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RESEARCH PAPER

Using videos from social media to study the begging behaviour of peregrine falcon (*Falco peregrinus*) nestlings

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Abstract

In 2013, two papers suggested behavioural biologists to use videos available on social media as a tool for investigating animal behaviour, a methodology referred to as video mining. Here, this approach was applied to the study of specific aspects of peregrine falcon (*Falco peregrinus*) nestlings' behaviour at critical developmental stages. Special attention was given to food begging behaviour and its development. The materials included 254 videos (from 31 nests and 51 different broods) that underwent strict selection procedures to ensure their reliability and quality. Following age estimation of the nestlings, videos were divided into four classes to study age-related differences in begging behaviour. No statistically significant differences emerged among age classes. Video mining may represent a valuable tool for qualitative analyses if wisely and rigorously applied in suitable species and for appropriate research questions. Besides, the video mining approach could also be applied in citizen-science-based studies.

Keywords Aggressive behaviour · Development · Food begging · Self-maintenance behaviour · Video mining

1 Introduction

The currently ongoing COVID-19 pandemic is severely affecting higher education and research. Students have often limited access to laboratories; moreover, frequent lockdowns hamper the possibility to perform field research, as well (Agasisti and Soncin 2021). Thus, an alternative approach is needed. Two articles published in 2013 suggested behavioural biologists to employ videos from social media (i.e., YouTube) as a research source, a methodology referred to as video mining (Nelson and Fijn 2013; Rault et al. 2013).

As stated by Nelson and Fijn (2013), video mining could be especially useful when analysing previously unknown or poorly described behavioural patterns, thus providing evidence of their occurrence. According to Rault and co-authors, this methodology could be used to examine not only the behaviour of rare or even endangered species, but also that of species like dogs, horses, etc. that appear very frequently in visual media (Rault et al. 2013). So far, scientists have given videos available on social media platforms little if any attention and, therefore, scarce practical guidance is currently available.

Although, in principle, video mining could be potentially applied to the study of the behaviour of any species for which videos are available on social media, we decided to focus on a particularly suitable species based on the following characteristics: (1) easy identification of individuals of the species; (2) adequate pre-availability of data regarding ecological and behavioural aspects of the species; (3) little, if any, direct influence on behaviour from humans (compared to ground-dwelling species); (4) abundance of videos on social media.

Based on these considerations, we considered appropriate to use the peregrine falcon (*Falco peregrinus*; Tunstall 1771) as a model for video mining.

Being nearly cosmopolitan, the peregrine falcon is well known throughout the world (Glutz von Blotzheim et al. 1989). Besides its worldwide diffusion, other characteristics contribute to making peregrines an iconic species in the public eye: among others, their excellent hunting skills, with the record diving speed of more than 320 km/h (Ponitz et al. 2014), their increasing presence in the cities (Zoratto et al. 2010), and finally the success story of their recovery after being severely endangered by the bioaccumulation

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of DDT and other biocides (Cramp 1980; Ratcliffe 1970; White et al. 2002). Moreover, being an apex predator, the peregrine is considered a good indicator of an ecosystem's health (Schwarz et al. 2016). The iconic value of this species explains the relative abundance of peregrines' videos on social media. Many of these videos were shot through the so-called nestcams, small cameras mounted in front of nests, mostly in cities. Nestcams continuously stream videos that are usually freely accessible to the public. Although it is usual for scientists to mount cameras in front of nests (Booms and Fuller 2003; Franzreb and Hanula 1995; Mallord et al. 2012; Robinson et al. 2015), so far videos from third-party nestcams have been scarcely used (Kettel et al. 2016).

Food begging is a behavioural pattern, particularly widespread among birds and mammals, by which a young individual communicates to its parental generation a short-term information, usually corresponding to a request for food (Bengtsson and Rydén 1983; Godfray 1995). Most of the current knowledge about the development of food begging in peregrines derives from Nelson's work (Nelson 1970, 1972, 1977). Until 17–18 days old, chicks beg in a nearly vertical position, with the head pointing up to the parent (generally the mother) and the beak that is repeatedly opened, preparing to the feeding event. While they barely move during the first few days, starting from approximately 22 days old, chicks can move smoothly in the nest, although often standing still when the adult arrives with the prey. Begging behaviour at this stage includes loud and insistent vocal emissions, especially when the adult lands without food or leaves the nest before all nestlings are satiated. In the meanwhile, chicks tend to adopt a more horizontal posture. When 29 days old, nestlings beg vigorously whether the adult provides food or not; moreover, they actively catch the bite, instead of just waiting for a beak-to-beak feeding. Often, after catching a large volume of food (even the entire prey), the nestling isolates itself from the others to eat alone. At 36 days old, the posture is fully horizontal. Finally, Nelson reported that the nestling begging the most is also the most likely to receive the largest amount of food (Nelson 1970).

Here, we report an observational study conducted by employing video mining on a suitable species, the peregrine falcon. Specifically, our exploratory study aimed to further investigate specific aspects of nestlings' behaviour (i.e., food begging, self-maintenance behaviours, and inter-siblings aggressive behaviour) with special attention to their development, a key concern in behavioural biology. Notably, this approach allowed us to overcome the limitations due to the COVID-19 pandemic, since all activities could be performed on a laptop (Agasisti and Soncin 2021). In addition to presenting the results of the behavioural analysis, we aimed to assess the reliability and practicability of video mining as a research methodology for behavioural studies.

2 Materials and methods

2.1 Collection of videos

We used videos collected from Facebook, YouTube, and Vimeo, since these platforms provide an internal search engine that allows a systematic search of videos. Moreover, videos published on these platforms are generally longer than those found in other websites (Bik and Goldstein 2013).

For the collection of videos, we used the following keywords in several combinations: 'falcon', 'peregrine', 'nest', 'fledglings', 'chicks', 'feeding', 'nestcam', and 'webcam'. Videos were summarily looked at and then included in a database. For each video, the following data were listed: title, URL, social media platform, date of recording and/or publication, place, author, and duration. Videos and nests were numbered, to keep track of the different broods when more videos of a given nest were found. A total of 254 videos were collected, referring to 31 nests and 51 different broods and accounting for more than 44 h of duration (Table 1). The full database is reported in Supplementary Item 1. The duration of the videos was highly variable (mean ± standard deviation: 633 ± 3631 s) and ranged from 4 s to about 12 h. Videos were shot in Australia, Canada, Germany, Italy, Holland, Poland, Spain, UK, and USA (Fig. 1).

2.2 Selection criteria

The selection occurred through the application of inclusion and exclusion criteria defined prior to the collection of videos. The criteria, intended to assess the reliability and the validity of the videos, were defined by following, expanding, and readapting what was suggested by Rault and co-authors (2013) and by Nelson and Fijn (2013).

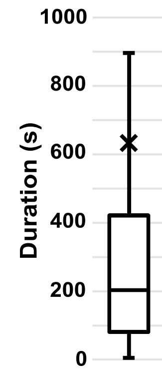
Inclusion criteria: (I1) Subjects accepted: parental generation and offspring (post-hatching) OR offspring (post-hatching); (I2) scarce or absent interaction with humans, noted if any; (I3) raw footage, no signs of editing; (I4) video consisting of one main scene with few different clips—a maximum of four clips was accepted; (I5) titles, subtitles, and music were accepted as long as they could be ignored.

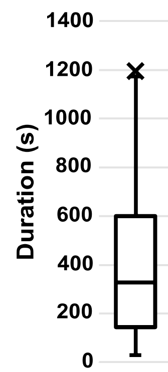
Exclusion criteria: (E1) Length lower than 30 s; (E2) poor image quality (i.e., low resolution, video too blurry or hard to follow, subject too far and hardly visible); (E3) subject not continuously visible; (E4) presence of other animal species; (E5) suspect of possible influence or manipulation by non-visible elements (i.e., previous and unrecorded events); (E6) nature of documentary film; (E7) time-lapse video.

Only 102 of the 254 initially collected videos (40.2%) overcame the selection phase, reducing the total duration

Table 1 General information regarding the videos collected in the database, before (column in the middle) and after (column on the right) the application of the inclusion and exclusion criteria described in paragraph 2.2 ("selection criteria")

	Database of collected videos	Videos resulting from application of selection criteria
N of videos	254	102
N of nests	31	18
N of broods	51	33
Average N of videos per nest	8.19	5.67
Average N of videos per brood	4.98	3.09
Videos source:		
YouTube	184 (72.4%)	79 (77.5%)
Facebook	51 (20.1%)	16 (15.7%)
Vimeo	17 (6.7%)	5 (4.9%)
Other	2 (0.8%)	2 (2.0%)
Videos duration:		
Total	160841 s (44h 40' 41'')	121808 s (33h 50' 8'')
Minimum	4 s	30 s
Q_1	82.3 s (1' 22.3'')	145 s (2' 25'')
Median	203 s (3' 23'')	328 s (5' 28'')
Q_3	418.5 s (6' 58.5'')	600 s (10')
Maximum	42896 s (11h 54' 56'')	42896 s (11h 54' 56'')
Average	633 s (10' 33'')	1194.2 s (19' 54.2'')
Standard deviation	3630.6 s (1h 0' 30.6'')	5683.3 s (1h 34' 43.3'')





The figure insets (Box and Whisker plots) represent the duration of all collected videos (above) and the duration of videos after the application of selection criteria (below)

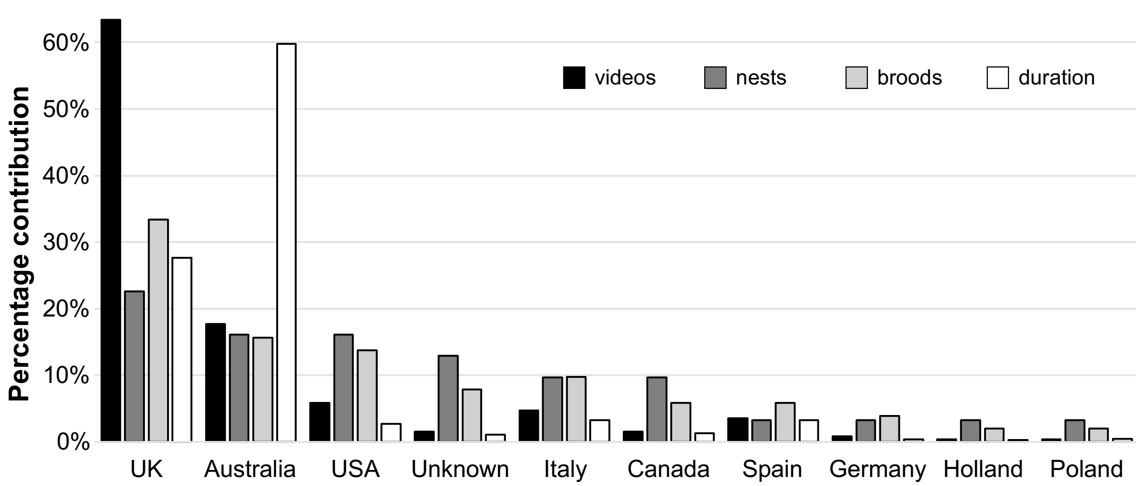


Fig. 1 Percentage contribution of the different countries to the number of videos, nests, broods, and duration of all 254 videos collected in the database

to approximately 33 h (Table 1). The exclusion of a video was often due to the application of two or more criteria. The list of the nests and broods included in these 102 videos is reported in Table 2, together with the location of the nest and the size of each brood.

2.3 Age classes

Since the period between hatching and first flight in peregrine falcons lasts from 35 to 42 days (Cramp 1980), we considered four age classes: (A) 0–7 post-hatching days (phd); (B) 8–15 phd; (C) 16–23 phd; (D) more than 23 phd.

We assigned each of the 102 selected videos to the corresponding age class (Table 2) by observing the morphology

Table 2 List of the nests and broods included in the 102 videos resulting from the application of the inclusion and exclusion criteria described in paragraph 2.2 ("selection criteria")

Nest	Brood	Video duration (s) per age class				Location	Video duration (s)	Brood size
		A	B	C	D			
01					315	Unknown	315	2
03					1092	Unknown	1092	3
05	a		84			Alcalá de Henares, Spain	84	3
	b	426	2026		189		2641	4
	c	919	584	989			2492	4
07	a				149	Bath, UK	149	4
	b	602			1916		2518	4
	c	346	143				489	4
	d	35	157		350		542	4
08			46			Bologna, Italy	46	3
09	a				47	Bowling Green, Ohio, USA	47	3
	b	652					652	4
14		161				Hopewell Cape, Canada	161	3
17			696			Lublino, Poland	696	5
18			82,168			Melbourne, Australia	82,168	3
19	a	601				Milano, Italy	601	3
	b	100					100	3
	c	437					437	3
20				301		Mississauga, Ontario, Canada	301	3
21	a				380	Munich, Germany	380	4
	b				195		195	3
22		1621				Montreal, Canada	1621	3
23	b			594	351	Mornington Peninsula, Australia	945	3
25	a			897	1373	Nottingham, UK	2270	4
	b	3057		61	302		3420	4
	c	418					418	3
	d	304					304	4
	e	939			552		1491	4
	g	3180			1602		4782	3
	h	3721		705	1476		5902	3*
26			305			Roma, Italy	305	4
29	a			483	1908	Victoria, Australia	2391	4
30				268	1585	Victoria, Australia	1853	3
N of nests 18	**N of broods 33**	**Tot. duration 17,519 s**	**86,209 s**	**4298 s**	**13,782 s**	**–**	**Tot. duration 121,808 s**	**Average brood size 3.5**

As described in paragraph 2.4, all videos of a given brood were put in a random order and considered as one long video, whose duration (in seconds) is reported in the table. The location of the nest and the size of each brood are also shown. Videos are distributed among the four age classes (A: 0 to 7 phd; B: 8 to 15 phd; C: 16 to 23 phd; D: more than 23 phd). Nests, broods, and videos follow the same numbering used in the database. phd: post-hatching days. *only 1 viable egg and the plumage. In particular, the age was estimated through the indications available in the literature, which provide a detailed description of the development of the plumage cover from hatching to adulthood (e.g., Cade and Enderson 1996). When the exact date of hatching was known, the age was calculated from the recorded date.

2.4 Sampling and observations' planning

Since all selected videos frame a given nest without interruptions, we decided to sample periods of 300 s for each single brood. Such period could derive from one or more videos and was determined as follows: (1) all selected videos of a given brood were put in a random order and considered as one long video, whose duration (measured in seconds) was defined as '*d*'; (2) for each single brood, a random number '*n*' between '0' and '*d*—300' was drawn; (3) the period of observation began on the *n*th second of the long video and ended 300 s thereafter. It followed that '*n*' and '$n+300$' did not necessarily belong to the same original video; when this was the case, the observation period consisted of multiple videos. Only broods with no less than 300 s of videos available were sampled.

By means of this approach, 38 observations were planned: 14 for age class A, 5 for B, 6 for C, and 13 for D. Table 3 reports the full list of the observations. These observations were not fully independent as some broods were listed in two or three age classes. However, had we considered each brood only once, this would have resulted in an insufficient number of observations (i.e., 26 fully independent observations).

2.5 Data collection

During each single observation, we measured the frequency and duration of the following behavioural patterns: food begging (identified when the nestling would open the beak towards the adult), self-maintenance, and aggressive behaviours. In broods with two or more chicks, measurements were referred to one randomly chosen focal nestling. Since all observations lasted 300 s, frequency was expressed as the absolute number of occurrences. Finally, we added short qualitative descriptions to the behaviours observed.

2.6 Statistical analysis

We used both parametric and non-parametric tests to assess the statistical significance of any difference observed among the age classes. In particular, we applied the Mann–Whitney *U* test to compare the six couples of age classes and the ANOVA to compare the four age classes at once. Data transformation was applied to ensure more homogeneous variances for parametric analyses.

3 Results

3.1 Description of the observations

Descriptions of all observation are reported in Supplementary Item 2. The adults' gender was scored only when sexual dimorphisms was evident. When present, vocal emissions were also noted, although they were not further investigated (see Supplementary Item 2).

3.2 Food begging

Concerning its frequency, no statistically significant difference was observed within any of the six couples of age classes ($p>0.05$, Mann–Whitney *U* test). A similar result was obtained when analysing the average total duration of begging behaviours through ANOVA (Fig. 2). Interestingly, most of the variability appeared within each age class, while the different classes were rather homogeneous. Hence, the calculated value of F was <1, leading to the acceptance of the null hypothesis.

3.3 Self-maintenance behaviours

The statistical analysis of both frequency and duration of the self-maintenance behaviours was hampered by the significant heterogeneity of the variances, which prevented the use of parametric tests, as well as by the high frequency of identical values (*ex aequo*), which made non-parametric tests less reliable. In age classes A and C, all values were equal to 0.

Self-maintenance behaviours were mostly observed in age class D and more rarely in age class B (Table 4). They included preening, scratching, and toes and talons nibbling.

3.4 Aggressive behaviours

Statistics of aggressive behaviours presented the same limitations described for self-maintenance ones. We analysed them through a contingency table by converting the values of duration to a binary value 1 (duration >0) or 0 (duration $=0$). Although the $X^2{}_4$ value of 17.78 exceeded the critical value of 11.07 ($p=0.05$), the result was not fully reliable as the expected values were low (Table 4).

All aggressive behavioural patterns observed consisted in a direct beak-to-beak competition for food among nestlings (for a detailed description, see Supplementary Item 2).

Table 3 List of the 38 observations resulting from the application of the sampling method described in paragraph 2.4 ("sampling and observations planning")

Age	Observation	Nest (number)/brood (letter)	Video(s)
A	1	05b	6
	2	05c	12
	3	07b	17
	4	07c	25, 24
	5	09b	57, 55, 56, 59
	6	19a	79
	7	19c	84
	8	22	89
	9	25b	132
	10	25c	148
	11	25d	150, 152
	12	25e	158
	13	25 g	171
	14	25 h	201, 203
	14 observations	**14 broods from 6 different nests**	**20 videos**
B	15	05b	7
	16	05c	11
	17	17	75
	18	18	77
	19	26	215
	5 observations	**5 broods from 4 different nests**	**5 videos**
C	20	05c	13
	21	20	86
	22	23b	94
	23	25a	98
	24	25 h	207
	25	29a	230
	6 observations	**6 broods from 5 different nests**	**6 videos**
D	26	01	1
	27	03	3
	28	07b	19
	29	07d	48, 47, 45, 49, 46
	30	21a	87
	31	23b	95
	32	25a	100
	33	25b	137
	34	25e	161
	35	25 g	176
	36	25 h	212, 208
	37	29a	239, 231
	38	30	248
	13 observations	**13 broods from 8 different nests**	**19 videos**
Total	**38 observations**	26 broods from 16 different nests	50 videos

Observations are distributed among the four age classes (A: 0–7 phd; B: 8–15 phd; C: 16–23 phd; D: more than 23 phd). Nests, broods, and videos follow the same numbering used in the database. phd: post-hatching days

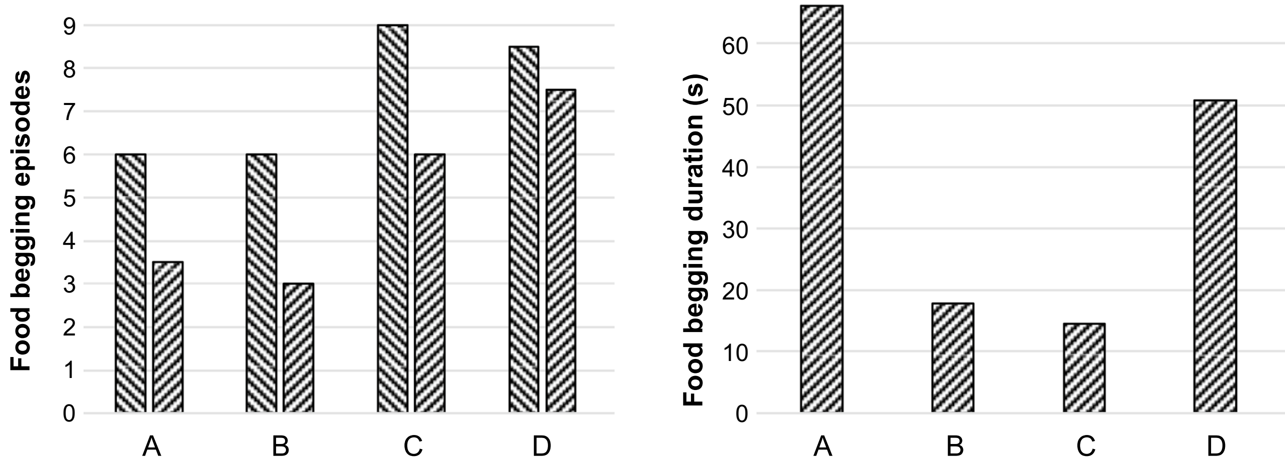


Fig. 2 Food begging in the four age classes (A: 0–7 phd; B: 8–15 phd; C: 16–23 phd; D: more than 23 phd). (Left) Within each age class, the column on the left (descending stripes) represents the median number of all food begging episodes, whereas the column on the right (descending stripes) represents the median number of food begging episodes followed by the beakful of food. (Right) Total duration (average) of food begging expressed in seconds. phd: post-hatching days

Table 4 Total duration (s) of self-maintenance and aggressive behaviours in the four age classes

	Age class			
	A	B	C	D
Duration (s) of self-maintenance behaviours	0 s	0.90 s	0 s	94.6 s
Duration (s) of inter-siblings aggressive behaviours	0 s	0.36 s	14.08 s	0.40 s

Observations are distributed among the four age classes (A: 0–7 phd; B: 8–15 phd; C: 16–23 phd; D: more than 23 phd). Values were divided for the number of observations within each age class. phd: post-hatching days

4 Discussion

4.1 Development of nestlings' behaviour

Although no statistically significant differences emerged among the four age classes, possibly due to the small size of the samples, the examined qualitative aspects were consistent with the literature available for peregrines and other Falconidae.

First, all main stages of the development of food begging described by Nelson were confirmed, even with good correspondence to the age of the nestlings (Nelson 1970). A special case, anecdotal yet remarkable, was that of brood '25 h', in which only one of the three eggs laid hatched. A few days after hatching (age class A, observation 14), the chick (already open-eyed) begged not unlike all other nestlings of the same age. However, at 2 or 3 weeks old (age classes C and D, observations 24 and 36, respectively), the same individual seemed not to beg at all. This observation suggests that food begging behaviour may be triggered by the simultaneous presence of both an adult and at least one sibling competing for the same food. This finding deserves further in-depth analyses exploring the role of factors known to trigger food begging behaviour in other species.

Second, the only aggressive behavioural pattern observed consisted in beak-to-beak competitions (lasting only few seconds) for food in siblings aged no less than 7–10 days from hatching. Consistently, there was no evidence of severe inter-siblings aggression in peregrine nestlings; moreover, unlike other raptors, siblicide was never observed (Boulet et al. 2001; Morandini and Ferrer 2015; Nelson 1970).

Thirdly, self-maintenance behaviours (including mainly preening, scratching, and toes and talons nibbling) were scored only sporadically in young peregrine falcons, which hindered sound statistical analysis. This may be due to the fact that most of the videos showed nestlings during their feeding, when peregrines are not likely to exhibit these behavioural patterns.

4.2 Limits to the behavioural analysis

The utilisation of videos published on social media poses some intrinsic limitations. For example, it is not possible to analyse the role of several factors, including the gender of the nestlings, their body weight, the amount of food ingested, and the characteristics of the environment where the nest is set. These limitations may be overcome by means of an integrated approach that could be feasible in case a nest recorded in a video published on social media is also involved in a project collecting data on the sex and/or the weight of nestlings.

Additionally, a potential bias is related to the typically monogamous mating system of *Falco peregrinus* and the tendency of a pair to use the same nest over different breeding years (Cramp 1980). As nestlings' behaviour could be influenced by the experience of their parents, different broods from a given pair may not constitute completely independent observations, as we implicitly assumed. It could be interesting to investigate aspects of reproductive biology (e.g., plasticity or ageing) by collecting data from the same pairs over different breeding years, but this would require an even larger sample size.

Finally, the quantitative analysis focused on differences among the four age classes was partially hampered by the small sample size and high variability. Indeed, we propose that the non-significance arose mainly from the small size of the samples. This is a limitation of the present study that does not necessarily apply to the video mining approach.

4.3 Conclusion: video mining as a research methodology

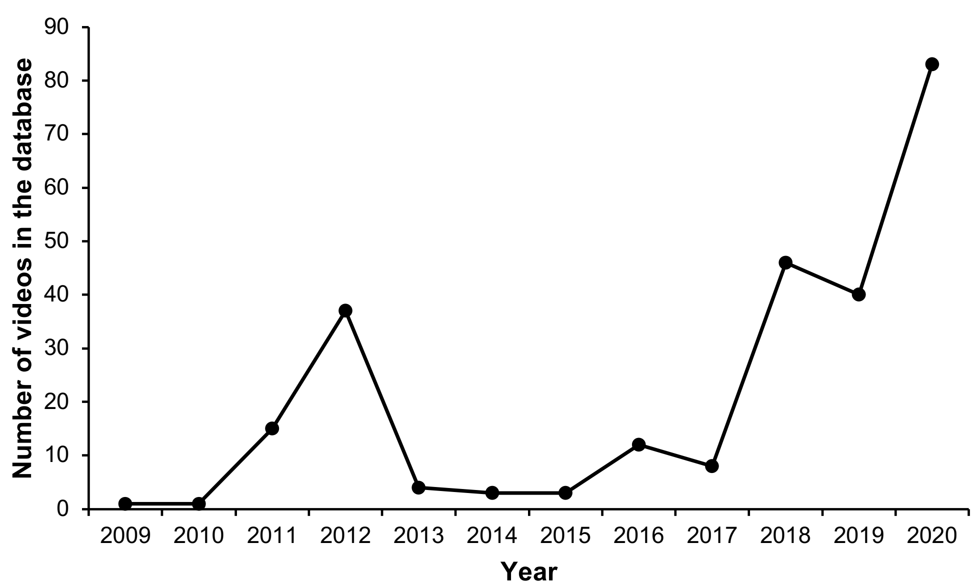
Video mining certainly deserves consideration by behavioural biologists. Every year, the number of videos available on social media increases enormously, representing a progressively richer research source (Fig. 3). Nevertheless, it seems unlikely that video mining will establish itself as a widespread research approach. Traditional methodologies, whether in laboratory or in field, usually enable better control over the variables involved and tend to provide more robust data. Not even the strictest selection criteria of videos would guarantee such control over the research material, nor would it be possible to collect sufficient information about the context and the environment where the animals live.

Yet, our study allowed to highlight a couple of circumstances where video mining could be usefully employed in behavioural research. First, researchers could benefit from the analysis of videos published on social media when assessing the occurrence of a behavioural module in a given species/population or under certain conditions easily controlled in videos. Second, researchers could successfully employ video mining when good qualitative—rather than quantitative—analyses are needed, as in the case of the present study focusing on specific aspects of peregrine nestlings at critical developmental stages.

The marked increase in the last decade of easily accessible webcams worldwide, and the growing interest in ecosystem analysis in the general public, could also stimulate educational projects and promote citizen-science data collection. Specifically, given its relative ease, our sampling method involves the possibility for an enrolment of citizens to collect data about different behavioural patterns in the context of peregrines' nest environment, over extended periods from different locations, endowed by different habitat types (Bonney et al. 2009; Cordeschi et al. 2021). Citizen-science represents a powerful mean to raise citizens' awareness on environmental issues, natural resources' management and public health, and to encourage communication between scientific institutions, administrators, and local communities.

In conclusion, videos from social media may well represent a valuable tool of growing relevance in behavioural biology. However, this can be true only if video mining is wisely and rigorously applied in suitable species and for appropriate research questions.

Fig. 3 Date of recording/publishing of the videos collected in the database. Note the sharp increase in the number of videos published after 2015



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Data availability statement The datasets generated and analysed during the current study are available from the corresponding author on request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Research involving animals No ethical considerations arose from this study as it was entirely based on videos available on social media platforms, freely accessible to the public.

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