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# Jewels in the dark: fluorescence of *Icius hamatus* (C.L.Koch, 1846) (Araneae: Salticidae) under UV blacklight at night

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**Ab Abstract:** The first known case of fluorescence under UV light of *Icius hamatus* (C.L. Koch, 1846) (Aranae: Salticidae) and this spider's nocturnal resting behaviour are reported and described, with short comments on variability at the intraspecific level. A brief review of UV fluorescence in spiders and its functions is also presented.
**Key words:** Araneae, Salticidae, *Icius hamatus*, fluorescence, UV, courtship, mimicry, predation.

**Joyas en la oscuridad: fluorescencia nocturna de *Icius hamatus* (C.L.Koch, 1846) (Araneae: Salticidae) bajo luz ultravioleta**
**Resumen:** Se describe el primer registro de fluorescencia bajo la luz ultravioleta de *Icius hamatus* (C.L.Koch, 1846) (Araneae: Salticidae), así como el comportamiento de reposo nocturno de esta especie, con una discusión sobre su variedad intraespecífica por edad o sexo e individual. También se presenta una breve revisión de la reflectancia UV en las arañas y sus funciones.
**Palabras clave:** Araneae, Salticidae, *Icius hamatus*, fluorescencia, UV, cortejo, mimetismo, depredación.

**Gioielli nel buio: osservazioni notturne sulla fluorescenza ai raggi UV di *Icius hamatus* (C.L.Koch, 1846) (Araneae: Salticidae)**
**Riassunto:** Vengono riportati e descritti per la prima volta la fluorescenza ai raggi ultravioletti ed il comportamento notturno di riposo di *Icius hamatus* (C.L.Koch, 1846) (Araneae: Salticidae), con brevi commenti riferiti alla variabilità intraspecifica. Viene inoltre presentata una sommaria revisione della letteratura relative alla fluorescenza agli UV nei ragni e le relative funzioni.
**Parole chiave:** Araneae, Salticidae, *Icius hamatus*, fluorescenza, UV, corteggiamento, mimetismo, predazione.

## Introduction

Fluorescence occurs when molecules (fluorophores) absorb light at a certain wavelength and emit it at a different one.

In recent years, fluorescence has been detected in many plants and animals, such as corals, birds and crustaceans (Lagorio *et al*., 2015).

Scorpions have been for long time the most well-known fluorescent terrestrial invertebrates (Lawrence, 1954; Pavan, 1954; Pavan & Vachon, 1954), and recently this cuticular feature has been assessed as plesiomorphic in chelicerates, with records for example in horseshoe crabs (Rubin *et al*., 2017), ticks (Shade, 2018) and spiders (Young & Wanless, 1967; Zschokke, 2002; Andrews *et al*., 2007). Reed *et al*. (2008) demonstrated that fluorophores in spiders are different from fluorophores in scorpions.

In fact, fluorescence is widespread in many spider species and seems to vary at intraspecific level, according to age (Brandt, 2012; Lim & Li, 2007), sex (Brandt & Masta, 2017) and health conditions (Lim & Li, 2007; Painting *et al*., 2017).

In particular, studies on spiders' eyes and vision have underlined that jumping spiders (Araneae: Salticidae) can see ultraviolet (UV) light (Donovan, 2010; Lim *et al*., 2006) thanks to specific receptors and filtering (Cronin & Bok, 2016; Zurek *et al*., 2015), and that their body fluorescence can be involved in courtship behaviors (Herbstein, 2011; Lim *et al*., 2008; Painting *et al*., 2016). In other spider families, fluorescence seems to be linked to predator-prey relationships (Craig & Bernard, 1990; Heiling *et al*., 2005; Herbstein, 2011, Tso *et al*., 2004; Zschokke, 2002).

In this work, observations on a jumping spider species in Italy, *Icius hamatus* (C.L.Koch, 1846), under an UV light are discussed for the first time.

## Material and methods

Spiders were discovered at night, using a TOMOUNT 51 UV Led Ultra Violet Blacklight (395 nm) and a standard torch. The habitats inspected included gardens of country houses, in particular *Pittosporum* hedges and olive trees (Sardinia, Italy) and urban habitats (Lombardia, Italy). All spiders were sent for identification to the Dept. Of Life Sciences and Systems Biology (University di Torino), where specimens were studied with a Leica M80 stereoscope, and are now preserved in 90% alcohol.

Photographs of live specimens were taken with a Nikon D850 camera and 105 mm AF Micro Nikkor lens, in combination with Nikon SB R1-C1 Macro flash system (natural light, on white background) or TOMOUNT 51 UV Led Ultra Violet Blacklight (UV light, on dark background). Many trials with different settings have been done in order to obtain photographs which reliably represent the UV-lit habitus of the spiders. Postproduction of the files has been limited to basic preparation (crop, slight contrast, curves, colour balance and saturation calibrations) with Adobe Photoshop 7.0.

MATERIAL EXAMINED: 29.VIII.2019, Maristella (SS), Sardinia, Italy. 40°35'09.9"N 008°13'28.6"E. At night on hedges of pittosporum (*Pittosporum tobira*), inside country house' garden surrounded by Mediterranean maquis, hanging with a line on the bottom side of leaves. 9 juveniles (including 3 sub-adult males), 1 adult female; M.Colombo leg., M.Isaia det. ● 10.IX.2019, Busto Arsizio (VA), Lombardy, Italy. 45°36'27.6"N 008°51'01.5"E. Inside flat in city, on the ceiling. 1 adult female; M.Colombo leg., M.Isaia det. ● 14.IX.2019, same locality. Inside flat in city, on the ceiling. 1 adult male; M.Colombo leg., M.Isaia det.

## Results and discussion

All specimens were found at night, hanging from silk lines on the bottom sides of leaves, and all showed fluorescence under an UV light. Differences in fluorescence was found among spiders of different ages, sexes and also among individuals. Hereafter, brief descriptions of the spiders' features are given.

**Qualitative description of specimens under UV blacklight**

*Juveniles*. Very bright green all over the abdomen surface, legs (apart from trochanters, coxae and proximal portion of femurs) and pedipalps. Prosoma shows slight green fluorescence on rear half and sides (Fig. 1A-B).

*Sub-adult females (penultimate)*. Elongated patch in the middle of abdomen very light green, with dark, black borders; sides of the abdomen slightly fluorescent. Joints between legs segments (femur-patella, patella-tibia) and metatarsus greener than adult females. Pedipalps very bright green, apart from proximal portion. Prosoma not fluorescent (Fig. 1C-D).

*Sub-adult males (penultimate)*. Abdomen with middle, light coloured patch completely surrounded by dark pattern that becomes

vivid emerald green under UV light. Legs with bright green fluorescence, in particular on hind pairs, at the joints between segments (femur-patella, patella-tibia) and on metatarsus; pedipalps very bright green, apart from proximal portion. Prosoma not fluorescent (Fig. 1E-F).

*Adult females*. Very similar to sub-adult females. Elongated patch in the middle of abdomen very light green, with dark, black borders; sides of the abdomen slightly fluorescent. Joints between legs segments (femur-patella, patella-tibia) and metatarsus slightly green. Pedipalps very bright green, apart from proximal portion. Prosoma not fluorescent (Fig. 1G-H).

*Adult males*. Hind end of abdominal patch with slight green fluorescence, as a thin stripe, starting at the base of spinnerets and fading forward; variability observed seems to reflect variability of habitus in standard white light. Very weak green fluorescence, not always detectable, in basal joints of the legs (trochanter-coxa). Prosoma not fluorescent (Fig. 1I-L-M-N).

## Discussion

All spiders have fluorophores in the hemolymph, but external expression of this condition seems to be restricted to some species (Andrews *et al*., 2007).

In species with poor-vision and courtship mainly based on vibrations, this feature has been usually linked to predator-prey interactions (Brandt, 2012).

In some Araneidae as *Nephila pilipes* (Fabricius, 1793), for example, UV reflectance of the body has been evaluated as a prey attractor, together with that of the web (Craig & Bernard, 1990; Tso *et al*., 2004). However Brandt (2012) observed that this does not apply to other species of the same family, as *Araneus diadematus* Clerck, 1757.

According to some recent studies on Thomisidae such as *Misumena vatia* (Clerck, 1757), UV reflectance may allow mimicry with flowers, as protection from predators and for disguising from potential preys (Brandt, 2012; Brandt & Masta, 2017; Heiling *et al*., 2005).

Salticidae can definitely see UV wavelengths (Cronin, 2016; Lim & Li, 2006) and show bright, medium or a dim amount of reflectance among taxa or individuals (Andrews *et al*., 2007).

Laboratory research has shown that fluorescence is linked to intraspecific communication in this family.

In particular, males of *Cosmophasis umbratica* Simon, 1903 activate antagonistic or courtship behaviors depending on whether UV filters are applied or not on lights in experimental conditions (Lim *et al*., 2008), and are involved in mate recognition (Painting *et al*., 2016).

Fluorescence in *Icius hamatus* (C.L.Koch, 1846), the subject of this work, has never been recorded before, but shows clear similarities with other species in the literature.

Since the species is not often found on flowers and bases its courtship on sight, we can assume UV fluorescence is unlikely to be related to mimicry or prey-predator interactions, as in Thomisidae (Brandt, 2012; Brandt & Masta, 2017; Heiling *et al*., 2005) but more likely to intraspecific signals, as in Salticidae *Cosmophasis umbratica* (Lim *et al*., 2008).

In the studied specimens, fluorescence seems to change depending on at least three factors: age, sex and (possibly) individual variability.

Juveniles showed the highest fluorescence level, with green hues all over abdomen, legs and pedipalps, and are also the only observed specimens with hints of fluorescence on prosoma (Fig. 1A-B).

Adult *Icius hamatus* appear to have less UV fluorescence on their abdomen and legs (Fig. 1C-D-E-F), as compared to juveniles. *Icius hamatus* most probably do not attract preys through UV reflectance as crab spiders may do (Brandt & Masta, 2017), because they are not sit-and-wait hunters (Richman & Jackson, 1992).

In juveniles, hemolymph fluorophores could be more visible all over the body (Andrews *et al*., 2007), even though fluorophores inside the cuticle are recorded in other species (Brandt, 2012).

As far as differences between sexes are concerned, in *Icius hamatus* females are the brighter sex, with a light green pattern on abdomen and legs, and a bright green colour on pedipalps (Fig. 1G-H), while males just show a thin green stripe on hind end of abdominal patch, starting at the base of spinnerets and fading forward (Fig. I-L-M-N).

Differences in UV fluorescence between sexes have already been observed in other families. *Misumena vatia* shows bright UV reflectance in adult females, but not in males, possibly due to different ecological and hunting demands. The females in fact prey upon big insects on flowers and have to both protect themselves from predators and visually mislead preys, while males do not hunt and just look for partners (Brandt & Masta, 2017). In *Araneus diadematus*, instead, the males are the brighter sex, to hide their shape to birds eyes, probably because they are more exposed while wandering in search of females (Brandt, 2012).

Among Salticidae, a similar pattern to *Icius hamatus* UV reflectance has been recorded for *Cosmophasis umbratica*, with females just showing green pedipalps, and males not reflecting at all (Lim *et al*., 2008). Moreover, in this species fluorescence has been demonstrated to be a good signal for mate choice, as middle-aged females are brighter than old ones, and well-fed females are brighter than starving ones (Painting *et al*., 2017).

Results of this study show differences in UV blacklight appearance between *Icius hamatus* analyzed adult males, with abdominal green stripes of different length and width, but most probably these features reflects variability in dorsal pattern, typical of the species (Alicata & Cantarella, 1993).

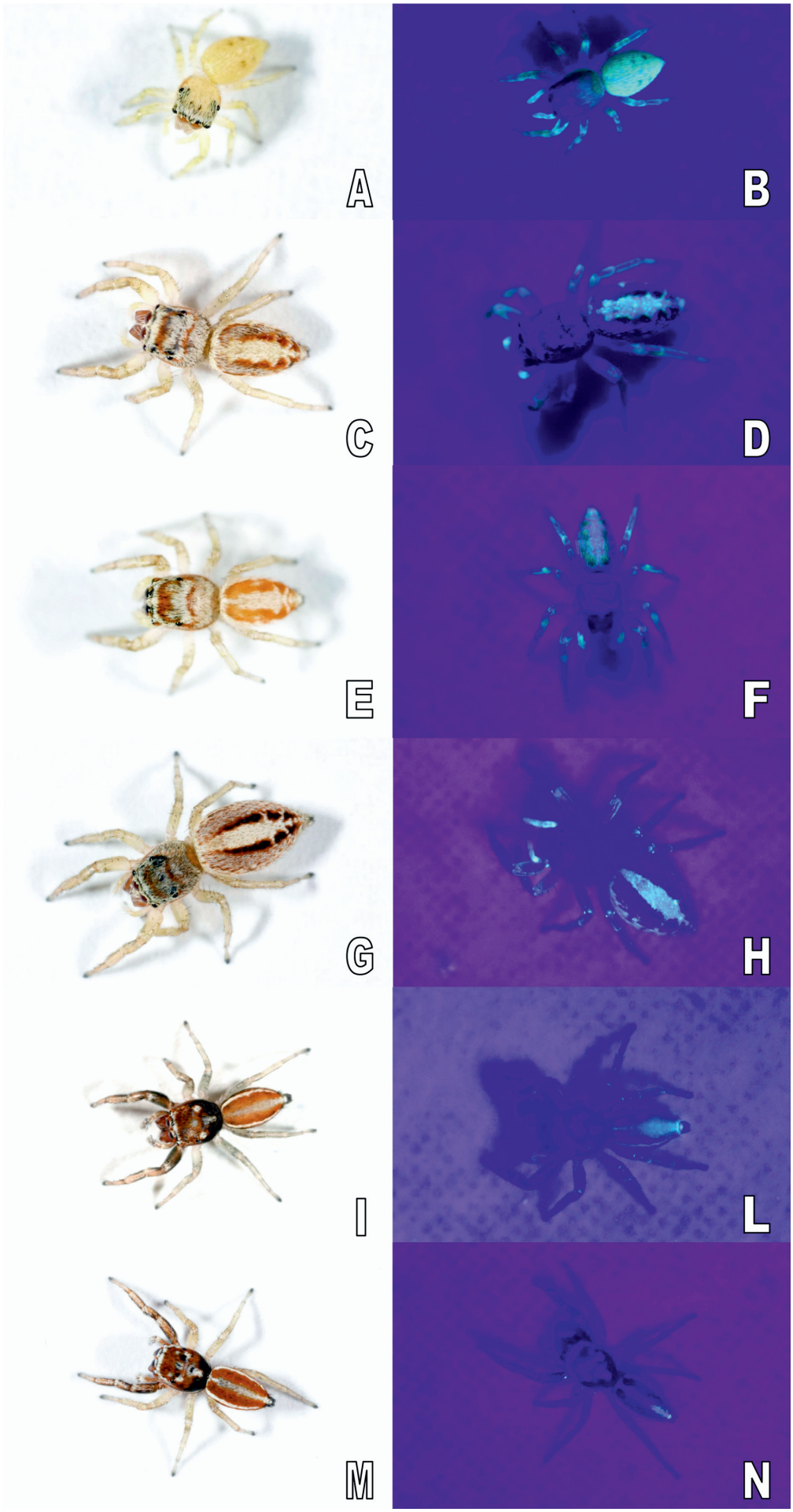
Use of spectrometer and advanced technology, as well as experimental settings in laboratory, are highly desirable to assess the exact function of UV-induced fluorescence in *Icius hamatus* and its role among intraspecific signals.

The use of UV blacklights in the field at night also opens interesting perspectives in spider research, possibly leading to new ethological observations, such as the resting behavior seen while hanging to a line on the bottom side of a leaf, which has been already recorded for other species (Carroll, 1977; Richman & Jackson, 1992) but not previously for *Icius hamatus*.


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► **Fig. 1.** Dorsal habitus of *Icius hamatus*, different life stages, sex and provenance. **A**, juvenile from Sardinia in standard light; **B**, juvenile from Sardinia in UV light; **C**, sub-adult female from Sardinia in standard light; **D**, sub-adult female from Sardinia in UV light; **E**, sub-adult male from Sardinia in standard light; **F**, sub-adult male from Sardinia in UV light; **G**, adult female from Lombardy in standard light; **H**, adult female from Lombardy in UV light; **I**, adult male from Sardinia in standard light; **L**, adult male from Sardinia in UV light; **M**, adult male from Lombardy in standard light; **N**, adult male from Lombardy in UV light (all photographs by M.Colombo)


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