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Short communications - *Brevi note*

The multidimensional value of long-term individual-based studies: more than lots of data

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With the present rate of biodiversity loss and the profound effects of global changes, population and conservation ecologists face new questions (Oro 2013). Many of these are related to how fast individuals can adapt to the strength and pace of environmental variability and can only be answered using individual data collected over long-term (Long Terms Individual Based Studies; Clutton-Brock & Sheldon 2010). Here, we argue that the value of LTIBS is multidimensional and it grows steadily with time. Beside the scientific values, a 20-30 years study is likely to have trained several generations of scientists, fostered collaborations between a large number of research institutes and promoted public awareness on scientific themes and wildlife conservation problems. With current public systems providing funds for 3 to 4 years, it is increasingly difficult to initiate and maintain a long-term individual based study. As a consequence, many field studies end before time, without reaching the number of years or the amount of data needed to meet current scientific challenges and to demonstrate their educational value.

How and when does a long-term field study become important? Even though finding a metric that captures the multiple values of a long-term study is difficult, we tried to answer this question by analyzing the progression of three real LTIBS on bird species: Greater Flamingos Phoenicopterus roseus (Johnson 1970), Storm Petrels *Hydrobates pelagicus* (Mínguez 1994) and Audouin's gulls *Larus audouinii* (Oro & Martinez 1992; Table 1). We considered two simple measures: the scientific production, measured as the yearly average impact factor (AIF) of papers in SCI journals, and the 'educational' value, measured as the cumulative number of new authors in these publications (CNNA). For each study we also recorded the number of volunteers who participated in ringing operations and in ring resightings. For the analysis we considered the period from the first publication on SCI journal to 2012. We calculate the AIF and CNNA for 2014 to validate predictions. The three studies considered showed a similar temporal pattern in scientific output (Fig. 1). The observed AIF in 2014 confirmed the positive trends with an average yearly linear increase of 9.5%, which is above the 3.4% calculated for papers published in biological journals (Karageorgopoulos *et al*. 2011). The increase in the AIF is likely the consequence of addressing questions of more general interest, partially reflected in the continuously increasing number of new authors (Table 1). By 2012 more than 80 different scientists have been involved in studying the Flamingos and the Audouin's gulls and more than 30 the Storm petrel with an average annual increase of new collaborators of 22% per year. But the value of LTIBS goes beyond the strictly academic metrics: 2830 different volunteers have collaborated with at least one of the study (59

Table 1. Metrics of LTIBS. AIF = average impact factor per year.

Species	**Location** (Country)	**Years**	**SCI Publications**	**AIF**	**Number of co-authors**	**Number of volunteers involved in ringing**
Greater Flamingo	Camargue (France)	1966-2012	56	1.74	84	1452*
Storm Petrel	Benidorm Is. (Spain)	1994-2012	24	2.10	31	312
Audouin's gull	Ebro Delta (Spain)	1992-2012	65	2.12	85	1066

* from 2002

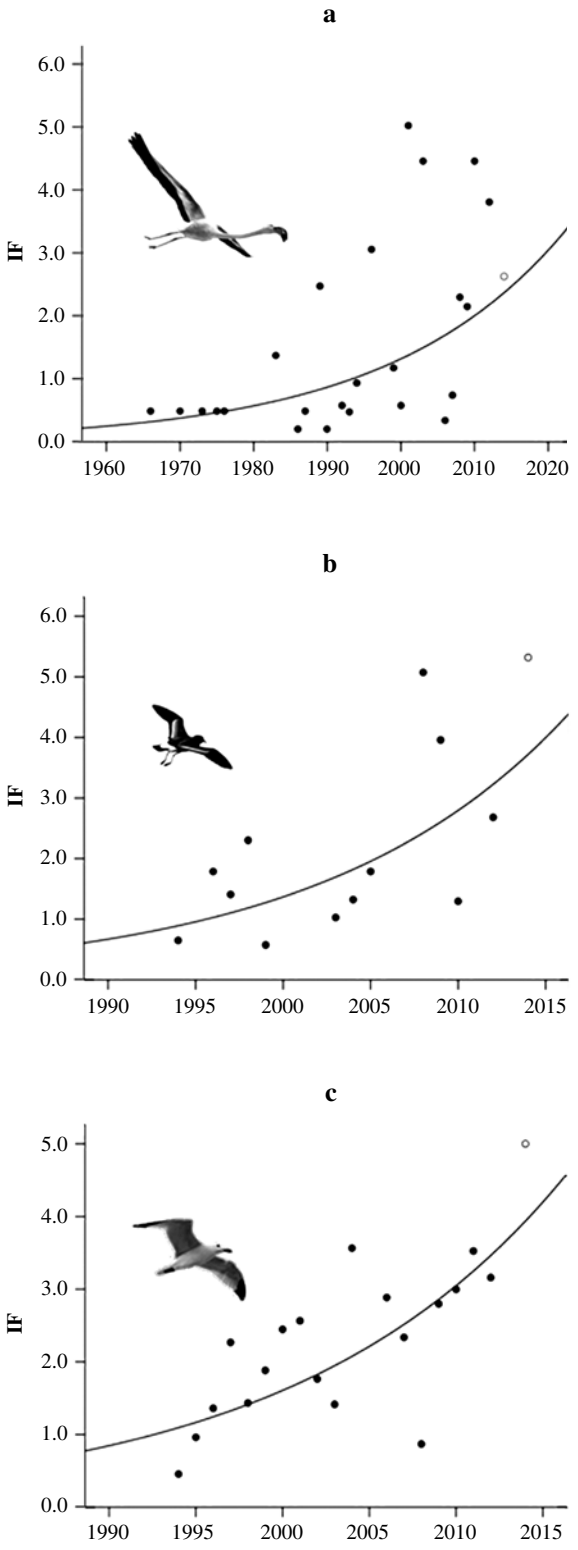

Figure 1. Average impact factors of publications for Greater Flamingos (**a**), Storm petrel (**b**) and Audouin's gull (**c**). The white dot (2014) was not considered in the exponential model (solid line).

per year, Table 1) and, since 1977, 4445 different persons worldwide have reported the resighting of the ring of a Flamingo born in the Mediterranean. Other actual dimensions of LTIBS such as the number of articles in journals other than SCI, the number of Ph.D. thesis completed, documentary films and citizen science projects have not been quantified here. Citizen-science projects in particular are now playing an important role in large-scale and long-term ecological studies (Silvertown 2009). There are of course other long-term detailed studies available at different geographical locations, for different periods and on different taxa (e.g. Clutton-Brock & Sheldon 2010 and references therein). We expect however results to be similar to those found here across many of these studies.

National and international networks (e.g., the Long Term Ecological Research), or institutions (e.g., Societé Française d'Ecologie, the Centre for Population Biology or the European Science Foundation) are now promoting LTIBS. However, long-term funding is still a major challenge and nearly all LTIBS are or have been threatened by extinction (Mills *et al*. 2015) . We do not suggest financing LTIBS by ceasing to promote short-term ones, but the multidimensional values of long-term studies should be recognized and better considered. Swaisgood *et al*. (2010) envisage a funding method to maintain alive those projects that are too valuable to be ended, but this would need a change in the funding system that most countries are unwilling to make. In this scenario, existing long-term detailed datasets should be treasured. They represent an 'insurance policy' to face forthcoming scientific challenges and an invaluable educational tool.

This text is in honor of Dr. Alan Roy Johnson (1941-2014, Photo), Dr. Heinz Hafner (1940-2003) and other pioneers of LTIBS. By focusing the attention on the multidimensional value of LTIBS we aimed to pay a tribute to them and to those people who, thanks to their passion, personal sacrifices and tenacity are keeping alive these projects.

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Photo 1. Dr. A. Johnson during the annual ringing of Greater flamingoes (photo: Hervé Hôte).

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