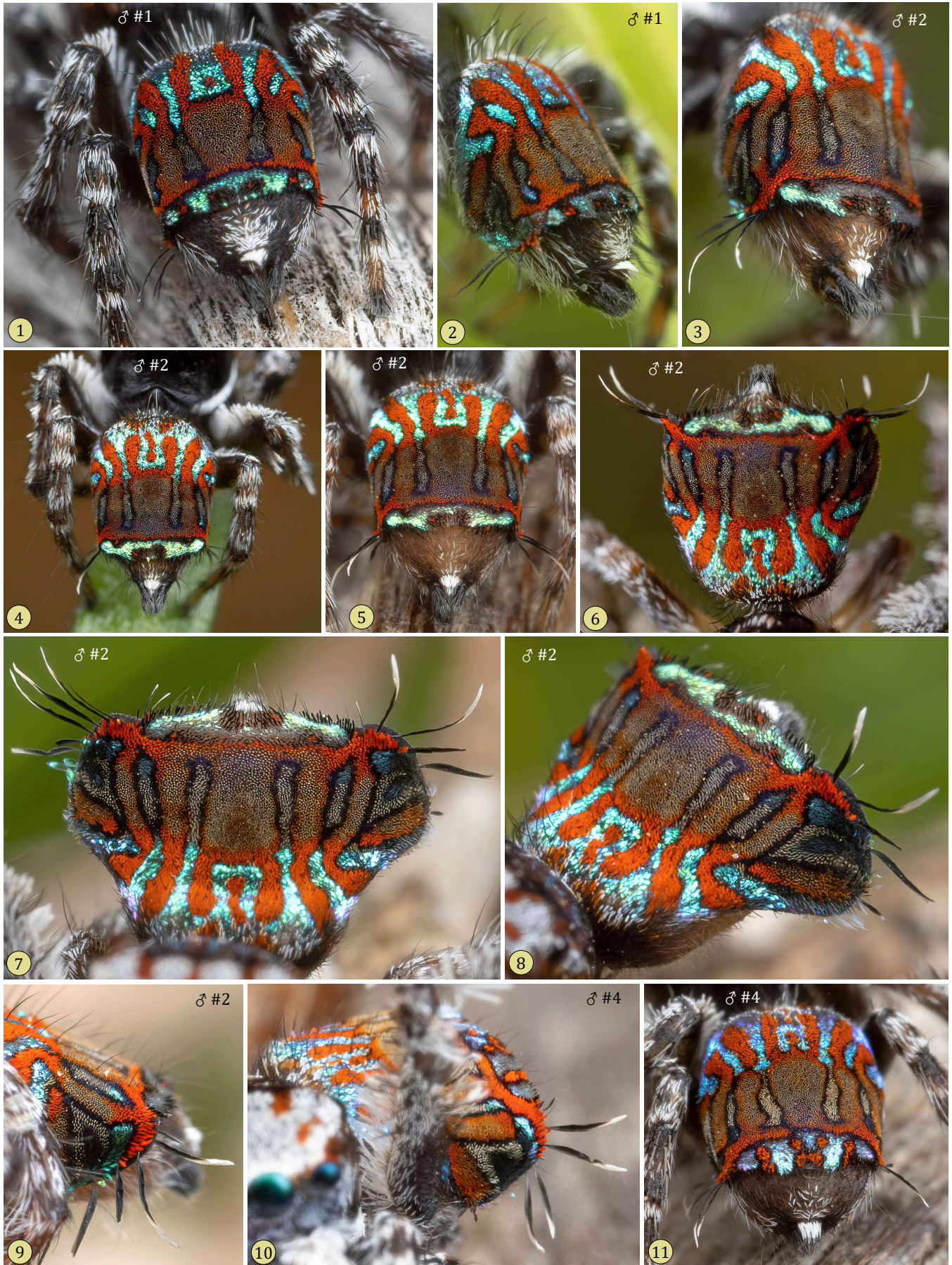


Figure 3 (continued on next page). Living type males for *Maratus pinniger*.



**Figure 3 (continued from previous page).** Living type males for *Maratus pinniger*. 13, Advertisement with a single leg III held in a vertical position.



**Figure 4.** Detailed views of the fan of living type males, *Maratus pinniger*.

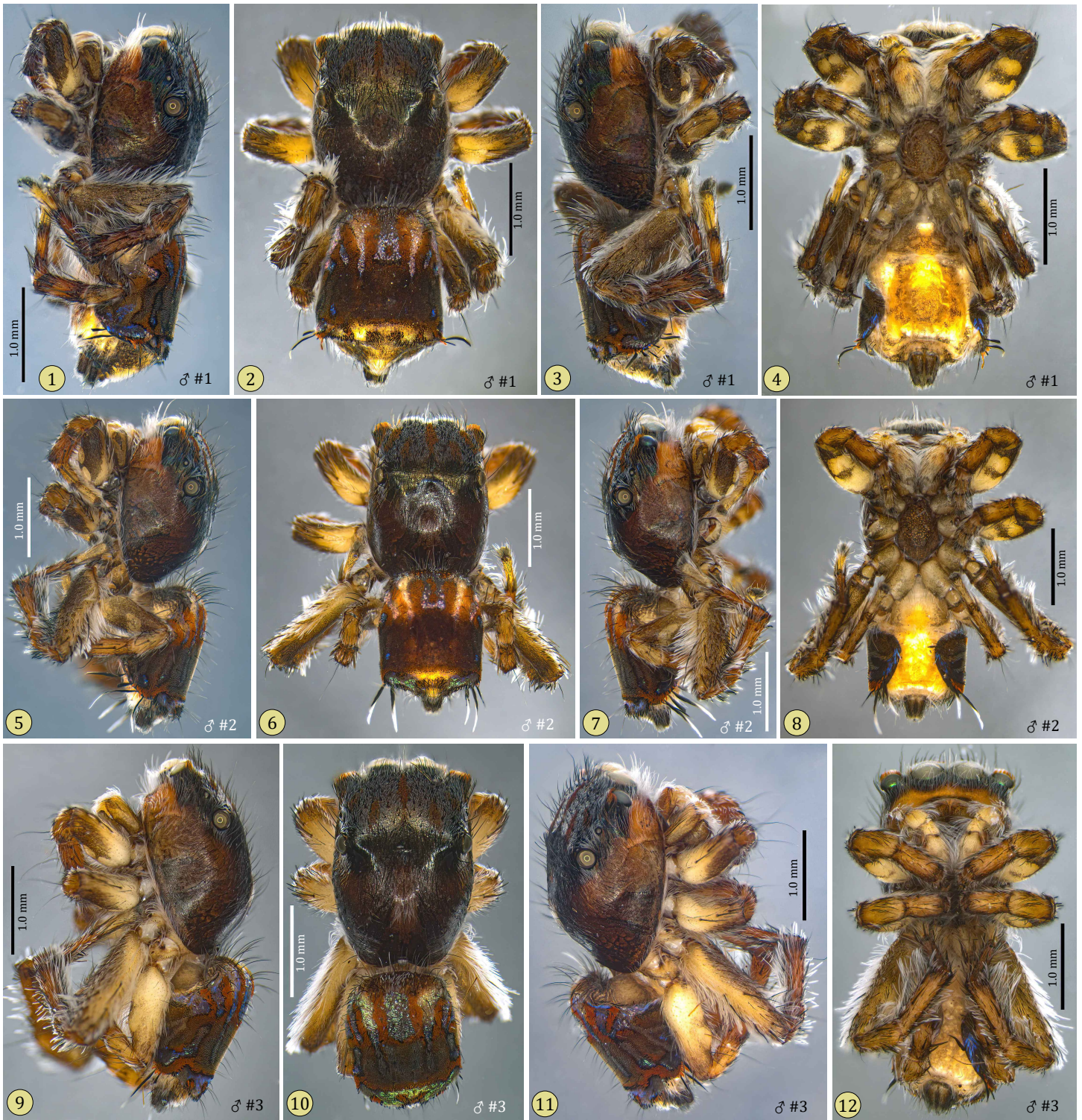


Figure 5 (continued on next page). Type males in alcohol, *Maratus pinniger*.





Figure 5 (continued from previous page). Type males in alcohol, *Maratus pinniger*.

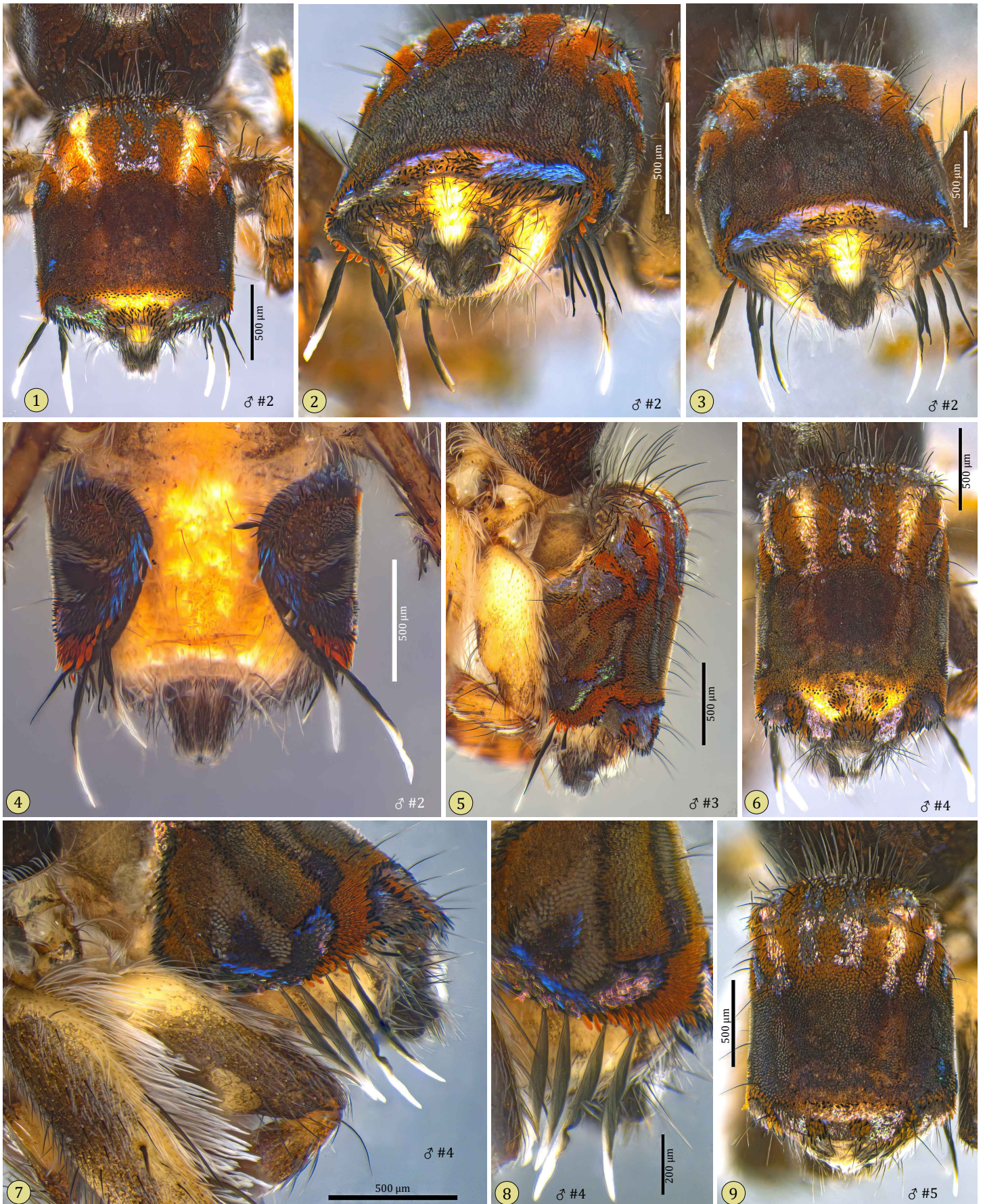


Figure 6 (continued on next page). Detail of type males in alcohol, *Maratus pinniger*. 7, Note the dorsal fringe of long white setae on the femur of leg III.

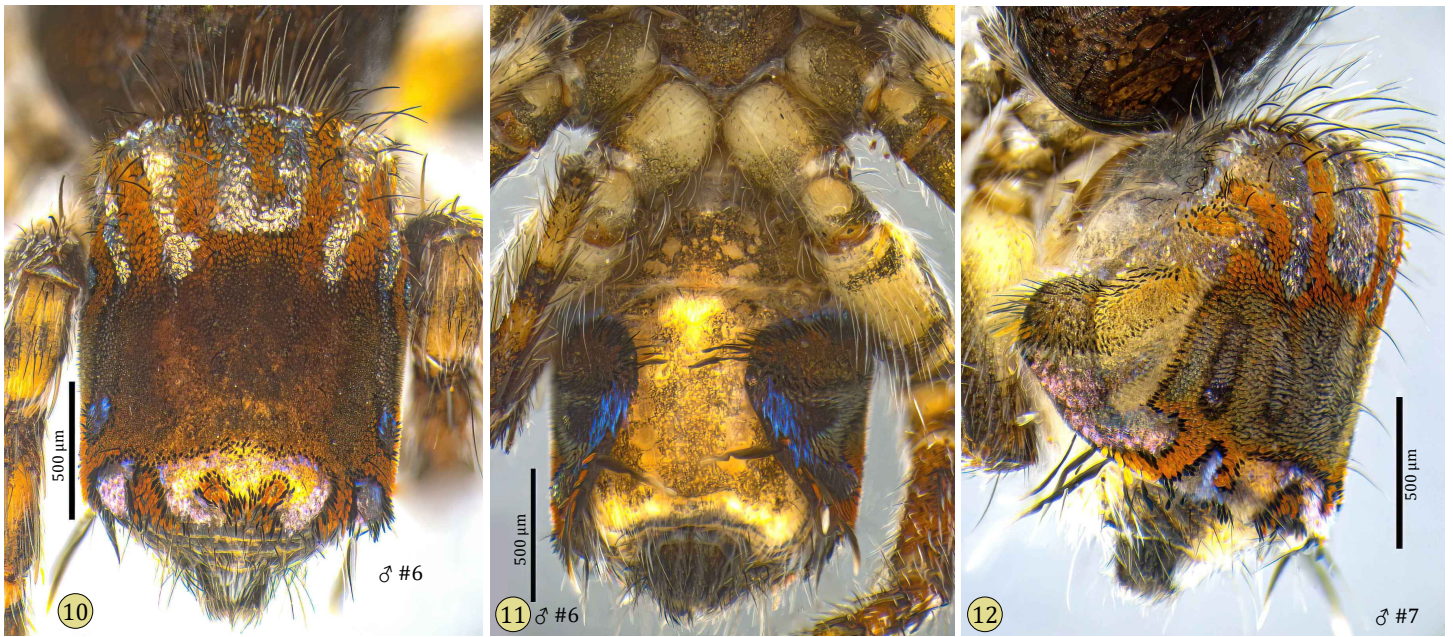
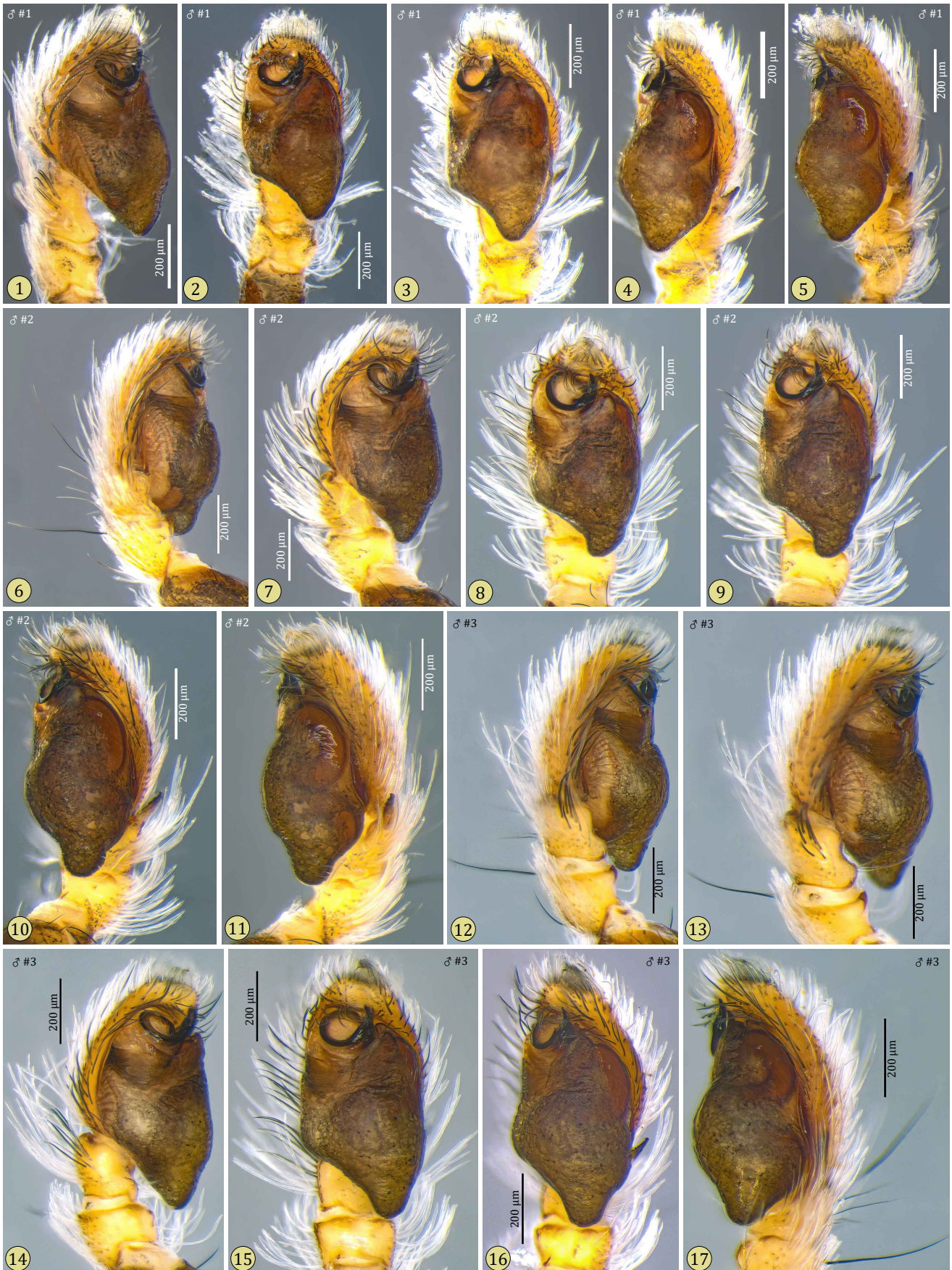


Figure 6 (continued from previous page). Detail of type males in alcohol, *Maratus pinniger*.



Figure 7. Anterior view of type males in alcohol, *Maratus pinniger*.



**Figure 8 (continued on next page).** Medial to lateral views of left pedipalp for type males in alcohol, *Maratus pinniger*.

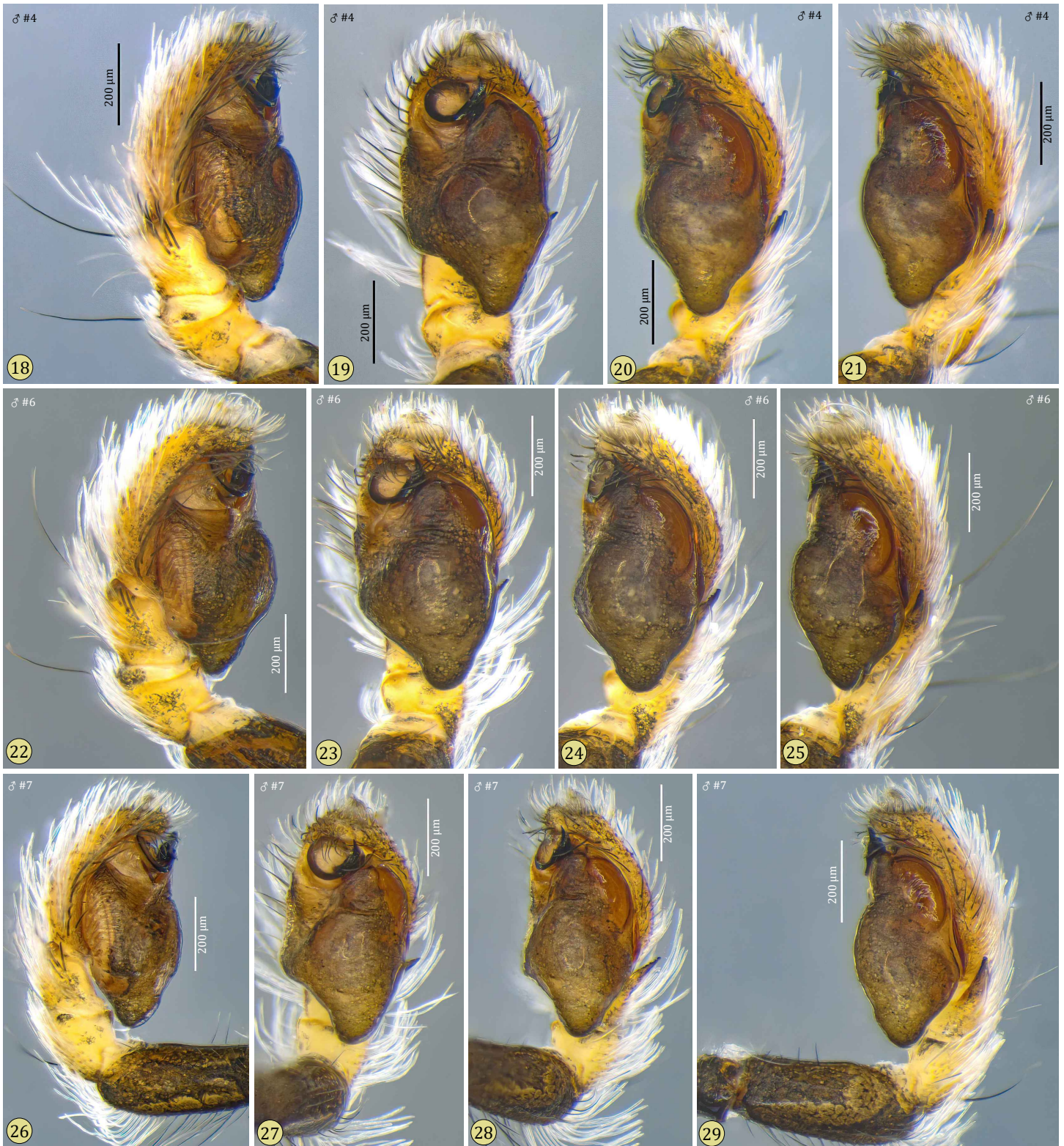


Figure 8 (continued from previous page). Medial to lateral views of left pedipalp for type males in alcohol, *Maratus pinniger*.



**Figure 9.** Ventral view of living paratypes, male *Maratus pinniger*.

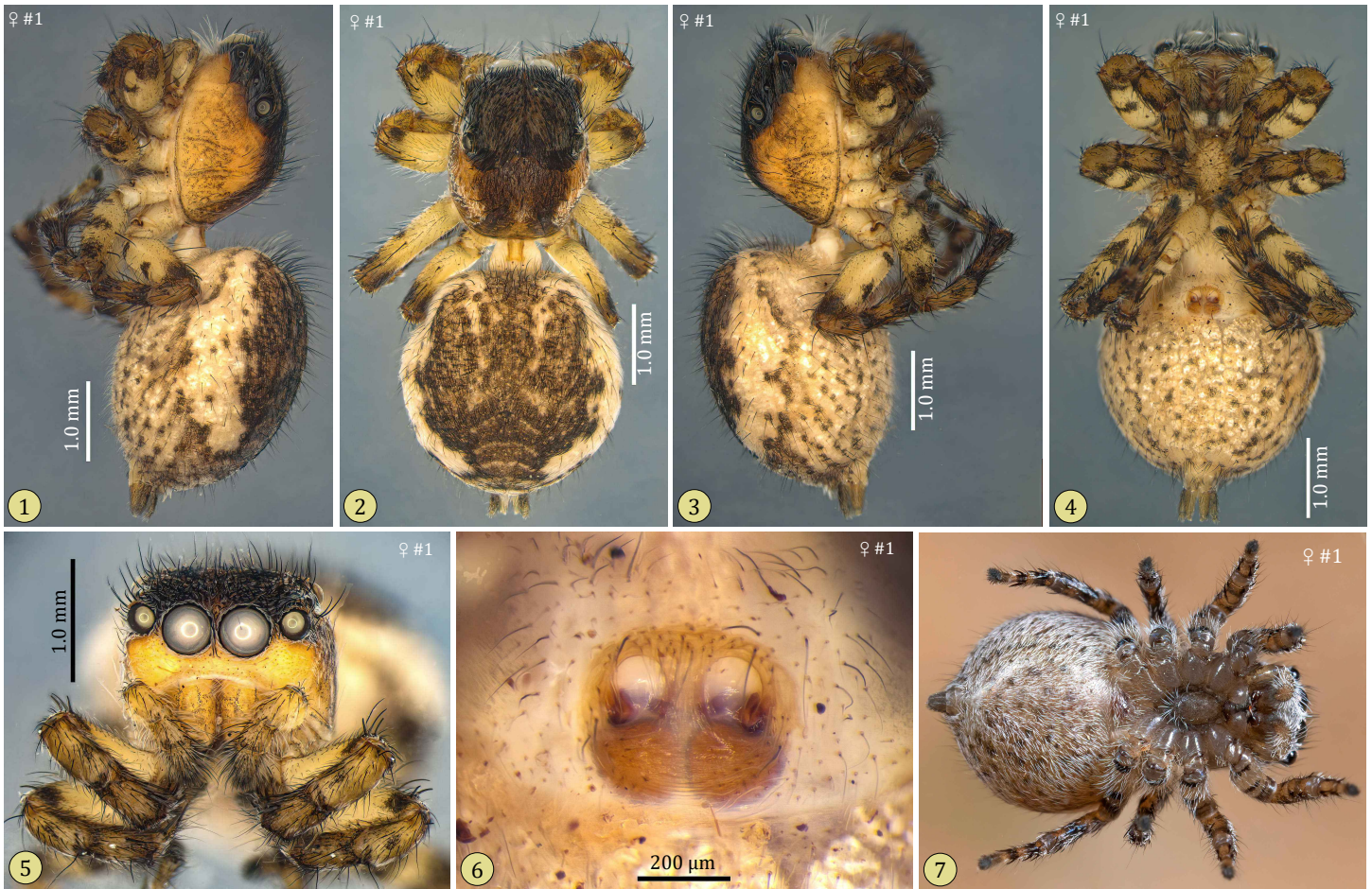
**Description of female** (Figures 10-11). Body length (n=1) 5.4 mm. In general the cuticle of the female is light-brown to brown and translucent, with darker brown banding on the legs, and dark brown on the dorsal carapace and opisthosoma. The paturon of each chelicera is mostly glabrous, with a sparse covering of white setae. The pedipalps are light-brown with a cover of projecting white setae. From the face, below the anterior eyes, and the clypeus a number of long white setae extend to the front. These are not as dense as they are in the male. Both the carapace and opisthosoma have scattered white and red-brown scales on a dark brown background dorsally, with bands of mostly white scales on either side. Except for a line of white setae in front, above the chelicerae, the margins of the carapace are almost entirely glabrous, without the marginal band seen in the male.

The white bands on the lateral margins of the dorsal opisthosoma do not meet at the rear. A small triangular anal tuft of white scales is present, above the brown spinnerets. The venter of the opisthosoma is light-brown, with many small brown spots, with a fairly uniform cover of white setae. Coxae, sternum, endites, chelicerae and pedipalps are mostly light brown and glabrous from below. Legs I and II shorter and of similar length, legs III and IV also of similar length but longer. From above all legs are distinctly to indistinctly banded with alternating white setae and exposed dark cuticle.

The epigynum (Figure 11:6) is typical for the group, with a smaller fossa in front of each large posterior spermatheca, and more sclerotized ducts visible through the posterior half of each fossa.



Figure 10. Living female paratype, *Maratus pinniger*.



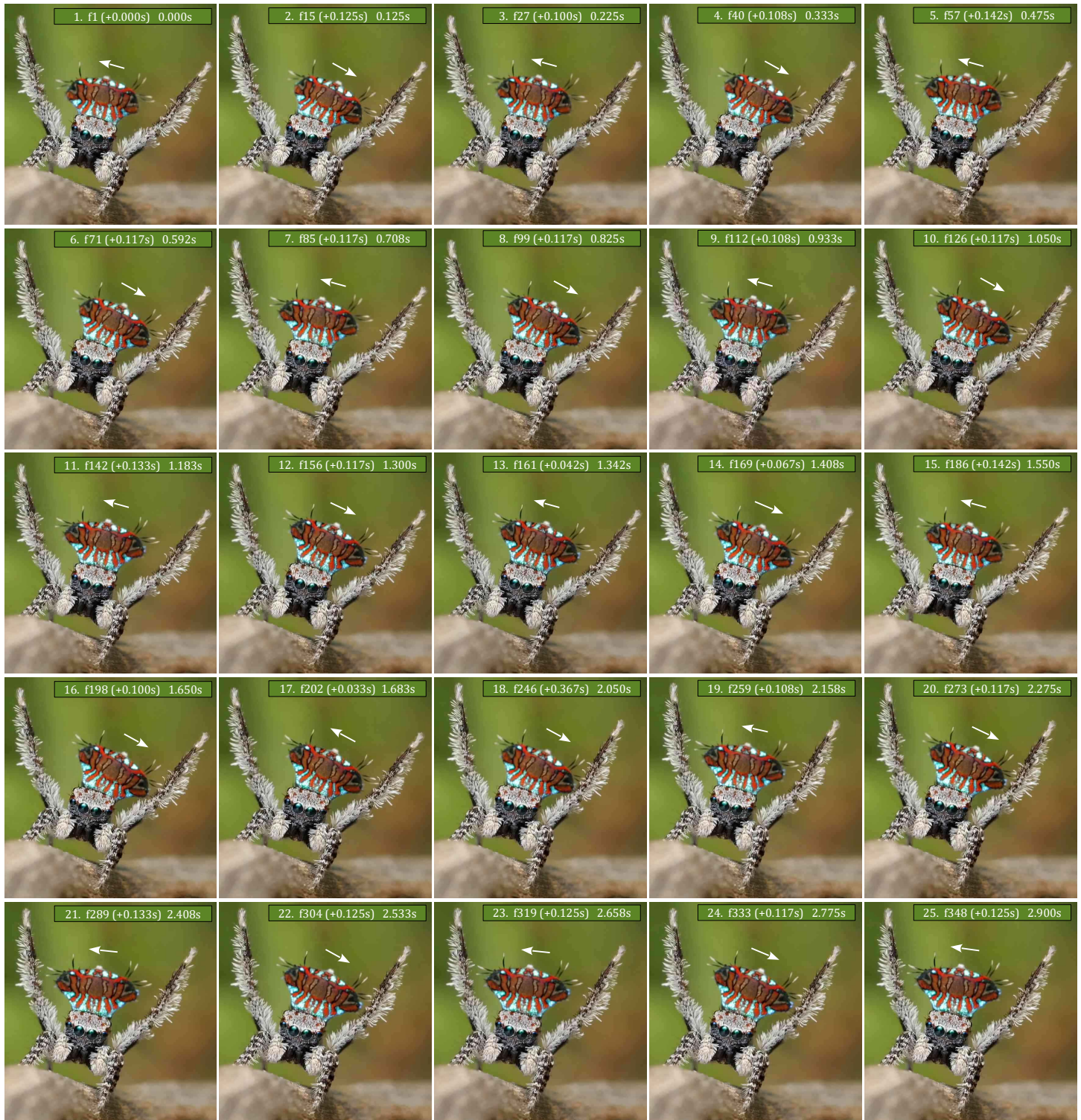
**Figure 11.** Female paratype, *Maratus pinniger*. 1-5, Submerged in alcohol. 6, Ventral view of epigynum (anterior toward top of page). 7, Ventral view of living spider.

*Courtship display* (Figures 12-20). All observations of courtship took place under simulated natural conditions in the laboratory. Like other *Maratus*, male *M. pinniger* may raise one or both legs III to gain the attention of a nearby female (Figures 3:13, 12). Display may include slow, intermittent movement of legs III with occasional flexing at the tibiometatarsal joint. Advertising males could also extend legs III in a V-shaped configuration, and wave the elevated fan in a median position (Figures 13, 20:1-2).



**Figure 12.** Sequential photographs showing advertisement with a single raised and extended leg III by a male *Maratus pinniger*. Note the long setae on this leg, and the thick white fringe of the dorsal femur in particular.

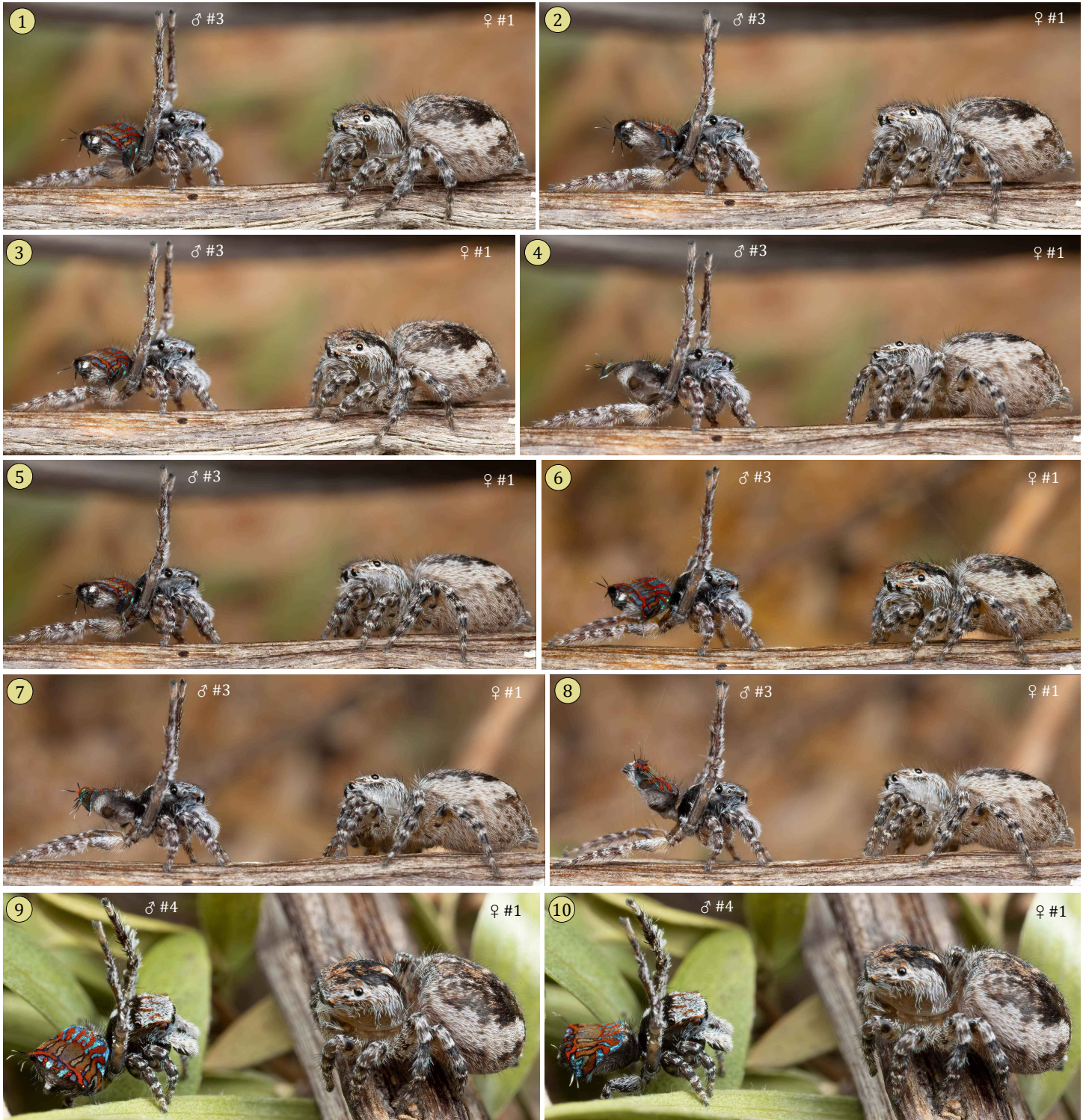




**Figure 13.** Serial frames from a 120fps video of courtship display by a male *Maratus pinniger*. Lateral movement of the elevated fan relative to the preceding frame is indicated with an arrow. Movement was fairly constant, at a rate of  $\sim 4.3\text{Hz}$  (12.5 left-right cycles in 2.9s). There was little movement of the extended legs III, or the pedipalps, during this display. For each numbered frame (1-25) in this series (and in other series shown below), the sequential frame number (f), time elapsed since the previous frame (+), and the total elapsed time is shown.

As is the case for other members of the *vespa* group, a close approach of the female to examine the male led to rotation of the fan from one side to the other behind legs III, held in more of a "calipers" position (Figures 14-20). During this display, the pedipalps, separated to reveal the glabrous black chelicerae, and legs III of the male were held in a stationary position. As with the previous (advertisement) display,

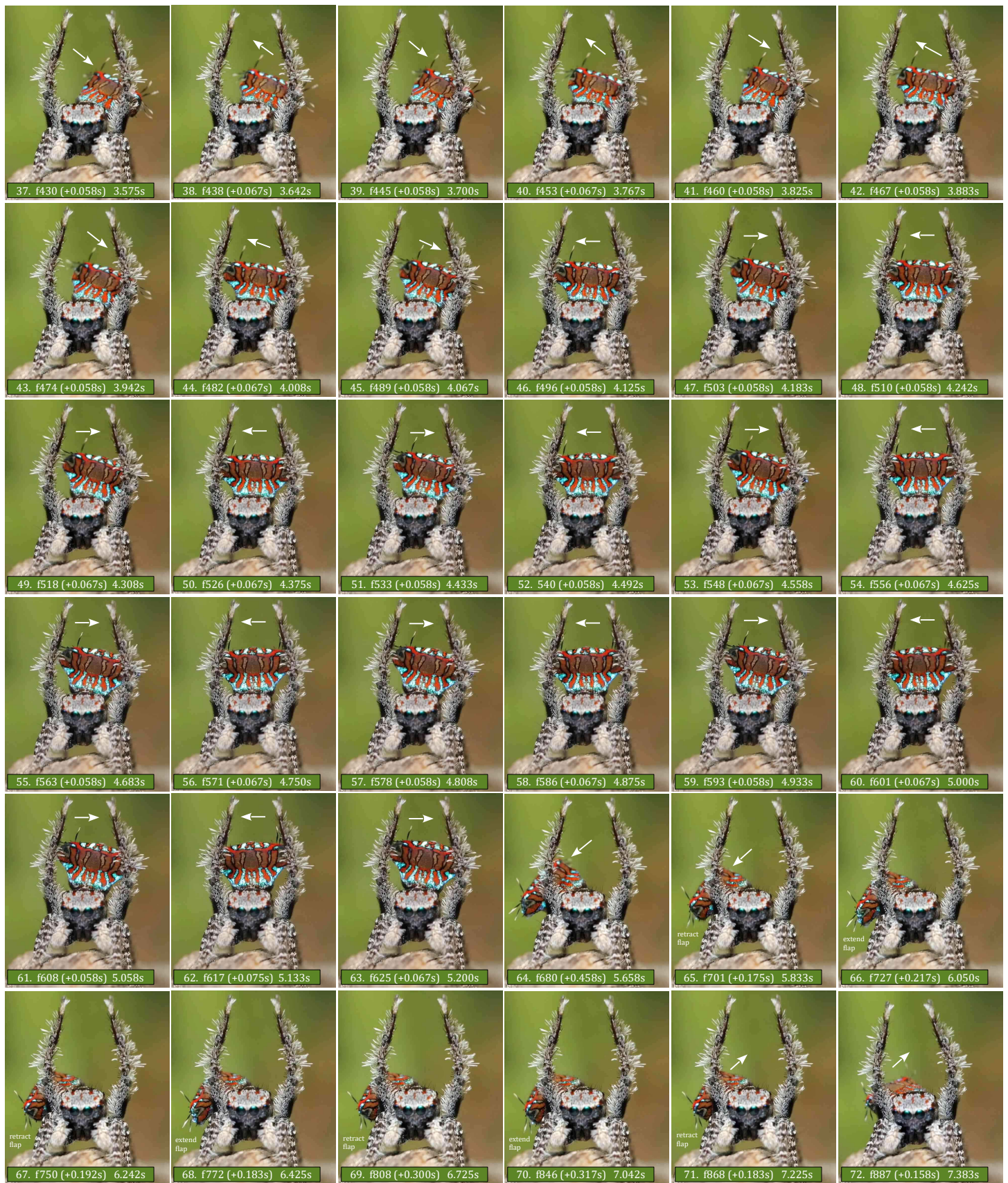
movement of the fan was fairly continuous when observed with 120 fps video, involving left-right cycles of side to side movement at 5-9Hz, accompanied by "bobbing" or vibration of the opisthosoma at ~50Hz. Slower (2-3Hz) extension-retraction cycles of each lateral flap, as it was turned toward the female at one side or the other, were also observed.



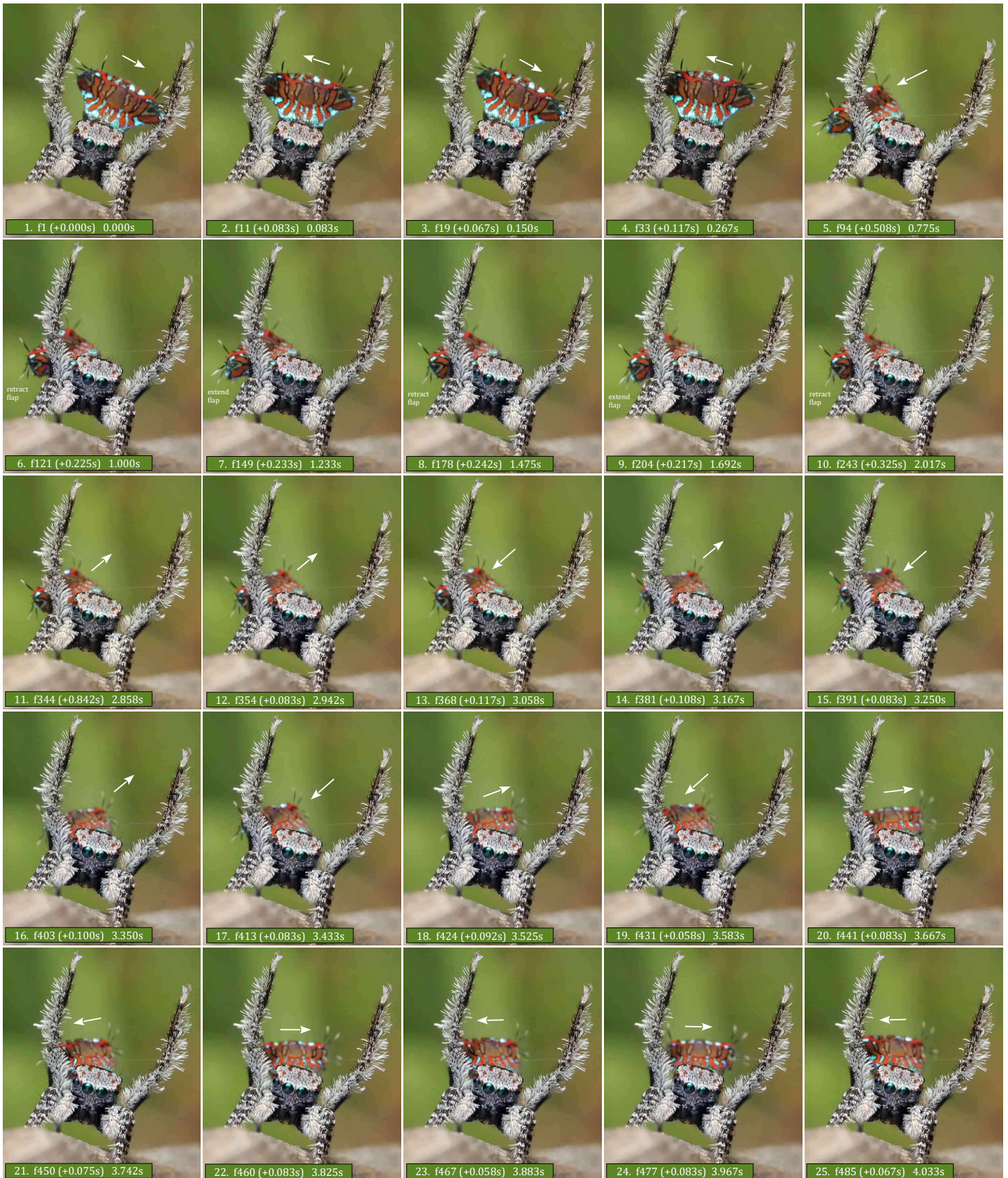
**Figure 14.** Two series (1-8, 9-10) showing the female *Maratus pinniger* (at right) following the side to side movement of the fan by a male engaged in the final stage of courtship. As each male turned the fan to display the "feathered" flap on either side, alternating from left to right, the female, at a distance of 4-5 mm, turned to follow this movement.



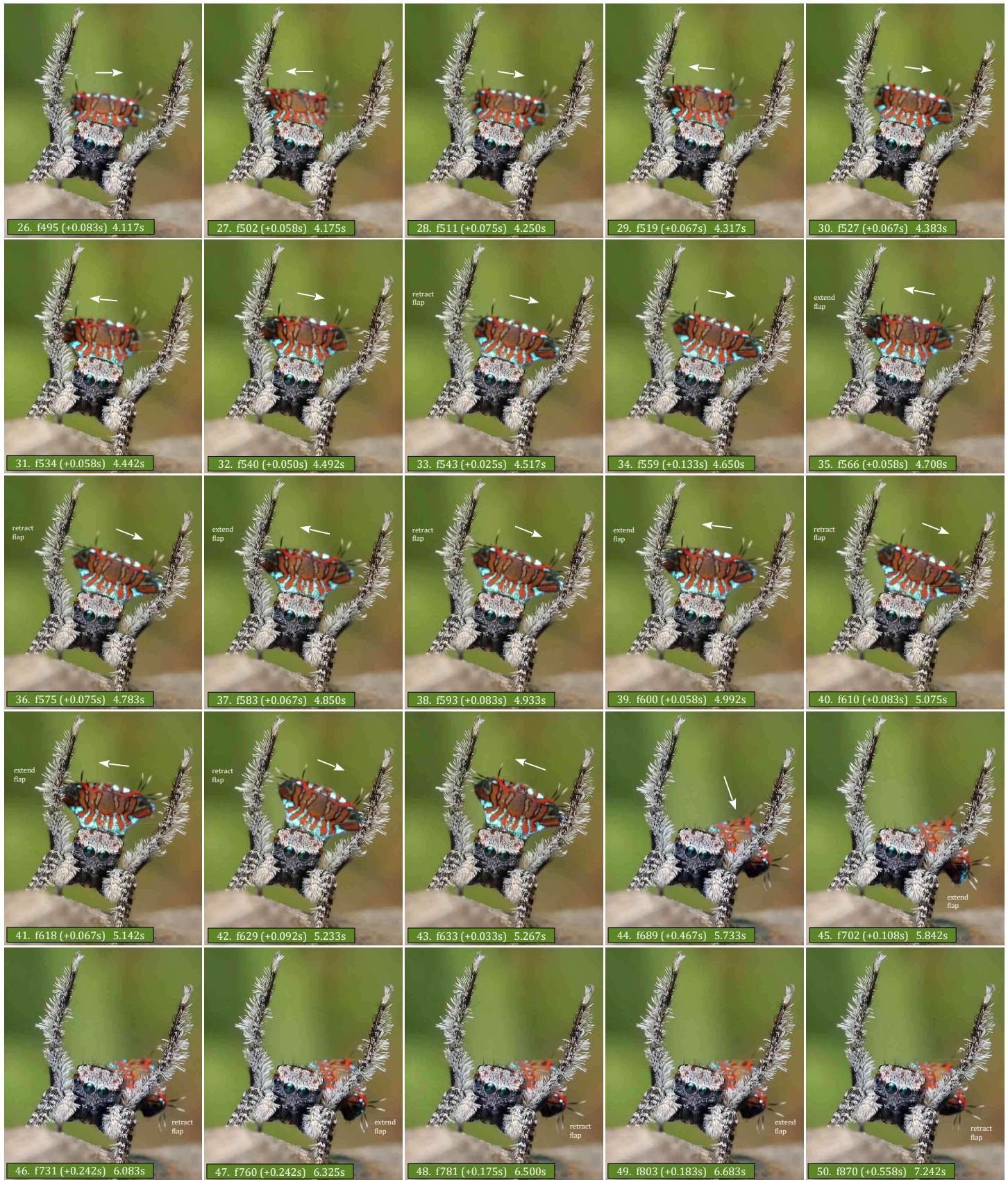
**Figure 15 (continued on next page).** Serial frames from a 120fps video of courtship display by a male *Maratus pinniger*. **1-12**, 5.5 8.5Hz left-right cycles of rotation of the elevated fan in a median position. **14-19**, Three slight bobs (up-down movements) of the opisthosoma in a lateral position at 51Hz. **20-28**, Four cycles of slight fan extension and retraction in the lateral position at 2.9Hz. **29-63**, 17 left-right cycles of the fan as it was elevated at 7.7Hz.



**Figure 15 (continued from previous page).** Serial frames from a 120fps video of courtship display by a male *Maratus pinniger*. **29-63**, 17 left-right cycles of the fan as it was elevated at 7.7Hz. **65-71**, 3 cycles of flap extension and retraction at 2.2Hz. All movement was fairly continuous, accompanied by low amplitude bobbing or rolling of the opisthosoma at ~50Hz.



**Figure 16 (continued on next page).** Serial frames from a 120fps video of courtship display by a male *Maratus pinniger*. **1-4**, 1.5 cycles of left-right fan rotation at 5.6Hz. **5-10**, 2.5 cycles of flap retraction at 2Hz. **12-43**, 16 left-right cycles of fan rotation as the fan was raised to an elevated position, at 6.9Hz.



**Figure 16 (continued from previous page).** Serial frames from a 120fps video of courtship display by a male *Maratus pinniger*. 12-43, 16 left-right cycles of fan rotation as the fan was raised to an elevated position, at 6.9Hz. 32-42, 4.5 cycles of right fan retraction and extension, with the fan in a median position, at 6.1Hz. 44-50, 3 cycles of fan extension and retraction at 2.0Hz. Continuous movement was accompanied by low-amplitude bobbing or vibration of the opisthosoma at ~50Hz.

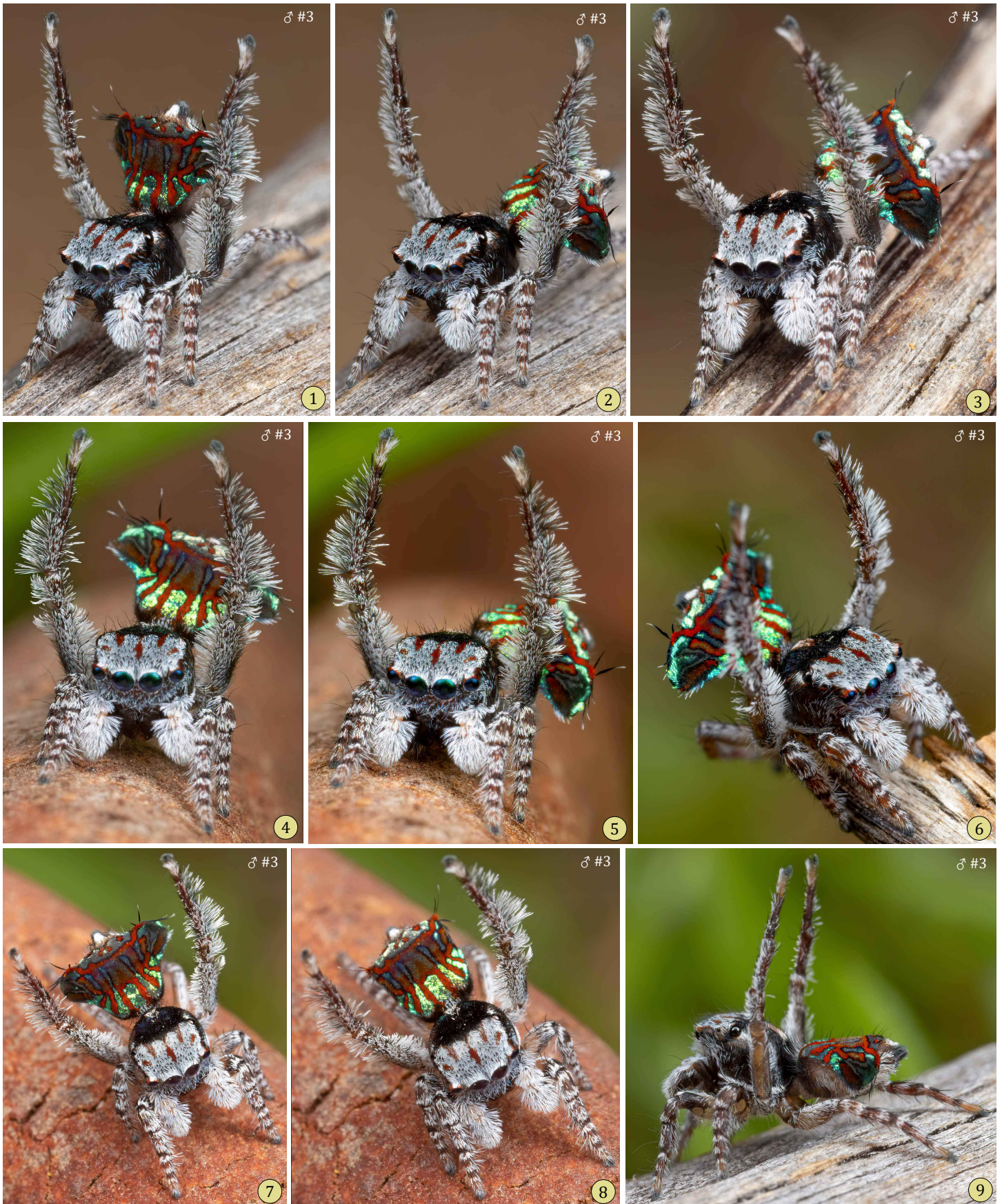


**Figure 17.** Three series (1-3, 4-9, 10) of photographs showing a male *Maratus pinniger* engaged in the final phase of courtship display. 3, When a flap is displayed at one side, it may be moved up and down, or the flap itself may be extended and then retracted. 4-9, Flaps may be retracted as the fan is rotated from the center position to one side or the other.

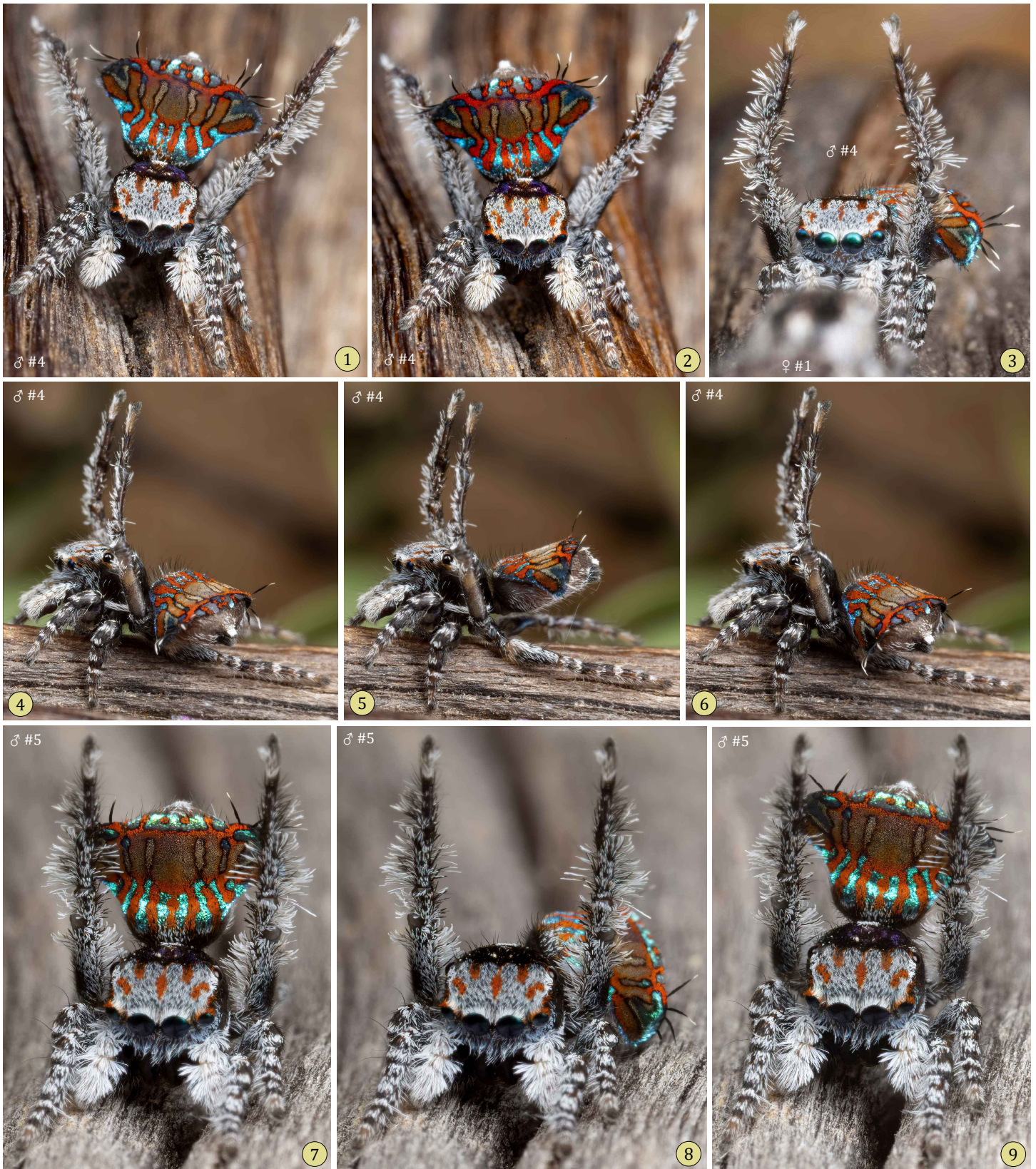


**Figure 18.** Sequence (1-16) of photographs showing a male *Maratus pinniger* engaged in the final phase of courtship display, showing alternation between display of the left (3, 9) and right (7, 11) flaps. Here the male extended the flaps but did not raise the fan in the centered position. Elevation of the fan appears to represent a useful form of advertisement that may not be needed when the female is actively engaged with the male.





**Figure 19.** Photographs and sequences (1-2, 3, 4-5, 6, 7-8, 9) of a male *Maratus pinniger* engaged in the final phase of courtship display.



**Figure 20.** Photographs and sequences (1-2, 3, 4-6, 7-9) of two male *Maratus pinniger* engaged in courtship display. **1-2**, Legs extended in a V-shaped configuration as the fan was rotated from side to side in a central position. **3**, Female (in foreground) looking directly at the "feathered" left flap of the male. **4-6**, Typical positions of the final phase of courtship, with the fan held in a lower position, even when centered. Note extension of legs IV to the rear. **7-9**, Here the fan was elevated in the center position, apparently as an advertisement to obtain the attention of the female.

*Habitat.* *Maratus pinniger* was found on coastal sword-sedge (*Lepidosperma gladiatum*) in a damp swale area surrounded by Jarrah/Marri forest, in Blackwood State Forest, Western Australia (Figure 21).



**Figure 21.** Habitat of *Maratus pinniger*. Females (5) and males (6) were found on low vegetation in an open swale, near Jarrah/Marri forest. Photographs © Paul Winthrop, used with permission.

## Discussion

The *Maratus vespa* group appears to represent the same kind of *high species diversity* and *narrow endemism* (small range) that characterizes the vascular plant communities of southwestern Australia, also known as the *Southwest Australian Floristic Region* (SWAFR), a well-known global biodiversity hotspot (Cowling et al. 1996; Ebach 2012; González-Orozco et al. 2014; Thiele & Prober 2014; Ebach et al. 2015; Gioia & Hopper 2017; Monks et al. 2019). Diversity in this region is associated with the evolution of many *species*, but also a smaller number of *genera* or *families* than might be found in other areas with less *species diversity*.

Explanations for high species diversity and endemism in this area of fairly uniform topography include depletion of soil nutrients leading to less interspecific competition, diversity and patchiness of habitats, a high level of local disturbance including a high but stochastic fire regime, high species turnover, community heterogeneity, isolation of relict biota, and long-term stability of a well-watered ecosystem (Cowling et al. 1996; Beard, Chapman & Gioia 2000; Rix et al. 2015; Gibson et al. 2017; Luxton et al. 2021). Management of fire regime (frequency, seasonality, intensity, scale) has been an important concern for maintenance of biodiversity in this area, considering the important role of pyrophilic plants, but the relationship of any particular regime to specific plant communities is complex or stochastic and potentially threatening to narrow endemics (Burrows & Friend 1998; Bradshaw et al. 2018; Burrows et al. 2019). Of these factors, *long-term climate stability* is most-often cited as an explanation for *biodiversity*, in turn viewed as a major contributor to *ecosystem stability*, itself a contributor to biodiversity through its ability to reduce extinction rates (Lehman & Tilman 2000; Loreau & de Mazancourt 2013; Sniderman, Jordan & Cowling 2013).

In a comparative study of 20 plant genera with both narrow endemic and widespread species, Lavergne et al. (2004) found that the narrowly endemic species tended to be smaller, with smaller and fewer flowers, and less seed produced for each plant. This could be viewed as one result of selection for *local persistence* as an alternative to dispersal. We may find an analogy here with the small size, and small broods, of peacock spiders. Models suggest that low dispersal strategy may be favored by a combination of low disturbance, low habitat availability, and low local adult survival (Büchi & Vuilleumier 2012). As long as local conditions do not lead to local overpopulation, and frequent disturbance does not make dispersal a requirement, local persistence may be the favored approach. Disturbance associated with a fire regime might work against the persistence strategy, but we still know little about the use of shelters by peacock spiders. If built in the soil, these might be very resistant to fast-moving fires of low intensity. However, in captivity most *Maratus* species do not build shelters, apart from those used for molting or brood protection, and we have never seen one returning to a shelter at the end of an active day. Based on their movement during the day, it appears unlikely that they return to a previous shelter at dusk. A swampy habitat might provide protection from some fires.

Clearly the speciation of *Maratus* has been closely associated with sexual selection (female choice), or coevolution of the male display with female preference, rather than modification of genitalia as an isolating factor. Almost all of the *Maratus* species found in southwestern Australia, including all members of the *vespa* group, appear to represent the results of rapid, *in situ* (after Rix et al. 2015) speciation. Whether the narrow endemism that we observe for these spiders represents a case of *high species turnover* where *incidence* alone is more important than competitive *dominance* (Gibson et al. 2017), or a local persistence strategy supported by a very high degree of sexual selection, remains an open question for future studies to address. There are many more localities that need to be studied over longer intervals, and many new peacock spiders to be discovered in the process.

## Acknowledgements

We thank Paul Winthrop for sharing his discovery of *Maratus pinniger* with us, for collecting the type specimens, and for providing us with habitat photographs and related information about the type locality. We also thank Adam Fletcher for allowing us to include a photograph of *M. fletcheri*, and the Department of Biodiversity, Conservation and Attractions of Western Australia for issuing collecting and export licenses. Unless otherwise indicated, all photographs are Copyright © Jürgen C. Otto.

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