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Letter to the Editor

Gauging the impact of *Forensic Science International: Genetics*—Citation metrics for top articles in the journal

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ABSTRACT

Using the Thomson Reuters' Web of Knowledge bibliometric tool enables the analysis of citation patterns for the articles published in *FSI: Genetics* since it was launched. This brief survey identifies the most cited articles published by the journal since its inception and amongst these, the most impactful original research articles: those showing the highest citation rates per year since their publication.

Dear Editor,

As *Forensic Science International: Genetics* enters the eighth year of publication, this could be a timely point to review the most highly cited articles published since the journal's inception. Citation records reflect a published study's scientific impact, influence on the research focus of fellow specialists and significance to the field. Forensic genetics has a long-standing reputation for innovation and rapid adoption of cutting-edge molecular techniques, so it is only appropriate to see how the output of the one journal that is wholly dedicated to this area of forensic analysis has influenced new research. In addition to being innovative, forensic geneticists also appear to more readily share their data with the scientific community [1] a trend since the first issue in 2007 that has gathered pace in genetics at large, with the continued growth of public data release from multi-centre community resource projects such as 1000 Genomes [2]. Listing the most cited *FSI: Genetics* articles from March 2007 to December 2013 in Thomson Reuters' Web of Knowledge internet-based bibliometric tool [3] provides an insight into the nature and scope of those journal articles with the highest scientific impact. This study is designed to compliment the recent review of publication patterns and impact of the journal as a whole made by John Butler [4], by concentrating on articles that have brought significant numbers of citations to *FSI: Genetics*. Web of Knowledge citation data changes daily but for the purposes of this survey was accessed up to the 25th of November 2013, which covers all of *FSI: Genetics* volumes 1–6 but excludes some citation activity in other journals towards the very end of 2013.

1. Journal citation rates since launch

Up to the final issue 6 of volume 7, December 2013, *FSI: Genetics* has published 778 articles, including 'online extra' articles such as letters to the editor and population reports (electronic articles). The division of published papers into printed full length research articles or reviews vs. electronic articles has enabled more original articles to be accommodated – keeping the journal impactful while maintaining the tradition of rapid dissemination of population data. This change in the division of output into printed and non-printed papers produced an average 53 original articles out of an average total 81 papers per year in 2007–2010, doubling to an average 110 out of a total 152 per year in 2011–2013. This trend is shown by the clear divide in publication output between the first four years and the following three years plotted in Fig. 1.

At the end of November 2013, the journal has a total of 4651 citations to all publications: equating to six citations per paper – a very good figure given the specialist nature of forensic genetics as a field of science. Moreover, original articles are certain to hold a higher average citation rate than this and electronic articles a much lower average rate, indicated by the average citations per original article shown in the sixth line of Table 1, reaching a value of 8.6 in 2013. A trend that leads up to this number of citations is a continuously rising citation rate since 2007 shown by the plot line in Fig. 2, with values indicated for 2009–2013, where previously published articles begin to accumulate citations. The exponential rise in citations is likely to slow down in the near future as papers published in 2007 onwards begin to lose their immediacy. Scrutiny of the gray bar graphs in Fig. 2 indicates citations made to the original articles published in each year since 2007 peak at 3–4 years after publication, although in the author's own experience this pattern is not followed by every article. It is also noteworthy that the average citation rate for original articles published in the first year is somewhat higher than following volumes, beyond the fact that they have had six years to accumulate citations. This may have been the result of pent-up demand for a suitable journal for forensic genetics research, but is much more likely to be due to the quality of articles published in the 2007 special edition of volume 1, issue 2, that selected many of the presentations made at the *DNA in Forensics* conference in Innsbruck 2006, combined in that year with the biennial Y-chromosome/mtDNA meeting. This is more than speculation, as shown in the next section, where no fewer than 10 of the fifty most cited articles come from that one special issue alone.

Given the limited number of active researchers in the field of forensic genetics compared to other areas of science, it might be expected that self-citation is a very dominant feature of citation records. However, this does not appear to be the case from the proportion of self-citations recorded in the first four years (third

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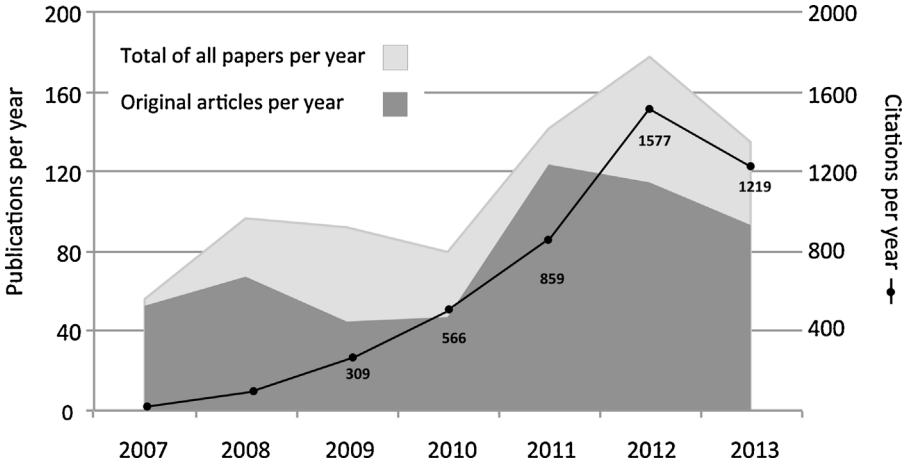

Fig. 1. Total papers and original articles published in *FSI Genetics* per year plus the citations made to these articles.

Table 1
FSI Genetics citation and article publication records by year. The second pane shows accumulated citations as research articles gain 'impact currency' since publication, to produce a rising citation rate per article, currently 8.6 citations per original article. The third pane separates self-citations from all citations indicating a remarkably low self-citation rate that is rising in more recent years. The fourth pane shows the average citations per article per year based on citations made to date of articles from each year. This data follows a pattern of peaking impact 3 and 4 years after publication for original articles in general. Some data for 2013 excluded as insufficient citations have accumulated so far.

	2007	2008	2009	2010	2011	2012	2013
Citations made that year	10	111	309	566	859	1577	1219
All *FSI: Genetics* papers published	56	96	92	79	142	178	135
Original articles published	53	67	45	47	124	114	93
Cumulative original articles	–	120	165	212	336	450	543
Cumulative citations	–	121	430	996	1855	3432	4651
Citations/original article	–	1.0	2.6	4.7	5.5	7.6	8.6
Citations made, to date, of articles from that year	1095	950	767	627	723	430	–
Not self-citations	1092	939	757	621	684	375	–
Self-citation rate	0.3%	1.2%	1.3%	1.0%	5.4%	12.8%	–
Average citations per original article	20.7	14.2	17.0	13.3	5.8	3.8	–
Average citations per article per year	3.4	2.8	4.3	4.4	2.9	3.8	–
Percentage of original articles with zero citations	2%	0	0	0	4.7%	17.7%	–

pane of Table 1) amounting to a little over 1%. Self-citations rise more recently up to 12.8% and this increase might occur as groups continue with a particular line of research speciality where they play an active role.

This review of highly cited articles in *FSI: Genetics* has avoided direct comparisons with other journals in the forensic science/medico-legal field, because this is much of the focus of the article by Butler [4] and citation measures such as the H-index of the journal as whole, in large part reflect the period of time the journal has been publishing impactful articles. However, journal ranking websites such as SJR [5] provide comprehensive surveys of more than 20,500 journals across all fields of scientific research, so those covering forensic topics can be compared. Table 2 summarizes the citation activity of eight forensic journals in the period between 2009 and 2012: the current assessment period of SJR. Data show that in this interval *FSI: Genetics* was able to achieve the highest number of citations per citable article, although *International Journal of Legal Medicine* and *Forensic Science International* have similar citation rates per article. Additionally, the ratio of cited to uncited articles can often provide an informative perspective on the impact of a journal's output. The percentage of articles with zero citations is shown in the lowest pane of Table 1. Although no formal comparisons have been made here with other forensic journals, the rates appear very low indeed – in fact no *FSI: Genetics* articles published in 2008–2010 have zero citations. The outlier figure of 17.7% zero citation articles in 2012 may reflect the period of rising impact for new research as these articles begin to stimulate further research some time after publication. It should also be stressed that citation records alone are not the be-all-and-end-all of any scientific journal's impact on their field and three publications emphasize that a variety of other bibliometric measures can provide further insight into how research activity is fostered by the scientific publication process [6–8]. The author notes that at the time of writing preprint servers (e.g. http://biorxiv.org) are gaining popularity as a way to disseminate important data to fellow researchers ahead of potentially lengthy publication processes.

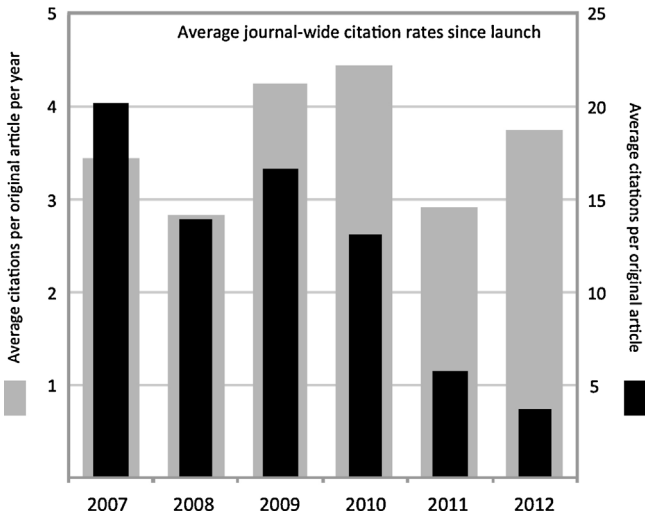

Fig. 2. Average citation rates for FSI Genetics original articles 2007–2012 (2013 is excluded as insufficient citations will have accumulated).

Table 2
A comparison of citation metrics amongst eight journals in the forensic science/medico-legal field. Note that data is based on the period 2009–2012. In this period *Forensic Science International: Genetics* achieved the highest number of citations per citable article, closely followed by *International Journal of Legal Medicine* and *Forensic Science International*.

Citation rate ranking	Journal	2012 H-index	Citable articles 2009–2012	Total citations 2009–2012	Citations/article 2009–2012
3	*Forensic Science International*	67	911	2400	2.63
5	*Journal of Forensic Sciences*	53	820	1172	1.43
2	*International Journal of Legal Medicine*	51	290	780	2.69
1	*Forensic Science International: Genetics*	25	258	832	2.87
7	*Legal Medicine*	23	366	363	1
6	*Science and Justice*	21	98	141	1.44
8	*Journal of Forensic and Legal Medicine*	21	285	312	1.09
4	*Forensic Science, Medicine, and Pathology*	12	133	234	1.76

Table 3
The top fifty most cited articles in FSI Genetics, divided into an upper pane of the 28 articles that give the journal an H-index of 28 and the lower pane listing the additional articles with a citation index of 19 or more (the fifty total excludes the top-listed 'Publication of population data for forensic purposes' which is a guidance paper rather than an original article).

Total citations ranking	FSIGEN volume, issue: pages	Article (some titles abbreviated slightly)	Date of publication	2007	2008	2009	2010	2011	2012	2013	2014	Total	Av. per year[a]
				10	111	309	566	859	1577	1219	6	4657	664.4
1	4, 3: 145–147	Publication of population data for forensic purposes	April 2010				4	28	67	39	0	138	34.5
2	1, 2: 83–87	Y-chromosome haplotype reference database (YHRD): Update	*June 2007*	1	11	15	24	23	29	23	0	126	18.0
3	1, 2: 88–92	EMPOP-A forensic mtDNA database	*June 2007*	0	6	10	11	13	16	12	0	68	9.7
4	1, 3–4: 273–280	Inferring ancestral origin using a single multiplex assay of ancestry-informative marker SNPs	December 2007	0	3	10	8	10	17	16	1	65	9.1
5	1, 3–4: 223–231	ISFG: recommendations on biostatistics in paternity testing	December 2007	0	3	7	12	12	19	6	0	59	8.4
6	1, 2: 191–195	High efficiency DNA extraction from bone by total demineralization	*June 2007*	2	3	6	9	9	13	15	0	57	8.1
7	1, 2: 93–99	X-chromosomal markers: past, present and future	*June 2007*	0	2	4	10	11	20	7	0	54	7.7
8	1, 1: 3–12	DNA commission of the International *Society for Forensic Genetics* (ISFG): recommendations regarding the role of forensic genetics for DVI	March 2007	1	4	9	7	12	15	5	0	53	7.6
9	3, 2: 80–88	mRNA profiling for body fluid identification by reverse transcription endpoint PCR and realtime PCR	March 2009			0	6	10	19	13	0	48	9.6
10	1, 1: 13–19	Extended guidelines for mtDNA typing of population data in forensic science	March 2007	0	2	5	12	10	11	8	0	48	6.9
11	2, 1: 69–74	Population genetic evaluation of eight X-chromosomal short tandem repeat loci using Mentype Argus X-8 PCR amplification kit.	January 2010		2	7	10	13	9	3	0	44	7.3
12	1, 1: 69–74	RNA in forensic science	March 2007	1	1	5	6	10	13	7	0	43	6.1
13	4, 1: 1–10	Interpreting low template DNA profiles	December 2009			0	2	11	17	11	0	41	8.2
14	3, 3: 154–161	DNA-based prediction of human externally visible characteristics in forensics: motivations, scientific challenges, and ethical considerations	June 2009			0	3	12	12	13	0	40	8.0
15	1, 1: 44–55	Coding region mitochondrial DNA SNPs: targeting East Asian and Native American haplogroups	March 2007	1	6	4	7	7	11	3	0	39	5.6
16	2, 3: 198–204	Resolving relationship tests that show ambiguous STR results using autosomal SNPs as supplementary markers	June 2008		0	4	4	5	18	8	0	38	6.3
17	1, 2: 180–185	Evaluation of the Genplex SNP typing system and a 49plex forensic marker panel	*June 2007*	1	6	5	2	9	8	4	0	35	5.0
18	3, 4: 222–226	Estimating the probability of allelic drop-out of STR alleles in forensic genetics	September 2009			1	6	7	12	8	0	34	6.8

Table 3 (*Continued*)

Total citations ranking	FSIGEN volume, issue: pages	Article (some titles abbreviated slightly)	Date of publication	2007	2008	2009	2010	2011	2012	2013	2014	Total	Av. per year[a]
				10	111	309	566	859	1577	1219	6	4657	664.4
19	2, 3: 176–183	Forensic typing of autosomal SNPs with a 29 SNP-multiplex-Results of a collaborative EDNAP exercise	June 2008		1	7	9	7	8	2	0	34	5.7
20	5, 3: 155–169	Analysis of global variability in 15 established and 5 new European Standard Set (ESS) STRs using the CEPH human genome diversity panel	June 2011					7	20	4	1	32	10.3
21	2, 4: 301–309	Real-time forensic DNA analysis at a crime scene using a portable microchip analyzer	September 2008		0	5	5	8	7	6	0	31	5.2
22	1, 1: 29–34	A modular real-time PCR concept for determining the quantity and quality of human nuclear and mitochondrial DNA	March 2007	0	5	9	4	5	4	4	0	31	4.4
23	4, 3: 178–186	An integrated microfluidic device for DNA purification and PCR amplification of STR fragments	April 2010				6	10	9	5	0	30	7.5
24	1, 2: 186–190	Forensic validation of the SNPforID 52-plex assay	*June 2007*	0	0	4	7	7	10	2	0	30	4.3
25	5, 4: 269–275	Concordance and population studies along with stutter and peak height ratio analysis for the PowerPlex ESX 17 and ESI 17 Systems	August 2011					6	13	10	0	29	9.7
26	3, 2: 104–111	The low-template-DNA (stochastic) threshold-Its determination relative to risk analysis for national DNA databases	March 2009			2	7	8	7	5	0	29	5.8
27	2, 4: 292–300	Performance of the SNPforID 52 SNP-plex assay in paternity testing	September 2008		1	6	6	6	8	2	0	29	4.8
28	4, 4: 244–256	The development of a mRNA multiplex RT-PCR assay for the definitive identification of body fluids	July 2010				1	9	9	9	0	28	7.0
29	5, 3: 170–180	IrisPlex: a sensitive DNA tool for accurate prediction of blue and brown eye colour in the absence of ancestry information	June 2011				1[b]	7	8	9	1	26	8.3
30	4, 1: 34–42	Validation of a SNP typing assay with 49 SNPs for forensic genetic testing in a laboratory accredited to ISO 17025	December 2009			0	5	8	9	4	0	26	5.2
31	1, 2: 175–179	Application of novel "mini-amplicon" STR multiplexes to high volume casework on degraded skeletal remains	June 2007	1	0	5	4	4	10	2	0	26	3.7
32	3, 4: 205–213	Improving global & regional resolution of male lineage differentiation by simple single-copy Y-chromosomal STR polymorphisms	September 2009			1	6	9	5	3	0	24	4.8
33	2, 4: 318–328	Direct comparison of post-28-cycle PCR purification and modified capillary electrophoresis methods with the 34-cycle LCN method	September 2008		0	3	3	2	8	7	0	23	3.8
34	2, 3: 212–218	Case report: short-amplicon marker analysis of severely degraded DNA extracted from a decomposed and charred femur	June 2008		1	2	1	4	12	3	0	23	3.8
35	2, 1: 41–46	Characterisation of the STR markers DXS10146, DXS10134 and DXS10147 located within a 79.1 kb region at Xq28	January 2008		1	2	6	7	5	2	0	23	3.8
36	3, 1: 37–41	Analysis of linkage and linkage disequilibrium for eight X-STR markers	December 2008		0	0	6	7	9	0	0	22	3.7
37	2, 2: 91–103	Interpretation of complex DNA profiles using empirical models and a method to measure their robustness	March 2008		1	5	4	7	3	2	0	22	3.7
38	4, 5: 311–315	The use of bacteria for the identification of vaginal secretions	October 2010				0	3	12	6	0	21	5.3

Table 3 (*Continued*)

Total citations ranking	FSIGEN volume, issue: pages	Article (some titles abbreviated slightly)	Date of publication	2007	2008	2009	2010	2011	2012	2013	2014	Total	Av. per year[a]
				10	111	309	566	859	1577	1219	6	4657	664.4
39	4, 5: 323–328	Human eye colour and HERC2, OCA2 and MATP	October 2010				0	3	8	9	0	20	5.0
40	4, 4: 221–227	A universal strategy to interpret DNA profiles that does not require a definition of low-copy-number	July 2010				1	8	8	4	0	21	5.3
41	3, 4: 233–241	Tri-allelic SNP markers enable analysis of mixed and degraded DNA samples	September 2009			0	3	5	8	5	0	21	4.2
42	2, 3: e31–35	Analysis of mutations in father-son pairs with 17 Y-STR loci.	June 2008		0	5	5	4	2	5	0	21	3.5
43	2, 1: 76–82	National recommendations of the Technical UK DNA working group on mixture interpretation for the NDNAD and for court going purposes	January 2008		1	9	4	3	1	3	0	21	3.5
44	1, 2: 111–114	Kinship testing with X-chromosomal markers: Mathematical and statistical issues	June 2007	0	4	2	3	2	8	2	0	21	3.0
45	1, 2: 201–204	Development and forensic validation of a new multiplex PCR assay with 12 X-chromosomal short tandem repeats	June 2007	0	1	1	2	6	9	2	0	21	3.0
46	3, 3: 185–192	DNA from processed and unprocessed wood: factors influencing the isolation success	June 2009			0	2	6	6	6	0	20	4.0
47	2, 2: 108–125	A quadruplex real-time qPCR assay for the simultaneous assessment of total human DNA, human male DNA, DNA degradation and inhibitors	March 2008		0	3	1	5	5	6	0	20	3.3
48	4, 3: 148–157	Forensic implications of genetic analyses from degraded DNA-A review	April 2010				3	6	7	3	0	19	4.8
49	2, 3: 226–230	Comparison of five DNA quantification methods	June 2008		0	4	5	1	8	1	0	19	3.2
50	1, 2: 154–157	Development and expansion of high-quality control region databases to improve forensic mtDNA evidence interpretation	June 2007	0	0	4	7	2	2	4	0	19	2.7
51	1, 1: 20–28	Towards understanding the effect of uncertainty in the number of contributors to DNA stains	March 2007	0	2	4	2	4	5	2	0	19	2.7

Italicized publication month and year indicates the first special issue "DNA in Forensic Conference, Inssbruck 2006".

[a] Average citations per year excludes 2014.

[b] Citation listed before publication year (likely cited from e-pub version of article).

In summary, after seven years, the journal appears to be heading for a stable publication framework of approximately 100 original articles a year that are likely to reach an average peak of 4.5 citations per year, some three to four years after publication. Whether the impact of future published articles increases beyond this point is not guaranteed, but as with all journals, *FSI: Genetics* is aiming towards a 'virtuous circle' of a rising impact factor attracting ever better quality submissions from researchers in the field, and appears to be heading in the right direction to achieve this.

2. The journal's most cited articles

The journal H-index in November 2013 was 28, i.e. amongst the most cited articles there are 28 with at least 28 citations each, measured 2007–2013 – in slight contrast to the H-index of 25 reported by SJR in Table 2 that just measured 2009–2012. Table 3 lists these top 28 in a separate part to the other 22, which make up the top fifty based on total citations recorded to date. Only one, ranked 42, is an electronic article, despite reporting original research and achieving 21 citations. Although fifty is no more than a round number, the 52nd paper drops from a total 19 citations to 17; therefore, 51 are listed in this table and the top cited paper with 138 can largely be discounted from this list, as it is no more than a set of guidelines cited by nearly all population reports submitted to the journal. Topics covered in this top list of reported research encompass all the emerging technologies in forensic genetics since autosomal STR profiling became established as the global norm for DNA analysis and most STR R&D stopped as kits brought standardized approaches. The two research areas covered the most are DNA processing (extraction, amplification, quantitation) and SNPs: both with 9 papers. After these topics, complex profile analysis and X-chromosome STRs have 7 and 6 top cited articles respectively. Other areas unsurprisingly concentrate to a large extent on key emerging forensic technologies since 2007: RNA, mtDNA (both 4); Y-chromosome markers, Conventional STR analysis, External Visible Characteristics (EVC) analysis (each 3) and ISFG guidelines-statistics (2).

More refined measurement of the long-term impact of the top articles described above can be made by assessing the citation rate per year since publication. These values are listed in the final column of Table 3 and the 12 articles with eight or more citations

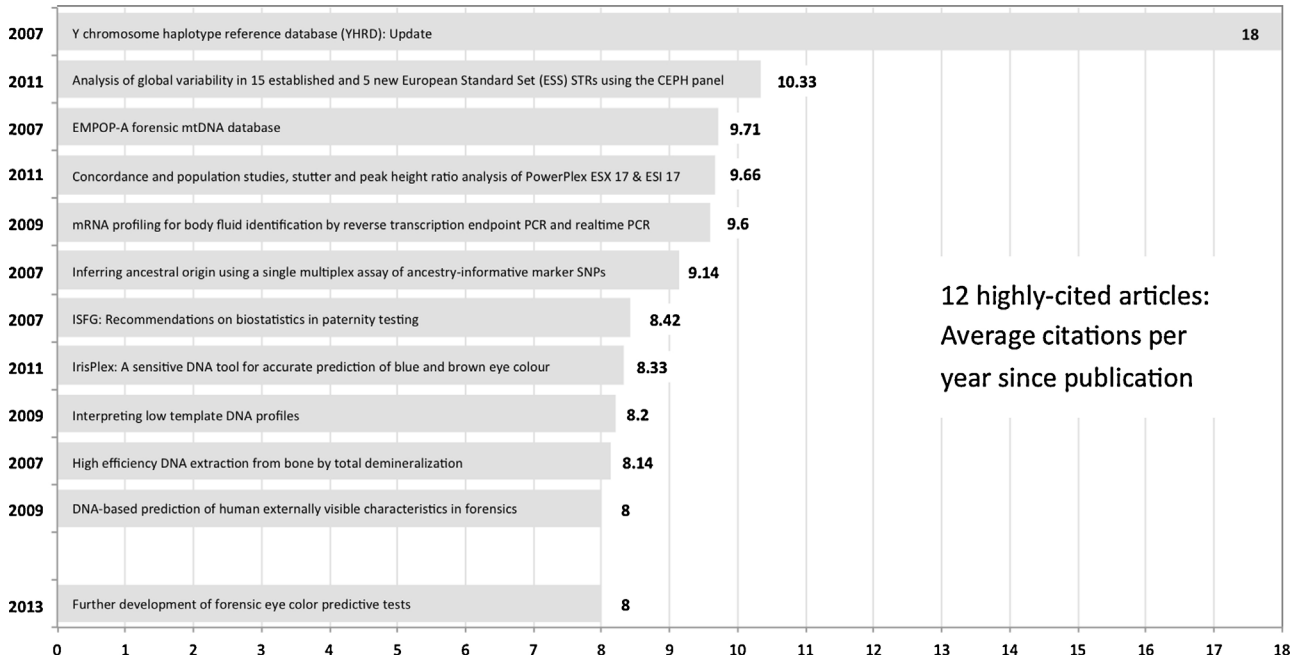

Fig. 3. The most highly cited FSI Genetics research-based original articles based on average citations per year. The twelfth article: 'Further development of forensic eye color predictive tests' [9] is included here as it has reached eight citations in the first year of publication.

per year since they were published can be considered the most impactful from the journal so far. Eleven of the twelve highly cited articles are listed in Fig. 3 (excluding the 'Publication of population data for forensic purposes' paper). Fig. 3 shows the establishment of the forensic community resources for the Y-chromosome and mitochondrial haploid variation databases in the form of YHRD and EMPOP has clearly produced a sizeable impact on other research. The additional article on eye colour prediction at the bottom of the figure has a total of 8 citations but was published less than a year ago [9]. It is worth mentioning that another article with a high citation rate in its first publication year is Walsh et al. 'The HIrisplex system for simultaneous prediction of hair and eye colour from DNA' [10] with six citations in November 2013. Therefore as many as four articles covering research on EVC-prediction tools for pigmentation variation can be found amongst the current most highly cited articles, indicating this area of research is not only one of the most exciting recent developments in forensic genetics but has prompted a great deal of interest in the field.

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Chris Phillips*
Forensic Genetics Unit, Institute of Legal Medicine, University of Santiago de Compostela, Spain

*Tel.: +34 981 583 015
E-mail address: c.phillips@mac.com (C. Phillips).

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