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Conserving urban habitats: Enhanced detection of common swift nests in buildings using a video fusion method

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Abstract

1. Common swifts (*Apus apus*) nest in cavities and cracks in building facades and roofs. It is a declining species in Europe, partly due to the loss of suitable breeding habitat caused by urban building renovation (e.g. thermal insulation). In several countries, building renovation projects imply quantifying the amount of habitat occupied by swifts that will be destructed, and proposing compensatory measures, such as installing nest boxes in the renovated building. A difficulty is that nesting swifts are uneasy to detect visually.
2. Here, we report a new video method we used to improve swift nest detection. It is based on continuous filming of a building's facade (for 1–2 h) and later video frame fusion to reveal swift flying in and out of cavities in the facade.
3. We successfully used this method on two large building renovation projects, revealing larger than expected breeding populations (78 nests) and resulting in the implementation of ambitious compensation measures (212 nestboxes), commensurate with the habitat actually destroyed.
4. Based on a continuous dataset of swift passages during a full breeding season, we discuss the favourable period in the season and day hours to efficiently detect nesting activity and assess building occupancy.
5. *Solution*. A video method is proposed to survey bird populations nesting in walls or cliffs. Video frame fusion reveals the fleeting movements of birds to their hidden nests. We provide software to use this tool in conservation projects, in particular ecological inventories prior to building renovation work.

KEYWORDS

Apus apus, building renovation, cavity-nesting birds, habitat loss, urban biodiversity

1 | INTRODUCTION

The common swift (*Apus apus*) is a declining species in France (population decline estimated at –46% between 2001 and 2019; Fontaine et al., 2020) and in other European countries (e.g. –38%

between 1995 and 2010 in the UK; Balmer et al., 2013). This species has a *Near Threatened* status in France (UICN France, MNHN, LPO, SEOF, ONCFS, 2016). Among the possible causes of decline, studies have focused on climate change and climate anomalies, both in Europe (Rajchard et al., 2006; Thomson et al., 1996) and in the

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wintering area of the common swift (Ambrosini et al., 2011; Boano et al., 2020), located in sub-Saharan Africa (Åkesson et al., 2020). Furthermore, as these birds are aerial insectivores, the decline in the quantity of insects available (Goulson et al., 2015; Hallmann et al., 2017), due in particular to the use of pesticides, is also considered to be a direct cause of the species' decline (Møller et al., 2021). Lastly, as common swifts mainly nest in cavities and cracks in the facades and roofs of buildings, the gradual depletion of this urban habitat, due to the modernisation of buildings (e.g. renovation, waterproofing, external thermal insulation, demolition and new construction techniques) is a third cause of decline (Balmer et al., 2013; Crowe et al., 2010; Dulisz et al., 2022; Genton & Jacquat, 2014; Schaub et al., 2016).

When building demolition or renovation projects may impact this urban habitat, recommendations exist in several European countries for conserving or recreating habitat suitable for breeding swifts (e.g. Switzerland: Scholl, 2016; Ireland: Whelan et al., 2018; Italy: Gelati et al., 2019; France: LPO, 2024). In France, the destruction of common swift habitat is prohibited by law (as for any other protected species; Légifrance, 2025a, 2025b) and can only be done after obtaining a derogation, which implies compensatory measures, in particular by installing nest boxes as part of the building project and subsequent monitoring of nest box occupancy. Similar obligations exist in other countries, such as Germany and Poland (Schaub et al., 2016). The installed nest boxes can help keep common swift

colonies in place, but it often takes several years for them to be occupied (Dulisz et al., 2022; Schaub et al., 2016).

The first step is to determine whether a building actually is a habitat occupied by swifts. An inventory of the number of cavities and cracks occupied by breeding birds on each façade of the building has to be carried out during one or more breeding seasons preceding renovation. This inventory is the basis on which the compensatory measures can be sized: in France, 2 to 3 nest boxes are usually required per active nesting cavity destroyed. The usual census method consists of visually observing the façade for at least 1 h to detect swifts arriving or leaving their cavity (e.g. Nöbauer et al., 2018; Schaub et al., 2016). In practice, this method requires a great deal of visual attention, as nesting swifts only pass through in a fraction of a second and are very discreet (contrary to non-breeding, screaming swifts). Even for experienced observers, this direct visual method is not infallible, particularly on large buildings where numerous cavities may be present. It is easy to confuse two neighbouring cavities if several passages occur at the same time, or if the observer's attention is not full and constant.

2 | METHODS

To overcome these difficulties, we developed a video method that increases the likelihood of detecting common swifts' nests (Figure 1).

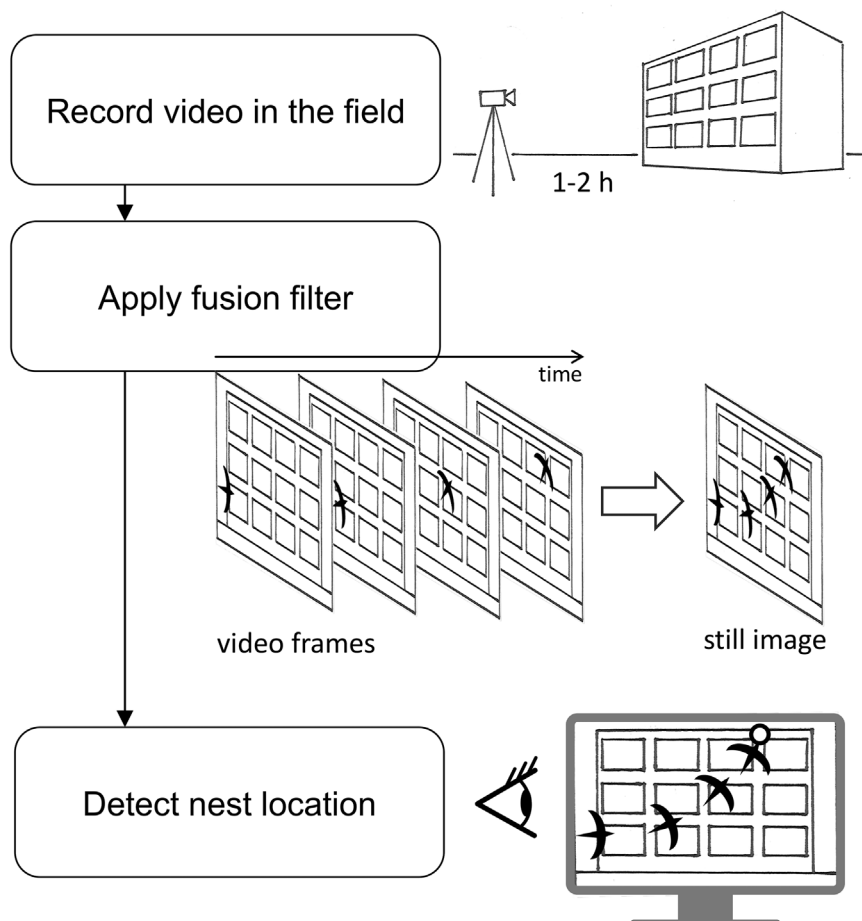


FIGURE 1 Schematic flowchart of the video fusion method.

First, we film a facade continuously for 1 to 2h from a fixed point. Second, to facilitate and accelerate the videos' analysis back in the laboratory, we merge the frames of the video by applying a *minimum* filter that retains only the darkest value of each pixel over the chosen number of frames (i.e. the chosen duration). This *video fusion* process sums up the duration of the video in a single still image, where the swifts' passages appear clearly. This way, we obtain a record of all the birds passing through the wall during the recording session, with the precise locations of all the nesting cavities. Figure 2 below shows the results obtained in a real-world example.

The fusion filter can be formally written as follows:

$$V_{x,y} = \min \{v_{x,y,t}\}_{t=1}^n \quad (1)$$

with $v_{x,y,t}$ the value of a pixel at position x (horizontally), y (vertically) and at time t in a video sequence (containing n frames). $V_{x,y}$ the value of a pixel at position x, y in the final merged still image.

This filter is applied to each channel of the video file (i.e. 3 channels for RGB videos).

As storing all frames of a video in memory to find the overall minimum value is unpractical, the filter can be applied recursively while playing the video file:

$$V_{x,y} = \min \{v_{x,y,t}, V_{x,y}\} \quad (2)$$

In practice, merging a very long video sequence into a single image is not the best option, because too many birds (and possibly insects) passing through the frame decreases the readability of the image and can make it difficult to see whether the bird has really entered a cavity in the facade (i.e. the bird trajectory must disappear at the cavity entrance). Hence we usually merge the video by one-minute segments, which for a 2-h video produces 120 still images, which are quick enough to inspect and hence assess facade occupancy.

The favourable period to detect common swifts' nests is when the adults perform regular roundtrips to feed the young (Arens, 2011a, 2011b; Nöbauer et al., 2018). In French Brittany, this usually corresponds to late June to mid-July, but note that the period varies greatly depending on the latitude and year (Åkesson et al., 2020; Genton & Jacquat, 2014). The usually recommended hours for visual detection are in the evening around sunset (Nöbauer et al., 2018), but may also include the late morning (Schaub et al., 2016), where feeding visits are also frequent (Arens, 2011a, 2011b; Rodriguez-Teijeiro, 1981). With the present video method, the efficiency of detection depends on the recording duration, as shown in Figure 3: while a 1-h video can be enough to detect a nest in the highest activity periods (i.e. late afternoons and evenings after hatching), a 2-h video duration can provide an

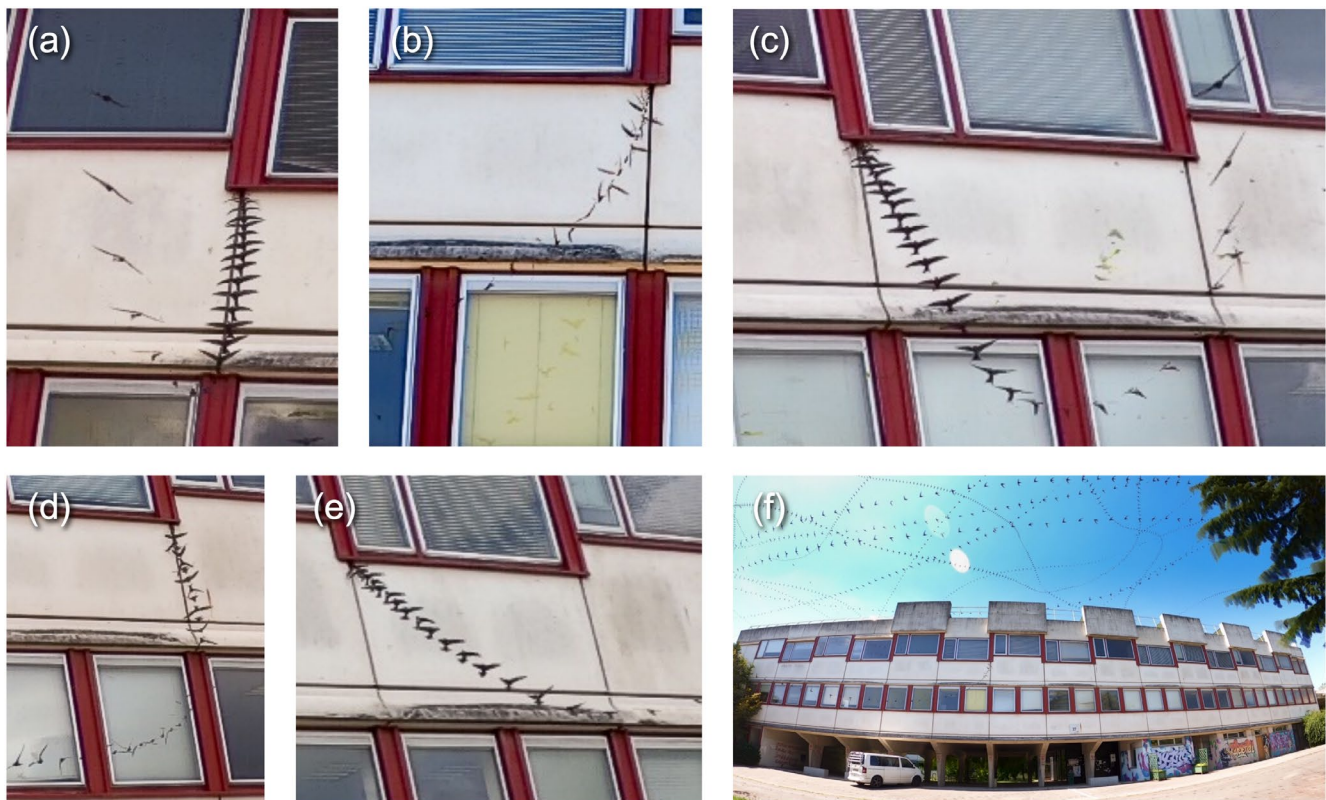


FIGURE 2 (a–e). Common swifts passing through cavities in the facade of a building (f), filmed for 2h at 30 frames per second with a static wide angle camera (Gopro® Hero 8 black). Video frames were merged to produce a still image, by applying a filter that retains the darkest value of each pixel over the video duration. As swifts are darker than the building, their flight trajectories to and from cavities are revealed and easily detectable. Note that gliding flight (a, c, e) indicates a swift entering the facade, whereas flapping flight (b, d) indicates a bird exiting the building.

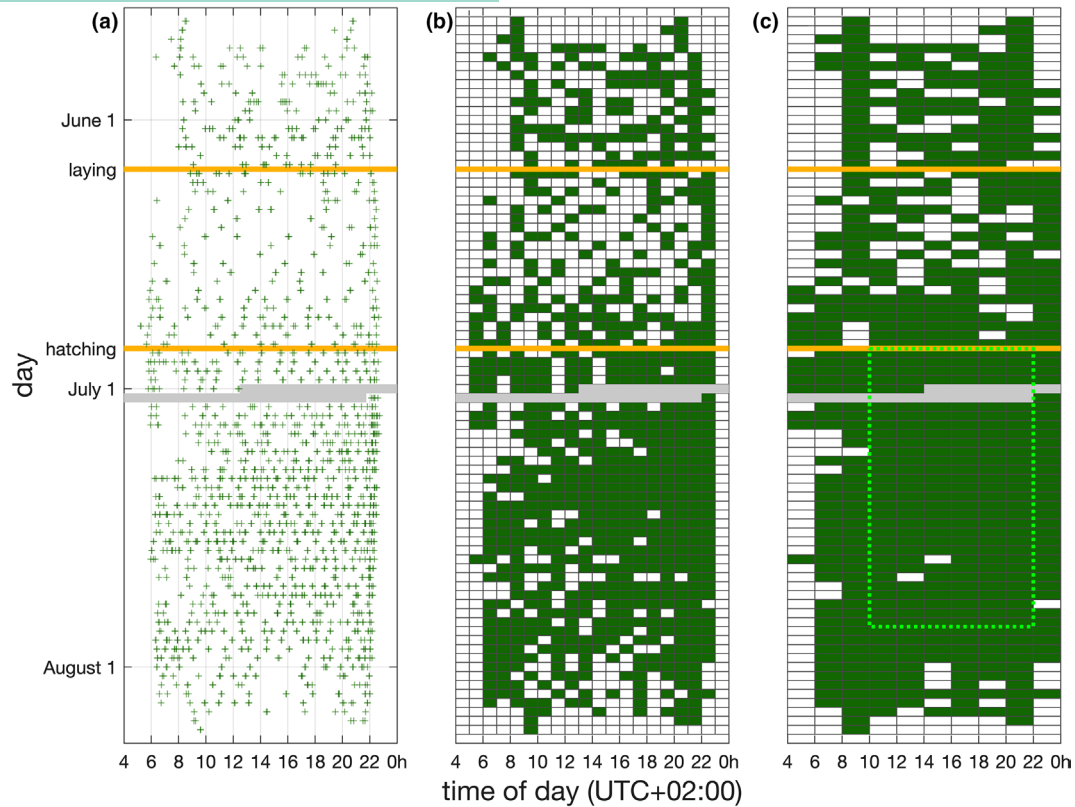


FIGURE 3 Example time distribution (days vertically downwards, hours horizontally) of passages performed by a couple of common swift adults flying in and out of their nest cavity. (a) Representation of each bird passage (green crosses) recorded using an IP camera placed inside a nest box in Rennes, France, from May to August 2024. Recording started on the first morning with both birds in the nest box (May 21). Two eggs were laid on June 7–8 and hatched on June 27–28. There was a network interruption on July 1–2, causing some data loss (grey area). Both adults and both juveniles left the nest box on August 7–8. Comparing the pre-laying period (May 21–June 7), the incubation period (June 8–27) and the feeding period (June 27–August 8), the third period had the highest density of passages. (b) 1-h time slots containing at least 1 passage are coloured in green, while time slots containing no passage are left blank. Assuming an observer filming from outside the building for 1 h continuously, the nest detection would have been most effective during the late afternoons and evenings (18–22 h), as this period contains green slots almost entirely for approximately 20 days following hatching. (c) Following the same procedure with 2-h time slots shows that doubling the video duration greatly improves passage recording probability: Almost any 2-h slot between 10 and 22 h, for at least 30 days after hatching (green dotted perimeter) would have detected 1 passage (or more) in or out of the nest box.

efficient detection throughout most of the day (10–22 h), for approximately 30 days after hatching.

3 | RESULTS AND DISCUSSION

We applied this video method to survey common swift nests before two university campus renovation projects (external thermal insulation), in Rennes, France. By filming each facade of these large campus buildings for 2 h, we were able to detect 78 active swift nests (de Margerie, Bernard, & Sandoz, 2023; de Margerie, Bernard, Sandoz, & Chauvin, 2023), much larger populations than initially anticipated from early visual observations (30 min. visual inspection per facade detected only about 1/3 of active nests). Figure 2 displays the result of the *video fusion* filter for one of the campus building facades and shows that split-second passages of swifts to their hidden nests are revealed and easily identified. As compensatory measures, the local biodiversity authority (DDTM 35)

decided that 212 nest boxes should be integrated into the renovated facades, from 2024 to 2027.

Another benefit of the present method is that recorded images provide concrete evidence that birds inhabit a facade. Still images can easily be shared with the various parties involved in the building project, who may not have been able to see swifts entering the building for themselves.

To allow this video detection method to be used on other conservation projects, we provide free software for merging video frames (<https://github.com/edemargerie/videoFusion>), with a detailed user manual and technical guidelines on how to implement the method in the field.

Note that the present method can be used to detect other bird species nesting in cavities in walls, roofs or cliffs (e.g. martins, sparrows, tits, redstarts) or even bats with some diurnal activity. A limitation is that, for the frame fusion filter to yield easily interpretable images, the brightness value from the animal's body should be contrastingly darker than the image background, which

is not always possible with darker building facades. In the case of a species appearing brighter than the facade, one can modify filter (1) by replacing the *min* function with a *max* function, as shown in Figure 4.

Another technical limitation can come from the size of the birds relative to the camera field of view. If evidence of occupation is sought for small species that are visually similar (e.g. blue tit vs. great tit), care must be taken to ensure that the resolution of the video images (i.e. number of pixels on the bird) allows the species to be identified. Therefore, if the façade being surveyed is very wide or tall, it may be necessary to use two cameras, each covering half of the façade.

A last limitation of the technique occurs when there is a lot of activity, with birds constantly flying in front of the facade. This happens regularly with swifts, with non-nesting birds that may come very close to the entrance of the nests without actually entering. To avoid confusing this type of behaviour with a nesting bird, it may be

useful to go back and check the video file to validate that the bird actually entered and stayed in the nest for some time. If too many trajectories are mixed together in the merged image from 1 min of video, it is also possible to redo the fusion based on a shorter duration, for example one merged image per 20s video segment.

Compared to traditional visual inventories, the video fusion method may appear more complex, as it requires the use of a camera in the field and a subsequent phase of video file processing (Table 1). In practice, this can be an advantage, as there are many more people trained to record video than there are trained to visually detect a swift or a redstart entering a small cavity. In other words, the field data collection phase can be carried out by non-ornithologist professionals or even by anyone who has learned how to use a camera. This method could therefore potentially be used as part of a citizen science approach to collect data on a larger scale, for example in a neighbourhood or across an entire city.

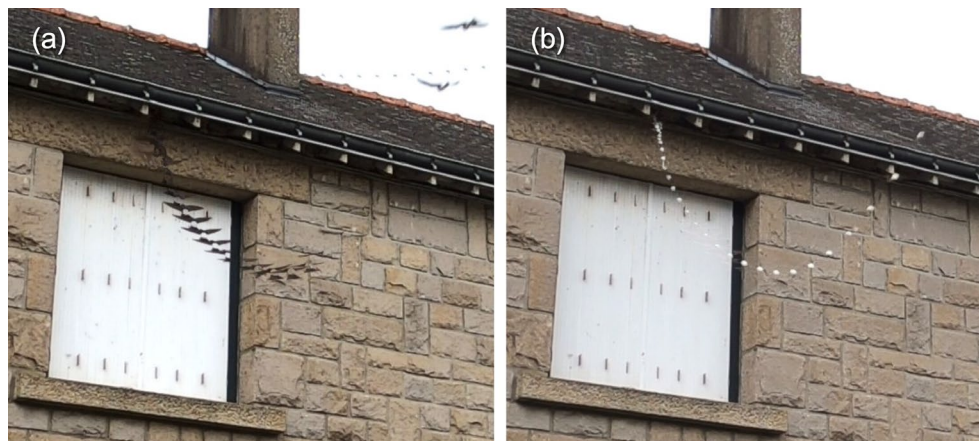


FIGURE 4 Examples of video fusion results for a house martin (*Delichon urbicum*) approaching a nest. (a) *min* fusion filter: As the facade of the building is grey, with a dark roof, the bird silhouette does not detach well from the background, and detecting the bird's trajectory is not straightforward. (b) Changing the fusion filter to a *max* function retains the trajectory of white spots in the bird's plumage, which helps visualizing the bird's path to its nest.

TABLE 1 Summary comparison of video fusion versus conventional visual survey.

	Strengths	Limits
Visual survey	<ul style="list-style-type: none"> No camera needed Self-contained field observations, no post-processing of data 	<ul style="list-style-type: none"> Requires experienced observers with constant visual attention Each observer can only survey one facade at a time Large building facades with many cavities require more attention, possibly 2 or more observers
Video fusion	<ul style="list-style-type: none"> Video recording in the field can be carried out by non-ornithologists, with minimal technical training 2 or more building facades can be recorded simultaneously with 2 or more cameras Provides visual, shareable evidence of building occupancy by birds 	<ul style="list-style-type: none"> Requires time for post-processing videos and observing generated still images

AUTHOR CONTRIBUTIONS

Emmanuel de Margerie conceived the ideas and designed methodology and software; Nicolas Sandoz and Emmanuel de Margerie collected the data; Nicolas Sandoz and Emmanuel de Margerie analysed the data; Emmanuel de Margerie led the writing of the manuscript. Both authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

PEER REVIEW

The peer review history for this article is available at <https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/2688-8319.70183>.

DATA AVAILABILITY STATEMENT

The swift nest data used to generate (Figure 3) are available (de Margerie & Sandoz, 2025).

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