Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Identification of a new acute body pattern in Octopus vulgaris: rapid variations in iris color while maintaining cryptic mantle color when interacting with a human observer

Pascal Carlier

pascal.carlier@univ-amu.fr

Aix-Marseille Université

Franck Bessière

Short Report

Keywords: Octopus. Body patterns. Iris color. Tension. Interspecies encounter

Posted Date: November 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11557144/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

The body color patterns of the Mediterranean octopus (*Octopus vulgaris*) are well documented. These patterns are based on color, texture, posture, and specific movements. However, it is difficult to observe the full range of these patterns in a laboratory setting, especially those related to interactions with conspecifics or other species. In May 2026, during a diving and filming expedition in Toulon Harbor, France (43°6'24“N, 5°58'46”E), FB, a co-author of this article, recorded a change in an octopus's iris color while its mantle remained stable in camouflage mode. The same phenomenon occurred and was filmed in June and October of that year in the same area on six other individuals. This pattern also occurred in the absence of filming equipment but did not appear in two individuals previously encountered by the diver. This body pattern may correspond to the octopus's response to situations requiring a certain level of vigilance during encounters with potential predators. It may represent an intermediate state of tension between the cryptic state, which is associated with low tension, and the deimatic display, which corresponds to maximum tension. Further research is needed to determine whether this pattern occurs during interactions with conspecifics or other species.

Introduction

The Mediterranean octopus (*Octopus vulgaris*) shares with other octopus species, and more broadly with other cephalopod species, the characteristic of exhibiting various body patterns, which may be chromatic, textural, postural, or involve certain movements. Depending on whether they last for hours versus a few minutes or seconds, these body patterns can be chronic or acute (Packard and Sanders 1971; Hanlon 1988; Hanlon and Messenger 1996). The appearance and variation of these patterns depend on the environmental context and the octopus's activity. For example, there are chronic cryptic color patterns for camouflage; a dark red color associated with predation or aggression; a livid white color in response to a predator; and small color variations during intra- and interspecific interactions. Chromatophores, cells that are sometimes likened to neuromuscular organs (Messenger 2001), are located in the octopus’s skin along with iridophores and leucophores. These cells enable rapid color changes.

Laboratory settings provide opportunities to observe color variations related to camouflage, predatory behavior, purposeful movements, and fear. However, the somewhat artificial laboratory setting does not allow for observation of variations related to intra- and interspecific interactions, particularly those associated with specific situations, such as a naïve octopus's first encounter with a human. Field observations therefore complement laboratory observations, providing a more complete understanding of the full range of color variations and the behaviors associated with them.

This article discusses an undescribed pattern of color variation. One of the article’s co-authors, FB, filmed numerous videos of octopuses (mostly *O. vulgaris*) along the eastern coast of Toulon, France (43°6'24“N, 5°58'46”E), to highlight certain aspects of their behavior. In late May 2026, he approached an octopus while filming it. The octopus’s mantle color made it cryptic within its immediate environment. FB

then noticed dynamic variations in the color of its iris. After analyzing the video footage, it appeared that the octopus remained motionless in a camouflaged state, with no change in the color or texture of its mantle. Its pupil also remained stable, showing neither dilation nor contraction. Only the iris exhibited rapid color variations. Since the iris and mantle are composed of the same cells responsible for coloration (Froesch 1973; Hanke & Kelber 2020), different iris colors in a single individual are frequently observable. What made our observation peculiar was that the iris changed color rapidly, in contrast to the stable, cryptic pattern of the mantle.

The first question that arose at this stage was: Is this dynamic pattern exceptional and therefore perhaps not reproducible? Had we not observed it again, it would have remained an anecdotal observation. However, if it could be observed again, then it would be necessary to identify the contextual factors surrounding its occurrence. Therefore, the purpose of this article is, first, to confirm the existence of the phenomenon and, second, to formulate hypotheses about the context or causes that trigger it.

Material and Methods

In the regularly surveyed coastal area, natural shelters known to be occupied by octopuses were prioritized. Some of these shelters had already been approached, while others had not. It was therefore possible to distinguish between individuals that had never been approached before and those accustomed to the human presence in their environment. Visible individuals outside of shelters were also approached. The diver, FB, was equipped with freediving gear consisting of a wetsuit, a diving mask, a snorkel, fins, and a weight belt. His filming equipment consisted of a Canon 5D Mark IV camera with a 100 mm lens protected by a waterproof housing. At this exploratory stage, it was important that the observer filming the subjects be the same person each time, in order to avoid introducing an additional source of variation. When the first observation of iris color variation was made, it was necessary to eliminate any bias from the filming equipment that could have caused the phenomenon. Two observations, conducted without filming equipment, confirmed that iris color change without a change in mantle color also occurred under these conditions. Nine individuals were observed and filmed. The study period was late May 2026 for the first individual, June 2026 for six others, and October 2026 for the last two individuals. The freediver's approach sequence unfolded as follows: He descends vertically, slightly offset from the octopus's location, and remains motionless 30–40 cm from the octopus. If conditions permitted, two consecutive descents could be performed in the same way to test the potential impact of an initial familiarization on this behavior. The primary objective of the study was to highlight and describe the phenomenon based on the filmed footage. To visualize this phenomenon, relevant segments of the footage were divided into ten photos spaced 0.5 seconds apart. The editing program used was VLC Media Player. The 0.5-second interval was chosen because it allows for clear visualization of the color change progression. Additionally, a video of the phenomenon will be available via a link.

Results and discussion

A presentation of the octopuses observed

Figure 1 shows O1, the first individual observed in late May 2026, which marked the beginning of the study. This individual exhibited a very conspicuous change in iris color. This individual had most likely not been observed previously. It exhibited a cryptic pattern, and the colors of its iris alternated between dark and light shades.

Between 5:00 and 6:00 pm in June 2026, six other individuals were filmed at depths ranging from 1.50 to 7 meters. Subject O2 exhibited a slight change in iris color during the initial dive but no change during the second. In contrast, subject O3's iris color changed noticeably during the first dive (Fig. 2(a)), though less so during the second dive (Fig. 2(b)).

Figure 2 (a) and (b) A 5-second continuous segment of the sequence for subject O3, with one frame every 0.5 seconds, to be viewed by following the numbering from left to right and top to bottom.

This octopus is a good example, because in less than two minutes, the color of its iris remains much more stable compared to the first visit. This tendency has been observed to varying degrees in other individuals. Subject O4 was observed from the front and exhibited a difference in response between the two eyes, illustrating a possible asymmetry in the pattern. This asymmetry has been identified in several chromatic patterns (Packard and Sanders 1971) and may reflect ambivalence (Carlier and Renoue 2007). Two other subjects, O5 and O6, had interacted with the diver previously and showed no reaction during the first dive. In contrast, O7 that had never been observed before exhibited a change in iris color (Fig. 3). O7 has a particularly golden iris, but a noticeable color shift toward a whiter shade occurs in the lower part of its iris.

The first individual, O8, filmed in October, was distinguished by a highly textured and colorful coat. This coat, with its stable coloration, did not obscure the distinct color variations in its iris; (Fig. 4). Individual O9 was filmed in early October 2026 and appears in a 12-second real-time video accessible via the following link: [insert link]. This video shows the pattern under real-world conditions.

Descriptive Findings

First, it should be noted that seven out of nine octopuses filmed under identical conditions exhibited changing iris colors in the presence of the diver. This result confirms that this behavior is an acute bodily pattern likely to occur in *O. vulgaris*'s interactions. The phenomenon appears to occur when the octopus has not previously been exposed to humans. Consistent with this hypothesis, the two animals that the diver had already identified on-site did not exhibit significant color variation in their irises. Furthermore, when the diver descended a second time to film the same octopus, the color variations were absent or much less pronounced. For all observed individuals, the changing iris was associated with a camouflaged mantle pattern that did not vary. It should also be noted that the pupil does not change. One individual had a few small black streaks on the mantle protrusions around the eye. The pattern of iris color variation was always observed in stationary animals. From a physiological standpoint, it is important to know that iris tissues include chromatophores, iridophores, and leucophores, the same as the whole mantle. Therefore, the iris has the same potential to change color as the mantle. One might

have expected a continuous transition between the iris and the rest of the mantle. The most striking aspect of this change in iris color is the contrast it creates with the no changing stable camouflage pattern covering the entire mantle.

An Attempt at an Explanation

When explaining a behavior, ethologists may draw on Tinbergen's (1963) four questions: proximal causes (internal or external), ontogeny, function (ultimate causes), and phylogeny. Regarding the function of behaviors in *O. vulgaris*, we know the typical sequence of color changes and behaviors an octopus exhibits when approached by a predator. First, it displays a cryptic pattern when the predator is far away, allowing it to remain invisible. Then, if the predator gets very close, the octopus suddenly turns pale with black ocelli around its eyes (deimatic display), which may intimidate the predator. Finally, if this fails, the octopus flees while concealing its escape with a jet of ink. The functions of this response to a predator's approach are therefore: 1) to not exist, 2) to frighten, and 3) to become invisible. The functional interpretation of the deimatic display, however, says nothing about the octopus's internal state, the analysis of which falls under the category of internal proximal causes. This internal state likely corresponds to a high level of psychophysiological arousal associated with an emotion comparable to fear. Another notable behavior is the "passing cloud," an acute body pattern associated with the prey-predator relationship that obscures the detection of an octopus by its prey by simulating its movement. Furthermore, the passing cloud is more often produced to capture a crab when an initial attempt has failed (Mather and Mather 2006). The key difference between these two acute body patterns is that, unlike the deimatic display, the "passing cloud" pattern may indicate agency on the part of the octopus because it may or may not be activated in response to a given context. This agency has been documented (e.g. Mather 2019). However, these two patterns have one thing in common: they may serve an ultimate function that promotes their preservation throughout phylogeny. What about the changing iris pattern? It is associated with a cryptic and stable mantle color. However, this pattern may make the octopus more detectable to other organisms without scaring off a diver or predator that might approach, as is the case with the deimatic display. Therefore, at this stage, a functional explanation suggesting this pattern provides a survival advantage for the animal does not seem obvious. Consequently, evolutionary history, which is closely linked to the ultimate function, is not relevant to consider as well. In terms of ontogenesis, it is unlikely that such a pattern is the result of social learning given that octopuses have limited social interactions and live for less than two years.

Therefore, understanding this behavior requires focusing exclusively on its immediate causes. The fact that this pattern has never been reported in a laboratory setting suggests that the color variation in the iris corresponds to a reaction to a new situation, manifested by an increase in the animal's arousal level. However, since the octopus retains its camouflage coloration without taking on colors associated with fear or aggression, we can imagine that the iris might be a sort of "window" into the octopus's internal state. According to this hypothesis, color changes in the iris could be compared to an "emotional safety valve." Considering the three contexts of color change—camouflage, emotion, and communication (Renoue and Carlier 2006; Carlier and Renoue 2007)—this variation in iris color falls into the category of

color changes associated with emotional expression, with acute body patterns e.g. as the deimatic display or the dark red color associated with predation. The complementarity of these two patterns, dark vs. clear, has been demonstrated in agonistic intraspecific interactions studied in *Octopus tetricus* (Scheel et al. 2016). These patterns are not constrained by camouflage. The coloration and posture of an octopus are determined by its emotions. One could also hypothesize a form of communication similar to that observed at the intraspecific level in *O. vulgaris* (Hanlon and Messenger 1996). The change in iris color would correspond to agentic behavior related to the diver's presence. However, this hypothesis is weakened by the observation that variations in iris color sharply decreased as early as the second descent. Had the octopuses been communicating with the diver, the changes in their irises would not have diminished so quickly. Additionally, octopuses have been shown to be able to distinguish between two humans visually (Anderson et al. 2010). This suggests that the observed behavior may reflect a moderate stress response to an initial encounter with an unfamiliar human that subsequently subsides.

In conclusion, the hypothesis that color variation in an octopus's iris in the presence of a diver could be explained by a gradient of emotional intensity—ranging from a relaxed state associated with cryptic mantle patterns to a deimatic display generating hyper-visibility, which is likely to frighten a predator—seems to work (Renoue and Carlier 2006). An iris that changes color while the mantle remains in a cryptic pattern could be near the middle of the spectrum between the chronic cryptic pattern and the acute deimatic pattern. Venturing slightly into anthropomorphism, one could argue that this pattern reveals a state that appears relaxed on the surface but is actually marked by growing emotional tension, expressed only through color variations in the iris. As a follow-up to this study, it would be interesting to examine the role of familiarity with octopuses in the emergence of this behavior and determine whether it also occurs during encounters with other octopuses or non-human species.

Declarations

Author Contribution

The two authors of this article made complementary contributions to this work. Franck Bessière is solely responsible for the video footage. FB and Pascal Carlier jointly developed the field filming protocol and analyzed the behavior under study based on the videos. PC then drafted the scientific article based on the state of the art as reflected in the literature, made the final selection of illustrations, and wrote the article.

References

1. Anderson RC, Mather JA, Monette MQ, Zimsen SRM (2010) Octopuses (*Enteroctopus doflenei*) recognize individual humans. J Appl Anim Welf Sci 13:261–272. https://doi.org/10.1080/10888705.2010.483892
2. Carlier P, Renoue M (2007) Variations colorées chez les céphalopodes selon l'environnement physique et social: un point de vue cognitif. ARCo'07: Cognition – Complexité – Collectif, ARCo

INRIA – EKOS 189–202. https://inria.hal.science/inria-00192153v1

3. Froesch D (1973) On the fine structure of the *Octopus* iris. Z Zellforsch 145:119–129
4. Hanke FD, Kelber A (2020) The eye of the common octopus (*Octopus vulgaris*). Front Physiol 14. https://doi.org/10.3389/fphys.2019.01637
5. Hanlon RT (1988) Behavioral and body patterning characters useful in taxonomy and field identification of cephalopods. Malacologia 29:247–264
6. Hanlon RT, Messenger JB (1996) Cephalopod Behaviour. Cambridge University Press, Cambridge
7. Mather JA (2019) What is in an octopus's mind? https://doi.org/10.51291/2377-7478.1370. Anim sentience 26
8. Mather JA, Mather LM (2006) Apparent movement in a visual display: the 'passing cloud' of *Octopus cyanea* (Mollusca: Cephalopoda). J Zool 263:89–94. https://doi.org/10.1017/S0952836904004911
9. Messenger JB (2001) Cephalopod chromatophores: neurobiology and natural history. Biol Rev 76:473–538. https://doi.org/100.1017/S1464793101005772
10. Packard A, Sanders GD (1971) Body patterns of *Octopus vulgaris* and maturation of the response to disturbance. Anim Behav 19:780–790
11. Renoue M, Carlier P (2006) Au sujet des couleurs de céphalopodes — rencontre de points de vue sémiotique et éthologique. Semiotica 160:115–139. https://doi.org/10.1515/sem.2006.042
12. Scheel D, Godfrey-Smith P, Lawrence M (2016) Signal use by octopuses in agonistic interactions. Cur Biol Rep 26:377–382. http://dx.doi.org/10.1016/j.cub.2015.12.033
13. Tinbergen N (1963) On aims and methods of ethology. Z Tierpsychol 20:410–433. https://doi.org/10.1111/j.1439-0310.1963.tb01161.x

Figures

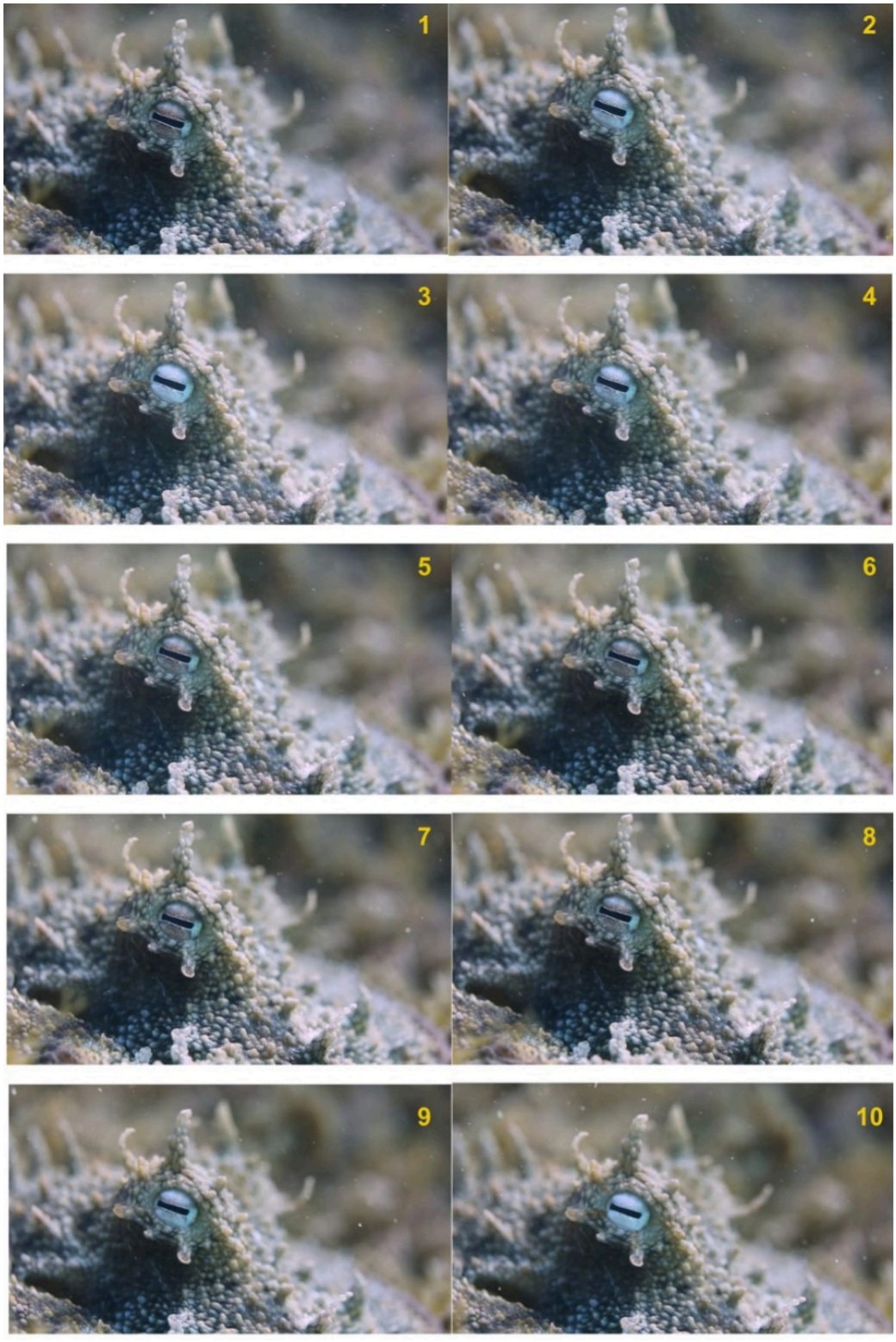


Figure 1

A 5-second continuous segment of the sequence for subject O1, with one frame every 0.5 seconds, to be viewed by following the numbering from left to right and top to bottom.

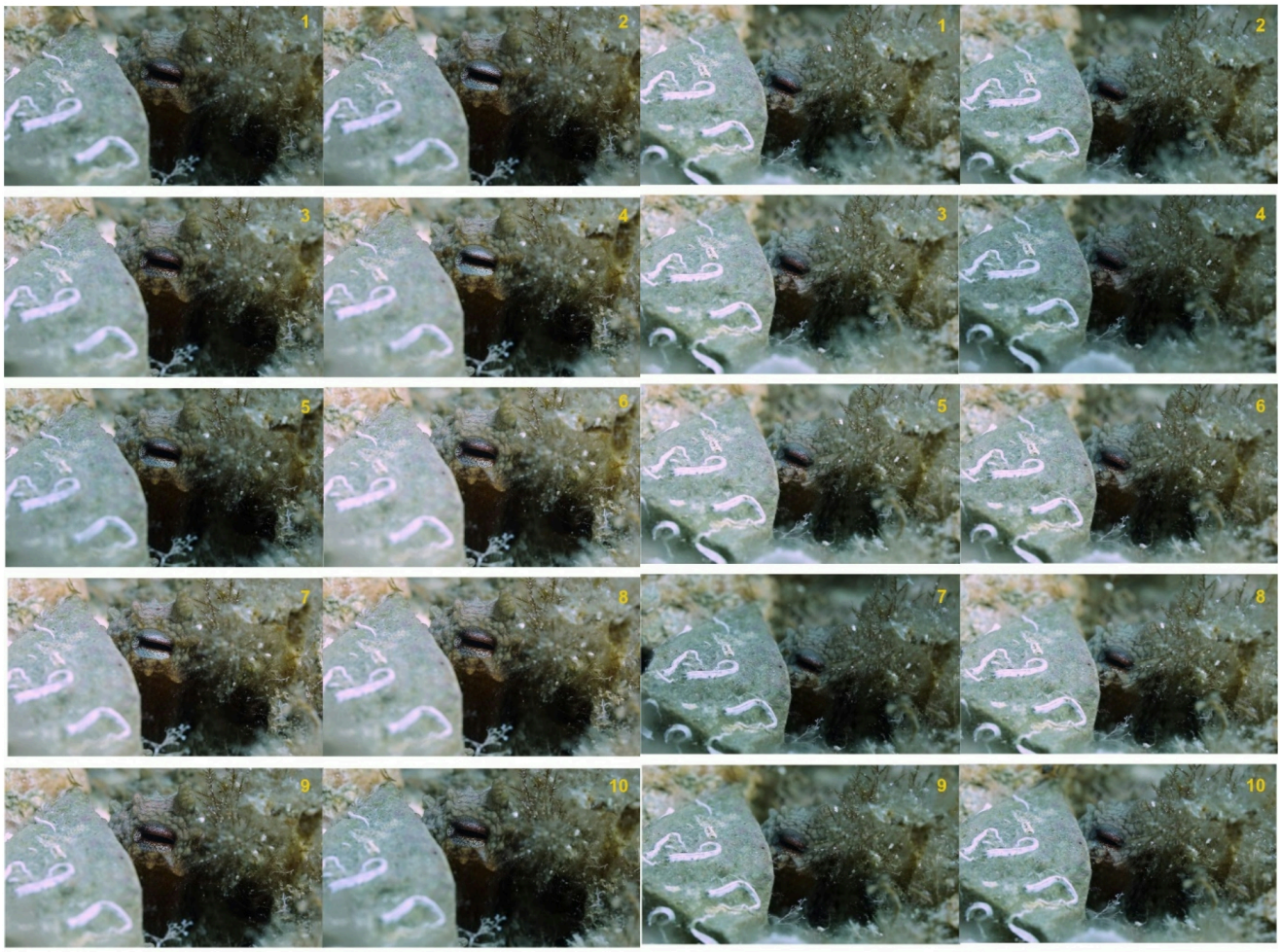


Figure 2

(a) and (b) A 5-second continuous segment of the sequence for subject O3, with one frame every 0.5 seconds, to be viewed by following the numbering from left to right and top to bottom.

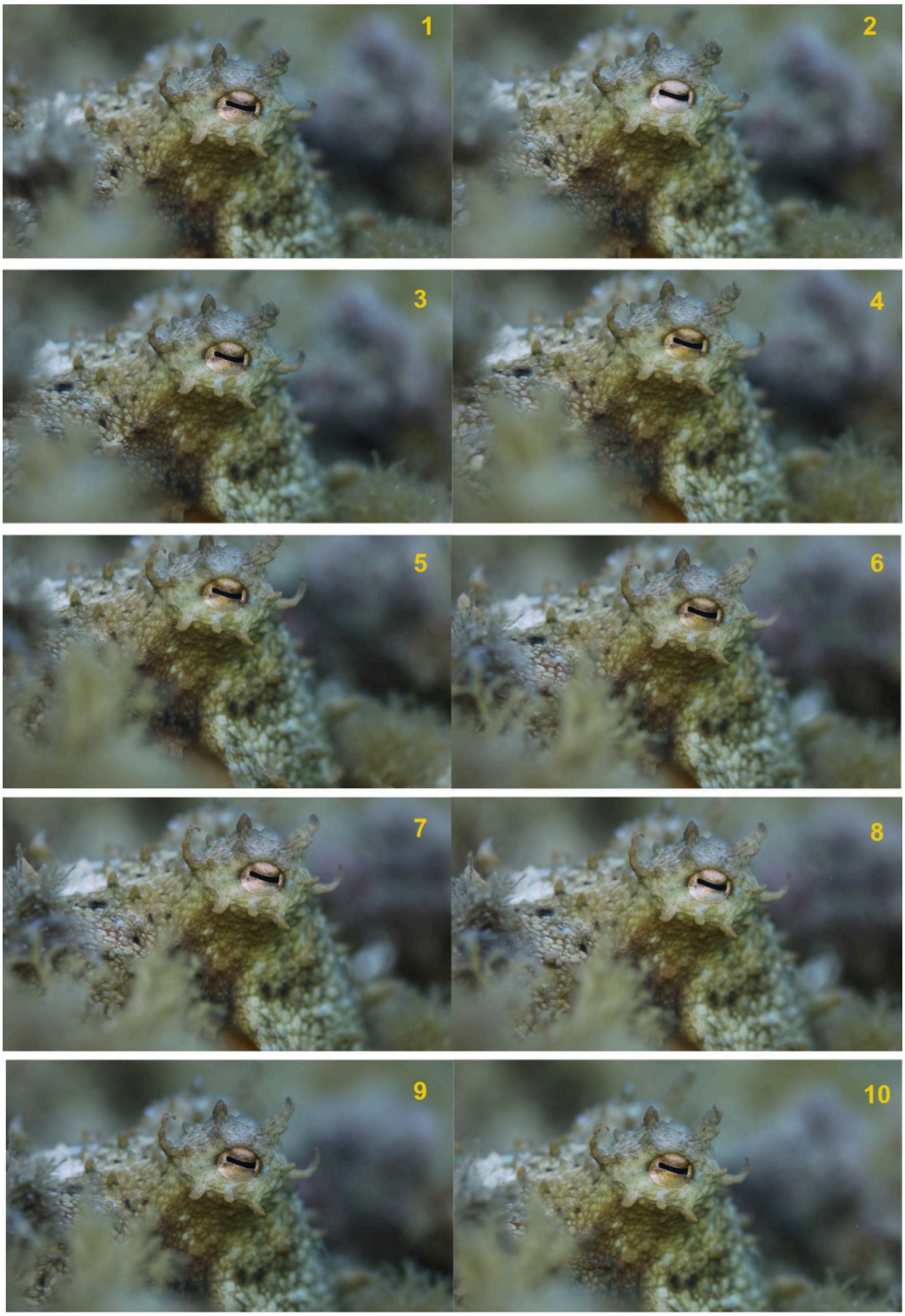


Figure 3

A 5-second continuous segment of the sequence for subject O7, with one frame every 0.5 seconds, to be viewed by following the numbering from left to right and top to bottom.

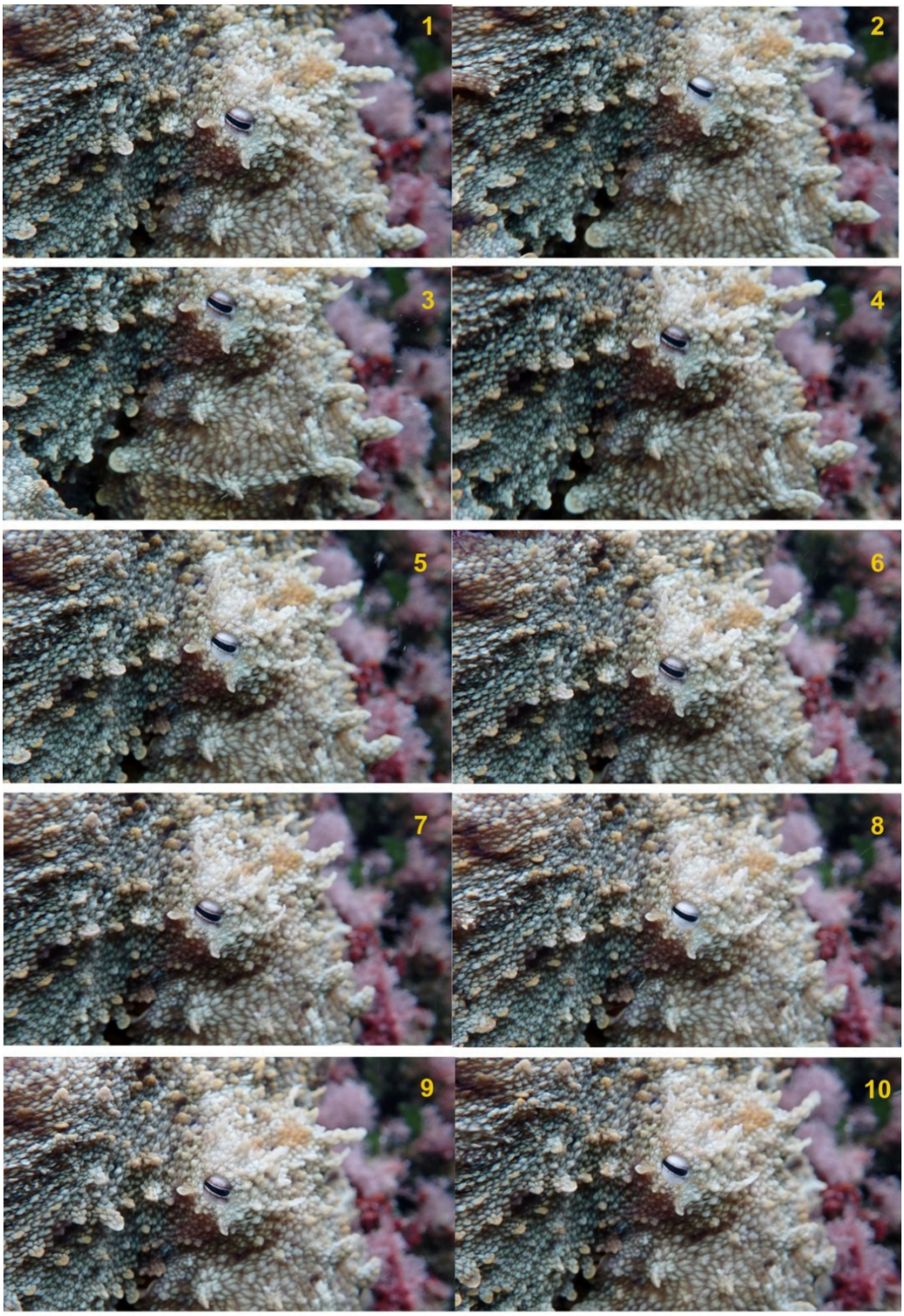


Figure 4

A 5-second continuous segment of the sequence for subject O8, with one frame every 0.5 seconds, to be viewed by following the numbering from left to right and top to bottom.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Videoirischanging.mp4