Use made of open access journals by Indian researchers to publish their findings

*Muthu Madhan and Subbiah Arunachalam**

Most of the papers published in the more than 360 Indian open access journals are by Indian researchers. But how many papers do they publish in high impact international open access journals? We have looked at India's contribution to all seven Public Library of Science (PLoS) journals, 10 BioMed Central (BMC) journals and Acta Crystallographica Section E: Structure Reports. Indian crystallographers have published more than 2,000 structure reports in Acta Crystallographica, second only to China in number of papers, but have a much better citations per paper average than USA, Britain, Germany and France, China and South Korea. India's contribution to BMC and PLoS journals, on the other hand, is modest at best. We suggest that the better option for India is institutional self-archiving.

Keywords: Impact factor, open access, science citation index, *Web of Science.*

HOW aware are Indian researchers of open access (OA) and its advantages 10 years after Stevan Harnad[1] visited India and spoke about the need for adopting OA archiving? To answer this question, we looked at India's participation in both OA institutional archiving and Indian researchers using OA journals to publish their findings. In this article, our emphasis is on the use made of selected high impact OA journals, particularly Public Library of Science (PLoS) and BioMed Central (BMC) journals and *Acta Crytallographica Section E*, the three leading publishers of open access papers in terms of number of papers published annually[2].

The Registry of Open Access Repository (ROAR)[3] lists 2,047 repositories (data gathered on 17 December) of which 59 are from India. Included in the 59 repositories are the National Institute of Science Communication and Information Resources (NISCAIR) journals repository, the *Institute of Integrative Omics and Applied Biotechnology* (IIOAB) *Journal* repository and repetitive entries of five institutional repositories, viz. EPrints@CMFRI, EPrints@IIMK, EPrints@MKU, repository of INFLIBNET and the repository at the Cochin University of Science and Technology. Many Indian repositories listed in ROAR are inactive. There are at least five other Indian repositories not listed in ROAR, viz. Mahatma Gandhi University, Kottayam, and Vidyanidhi, Mysore, both repositories of theses; International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Ministry of Earth Sciences and SARAI. In all, there are 33 OA repositories in India which include 24 institutional repositories, 4 subject repositories and 5 dedicated theses and dissertation repositories. The quality of these repositories varies widely as well as their maintenance. Considering that there are more than 450 universities and several hundred research laboratories in the government, corporate and the non-government sectors, one would expect a very large number of institutional repositories in India. Furthermore, many of these repositories are not filling fast enough.

Out of the 5,897 OA journals listed in the *Directory of Open Access Journals* or *DOAJ* (data accessed on 17 December 2010)[4], 276 are from India. Another database, *Open J-Gate*[5], developed by the Bangalore-based Informatics India, lists 7,967 OA periodicals worldwide which include 4,773 peer-reviewed journals including 339 peer-reviewed Indian journals (Figure 1). There are a few other Indian OA journals which are yet to be listed in *DOAJ* and indexed in *Open J-Gate*. For example, two journals published by the Indian National Science Academy (*Indian Journal of Pure and Applied Mathematics* and *Proceedings of the Indian National Science Academy*) and two journals published by Indian Council of Agricultural Research (*Indian Journal of Agricultural Sciences* and *Indian Journal of Animal Sciences*) are neither indexed in *Open J-Gate* nor listed in *DOAJ*. *DOAJ* does not index *Indian Journal of Natural Products and Resources* (formerly known as *Natural Product Radiance*), published by NISCAIR. In all, there are more than 360 Indian OA journals.

Needless to say a vast majority of papers, published in the Indian OA journals, are mostly written by Indian

Muthu Madhan is in the ICRISAT, Patancheru 502 324, India and Subbiah Arunachalam is in the Centre for Internet and Society, No. 194, 2nd 'C' Cross, Domlur 2nd Stage, Bangalore 560 071, India.
*For correspondence. (e-mail: subbiah.arunachalam@gmail.com)

researchers. Incidentally, two Indian journal publishers, viz. Indian Academy of Sciences and MedKnow Publications figure in the top 14 OA journal publishers in the Study of Open Access Publishing (SOAP) survey[2]. Our focus here is papers published by Indian researchers in high-impact OA journals published outside India. We chose all seven journals published by PLoS, 10 BMC journals and *Acta Crystallographica Section E: Structure Reports*. We gathered data from the *Science Citation Index – Expanded* section of *Web of Science* between 11 and 29 December 2010. Countries were assigned to papers based on addresses in the by-line. If three authors from three countries had collaborated to write a paper, then the paper was assigned to all three countries. Therefore, the sum of papers from different countries will be far more than the actual number of papers indexed in *Web of Science*.

Results

BioMed Central Journals

BioMed Central, established in May 2000, is the world's leading OA publisher[6] in the fields of medical research and biology and publishes 208 OA journals as noted on 28 December 2010. Not all of them commenced publication at the same time, not even the same year. Different journals started publication in different years. So far these journals together have published 99,717 articles, including 83,893 original research papers and 15,824 other types of articles (Table 1). Indian researchers have published 1,872 original research papers and 92 other types of articles (such as review articles) in these 208 journals. To see India's record in perspective, we have provided data for 11 other countries. These include the other three BASIC countries (Brazil, South Africa and China), South Korea and Israel, both of which have scientific enterprises comparable in size to that of India, and six advanced countries. USA stands out with close to 29,300 papers, followed by Great Britain (9,464 papers) and Germany (9,340 papers). China is way ahead of other BASIC countries, and India is ahead of Israel, Korea and South Africa in the number of papers published. Brazil is ahead of India in total number of papers but falls behind in the number of original research papers. It will be interesting to see why researchers from Brazil publish such a large number of review articles.

Of these 208 journals, only 77 have been listed in *Journal Citation Reports* (*JCR*) 2009 and assigned an impact factor. (For a journal to get indexed in *JCR* it should have been in existence for longer than two years.) We list in Table 2 those journals with impact factor greater than 4.000. Among BMC journals, *Genome Biology* has the highest impact factor (6.626). Other high impact factor journals are *Orphanet Journal of Rare Diseases* (5.825), *BMC Biology* (5.636) and *Breast Cancer Research* (5.326). The following nine journals have published more than 2,000 papers so far (since they became OA journals): *BMC Bioinformatics* (4,078), *BMC Genomics* (3,204), *Critical Care* (2,787), *BMC Public Health* (2,580), *Acta Veterinaria Scandinavica* (2,575), *BMC Cancer* (2,344), *Arthritis Research and Therapy* (2,286), *Journal of Experimental and Clinical Cancer Research* (2,255) and *Genome Biology* (2,069). Ten journals have published more than 1000 papers but less than 2000. Four journals have published less than 100 papers. Five journals have citations per paper (CPP) higher than 10. These are *Genome Biology* (18.35), *Veterinary Research* (12.27), *Genetics Selection Evolution* (11.71), *Respiratory Research* (11.03) and *Breast Cancer Research* (10.33).

The number of papers published by authors in India in 10 BMC journals during 2003–2010 (data gathered on 13

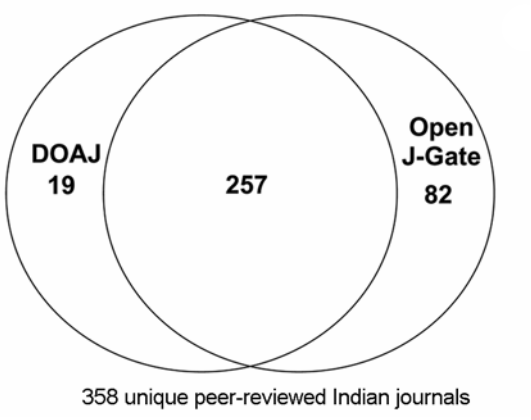

Figure 1. Coverage of open access Indian journals in *DOAJ* and *Open J-Gate* (data gathered in the first week of December 2010).

Table 1. Papers from 12 selected countries in all 208 BMC journals (Current Opinion journals excluded) – as seen from BMC on 28 December 2010 (http://www.biomedcentral.com/search/)

	Number of papers		Total	
Country	Research	Review	Number	(%)
USA	26,181	3,106	29,287	29.37
Great Britain*	9,114	350	9,464	9.49
Germany	8,041	1,299	9,340	9.37
Canada	5,471	538	6,009	6.02
France	4,245	642	4,887	4.90
China	3,593	109	3,702	3.71
Japan	2,951	369	3,320	3.33
India	1,872	92	1,964	1.97
Brazil	1,381	823	2,204	2.21
Korea	882	38	920	0.92
South Africa	761	51	812	0.81
Israel	924	158	1,082	1.09
World	83,893	15,824	99,717	100

*Only England, Scotland and Wales are included. Search strategy: England OR Scotland OR Wales (AND) NOT New South Wales (AND).

Table 2. BMC journals having impact factor (in *JCR* 2009) arranged by descending order of number of papers. Of the 77 titles, only 14 (with impact factor > 4.000) are listed

Journal	Impact factor	WoS start year*	Number of papers till 2010	Sum of citations	CPP
Critical Care	4.931	1999	2,787	21,196	7.61
Arthritis Research and Therapy	4.271	2003	2,286	17,426	7.62
Genome Biology	6.626	2000	2,069	37,956	18.35
Breast Cancer Research	5.326	2000	1,871	19,324	10.33
Retrovirology	4.105	2005	1,868	4,805	2.57
BMC Evolutionary Biology	4.294	2001	1,527	13,506	8.84
Molecular Cancer	4.160	2006	715	4,364	6.10
BMC Systems Biology	4.064	2007	463	1,670	3.61
BMC Biology	5.636	2005	401	3,096	7.72
Molecular Pain	4.187	2005	382	2,408	6.30
Journal of Neuroinflammation	4.675	2006	235	1,439	6.12
Orphanet Journal of Rare Diseases	5.825	1996	189	1,637	8.66
Molecular Neurodegeneration	5.091	2006	163	1,031	6.33
Biotechnology for Biofuels	4.118	2008	70	229	3.27

Source: http://www.biomedcentral.com/info/about/faq?name=impactfactor#jif
*Year from which the journal is indexed in *Science Citation Index.*

December 2010), the number of citations to these papers and cites/papers are provided in Table 3. To see the Indian papers in perspective, we have also given the total number of papers published in these 10 journals during the same period, number of citations received by them and the average number of citations per paper (CPP) as well as similar data for 11 other selected countries including five scientifically middle-level countries and six advanced countries. A quick look at the table reveals that there is a perceptible difference between the middle-level countries and the advanced countries.

Indian researchers have published 4.53% of the papers that have appeared in *Malaria Journal*, 2.49% of papers appearing in *BMC Genomics*, 1.77% of papers appearing *BMC Public Health*, 1.7% of papers appearing in *BMC Bioinformatics*, and 1.61% of papers appearing in *BMC Evolutionary Biology*. India's participation in the other five journals is rather meagre. Looking at CPP, Indian contributions in nine of the ten journals have a lower CPP than the world papers. Year after year, Thomson Reuters's *ScienceWatch* has shown that Indian research papers on an average have been cited less often than world papers in every field[7]. But Indian papers in *BMC Public Health* have been cited on average 7.45 times compared to the world average of 5.59 CPP. This is rare and the researchers responsible for this deserve to be congratulated. It will be worth examining if India's performance in public health research is of a higher class overall than research in other areas of medicine.

The number of papers from China in BMC journals accounts for a much larger per cent than papers from India. For example, papers from China account for 10.0% in *BMC Cancer*, 7.75% in *BMC Genomics*, 5.74% in *BMC Bioinformatics* and 5.41% in *BMC Evolutionary Biology*. This is to be expected, as China is second only to USA in the number of papers published in peer-reviewed scientific journals and publishes more than three times the number of papers as India. Except in *Breast Cancer Research*, in which journal China publishes about 1% of papers, in all other journals, China's CPP value is less than the journal average.

Although Brazil publishes fewer papers than India, it has an enviable CPP record in at least five journals considered here: *Arthritis Research and Therapy* (15.88; journal average 8.64), *Genome Biology* (23.43; journal average 22.50), *Critical Care* (11.96; journal average 8.23), *Breast Cancer Research* (10.71; journal average 8.52) and BMC Public Health (6.54; journal average 5.59).

Israel, a small country with only a few research institutions and universities, has published fewer papers, but has a CPP higher than the journal average in seven of the ten journals. South Korea has a higher CPP for its papers in *Arthritis Research and Therapy* than the journal average.

Except for *BMC Public Health*, in all the other journals USA accounts for not less than 25% of papers and in some well over 40%. Also, in each of the 10 journals, USA has recorded higher CPP than the journal average. Great Britain is a distant second, but its share of papers in *BMC Public Health* and *Malaria Journal* is even higher than that of USA. Britain's interest in public health and malaria research could be explained by over two centuries of her colonial connections. Also, in both these journals, Britain's CPP is greater than the journal average. In fact, in both *BMC Genomics* and *Malaria Journal*, the CPP is highest for Britain.

Germany has published a larger number of papers in *BMC Bioinformatics* and *BMC Cancer* than Britain and France and these have been cited more often as well. Germany has published close to 10% of the papers in

Table 3. Number of articles contributed by 12 selected countries to 10 BMC journals and number of citations received by those articles (Data gathered from *Web of Science*)

Journal (2003–2009)	India		China		South Korea		Brazil		South Africa		Israel	
	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)
BMC Bioinformatics 3,409 papers 35,201 citations 10.33 (CPP)	58 (1.70%)	524 (9.03)	196 (5.74%)	1,465 (7.47)	72 (2.11%)	600 (8.33)	34 (0.99%)	183 (5.38)	8 (0.23%)	58 (7.25)	31 (0.91%)	319 (10.29)
BMC Genomics 2,530 papers 24,817 citations 9.81 (CPP)	63 (2.49%)	462 (7.33)	196 (7.75%)	1,034 (5.28)	43 (1.70%)	231 (5.37)	43 (1.70%)	417 (9.30)	13 (2.45%)	92 (7.08)	39 (1.54%)	334 (8.56)
Critical Care 2,092 papers 17,218 citations 8.23 (CPP)	6 (0.29%)	11 (1.83)	22 (1.05%)	147 (6.68)	8 (0.38%)	23 (2.88)	45 (2.15%)	538 (11.96)	6 (0.29%)	66 (11.00)	22 (1.05%)	185 (8.41)
BMC Public Health 1,863 papers 10,406 citations 5.59 (CPP)	33 (1.77%)	246 (7.45)	75 (4.02%)	347 (4.63)	22 (1.18%)	66 (3.00)	37 (1.99%)	242 (6.54)	29 (1.56%)	146 (5.03)	11 (0.59%)	70 (6.36)
BMC Cancer 1,680 papers 12,880 citations 7.67 (CPP)	22 (1.31%)	73 (3.32)	168 (10.00%)	1,085 (6.46)	56 (3.33%)	420 (7.50)	43 (2.56%)	282 (6.56)	7 (0.42%)	37 (5.29)	12 (0.71%)	93 (7.75)
Genome Biology 1,589 papers 35,755 citations 22.50 (CPP)	6 (0.38%)	114 (19.00)	40 (2.52%)	743 (18.58)	7 (0.44%)	93 (13.29)	7 (0.44%)	164 (23.43)	5 (0.31%)	99 (19.80)	35 (2.20%)	487 (13.91)
Arthritis Research and Therapy 2,008 papers 17,348 citations 8.64 (CPP)	3 (0.14%)	9 (3.00)	27 (1.34%)	126 (4.67)	30 (1.49%)	296 (9.87)	8 (0.40%)	127 (15.88)	1 (0.04%)	56 (56.00)	17 (0.85%)	191 (11.24)
Breast Cancer Research 1,650 papers 14,059 citations 8.52 (CPP)	4 (0.24%)	7 (1.75)	16 (0.97%)	170 (10.62)	17 (1.03%)	114 (6.71)	7 (0.42%)	75 (10.71)	1 (0.06%)	0	11 (0.67%)	159 (14.45)

(*Contd*)

Table 3. (*Contd*)

Journal (2003–2009)	India		China		South Korea		Brazil		South Africa		Israel	
	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)
BMC Evolutionary Biology 1,184 papers 12,650 citations 10.68 (CPP)	19 (1.61%)	169 (8.89)	64 (5.41%)	340 (5.31)	6 (0.51%)	26 (4.33)	24 (2.02%)	136 (5.67)	16 (1.35%)	107 (6.69)	16 (1.35%)	133 (8.31)
Malaria Journal 1,060 papers 7,926 citations 7.48 (CPP)	48 (4.53%)	255 (5.31)	8 (0.75%)	26 (3.25)	6 (0.57%)	18 (3.00)	22 (2.08%)	91 (4.14)	57 (5.38%)	412 (7.23)	5 (0.47%)	65 (13.00)

Journal (2003–2009)	USA		Great Britain*		France		Germany		Canada		Japan	
	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)
BMC Bioinformatics 3,409 papers 35,201 citations 10.33 (CPP)	1,443 (42.33%)	17,241 (11.95)	357 (10.47%)	3,897 (10.92)	180 (5.28%)	1,649 (9.16)	374 (10.47%)	4,172 (11.16)	162 (4.75%)	1,940 (11.97)	121 (3.55%)	893 (7.38)
BMC Genomics 2,530 papers 24,817 citations 9.81 (CPP)	1,128 (44.58%)	12,544 (11.12)	301 (11.90%)	3,578 (11.89)	246 (9.72%)	2,299 (9.35)	235 (9.29%)	2,510 (10.68)	195 (7.71%)	2,230 (11.44)	103 (4.07%)	1,047 (10.17)
Critical Care 2,092 papers 17,218 citations 8.23 (CPP)	568 (27.15%)	5,881 (10.35)	298 (12.24%)	1,986 (6.66)	207 (9.89%)	1,894 (9.15)	232 (11.09%)	2,175 (9.38)	193 (9.22%)	1,967 (10.19)	16 (0.76%)	135 (8.44)
BMC Public Health 1,863 papers 10,406 citations 5.59 (CPP)	348 (18.68%)	2,396 (6.89)	389 (20.88%)	2,431 (6.25)	54 (2.89%)	248 (4.59)	109 (5.85%)	847 (7.77)	127 (6.82%)	743 (5.85)	41 (2.20%)	190 (4.63)
BMC Cancer 1,680 papers 12,880 citations 7.67 (CPP)	455 (27.08%)	4,517 (9.93)	120 (7.14%)	941 (7.84)	86 (5.12%)	695 (8.08)	230 (13.69%)	2,009 (8.73)	97 (5.77%)	891 (9.19)	85 (5.06%)	488 (5.74)

(*Contd*)

Table 3. (*Contd*)

Journal (2003–2009)	USA		Great Britain*		France		Germany		Canada		Japan	
	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)	Papers/ (% in total)	Citations/ (CPP)
Arthritis Research and Therapy 2,008 papers 17,348 citations 8.64 (CPP)	526 (26.19%)	5,703 (10.84)	313 (15.58%)	2,975 (9.50)	169 (8.42%)	1,307 (7.73)	282 (14.04%)	2,077 (7.37)	106 (5.28%)	1,278 (12.06)	143 (7.12%)	1,149 (8.03)
Genome Biology 1,589 papers 35,755 citations 22.50 (CPP)	983 (61.86%)	25,345 (25.78)	291 (18.31%)	5,505 (18.92)	83 (5.22%)	1,862 (22.43)	153 (9.63%)	5,107 (33.08)	80 (5.13%)	1,479 (18.49)	57 (3.59%)	1,182 (20.74)
Breast Cancer Research 1,650 papers 14,059 citations 8.52 (CPP)	574 (34.79%)	7,522 (13.10)	562 (34.06%)	2,373 (4.22)	59 (3.58%)	833 (14.12)	86 (5.21%)	733 (8.52)	89 (5.39%)	1,088 (12.22)	23 (1.39%)	335 (14.57)
BMC Evolutionary Biology 1,184 papers 12,650 citations 10.68 (CPP)	446 (37.67%)	5,150 (11.55)	184 (15.54%)	2,624 (14.26)	136 (11.49%)	1,241 (9.12)	163 (13.77%)	2,153 (13.21)	112 (9.46%)	1,172 (10.46)	49 (4.14%)	344 (7.02)
Malaria Journal 1,060 papers 7,926 citations 7.48 (CPP)	278 (26.23%)	2,300 (8.27)	317 (29.90%)	2,967 (9.36)	137 (19.92%)	1,071 (7.82)	79 (7.45%)	583 (7.38)	14 (1.32%)	104 (7.43)	21 (1.98%)	104 (4.95)

*Only England, Scotland and Wales are included.

Genome Biology and these papers have recorded the highest CPP (33.08 compared to 25.78 for USA).

Acta Crystallographica

The International Union of Crystallography (IUCr) publishes *Acta Crystallographica* in six sections. *Acta Crystallographica Section E: Structure Reports Online* is the IUCr's first electronic-only journal[18]. It is a rapid communication journal for the publication of concise reports on inorganic, metal-organic and organic structures. Unlike other fee-based OA journals published in the western world, this journal charges a modest USD 150 per article and it also offers a fee waiver for authors from developing countries.

During the seven years 2003–2009, this journal published 22,887 papers which were cited 35,078 times (Table 4). China accounted for more than 47% of these papers, followed by India (9.1%). However, papers from India averaged a higher CPP (2.13) than Germany, Britain and USA. Crystallography is a known area of strength in India. The earliest Indian paper in this field by Banerjee[9] of the Indian Association for the Cultivation of Science appeared in 1930. Today, chemical crystallography is arguably stronger than all other aspects of crystallography in India, although in the early years physicists dominated the field. Work in biological crystallography started when G. N. Ramachandran, a physicist, started his work at the University of Madras in the 1950s. It will be interesting to look at the historical evolution of crystallography in India.

PLoS journals

We will now turn our attention to the PLoS journals[10]. There are seven journals in all. *PLoS ONE* (eISSN-1932-6203) is somewhat different from the other six PLoS journals. It is an international, peer-reviewed, OA, online publication that accepts reports on primary research from any scientific discipline. In-house PLoS staff and international Advisory and Editorial Boards ensure fast, fair, and professional peer review. In Table 5, we provide data on the number of papers published each year by authors from the 12 countries during 2006–2010. The USA has published the largest number of papers, viz. 6,501, which is more than four times that of Britain, its nearest rival. India has published 262 papers and has the least CPP, viz. 2.34, whereas all the other countries have a CPP of above 3.0. Britain has the highest, viz. 4.76, closely followed by Germany (4.73). The values for other countries are: USA (4.36), France (4.23), Canada (4.29), Israel (3.98), Japan (3.86), South Korea (3.82), South Africa (3.46), China (3.24) and Brazil (3.01). The journal has published during this period 14,071 papers at a CPP of 3.99.

Table 4. Number of papers published in *Acta Crystallographica Section E – Structure Reports Online* by selected countries during 2003–2009 as seen in *WoS* on 22 December 2010

Country	Papers	Cites	CPP
People's Republic of China	10,925	14,343	1.31
India	2,094	4,462	2.13
Germany	1,618	2,999	1.85
USA	1,560	2,343	1.50
Great Britain*	1,148	2,007	1.75
Japan	591	1,201	2.03
Canada	369	579	1.57
South Korea	319	587	1.84
South Africa	301	481	1.60
Brazil	272	352	1.31
France	271	299	1.10
Israel	31	66	2.33
World	22,887	35,078	1.53

*England, Scotland and Wales only.

The number of papers published by the other six journals, number of times they are cited and impact factors of these journals are given in Table 6. In these journals, India has published 120 papers and these have been cited 1,022 times for an average of 8.52 CPP. The corresponding figures for other middle-level countries are: China (212 papers and 11.39 CPP), South Korea (62 papers and 17.47 CPP), Brazil (131 papers and 10.21 CPP), South Africa (137 papers and 18.42 CPP) and Israel (184 papers and 15.46 CPP).

Looking at individual journals (Table 7), one sees that in general the middle-level countries have published very few papers compared to the advanced countries. There are exceptions though. Israel has published 73 papers in *PLoS Computational Biology*, comparable to France's 92 and higher than Canada's 55 and Japan's 46. In this journal Israel's CPP (8.5) is comparable to the world average (9.1) and the CPP of Britain and higher than the CPP of Japan. In *PLoS Medicine*, India's 38 papers have a CPP of 6.92, far below the journal average of 14.12, and less than that of the other 11 countries considered. In *PLoS Biology*, India has a CPP of 15.77, far below the journal average of 31.69, whereas South Korea (54.78) and China (32.12) have a CPP higher than the journal average. In *PLoS Genetics*, Brazil, South Africa and Israel have a higher CPP than the journal average. Authors from USA publish the largest number of papers in each of the six PLoS speciality journals, followed by Britain. But USA leads in CPP in only two of them, viz. *PLoS Pathogens* and *PLoS Computational Biology*. Britain has the highest CPP for *PLoS Genetics* followed by USA. Japan has the highest CPP for *PLoS Medicine* followed by France. Canada has the highest CPP for *PLoS Neglected Tropical Diseases* and *PLoS Biology*, the first of the PLoS journals.

Discussion

There has been a perceptible increase in the number of OA papers published in journals. Björk *et al*. have shown

Table 5. Number of papers published in *PLoS ONE* (impact factor 4.351) from 12 selected countries and citations to them (Data gathered from *Web of Science* (11 December 2010))

	India		China		South Korea		Brazil		South Africa		Israel	
Year	Papers	Cites	Papers	Cites	Papers	Cites	Papers	Cites	Papers	Cites	Papers	Cites
2006	5	54	4	181	2	110	4	76	1	4	4	22
2007	16	102	36	444	10	147	17	189	11	88	30	290
2008	43	290	140	1,160	24	166	41	84	19	66	64	513
2009	81	136	204	557	36	91	46	245	34	224	74	181
2010+	117	31	372	108	70	29	98	27	51	19	85	16
Total	262	613	756	2,450	142	543	206	621	116	401	257	1,022

	USA		Great Britain*		France		Germany		Canada		Japan	
Year	Papers	Cites	Papers	Cites	Papers	Cites	Papers	Cites	Papers	Cites	Papers	Cites
2006	66	1,041	19	326	7	107	14	183	6	133	9	269
2007	628	8,594	183	2,383	133	1,632	127	1,854	85	1117	64	772
2008	1,277	11,705	359	3,505	278	2,303	282	2,618	167	1678	138	942
2009	1,750	5,901	330	1,043	352	1,064	291	940	202	526	163	433
2010+	2,780	1,071	704	338	477	165	506	172	371	113	276	91
Total	6,501	28,312	1595	7,595	1,247	5,271	1,220	5,767	831	3567	650	2,507

*Only England, Scotland and Wales are included. +Data gathered on 11 December 2010.

Number of papers and citations for world in *PLoS ONE* (impact factor 4.351)

Year	Papers	Cites
2006	137	2,060
2007	1,230	15,375
2008	2,717	22,748
2009	4,404	13,996
2010+	5,583	1,900
Total	14,071	56,079

+Data gathered on 11 December 2010.

Table 6. Number of papers and citations in 6 PLoS journals for world (as seen on 19 December 2010)

Journal	Impact factor	Journal start year*	No. of papers till 2010	Sum of citations	CPP
PLoS Medicine	13.050	2004	1,838	25,948	14.12
PLoS Biology	12.916	2003	1,835	58,147	31.69
PLoS Genetics	9.532	2005	1,776	27,064	15.24
PLoS Pathogens	8.978	2005	1,607	19,910	12.39
PLoS Computational Biology	5.759	2005	1,536	13,971	9.10
PLoS Neglected Tropical Diseases	4.693	2007	771	2,860	3.71

*These journals are indexed in *Web of Science* right from the start.

that the number of OA papers has been growing and for articles published in 2008, it stood at 20.4% of all papers published – 8.5% in journals (publisher sites) and 11.9% in searchable repositories[11,12]. A recent forecast by Springer based on *Web of Science* data has shown that at the current rate of growth journal articles which are OA will likely grow from 8.7% in 2010 to 27% by 2020 assuming a constant annual growth rate of 20% as against 3% growth rate of papers indexed in *Web of Science* (Figure 2)[13]. It will be interesting to see if the number of papers published by Indian researchers in OA journals also increase year after year. Sathyanarayana of Informatics India tells us that the per cent of OA papers published by Indian researchers as revealed by *Open J-Gate* is higher than the world average (private communication), but we need a proper scientometric study to confirm this.

Evans and Reimar have shown that for authors from developing countries free-access articles are cited much

Table 7. Number of papers in PLoS journals from 12 selected countries and number of citations received by them (Data gathered from *Web of Science*)

PLoS journal	India		China		South Korea		Brazil		South Africa		Israel	
	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP
PloS Medicine (2004–2010)	38	263 (6.92)	42	758 (18.05)	6	187 (31.17)	15	458 (35.33)	84	1621 (19.3)	19	399 (21)
PLoS Biology (2003–2010)	13	205 (15.77)	17	546 (32.12)	9	493 (54.78)	6	43 (7.17)	11	268 (24.36)	34	1070 (31.47)
PLoS Genetics (2005–2010)	9	116 (12.89)	46	430 (9.35)	13	86 (6.62)	8	336 (42.00)	10	233 (23.30)	37	678 (18.32)
PLoS Pathogens (2005–2010)	11	101 (9.18)	32	249 (7.78)	20	204 (10.2)	18	252 (14.00)	20	377 (18.85)	17	65 (3.82)
PLoS Computational Biology (2005–2010)	22	261 (11.86)	40	273 (6.825)	7	89 (12.71)	7	35 (5.00)	4	16 (4.00)	73	621 (8.50)
PLoS Neglected Tropical Diseases (2007–2010)	27	76 (2.81)	35	158 (4.51)	7	24 (3.42)	77	213 (2.74)	8	8 (1.00)	4	11 (2.75)

PLoS journal	USA		Great Britain		France		Germany		Canada		Japan	
	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP	Papers	Cites/ CPP
PLoS Medicine (2004–2010)	799	15146 (18.96)	451	7696 (17.06)	85	2133 (25.09)	70	1783 (25.47)	166	2717 (16.37)	13	311 (28.27)
PLoS Biology (2003–2010)	1134	42452 (37.43)	291	9557 (32.84)	129	3576 (27.72)	201	6680 (33.23)	107	4453 (41.61)	49	1662 (33.92)
PLoS Genetics (2005–2010)	1193	19630 (16.45)	307	6109 (19.90)	188	2988 (15.89)	187	2843 (15.20)	115	1819 (15.82)	95	1243 (13.08)
PLoS Pathogens (2005–2010)	982	13563 (13.81)	218	2908 (13.34)	196	2384 (12.16)	188	2124 (11.30)	111	1292 (11.64)	54	592 (10.96)
PLoS Computational Biology (2005–2010)	871	8956 (10.28)	231	1983 (8.58)	92	847 (9.21)	161	1494 (9.28)	55	534 (9.71)	46	339 (7.37)
PLoS Neglected Tropical Diseases (2007–2010)	349	1400 (4.01)	194	818 (4.22)	71	304 (4.28)	30	83 (2.77)	28	173 (6.17)	14	48 (3.43)

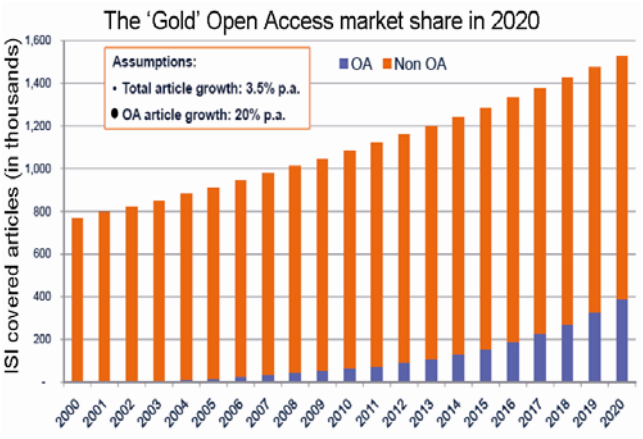

Figure 2. The Gold Open Access market share in 2020 assuming 3.5% overall annual article growth and 20% OA article growth per annum. Reproduced from 'Open Access Publishing at Springer', presented by P. Hendrics at Berlin 8 Open Access Conference, Beijing, China, 26 October 2010.

higher when they make them freely accessible over the Internet and that free Internet access widens the circle of those who read and make use of scientists' investigations[14]. An analysis of many MedKnow journals has shown that OA journals do not lose subscribers to print editions; on the contrary, the number of subscribers is increasing in most cases. Again, OA has helped MedKnow journals attract a larger number of paper submissions, hits and downloads, win more citations and improve impact factors[15]. The Indian Academy of Sciences has also seen similar trends for their journals (G. Chandramohan, pers. commun.).

Data in Table 5 show that the number of papers published by each one of the 12 countries in *PLoS ONE* has increased over the years dramatically. We found similar trends for all PLoS journals (except *PLoS Medicine*) and several BMC journals including *BMC Public Health*, *BMC Bioinformatics* and *BMC Genomics*[16].

Both BMC and PLoS charge article processing fees as do many other open access journals. BMC journals charge between $ 1450 and $ 1640, *PLoS ONE* charges $ 1350, and *PLoS Medicine* and *PLoS Biology* $ 2900 and other PLoS journals $ 2250. This could be a deterrent to most Indian and other developing country researchers. However, these journals waive the processing fees if authors request before submitting their papers. But not all Indian scientists would like to request such waivers. Here is what Balaram[17], a leading Indian molecular biophysicist, says: 'As an Indian scientist, I do not want my government funds to be subsidising Public Library of Science (PLoS) journals or any other non-Indian open access journal. Some journals waive these charges for authors from developing countries. But I do not think we should go begging for waivers.'

Conclusion

Indian researchers publish a large number of papers in OA journals, not necessarily because more than 360 Indian journals are OA. Their contribution to high-impact international biomedical OA journals is modest at best. However, India's contribution to *Acta Crystallographica Section E: Structure Reports* is substantial. There are two reasons for this: India has a strong and vibrant community of inorganic crystallographers and the journal charges only $ 150 for processing a paper. A similar study on India's participation in international OA journals in other fields, such as physics, chemistry, earth sciences and engineering will be interesting.

Ideally though, Indian researchers and funding agencies should prefer the institutional archiving route recommended by both Harnad[1,18] and Balaram[17]. One hundred per cent OA through archiving should be the national goal. As pointed out by Joshi[19] and as has been demonstrated most recently by the Central Marine Fisheries Research Institute, Kochi[20], starting and filling an institutional EPrints archive is easy, inexpensive, and immensely beneficial to all. However, six years after the first workshop on setting up OA repositories was held in May 2004, we have not more than 40 active repositories in the country. We believe that such repositories would come up in most, if not all, higher educational and research institutions in the country if the Ministers in charge of both higher education and science and technology send out a note stating that from now on all publicly-funded research should be available through OA channels.

1. Arunachalam, S., Advances in information access and science communication. *Curr. Sci.*, 2001, **80**, 493–494.
2. Dallmeier-Tiessen, S., First results of the SOAP project. Open access publishing in 2010; http://arxiv.org/abs/1010.0506v11
3. Registry of Open Access Repositories; http://roar.eprints.org
4. Directory of Open Access Journals; http://www.doaj.org
5. Open J-Gate; http://www. openj-gate.com
6. BioMed Central: The Open Access Publisher; http://www.biomedcentral.com/
7. Science in India 2004-2008, Scibytes 2010, ScienceWatch.com; http://sciencewatch.com/dr/sci/10/jan10-10_2/
8. *Acta Crystallographica Section E: Structure Reports Online*; http://journals.iucr.org/e/
9. Banerjee, K., Structure of anthracene and naphthalene. *Nature*, 1930, **125**, 456.
10. Public Library of Science Journals; http://www.plos.org/journals/
11. Björk, B.-C., Roos, A. and Lauri, M., Scientific journal publishing – yearly volume and open access availability. *Inform. Res.*, 2009, 14, Paper 391; http://InformationR.net/ir/14-1/paper391.html
12. Björk, B.-C., Welling, P., Laakso, M., Majlender, P., Hedlund, T. and Guðnason, G., Open access to the scientific journal literature: Situation 2009. *PLoS One*, 2010, **5**(6), e11273; http://www.plosone.org/article/info:doi/10.1371/journal.pone.0011273
13. Hendriks, P., Open Access Publishing at Springer, Presented at Berlin 8 Open Access Conference, Beijing, China, 2010; http://www.berlin8.org/userfiles/file/Berlin8_OA_Conference_PH_v1.pdf
14. Evans, J. A. and Reimer, J., Open access and global participation in science. *Science*, 2009, **323**, 1025.
15. Sahu, D. K., MEDKNOW: Open Access Publishing for Learned Societies and Associations, Presented at Berlin 8 Open Access Conference, Beijing, China, 2010; http://www.berlin8.org/userfiles/file/Berlin8.pdf
16. Comparison of BioMed Central's article processing charges with those of other publishers; http://www.biomedcentral.com/info/authors/apccomparison
17. Jayaraman, K. S., Open archives – the alternative to open access, interview with Prof. P. Balaram, SciDev.Net, 9 July 2008; http://www.scidev.net/en/features/q-a-open-archives-the-alternative-to-open-access.html
18. Harnad, S., How India can provide immediate open access now? *Curr. Sci.*, 2008, **94**, 1232.
19. Joshi, N. V., Institutional E-print archives: liberalizing access to scientific research. *Curr. Sci.*, 2005, **89**, 421–422.
20. Central Marine Fisheries Research Institute; http://eprints.cmfri.org.in

ACKNOWLEDGEMENTS. We thank Subbiah Gunasekaran of the Central Electrochemical Research Institute and Gautam Desiraju of Indian Institute of Science for some valuable suggestions.

Received 3 January 2011; accepted 19 January 2011