ASPA ACTIVITY

BIBLIOMETRIC REPORT

Some bibliometric indexes for members of the Scientific Association of Animal Production (ASPA)

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ABSTRACT

This study calculated several bibliometric indexes to analyze the scientific output of 363 members of the Scientific Association of Animal Production (ASPA) in Italy, based on their publications listed by ISI-Thompson, Web of Science database (search period from 1989 until 2006). Five main research areas were considered: AGR/17 (Animal genetics and breeding), AGR/18 (Animal nutrition and feeding), AGR/19 (Animal husbandry), AGR/20 (Poultry, rabbits and fish production) and External researcher (Ere). Position groups were: FP (Full Professor), AP (Associate Professor), Re (Researcher), EReUni (scientists working temporarily at the University or professors of an area different from AGR/17-20), and EReInst (scientists working at other institutions). Each institution was classified according to three geographical areas of Italy: North, Centre and South. Main calculated bibliometric indexes were: N_i = total number of papers published by member i over y_i years; y_i = number of years publishing of member i; $C_{i.}$ = total number of citations of member i; $IF_{personal.} = C_{i.}/N_i$, Personal Impact factor of member i; Total $IF_{journal.}$ = Sum of impact factor reported by the ISI-Thompson database of the journal in which a paper of member i was published (Journal Citation Reports Science Edition, 2004); Mean $IF_{journal.}$ = Mean impact factor of all papers published in journals having a recognized $IF_{journal.}$ by the ISI-Thompson database for member i; h = number of papers with at least h citations; m = h/y, i.e. average increase of h over the y_i years publishing; and $a = C_{i.}/h^2$. Among the studied bibliometric indexes, N_i, $C_{i.}$, Total $IF_{journal.}$ and h are reliable, while $IF_{personal.}$ and Mean $IF_{journal.}$ are not, to evaluate the scientific career of Animal Scientists in Italy. FP and members of AGR/17 tend to show the highest values of bibliometric indexes. Most ASPA members work in the North of Italy, which shows the highest median and highest percentage of scientists with maximum values for most bibliometric parameters. The scientific system of Animal Science in Italy has a fairly good degree of internationalization, but greater efforts should be made to increase the productivity and impact of Animal Scientists.

Key Words: Bibliometry, Scientometry, Research, Evaluation, ASPA.

RIASSUNTO

ALCUNI INDICI BIBLIOMETRICI DEI SOCI DELL'ASSOCIAZIONE SCIENTIFICA DI PRODUZIONE ANIMALE (ASPA)

Lo studio riguarda il calcolo di alcuni indici bibliometrici in grado di rendere conto dell'operosità scientifica dei soci dell'Associazione Scientifica di Produzione Animale (ASPA). I dati sono stati ricavati dalle pubblicazioni riportate per ciascun ricercatore dal database dell'ISI-Thompson nel periodo 1989-2006. I ricercatori sono stati suddivisi per settori scientifico disciplinari (AGR 17, Zootecnica Generale e Miglioramento Genetico; AGR 18, Nutrizione e Alimentazione Animale; AGR 19, Zootecnica Speciale; AGR 20, Zoocolture; ER, ricercatori esterni) e per ruolo (FP, professori ordinari; AP, professori associati; Re, ricercatori universitari; EReUni, ricercatori temporanei all'Università o professori di settore disciplinare esterno a AGR17-20; EReInst, ricercatori esterni all'Università). Ciascun ente è stato classificato sulla base della sua localizzazione geografica: Nord, Centro e Sud Italia. I principali indici bibliometrici calcolati sono stati: N_i = numero totale di lavori pubblicati in y_i anni; y_i = numero di anni di attività pubblicistica; $C_{i.}$ = numero totale di citazioni dell'i-mo membro ASPA; $IF_{personal.} = C_{i.}/N_i$, Impact factor personale dell'i-mo membro ASPA; Total $IF_{journal.}$ = Somma dell'impact factor riportato da ISI-Thompson database per la rivista in cui il lavoro dell'i-mo membro ASPA è stato pubblicato (Journal Citation Reports Science Edition, 2004); Mean $IF_{journal.} = IF_{journal}$ medio per tutti i lavori dell'i-mo membro ASPA pubblicati in riviste con $IF_{journal.}$ riportato da ISI-Thompson database; h = numero di lavori con almeno h citazioni; m = h/y, incremento annuo medio del parametro h; $a = C_{i.}/h^2$, volume delle citazioni totali su quelle minime dei lavori più citati.

Ai fini della valutazione della carriera scientifica degli studiosi di produzione animale in Italia, sono affidabili gli indici bibliometrici N_i, $C_{i.}$, Total $IF_{journal.}$ e h, mentre non lo sono $IF_{personal.}$ e Mean $IF_{journal.}$. Fra le categorie professionali, i professori ordinari presentano i maggiori indicatori; fra i settori scientifici, il migliore è risultato AGR 17. La maggior parte dei soci ASPA lavora nel Nord Italia, zona che mostra la mediana più alta e la percentuale più alta di studiosi con i valori maximi relativi alla maggior parte dei parametri bibliometrici. Il sistema scientifico di produzione animale in Italia presenta nel complesso un buon grado di internazionalizzazione, ma ulteriori sforzi sono necessari per accrescere la produttività e l'impatto degli studiosi di questo settore.

Parole chiave: *Bibliometria, Scientometria, Ricerca, Valutazione, ASPA.*

Introduction

In recent decades, investments in science and technology, essential for the development of countries, have increased worldwide. In fact, in a context of limited economic resources, science and technology have become an economic product. As a consequence, measuring scientific activity has become very important, due to the following reasons: 1) to account for expenses made by tax payers and companies on science and technology, 2) to compare the activities of public and/or private research institutions, with influences on funding distribution, and 3) to evaluate the research activity of single scientists for employment and career purposes (Galante *et al.*, 1998).

In the past, evaluation of the research activity of a scientist was subjective, qualitative and made by other researchers of his own scientific group (peers). However, now that the number of scientists and scientific journals is huge, such subjective evaluation is no longer feasible. For this reason, the use of scientiometry, which allows a complete and objective analysis of the scientific system, has increased in various nations. Bibliometry, a branch of scientiometry, provides several bibliometric indicators that allow to quantify the production and repercussion of scientific activities such as number of citations of a single paper, impact factor (IF), immediacy index (II) and cited half-life (CHL). Impact factor regards the number of times a paper published in a certain journal is cited by other papers, II measures the speed of diffusion of a journal's article and CHL is a quantitative

indicator of the mean citation duration of papers published in a journal. The Institute for Scientific Information (ISI, http://www.isinet.com/isi/index.html), a private organization located in Philadelphia (USA), has developed a large database which contains, among other things, the previously mentioned indexes (ISI-Thompson, Web of Science database).

The most commonly used bibliometric indexes aimed to quantify a researcher's scientific performance are: 1) total number of papers published by scientist i over y_i years (N_i), 2) total number of citations of scientist i ($C_{i.}$), 3) $IF_{personal.}$, i.e. $N_i / C_{i.}$ 4) Total $IF_{journal.}$, 5) Mean $IF_{journal.}$, 6) Number of "significant" papers, and 7) Number of citations to each of the q most cited papers. All these indexes have intrinsic advantages and disadvantages (Ponzani, 2002; Pulina *et al.*, 2003) that should be weighed whenever they are used. Recently, the h index, defined as the number of papers with at least h citations, has been proposed as a good single-index to measure the broad impact of an individual's work (Hirsch, 2005).

Several studies evaluating the scientific production of different research areas, countries, as well as of the European Union, have been done (Karki, 1990; Silversten and Persson, 2000; Garcia-Rio *et al.*, 2001; Pulina *et al.*, 2003), but detailed information on the research activities of animal researchers in Italy is not available.

This paper deals with the calculation of several bibliometric indexes to describe the scientific performance of members of the Italian Scientific Association of Animal Production (ASPA). The main goals are: 1) to determine the average scientific level of such researchers, 2) to compare the scientific output among researchers having different positions or research areas within the University or working at different places (i.e. University vs. Other Institutions) and geographical zones, and 3) to compare and describe the frequency distribution of the recently proposed h index with some traditionally used bibliometric indexes.

Material and methods

Data collection

The period of data collection from internet lasted from February 6th to February 23rd 2006. First, a list containing name and working place of all members of ASPA was downloaded from its web site [//genweb.scizoot.unipd.it/aspa], while a list of the honorary members of ASPA was provided by the same Association. The final list of ASPA members considered in this study was formed by active (not retired) members only. Then, a list containing the name and position of all University faculties belonging to the four research areas of ASPA was downloaded from a web site of the "Ministero dell'Istruzione, dell'Università e della Ricerca" (the Italian Ministry of Education and Research, MIUR) [http://www.miur.it]. The research areas were: AGR/17 - Animal genetics and breeding ("Zootecnica Generale e Miglioramento Genetico"), AGR/18 - Animal nutrition and feeding ("Nutrizione e Alimentazione Animale"), AGR/19 - Animal husbandry ("Zootecnica Speciale"), and AGR/20 - Poultry, rabbits and fish production ("Zoocolture").

After that, a list of the scientific publications of each ASPA member was downloaded from the Institute for Scientific Information (ISI)-Thompson, Web of Science database [http://isiknowledge.com]. The full citation and the number of citations for each paper were always found, while the impact factor of the journals was not always available in the ISI-Thompson database. The period of publications covered by the ISI-Thompson database during this search lasted from 1989 until 2006, for a total of 18 years.

Data collection was a crucial phase of the work because it required a lot of attention to drastically reduce problems related to search by author in the ISI database. The list of publications of each scientist was controlled carefully, in order to avoid the problem of different scientists that have the same name (or at least the same

surname and initial of the first given name) and thus have their papers unified in databases. In addition, to avoid underestimation of an author's scientific production, several searches had to be done for authors having compound last names, single or multiple middle names and/or last names with prefixes such as "de", "di", "del" and "dal". Double checks had to be done for authors who had changed their working place during their research career also. Therefore, it is assumed that total data accuracy is hard to achieve in this type of search.

Data analysis

A database containing the name, institution, geographical zone, research area and position of 363 ASPA members was created. Scientists were divided into five main research areas: AGR/17, AGR/18, AGR/19, AGR/20 and External researcher (ERe). The position groups of University faculties belonging to the fist four categories (88% of members) just mentioned were: FP - Full Professor, AP - Associate Professor, and Re - Researcher. The fifth group was divided into: i) scientists working temporarily at the University (e.g. Ph.D. students, visiting fellows, temporary workers) or professors of an area different from the other four categories (EReUni), and ii) scientists working at other institutions (EReInst). Each institution was classified into one of the following three geographical areas of Italy: i) North (regions of "Alto Adige", "Emilia-Romagna", "Friuli-Venezia Giulia", "Liguria", "Lombardia", "Piemonte", "Trentino", "Valle d'Aosta" and "Veneto"), ii) Center (regions of "Lazio", "Marche", "Toscana" and "Umbria"), and iii) South (regions of "Abruzzo", "Basilicata", "Calabria", "Campania", "Molise", "Puglia", "Sardegna" and "Sicilia").

For a better understanding of how the bibliometric indexes of our database were calculated, each definition will be followed by a numerical example for a hypothetical ASPA member i, whose publication data are in Table 1, as follows:

N_i = Total number of papers published of member i over y_i years, reported by the ISI-Thompson database, Web of Science

$N_i = 24$

y_i = Number of years publishing of member i = (last year of pub. – first year of pub.) + 1

$y_i = (2005 - 1991) + 1 = 15$

$C_{i.}$ = Total number of citations of member i = sum of citations of each paper j of member i (C_{ij})

$C_{i.} = 28 + 23 + 14 + 13 + 11 + 11 + 10 + 6 + 5 + 5 + 4 + 4 + 3 + 3 + 3 + 2 + 2 + 2 + 2 + 1 + 1 + 0 + 0 + 0 = 153$

$IF_{personal.} = C_{i.}/N_i$, Personal Impact factor of member i, i.e. mean number of citations per paper

$IF_{personal.} = 153/24 = 6.4$

Total $IF_{journal.}$ = Sum of impact factor reported by the ISI-Thompson database of the journal ($IF_{journal}$) in which a paper of member i was published (Journal Citation Reports Science Edition, 2004). Therefore, an author who has not published any paper is assumed to have a Total $IF_{journal.}$ of zero.

Total $IF_{journal.} = 2.134 + 2.134 + 2.134 + 2.134 + 1.734 + 2.134 + 2.134 + 2.134 + 2.134 + 2.134 + 0.941 + 1.363 + 1.645 + 0.856 + 1.363 + 1.734 + 0.941 + 1.734 + 0.606 + 1.363 + 0.606 = 34.092$

Mean $IF_{journal.}$ = Mean impact factor of all papers published in journals having a recognized $IF_{journal.}$ by the ISI-Thompson database for member i. In this case, a journal whose impact factor has not been reported in the database yet is not considered in the calculation.

Mean $IF_{journal.} = 34.092/21 = 1.623$

h = Number of papers with at least h citations (Hirsch, 2005).

h = 7, i.e. this author has 7 papers in which he/she has been cited at least 7 times, while the remaining 17 papers have been cited less than 7 times. The determination of this index is greatly helped by ordering all papers in descending order by number of citations, as done in Table 1.

m = h/y, i.e. the slope of h versus m which indicates the average increase of h over the y_i years publishing. This parameter allows to com-

Table 1. Example of data on the scientific publications of a hypothetical member i of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Paper	Journal	Times cited	Year	Journal impact factor
1	J Dairy Sci	28	1996	2.134
2	J Dairy Sci	23	1997	2.134
3	J Dairy Sci	14	1993	2.134
4	J Dairy Sci	13	2001	2.134
5	J Anim Sci	11	2000	1.734
6	J Dairy Sci	11	1991	2.134
7	J Dairy Sci	10	1994	2.134
8	J Dairy Sci	6	1995	2.134
9	J Dairy Sci	5	1997	2.134
10	J Dairy Sci	5	1994	2.134
11	Anim Sci	4	2001	0.941
12	Livest Prod Sci	4	1993	1.363
13	Genet Sel Evol	3	2003	1.645
14	J Anim Breed Genet	3	2002	0.856
15	Livest Prod Sci	3	1994	1.363
16	J Anim Sci	2	2004	1.734
17	Anim Sci	2	2000	0.941
18	J Anim Sci	2	1998	1.734
19	Small Rumin Res	2	1996	0.606
20	Livest Prod Sci	1	1997	1.363
21	Small Rumin Res	1	1996	0.606
22	Ital J Anim Sci	0	2005	absent
23	Ital J Anim Sci	0	2005	absent
24	Ital J Anim Sci	0	2005	absent

pare scientists of different seniority but is not useful when her/his level of productivity is not maintained (Hirsch, 2005). This parameter is not calculated for authors who have not published any paper.

m = 7/15 = 0.47

a = C_i/h^2, where h^2 represents the lower bound on the total number of citations of a scientist. Empirically, parameter "a" usually ranges from 3 to 5 (Hirsch, 2005); the lower is "a", the more uniform is the citation distribution throughout the papers. Again, this parameter is not calculated for authors who have not published any paper.

a = 153/(7 x 7) = 3

Data analysis consisted of calculating data distribution, mean, standard deviation, variance, minimum, 1st quartile, median, 3rd quartile, maximum, and Anderson-Darling Normality test, as well as the matrix of correlations (Pearson) for all parameters using Minitab 12.1 for Windows.

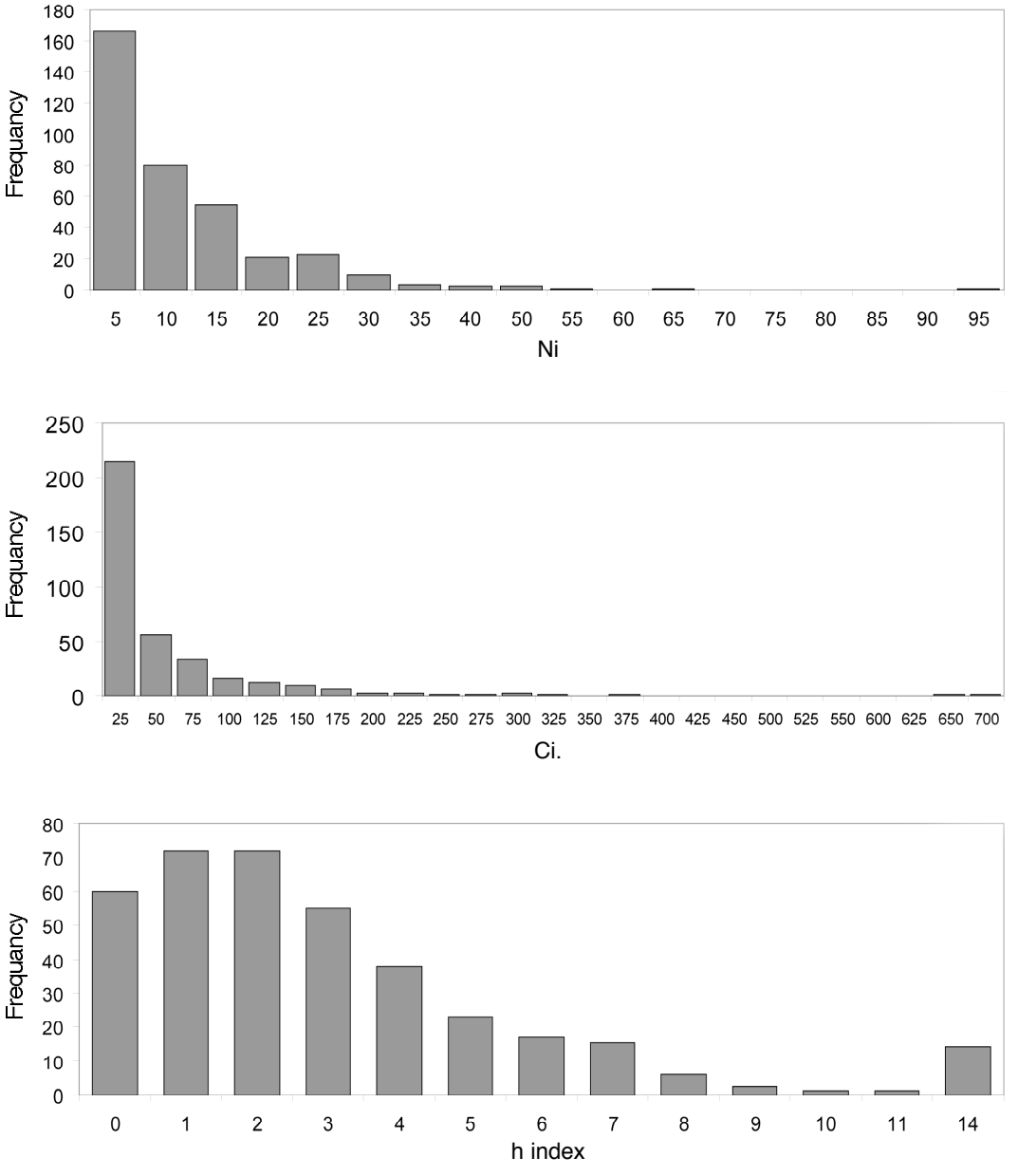

Figure 1. Frequency distribution of total number of papers published (N_i), total number of citations (C_i) and h index of members of the Scientific Association of Animal Production (ASPA) (from 1989 until 2006, ISI-Thompson database).

Table 2. Total number of papers published (N_i) by members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	28	12.00	5.25-23.00	61.00	Davoli R.	North
	AP	19	11.00	3.00-14.00	16.00	Cappio-Borlino A.	South
						Macciotta N.P.P.	South
	Re	16	7.00	3.00-9.75	23.00	Zambonelli P.	North
AGR 18	FP	31	9.00	2.00-20.00	44.00	Baldi A.	North
	AP	22	4.50	2.00-11.25	21.00	Spanghero M.	North
	Re	23	5.00	1.00-8.00	13.00	Pastorelli G.	North
						Rossi F.	North
AGR 19	FP	52	7.50	3.00-18.75	53.00	Russo V.	North
	AP	54	6.00	3.00-10.25	28.00	Albenzio M.	North
						Moretti V.M.	South
	Re	35	3.00	2.00-7.00	36.00	Fontanesi L.	North
AGR 20	FP	12	7.50	4.00-17.75	22.00	Saroglia M.	North
	AP	10	5.00	2.75-22.00	26.00	Cerolini S.	North
	Re	16	7.00	2.25-11.00	16.00	Cecchini S.	South
ERe	EReUni	13	6.00	2.00-10.50	24.00	Pietri A.	North
	EReInst	32	6.00	2.00-10.00	93.00	Ianuzzi L.	South
All AGR	FP	123	8.00	3.00-19.00	61.00		
	AP	105	6.00	3.00-12.00	28.00		
	Re	90	5.00	2.00-8.25	36.00		
AGR 17		63	9.00	5.00-14.00	61.00		
AGR 18		76	5.00	2.00-12.75	44.00		
AGR 19		141	5.00	3.00-11.50	53.00		
AGR 20		38	7.00	3.75-14.25	26.00		
ERe		45	6.00	2.00-10.00	93.00		
ASPA		363	6.00	3.00-12.00	93.00		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.

[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.

[3]It refers to the Italian geographical zone where the scientist with the highest value works.

Table 3. Total number of years publishing (y_i) of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	28	13.50	8.50-15.75	17.00	Nardone A.	Centre
						Vonghia G.	South
	AP	19	12.00	9.00-14.00	17.00	Molteni L.	North
	Re	16	10.00	4.50-12.00	16.00	Bolla P.	North
AGR 18	FP	31	10.00	3.00-14.00	17.00	Cheli F.	North
	AP	22	9.50	2.75-13.25	15.00	Acciaioli A.	Centre
						Rizzi L., Tedesco D.	North
						Spanghero M.	North
	Re	23	5.00	1.00-8.00	14.00	Rossi F.	North
AGR 19	FP	52	10.00	4.75-14.00	18.00	Stefanon B.	North
	AP	54	9.00	4.75-12.25	17.00	Gandini G.C.	North
						Lacetera N.G.	Centre
	Re	35	5.00	1.00-10.00	16.00	Rizzi R.	North
AGR 20	FP	12	12.50	8.50-15.75	17.00	Lanari D., Tibaldi E.	North
	AP	10	12.50	9.50-16.25	18.00	Meluzzi A.	North
	Re	16	7.00	3.00-8.00	12.00	Ferrante V.	North
ERe	EReUni	13	5.00	3.50-11.00	15.00	Cavalchini L.G.	North
	EReInst	32	7.50	2.25-9.75	17.00	Ianuzzi L.	Sud
All AGR	FP	123	11.00	6.00-15.00	18.00		
	AP	105	10.00	5.00-13.00	18.00		
	Re	90	6.00	2.00-10.00	16.00		
AGR 17		63	12.00	7.00-15.00	17.00		
AGR 18		76	7.50	3.00-13.00	17.00		
AGR 19		141	9.00	3.00-12.00	18.00		
AGR 20		38	10.00	6.00-13.25	18.00		
ERe		45	7.00	3.00-10.00	17.00		
ASPA		363	9.00	3.00-13.00	18.00		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.
[3]It refers to the Italian geographical zone where the scientist with the highest value works.

Table 4. Total number of citations ($C_{i.}$) by members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	28	42.00	14.75-124.00	656.00	Davoli R.	North
	AP	19	28.00	14.00-56.00	319.00	Ajmone-Marsan P.	North
	Re	16	29.50	11.00-73.25	112.00	Ciampolini R.	Centre
AGR 18	FP	31	35.00	1.00-103.00	265.00	Susmel P.	North
	AP	22	9.50	1.00-24.75	164.00	Spanghero M.	North
	Re	23	5.00	1.00-24.00	78.00	Pastorelli G.	North
AGR 19	FP	52	23.50	3.50-71.25	293.00	Stefanon B.	North
	AP	54	17.50	2.00-48.50	133.00	Lacetera N.G.	Centre
	Re	35	4.00	0.00-16.00	157.00	Fontanesi L.	North
AGR 20	FP	12	24.00	5.50-93.75	211.00	Lanari D.	North
	AP	10	45.50	5.75-119.75	241.00	Cerolini S.	North
	Re	16	15.50	0.25-40.75	83.00	D'Agaro E.	North
ERe	EReUni	13	13.00	1.00-34.00	190.00	Pietri A.	North
	EReInst	32	15.00	1.25-35.50	646.00	Ianuzzi L.	South
All AGR	FP	123	27.00	5.00-77.00	656.00		
	AP	105	18.00	3.50-51.00	319.00		
	Re	90	9.50	1.00-30.50	157.00		
AGR 17		63	30.00	14.00-75.00	656.00		
AGR 18		76	10.50	1.00-43.00	265.00		
AGR 19		141	15.00	2.00-39.00	293.00		
AGR 20		38	22.50	3.50-71.75	241.00		
ERe		45	15.00	1.50-34.00	646.00		
ASPA		363	17.00	2.00-51.00	656.00		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.
[3]It refers to the Italian geographical zone where the scientist with the highest value works.

Results and discussion

Since frequency distributions of all evaluated parameters are unimodal, not normal and strongly asymmetric to the left (e.g., N_i, $C_{i.}$ and h index, Figure 1), results are shown as median, 1st and 3rd quartiles and maximum value (with corresponding scientist's name and geographical zone) (Tables 2 - 8). Median and maximum values of parameters N_i, $C_{i.}$, Total $IF_{journal.}$ and h classified by geographical area are reported in Tables 9 and 10.

Table 5. Personal impact factor ($IF_{personal.}$, i.e., mean number of citations per paper) of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	28	3.80	2.30-6.78	11.30	Valentini A.	Centre
	AP	19	4.00	1.90-7.00	22.80	Ajmone-Marsan P.	North
	Re	16	4.50	1.60-8.15	37.30	Ciampolini R.	Centre
AGR 18	FP	31	2.90	0.50-5.80	10.20	Susmel P.	North
	AP	22	1.35	0.50-4.33	7.80	Spanghero M.	North
	Re	23	1.00	0.30-2.80	18.00	De Angelis A.	South
AGR 19	FP	52	3.00	1.35-3.98	11.00	Zezza L.	South
	AP	54	2.80	0.70-4.43	11.00	Pedron O.	North
	Re	35	1.00	0.00-4.00	9.00	Esposito L.	South
AGR 20	FP	12	3.90	0.78-6.40	15.10	Lanari D.	North
	AP	10	5.15	1.60-9.65	12.20	Ballestrazzi R.	North
	Re	16	2.20	0.13-3.73	10.40	D'Agaro E.	North
ERe	EReUni	13	2.20	0.50-4.55	7.90	Pietri A.	North
	EReInst	32	2.40	0.78-3.88	20.80	Aleandri R.	North
All AGR	FP	123	3.10	1.50-4.80	15.10		
	AP	105	2.80	1.00-4.70	22.80		
	Re	90	1.45	0.30-4.30	37.30		
AGR 17		63	4.00	2.20-6.90	37.30		
AGR 18		76	1.65	0.43-4.38	18.00		
AGR 19		141	2.60	0.50-4.25	11.00		
AGR 20		38	3.10	0.65-5.03	15.10		
ERe		45	2.40	0.85-4.00	20.80		
ASPA		363	2.70	0.80-4.60	37.30		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.
[3]It refers to the Italian geographical zone where the scientist with the highest value works.

Analysis of correlation among the bibliometric parameters is reported in Table 11.

Most ASPA members (92%) are cited by the ISI-Thompson database. Median N_i of ASPA members is 6, with 25% of them having more than 12 published papers. FP of AGR/17 shows the highest median N_i (median = 12, 3rd quartile = 23), while Re of AGR/19 shows the lowest one (median = 3, 3rd quartile = 7). Median N_i of the two ERe categories is equal to that of all

Table 6. Mean journal impact factor (Mean $IF_{journal.}$) of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	27	1.59	1.10-2.17	2.71	Masina P.	South
	AP	18	1.59	1.24-1.80	2.57	Pieragostini E.	South
	Re	16	1.56	1.23-2.11	3.23	Bigi D.	North
AGR 18	FP	28	1.15	0.88-1.38	1.66	Formigoni A.	North
	AP	19	1.17	0.77-1.24	2.34	Moniello G.	South
	Re	20	0.92	0.67-1.25	2.01	Moschini M.	North
AGR 19	FP	48	1.15	1.05-1.37	2.53	Russo V.	North
	AP	46	1.13	0.83-1.34	1.56	Nanni Costa L.	North
	Re	31	1.02	0.56-1.41	2.81	Fontanesi L.	North
AGR 20	FP	12	1.00	0.59-1.23	1.38	Tibaldi E.	North
	AP	9	1.10	0.57-1.27	1.37	Gualtieri M.	Centre
	Re	14	0.92	0.76-1.15	1.45	Iaffaldano N.	South
ERe	EReUni	12	1.11	0.87-1.58	2.55	Senese C.M.A.	South
	EReInst	30	1.30	1.06-1.58	2.37	Aleandri R.	North
All AGR	FP	115	1.18	1.01-1.45	2.71		
	AP	92	1.19	0.83-1.40	2.57		
	Re	81	1.06	0.75-1.46	3.23		
AGR 17		61	1.59	1.24-1.99	3.23		
AGR 18		67	1.06	0.77-1.33	2.34		
AGR 19		125	1.13	0.84-1.36	2.81		
AGR 20		35	0.93	0.74-1.23	1.45		
ERe		42	1.27	0.98-1.58	2.55		
ASPA		330	1.18	0.87-1.44	3.23		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.
[3]It refers to the Italian geographical zone where the scientist with the highest value works.

ASPA members. As expected, FP are the most productive faculties, AP are intermediate and Re are the least productive ones (Median N_i = 8, 6 and 5, respectively). Maximum N_i values range from 13 to 93 depending on the research area and position (Table 2). All maximum values of N_i belong to scientists with at least a good scientific career, i.e. with values of other important bibliometric parameters (i.e. C_i, Total $IF_{journal.}$ and h) above the median for all

Table 7. Total journal impact factor (Total $IF_{journal.}$) of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	28	16.80	5.08-33.19	154.32	Davoli R.	North
	AP	19	10.43	3.57-20.91	30.89	Pieragostini E.	South
	Re	16	10.93	4.12-16.20	64.68	Zambonelli P.	North
AGR 18	FP	31	8.90	1.74-22.65	45.58	Baldi A.	North
	AP	22	4.74	1.70-9.60	31.89	Bernabucci U.	Centre
	Re	23	3.99	0.61-6.87	20.73	Pastorelli G.	North
AGR 19	FP	52	8.42	2.15-22.22	128.83	Russo V.	North
	AP	54	4.69	1.90-11.40	34.83	Lacetera N.G.	Centre
	Re	35	3.37	1.01-7.79	101.27	Fontanesi L.	North
AGR 20	FP	12	7.51	2.16-15.97	24.27	Saroglia M.	North
	AP	10	4.73	1.16-16.83	25.85	Castellini C.	Centre
	Re	16	5.11	1.85-9.67	16.07	Dal Bosco A.	Centre
ERe	EReUni	13	3.88	1.17-11.33	39.57	Pietri A.	North
	EReInst	32	6.90	2.10-11.92	91.85	Iannuzzi L.	South
All AGR	FP	123	9.76	2.26-23.85	154.32		
	AP	105	5.61	2.12-12.76	34.83		
	Re	90	4.34	1.21-9.39	101.27		
AGR 17		63	12.89	5.04-25.71	154.32		
AGR 18		76	4.83	1.49-11.40	45.58		
AGR 19		141	4.52	1.72-13.85	128.83		
AGR 20		38	5.46	2.03-14.12	25.85		
ERe		45	6.57	1.78-11.66	91.85		
ASPA		363	6.08	1.93-14.94	154.32		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.
[3]It refers to the Italian geographical zone where the scientist with the highest value works.

ASPA members. N_i has the advantage of measuring productivity and the disadvantage of not measuring neither the importance nor the impact of papers (Hirsch, 2005). Nevertheless, N_i is an important and widely used bibliometric index to evaluate a scientist's activity.

Median y_i of ASPA members is 9, with 25% of members having at most 3 years and another 25% having more than 13 years of publication. Maximum y_i value is 18, which is the period cov-

Table 8. h index of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Position[2]	n.	Median	1st-3rd Quartile	Maximum value	Scientist with maximum value	Zone[3]
AGR 17	FP	28	4.00	2.00-5.75	8.00	Davoli R.	North
						Rando A.	South
	AP	19	3.00	1.00-4.00	6.00	Ajmone-Marsan P.	North
						Pieragostini E.	South
	Re	16	3.00	2.00-3.00	5.00	Zambonelli P.	North
AGR 18	FP	31	3.00	1.00-6.00	9.00	Susmel P.	North
	AP	22	2.00	1.00-3.00	7.00	Bernabucci U.	Centre
						Spanghero M.	North
	Re	23	1.00	1.00-2.00	6.00	Pastorelli G.	North
AGR 19	FP	52	3.00	1.00-4.75	10.00	Stefanon B.	North
	AP	54	2.00	1.00-4.00	7.00	Albenzio M.	South
						Lacetera N.G.	Centre
						Piasentier E.	North
	Re	35	1.00	0.00-2.00	7.00	Fontanesi L	North.
						Priolo A.	South
AGR 20	FP	12	2.00	1.00-5.75	8.00	Lanari D.	North
	AP	10	3.00	1.00-6.25	11.00	Cerolini S.	North
	Re	16	2.50	0.25-3.00	5.00	Dal Bosco A.	Centre
ERe	EReUni	13	2.00	0.50-3.00	9.00	Pietri A.	North
	EReInst	32	2.00	1.00-3.00	14.00	Iannuzzi L.	North
All AGR	FP	123	3.00	1.00-5.00	10.00		
	AP	105	2.00	1.00-4.00	11.00		
	Re	90	2.00	1.00-3.00	7.00		
AGR 17		63	3.00	2.00-4.00	8.00		
AGR 18		76	2.00	1.00-4.00	9.00		
AGR 19		141	2.00	1.00-4.00	10.00		
AGR 20		38	2.50	1.00-4.00	11.00		
ERe		45	2.00	1.00-3.00	14.00		
ASPA		363	2.00	1.00-4.00	14.00		

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.

[2]FP = Full Professor, AP = Associate Professor, Re = Researcher, EReUni = External Re working at the University, and EReInst = External Re working at other Institutions.

[3]It refers to the Italian geographical zone where the scientist with the highest value works.

Table 9. Geographical distribution of total number of papers published (Ni) and total number of citations (Ci.) of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Zone[2]	n.	N_i Median (Maximum)	$C_{i.}$ Median (Maximum)
AGR 17	North	26	10.50 (61.00)	63.00 (656.00)
	Centre	15	4.00 (29.00)	14.00 (145.00)
	South	22	12.00 (33.00)	39.50 (354.00)
AGR 18	North	41	8.00 (44.00)	27.00 (265.00)
	Centre	13	4.00 (22.00)	5.00 (113.00)
	South	22	3.50 (15.00)	5.00 (44.00)
AGR 19	North	61	7.00 (53.00)	15.00 (293.00)
	Centre	27	5.00 (23.00)	16.00 (133.00)
	South	53	5.00 (37.00)	9.00 (285.00)
AGR 20	North	20	9.50 (26.00)	38.50 (241.00)
	Centre	8	5.00 (25.00)	28.50 (107.00)
	South	10	3.50 (16.00)	5.50 (45.00)
ERe	North	17	5.00 (24.00)	12.00 (190.00)
	Centre	13	6.00 (13.00)	13.00 (31.00)
	South	15	10.00 (93.00)	25.00 (646.00)
All ASPA	North	165	7.00 (61.00)	27.00 (656.00)
	Centre	76	4.50 (29.00)	14.00 (145.00)
	South	122	5.50 (93.00)	10.50 (646.00)
ASPA		363	6.00 (93.00)	17.00 (656.00)

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]Italy can be divided into three main geographical zones: North, Centre and South.

ered by our database search (Table 3). As expected, scientists at higher career levels have published for a longer period than those at the beginning of their careers. In comparison to median y_i for ASPA members, AGR/17 and AGR/20 have published for a longer period, AGR/19 has published for the same period while AGR/18 and ERe have published for a shorter time. Maximum y_i values range from 12 to 18 (Table 3). In general, this parameter is not considered a crucial factor when evaluating the scientific productivity of a scientist.

Median $C_{i.}$ of ASPA members is 17 and is not very representative, since 25% of them has at most 2 citations and another 25% has more than 51 citations. FP of AGR/17 shows the highest median $C_{i.}$ (median = 42, 3rd quartile = 124), while Re of AGR/19 shows the poorest one (median = 4, 3rd quartile = 16). The ranking of median $C_{i.}$ is AGR17>AGR 20>AGR 19 and ERe>AGR 18. The trend of median $C_{i.}$ is similar to that of median N_i for FP, AP and Re (Tables 2 and 4). Maximum $C_{i.}$ values range from 78 to 656 (Table 4). Similarly to what observed for N_i, scientists

Table 10. Geographical distribution of total journal impact factor (Total $IF_{journal.}$) and h index (i.e., number of papers with at least h citations) of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

Research area[1]	Zone[2]	n.	Total $IF_{journal}$ Median (Maximum)	h index Median (Maximum)
AGR 17	North	26	14.50 (154.32)	3.00 (8.00)
	Centre	15	4.15 (40.09)	2.00 (7.00)
	South	22	15.70 (84.20)	3.50 (8.00)
AGR 18	North	41	8.09 (45.58)	3.00 (9.00)
	Centre	13	2.11 (31.89)	1.00 (7.00)
	South	22	3.44 (11.17)	1.00 (5.00)
AGR 19	North	61	5.36 (128.83)	2.00 (10.00)
	Centre	27	3.81 (34.83)	2.00 (7.00)
	South	53	4.51 (47.17)	1.00 (8.00)
AGR 20	North	20	8.77 (24.27)	3.00 (11.00)
	Centre	8	4.73 (25.85)	3.00 (7.00)
	South	10	3.03 (13.84)	1.00 (4.00)
ERe	North	17	6.06 (39.57)	2.00 (9.00)
	Centre	13	7.23 (12.89)	2.00 (4.00)
	South	15	6.95 (91.85)	3.00 (14.00)
All ASPA	North	165	8.20 (154.32)	3.00 (11.00)
	Centre	76	4.06 (40.09)	2.00 (7.00)
	South	122	4.69 (91.85)	2.00 (14.00)
ASPA		363	6.08 (154.32)	2.00 (14.00)

[1]AGR 17 = Animal genetics and breeding, AGR 18 = Animal nutrition and feeding, AGR 19 = Animal husbandry, and AGR 20 = Poultry, rabbits and fish production; ERe = External Researcher.
[2]Italy can be divided into three main geographical zones: North, Centre and South.

having maximum Ci. values have at least a good scientific career. The only exception is one scientist who has values of N_i and Total $IF_{journal.}$ below the median and an h parameter above the median for ASPA, because of the publication of few but highly cited papers. Hirsch (2005) states that even though $C_{i.}$ properly measures the total impact of a scientist's activity, it has the following disadvantages: 1) it is hard to find, 2) it may be inflated by few "big hits", which may not be representative of the individual if he/she is coauthor with many others on those papers and will correspond to a very atypical value of the "a" parameter ($a = C_{i.}/h^2$), larger than 5, and 3) it gives undue weight to highly cited review articles versus original research contributions. From our experience, $C_{i.}$ is not hard to find in the ISI-Thompson database. Diversely, the second limitation mentioned by Hirsch (2005) was found in our database and suggests that $C_{i.}$ should not be used as a single bibliometric index.

In general, $IF_{personal.}$ of ASPA members shows

Table 11. Matrix of correlation (Pearson) among bibliometric parameters of members of the Scientific Association of Animal Production (from 1989 until 2006, ISI-Thompson database).

	N_i	$IF_{personal.}$	$C_{i.}$	y_i	Mean $IF_{journal.}$	h	m	a
$IF_{personal.}$	0.291							
$C_{i.}$	0.845	0.550						
y_i	0.607	0.397	0.492					
Mean $IF_{journal.}$	0.351	0.352	0.371	0.342				
h	0.853	0.527	0.806	0.684	0.394			
m	0.191	0.214	0.256	-0.419		0.336		
a		0.457			0.152	-0.153	-0.187	
Total $IF_{journal.}$	0.875	0.301	0.801	0.501	0.575	0.717	0.170	

All reported values are significantly (P<0.05) different from zero.

a median of 2.7, with 25% of them having an $IF_{personal.}$ higher than 4.6 and a similar percentage of members having an $IF_{personal.}$ of at most 0.8. AP of AGR/20 shows the highest median $IF_{personal.}$ (median = 5.2, 3rd quartile = 9.7), while Re of AGR/18 and AGR/19 (median = 1, 3rd quartile = 2.8 and 4.0, respectively) show the lowest ones. ERe has a median $IF_{personal.}$ slightly lower than that of all ASPA members. In general, median $IF_{personal.}$ ranking is FP>AP>Re. However, in a very quickly evolving research area such as AGR/17, an inverse trend is observed. Maximum $IF_{personal.}$ values range from 7.9 to 20.8 (Table 5). About 21% of scientists having maximum $IF_{personal.}$ values have three or all four values of parameters N_i, $C_{i.}$, Total $IF_{journal.}$ and h below the median of ASPA members, i.e. they do not have a good scientific career. Hirsch (2005) states that $IF_{personal.}$ has the advantage of allowing comparison of scientists of different ages, but has the following limits: 1) it is hard to find, 2) it rewards low productivity, and 3) it penalizes high productivity. Except for the first limitation which we believe is not true, we do agree that $IF_{personal.}$ often favours low productivity in spite of high productivity. The misleading maximum $IF_{personal.}$ values and the low correlation between $IF_{personal.}$ and most of the other bibliometric indexes (Table 11) are other limits of this parameter. For all these reasons, we think that $IF_{personal.}$ is not a reliable index to evaluate the career of an Animal scientist in Italy at the moment.

Mean $IF_{journal.}$ of all ASPA members shows a median of 1.18 (3rd quartile = 1.44). The ranking of median Mean $IF_{journal.}$ by research area is AGR/17>ERe>AGR/19>AGR/18>AGR/20. Maximum $IF_{journal.}$ values range from 1.37 to 3.23, depending on the research area and position (Table 6). ASPA members have published in journals having a median Mean $IF_{journal}$ higher than the Mean $IF_{journal}$ reported by the subject category "Agriculture, Dairy and Animal Science" (Journal Citation Reports Science Edition, 2004, ISI-Thompson database) (1.18 vs. 0.85) for three main reasons: first, all $IF_{journal}$ of papers published in Italian journals which do not have an ISI impact factor yet were not considered in the calculation of such index; second, authors try to have their papers published in journals with higher $IF_{journal}$ as much as possible; third, scientists who publish in subject categories other than "Agriculture, Dairy and Animal

Science", especially those of AGR/17, usually publish in journals with a higher $IF_{journal}$. In order to correct for the third bias, $IF_{journal}$ should be standardized, when evaluating Mean $IF_{journal.}$ of different scientists. About 21% of scientists having maximum Mean $IF_{journal.}$ values have two or more values of other bibliometric indexes (i.e. N_i, C_i, Total $IF_{journal.}$ or h) below the median for ASPA members and many other scientists are not among the best ones in his/her research area and position. This suggests that many times the Mean $IF_{journal.}$ may not give a reliable description of the scientific performance of an animal scientist in Italy.

Median Total $IF_{journal.}$ of ASPA members is 6.1, with a wide range of variation (1st quartile – 3rd quartile = 1.9 - 14.9). FP of AGR/17 shows the highest median Total $IF_{journal.}$ (median = 16.8, 3rd quartile = 33.2), while Re of AGR/19 shows the lowest one (median = 3.4, 3rd quartile = 7.8). Median Total $IF_{journal.}$ of EReUni (3.9) is lower and that of EReInst (6.9) is slightly higher than that of ASPA members. As expected, FP faculties have the highest impact factor, AP have an intermediate one and Re have the lowest one (Median Total $IF_{journal.}$ = 9.8, 5.6 and 4.3, respectively). The ranking of median Total $IF_{journal.}$ is AGR17>ERe>AGR 20>AGR 18>AGR 19 (Table 7). All scientists having maximum Total $IF_{journal.}$ values (ranging from 16.1 to 154.3, Table 7) have the values of N_i, C_i and h at the 3rd quartile of ASPA members, highlighting the importance of this widely used bibliometric index.

Median h index is 2 (3rd quartile = 4) which is very low, compared to the h values reported by Hirsch (2005), and indicates a low impact of the most cited papers published by ASPA members. FP of AGR/17 shows the highest h (median = 4, 3rd quartile = 5.75), while Re of AGR/18 and AGR/19 show the lowest ones (median = 1, 3rd quartile = 2.00). AP of AGR/20 shows the highest 3rd quartile of h index (median = 3, 3rd quartile = 6.25) indicating that two of them have published 6 papers with at least 6 citations each (Table 8). All scientists having maximum h values (ranging from 5 to 14, Table 8) have all values of N_i, C_i and Total $IF_{journal.}$ placed at the 3rd quartile of ASPA members, thus its maximum values are representative of very good animal scientists.

Median "m" of ASPA members is 0.33 (1st - 3rd quartile = 0.22 - 0.47, maximum = 2.00) indicating a low increase in h over time during the 18 years of search period (i.e., the time required to increase h by one unity is about 2-3 years). FP of AGR/18 shows the highest median "m" of 0.40 (1st - 3rd quartile = 0.27 - 0.50, maximum = 1.40), while AP of AGR/18 shows the lowest one (median = 0.20, 1st - 3rd quartile = 0.15 - 0.36, maximum = 0.64). In general, the median "m" values of the various research areas and positions are equal or close to the median "m" of ASPA members, indicating no clear differences among these groups. Hirsch (2005) concluded that "m" values of about 1 (i.e., an h index of 20 after 20 years of scientific activity), 2, and 3 or higher characterize successful, outstanding and truly unique physicists, respectively. Obviously, such classification does not apply to ASPA members.

Median "a" of ASPA members is 3 (1st - 3rd quartile = 2 - 4, maximum = 33), which is in the range of the typical values (i.e. between 3 and 5) found by Hirsch (1995). AP and Re of AGR/17 show the highest median "a" of 4.50 with the latter group showing the highest 3rd quartile of "a" (1st-3rd quartile = 3.00 - 8.00, maximum = 12.00), probably because of highly cited papers on genetic maps published by large groups of scientists. Re of AGR/18 shows the lowest median "a" of 2.50 (1st - 3rd quartile = 2.00 - 3.25, maximum = 9.00). Among research areas, AGR/17 has the highest median "a" of 4.00 (1st - 3rd quartile = 3 - 6, maximum = 17.00), while all other areas have a median "a" of 3.00 (lowest and highest maximum = 9.00 and 33.00, for AGR/18 and AGR/19, respectively). The 1st and 3rd quartile of AGR/18, AGR/19 and ERe are identical to those of ASPA members, while those of AGR/20 are 2.00 and 5.00, respectively. In general, FP and Re have the same median "a" and 1st and 3rd quartile of "a" of ASPA members, while AP have the same

median and 1st quartile but a slightly higher 3rd quartile (5.00). Maximum "a" values of FP, AP and Re are 14, 33 and 12, respectively.

When proposing the h-index as a useful index to characterize the scientific output and impact of a researcher, Hirsch (2005) sustained that it has the following advantages: 1) it avoids all the disadvantages of other bibliometric indexes (e.g. N_i, $C_{i.}$ and $IF_{personal.}$), 2) it usually can be found very easily by ordering papers by "times cited" in the ISI-Thompson, Web of Science database and 3) it gives a ballpark estimate of the total number of citations ($C_{i.} = a \times h^2$). Therefore, "two individuals with similar h are comparable in terms of their overall scientific impact, even if their total number of papers or their total number of citations is very different. Conversely, that between two individuals (of the same scientific age) with similar number of total papers or total citation count and very different h values, the one with the higher h is likely to be the more accomplished scientist" (Hirsch, 2005).

Contrary to Hirsch's opinion, we find that bibliometric indexes such as $C_{i.}$ and $IF_{personal.}$ are not difficult to find and that the $C_{i.}$'s limit of giving undue weight to highly cited review articles versus original research contributions can influence the h index also, especially in areas of not very high productivity such as the one of our database. We are also aware that the discriminatory ability of the h index between Italian animal scientists is not as high as that observed for the highly productive physicists analyzed by Hirsch (2005). Nevertheless, we believe that the h index is a useful index for Animal Scientists in Italy.

Within each research group of ASPA, analysis of the geographical distribution of several bibliometric indexes demonstrates that the median and maximum values for N_i, $C_{i.}$, Total $IF_{journal.}$ and h are usually higher in the North, while differences between the Centre and the South are not so clear and vary with the parameter considered (Tables 9 and 10). This trend is similar to that of the geographical zones where scientists with maximum values, for each research area and position, work (Tables 2-8). In fact, most scientists with maximum values for N_i (71%), $C_{i.}$ (79%), Total $IF_{journal.}$ (57%) and h index (65%) work in the North of Italy. Differently, scientists working in the South of Italy represent 29%, 7%, 14% and 20% of those having maximum values for N_i, $C_{i.}$, Total $IF_{journal.}$ and h, respectively. Finally, scientists working in the Centre of Italy constitute 14%, 29% and 15% for $C_{i.}$, Total $IF_{journal.}$ and h, respectively (Tables 2, 3, 7 and 8). The geographical distribution of the maximum values of the bibliometric parameters within each research area shows a higher, but not total, concentration in the North of Italy, except for ERe values, which dominate in the South (Tables 9 and 10). The Italian zone with the highest number of ASPA scientists is the North (165 members), followed by the South (122) and the Centre (76) of Italy.

Overall, most evaluated bibliometric indexes are quite similar among the different research areas, except for AGR/17 that tends to show the highest values (Tables 2-10).

Among university faculties, the higher performance and impact of FP is associated with their longer career, expressed as number of years publishing (Tables 2 and 3), and with their often larger research groups. Besides the expected significant correlations between blibliometric indexes mathematically associated, N_i and $C_{i.}$ were highly correlated ($r = 0.845$, $P<0.001$) indicating that the research activity of ASPA members tends to be a routine work, without major revolutionary papers (Table 11).

Conclusions

This first exercise on calculating some bibliometric indexes for ASPA members demonstrates that the scientific system of Animal Science in Italy has a fairly good level of internationalization. Therefore, in order to monitor the evolution of this dynamic system, such calculations should be performed annually. It is important to high-

light that data collection should be done very carefully, in order to overcome the inherent sources of inaccuracy and/or imprecision of this type of database search.

The limits of the ISI-Thompson database and of the above mentioned indexes should be kept in mind, when evaluating the curriculum of candidates. For example, book chapters of great scientific quality and impact among scientists and/or extension agents and some important journals at a national level are not included in such database. An original paper may not be cited many times because it is not published in the most appropriate journal or it deals with a very specific topic studied by few scientists. For these reason, before submitting a paper to an international journal, an author should take into consideration the possible impact of that paper on the scientific community working on that field. Differently, the low citation number of an important paper can be simply related to its recent publication in an appropriate journal. Another problem is that a scientist responsible for or working in a large and/or strong research group is greatly favored even if his/her effective contribution to some papers is little, while a scientist working alone or in a small research group has to make greater efforts for each paper published and/or cited. Another important aspect is that some scientists who conduct mainly laboratory and/or database analysis (e.g. many AGR/17 members) usually obtain results a lot quicker than researchers conducting field work.

Despite the existing limits of the various bibliometric indexes available, the values of the median and 1st and 3rd quartiles of N_i, $C_{i.}$, Total $IF_{journal.}$ and h index reported in this paper could contribute to the definition of minimum standards for University faculty recruitment or advancement or for researcher positions at other Institutions. Establishing such standards would not only make job competitions more objective and more credible, but also stimulate animal scientists to publish more and better papers.

In order to illustrate the maximal productivity and impact of animal scientists in Italy, the individual bibliometric values for the top ten scientists (i.e., 3%) of ASPA are given for:

a) N_i: Ianuzzi L. (ERe, EReInst) = 93; Davoli R. (FP, AGR/17) = 61; Russo V. (FP, AGR/19) = 53; Baldi A. (FP, AGR/18) = 44; Stefanon B. (FP, AGR/19) = 41; Sevi A. (FP, AGR/19) = 37; Fontanesi L. (Re, AGR/19) = 36; Rando A. (FP, AGR/17) = 33; Valfrè F. (FP, AGR/19) = 31; and Lioi M.B. (FP, AGR/17) = 31;

b) $C_{i.}$: Davoli R. (FP, AGR/17) = 656; Ianuzzi L. (ERe, EReInst) = 646; Rando A. (FP, AGR/17) = 354; Ajmone-Marsan P. (AP, AGR/17) = 319; Stefanon B. (FP, AGR/19) = 293; Licitra G. (FP, AGR/19) = 285; Susmel P. (FP, AGR/18) = 265; Cerolini S. (AP, AGR/20) = 241; Lioi M.B. (FP, AGR/17) = 213; and Lanari D. (FP, AGR/20) = 211;

c) Total $IF_{journal.}$: Davoli R. (FP, AGR/17) = 154.32; Russo V. (FP, AGR/19) = 128.83; Fontanesi L. (Re, AGR/19) = 101.27; Ianuzzi L. (ERe, EReInst) = 91.85; Rando A. (FP, AGR/17) = 84.20; Masina P. (FP, AGR/17) = 64.99; Zambonelli P. (Re, AGR/17) = 64.68; Ramunno L. (FP, AGR/17) = 57.69; Licitra G. (FP, AGR/19) = 47.17; and Baldi A. (FP, AGR/18) = 45.58;

d) h index: Ianuzzi L. (ERe, EReInst), h = 14; Cerolini S. (AP, AGR/20), h = 11; Stefanon B. (FP, AGR/19), h = 10; Susmel P. (FP, AGR/18), h = 9; Pietri A. (Re, ReUni), h = 9; Sevi A. (FP, AGR/19), h = 8; Rando A. (FP, AGR/17), h = 8; Lioi M.B. (FP, AGR/17) h = 8; Lanari D. (FP, AGR/20), h = 8; and Davoli R. (FP, AGR/17), h = 8.

Based on the comparison between the list given above and the names of scientists of Table 8, we can see that about 50% of the scientists having maximum h values, within each research area and position, are among the "top" ten (i.e. 3%) scientists of ASPA for parameters N_i, $C_{i.}$ and Total $IF_{journal.}$. In addition, the h index is positively correlated with N_i (0.853), $C_{i.}$ (0.806) and Total $IF_{journal.}$ (0.717) (Table 11), reinforcing the realiability of this index. Unfortunately, the observed values of the studied bibliometric indexes in the field of Animal Science are a lot lower than those reported in the fields of Physics and Biological

and Biomedical Science (Hirsch, 2005). For this reason, the h index, which could be a useful single-bibliometric index for very productive scientists (e.g. American physicists), should not be used alone for the evaluation of Italian animal scientists, especially at the beginning of their careers. Furthermore, especially when evaluating the activity of a scientist applying for a higher position, his published books, which can demonstrate his/her ability to give a good overview and suggest future work in his field, are of great importance, even though the impact factor of such publications may be irrelevant. The participation of a scientist at international meetings as speaker or, even better, as chairperson or invited speaker should also be considered. The teaching activities of University faculties are also a relevant aspect for their curriculum and are certainly improved by their scientific findings and publications. Therefore, we suggest the simultaneous use of the h-index with other two or three bibliometric indexes (e.g. N_i, C_i, or Total $IF_{journal.}$) together with some other factors, when evaluating the research activity of an animal scientist.

As conclusive remarks, we can say that the comparison of the frequency distributions and the maximum values and respective scientist's names and zones among the various bibliometric indexes allowed a good understanding of the importance and limits of such parameters. In general, the maximum values of N_i, C_i, Total $IF_{journal.}$ and h index belong to animal scientists with a consistent research activity, while those of $IF_{personal.}$ and Mean $IF_{journal.}$ are sometimes related to scientists without a solid career. Currently, the first four indexes are reliable while the last two indexes are not, for the evaluation of the scientific career of an Animal Scientist in Italy. Most ASPA members work in the North of Italy, which shows the highest median and percentage of scientists with maximum values for most bibliometric parameters. Greater efforts should be made by Animal Scientists to improve their bibliometric indexes. Greater scientific productivity and impact, especially of members not belonging to AGR/17, could certainly favor more investments in Animal Science research.

Even if the use of bibliometric indexes might be subjected to criticism, establishing minimum standards for job competitions based on the bibliometric values of this database search could be helpful to increase the level of the scientific research in Animal Science in Italy.

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Any ASPA member interested in the values of his/her bibliometric indexes calculated in this paper is advised to contact Dr. Ana Helena Dias Francesconi.

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