

Analysis of publications on paratuberculosis from 1995 to 2009 with emphasis on the period from 2005 to 2009

M. KAEVSKA, K. HRUSKA

Veterinary Research Institute, Brno, Czech Republic

ABSTRACT: The importance of paratuberculosis, an infectious bowel disease of ruminants, and Crohn's disease, a type of inflammatory bowel disease in humans with suspected links with *Mycobacterium avium* subsp. *paratuberculosis*, is evident from the steadily increasing number of publications on these topics. Data from the Web of Science databases were analysed by authors, institutions, countries and funding agencies, involved in research. A summary of the descriptive data for the most frequently cited publications are presented here.

Keywords: Web of Science; Crohn's disease; food safety; environmental contamination; analysis of publications; *Mycobacterium avium*; Johne's disease

The portal Web of Knowledge® (Thomson Reuters) is a unique tool for analysing search results from a very representative pool of scientific journals. Its usefulness both for evaluation of different scientific disciplines (Aksnes and Hessen, 2009; Gokceoglu and Sezer, 2009; Makris et al., 2009; Ramos et al., 2009), and for the assessment of publication activity by institution (Hruska, 2006) or by country (Gupta and Dhawan, 2009; He et al., 2009; Makris et al., 2009) has been demonstrated by several recent publications. The previous analysis of publications pertaining to paratuberculosis covered the period from 1994 to 2004 (Hruska, 2004). During that period, 1032 papers were published by 2519 authors affiliated with 738 institutions. An apparent increase in the number of papers published on Crohn's disease and an increase in the number of publications on paratuberculosis from the year 2000 was evident. Analyses of papers on paratuberculosis published during the last five years and a comparison of trends over the last fifteen years with respect to different parameters are the aims of this paper. The number of publications on both paratuberculosis and Crohn's disease and their intersection was monitored in each year of the fifteen-year period.

MATERIAL AND METHODS

Web of Science, Science Citations Index Expanded, Social Sciences Citation Index and Art and Humanities Index databases® (Thomson Reuters) were used to search for relevant journal articles using "paratuberculosis OR Johnes OR Johnes'" (referred to from hereon in only as "paratuberculosis") as the topic words (search profile). The topic word "paratuberculosis" does not retrieve only paratuberculosis as a disease but *Mycobacterium avium* subsp. *paratuberculosis* as well. The time span within which the searches were performed was 1995 to 2009 (last updated 16 January 2010). Possible imperfections resulting from non-uniform names of institutions were not corrected and are listed as they appeared.

The search results have been analysed using Web of Science utilities and the following parameters are presented:

- The number of publications, authors, institutions and countries.
- Funding agencies which supported the publication of three or more papers. Obvious inconsistencies have been corrected where two and more publications supported by one agency were re-

Supported by the Ministry of Agriculture of the Czech Republic (Grant No. MZE 0002716202) and the Ministry of Education, Youth and Sports of the Czech Republic (AdmteVet; Grant No. CZ 1.05/2.1.00/01.0006).

corded under different names; the varying agency names have been united as noted in Table 7.

- Journals, publishing the highest number of papers on paratuberculosis.
- Authors who published 10 and more papers on “paratuberculosis” over a five-year period, 2005 to 2009, and in the periods 1995 to 1999 and 2000 to 2004 for comparison.
- Institutions from which 10 and more papers on “paratuberculosis” were published in the same five-year periods.
- Countries/territories from where 10 and more papers on “paratuberculosis” were published in the same five-year periods.
- Papers, published from 1995 to 2009, according to the “times cited” data.

Additionally we analysed the number of publications on “paratuberculosis”, “Crohn*” and “paratuberculosis AND Crohn*” as the search profile (topic words). The keyword “Crohn*” retrieves records dealing with Crohn’s disease. The results are presented in Figures 1 to 3, in order to get a clearer picture of increasing research activity in this areas. The relative increase in the numbers of publications is demonstrated in Figure 4 and the ratio of records “Crohn*” and “paratuberculosis” and their intersection in Figure 5.

RESULTS AND DISCUSSION

Citation frequency is a measure of the most influential publications. Publications on “paratuberculosis” (from 1995 to 2009), cited at least 80 times, are presented in Table 1. The report by Kobayashi et al. (2005) on NOD2 represents a topic of the highest interest, e.g., dependent regulation of innate and adoptive immunity in the intestinal tract was most often cited (496 times). This reflects its importance in understanding basic mechanisms of gut immunity. The second and third most often cited publications are review articles concerning clinical epidemiology of inflammatory bowel disease (Loftus, 2004) and current concepts of the etiology and pathogenesis of ulcerative colitis and Crohn’s disease (Sartor, 2006). The paper by Ott et al. (1999) was frequently cited because it was among the first studies to estimate the economic impact of the disease on a large population of dairy cattle herds. The review articles by Clarke (1997) and Harris and Barletta (2001), also frequently cited, highlight the value of authoritative reviews.

Papers on “paratuberculosis” published from 1995 to 2009 appeared in 405 journals, indexed in the Web of Science database. Sources (journals) with 20 or more papers are presented in Table 2. Monitoring all important literature sources manually is impossible without the assistance of well organized databases, search engines and a perfect library service. However, critical evaluation and management of search engine results remains essential. Journals indexed in the Journal Citation Reports (having an impact factor) have the highest priority.

A summary of the numbers of publications, authors, institutions and countries concerned with paratuberculosis is presented in Table 3. By all parameters an increase in paratuberculosis research as reflected in publications is evident in each subsequent five-year period. In the period from 2000 to 2004 the number of papers almost doubled (an increase to 189%). In the period from 2005 to 2009 compared to the periods from 2000 to 2004 and from 1995 to 1999 the numbers of publications increased to 160% and to 302%, respectively. In total, 5149 authors from 1465 institutions authored 2305 papers published from 1995 to 2009. The increasing number of authors mirrored the growing number of publications and institutions involved in research on paratuberculosis and reflects expanding global interest in paratuberculosis.

Authors who published 10 and more papers on paratuberculosis from 2005 to 2009 are listed in Table 4 along with a comparison of the number of publications for the periods from 2000 to 2004 and from 1995 to 1999. Fifty names are listed with J.P. Bannantine (USDA/ARS/National Animal Disease Center, Ames, USA) with 39 publications, heading the list. A further four authors (M.T. Collins, I. Pavlik, J.R. Stabel and R.J. Whittington) have participated in more than 30 publications. In this scientific productivity ranking, 14 authors published 10 or more papers already in the period from 2000 to 2004 and 36 authors (highlighted) have appeared on the list for the first time.

Institutions which produced 10 or more publications from 2005 to 2009 are listed in Table 5. The top positions belong to institutions with a strong tradition of research in paratuberculosis. More than 50% institutions (24 of the 41) represent new units in this category. Authors from 66 countries have participated in publications on paratuberculosis. Authors from 23 countries have contributed to the publication of 10 or more papers. Five countries have appeared in this category for the first time (Table 6).

Support from funding agencies is represented by new information available through the Web of Science utility “analyse results”. In papers published from 2005 to 2009 the most frequently acknowledged have been the European Commission, United States Department of Agriculture, Ministry of Agriculture of the Czech Republic, US National Institutes of Health, and Meat and Livestock Australia (Table 7). Unfortunately, more than 80% of publications do not contain data in the field being analysed. Moreover funding agencies are frequently acknowledged inconsistently. Nevertheless the importance of this information will likely increase and funding agencies and principal investigators should be more diligent in using official names of funding agencies and correct project numbers.

The number of publications with the topic words “paratuberculosis” (Figure 1), “Crohn*” (Figure 2) and with both words “paratuberculosis AND Crohn*” (Figure 3) has been increasing over the last fifteen years. The same is obvious from indexed data (Figure 4). The large and ever-increasing number of Crohn’s disease sufferers mirrors the importance of this disease for public health. The parallel increase of papers on Crohn’s disease and paratuberculosis confirm the likelihood of links between these diseases (Figure 5). Research in all three areas, in particular the number of publications concerning paratuberculosis and Crohn’s disease, has accelerated in the last five or six years. This rise in publication frequency is possibly due to the increasing incidence both of paratuberculosis in ruminants and Crohn’s disease in humans and new methods available in research, diagnostics and treatment.

The expanding level of research activity in paratuberculosis, reflected by the growing number of publications in scientific journals during the last five years, demonstrate the importance of this infectious disease of cattle and small ruminants. Kazda et al. (2009) recently published a book documenting the ubiquity of mycobacteria and their significant impact on the health of animals and humans alike. Moreover, the present knowledge on the function of bacterial triggers in chronic human diseases (Carbone et al., 2005), raises the question of whether the components of mycobacterial cell walls pose a risk as food pathogens or food borne immunoreactive factors involved in autoimmune diseases and Crohn’s disease. Financial losses through paratuberculosis in ruminants, food and environmental contamination

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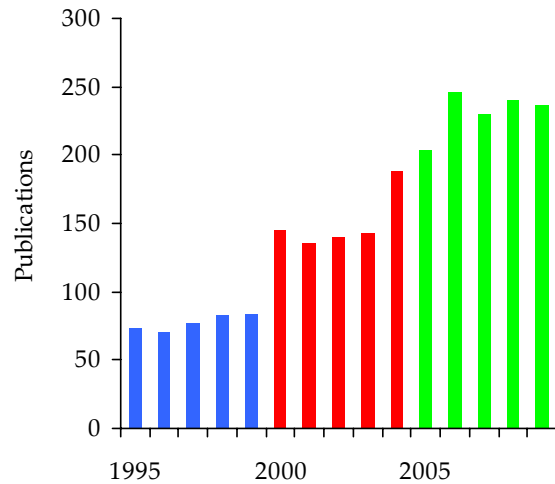


Figure 1. Publications on “paratuberculosis” in the Web of Science database from 1995

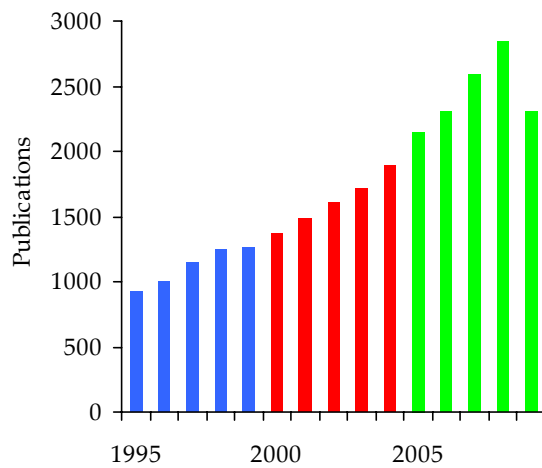


Figure 2. Publications on “Crohn*” (Crohn’s disease) in the Web of Science database from 1995

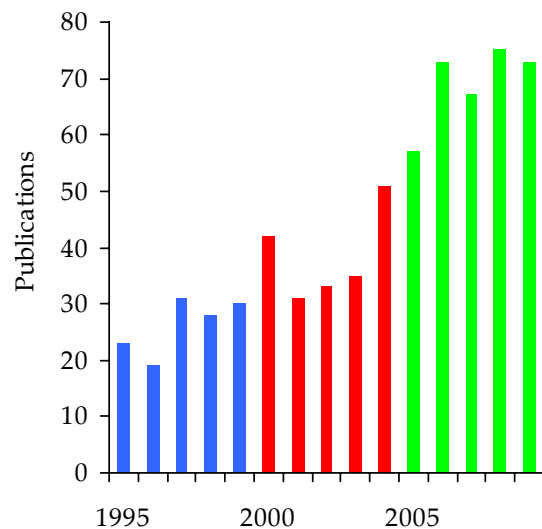


Figure 3. Publications on “paratuberculosis AND Crohn*” in the Web of Science database from 1995

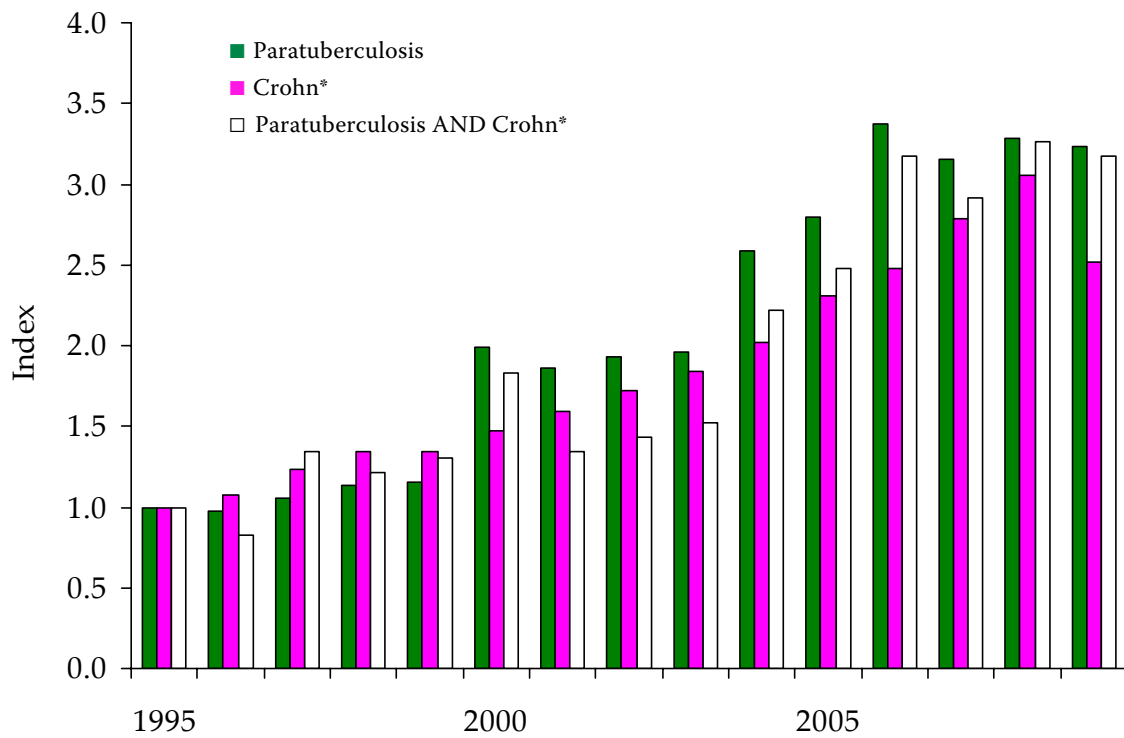
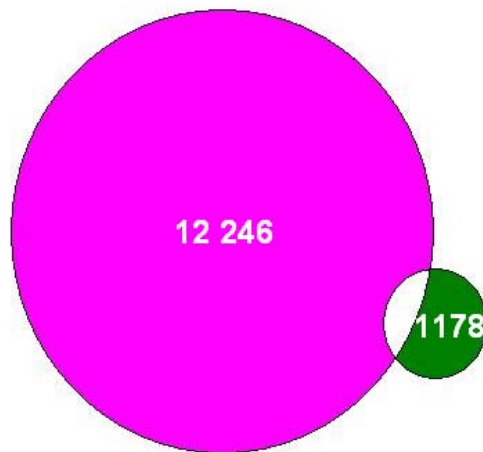


Figure 4. Publications on “paratuberculosis”, “Crohn*” and “paratuberculosis AND Crohn*” from 1995 to 2009 (index 1995 = 1)



Period	Crohn*	Paratuberculosis	Paratuberculosis AND Crohn*
2005–2009	12246 (1039%)	1178 (100%)	345 (29%)
2000–2004	8064 (1094%)	737 (100%)	192 (26%)
1995–1999	5592 (1433%)	390 (100%)	131 (34%)

Figure 5. Search profiles used in the analysis: numbers of publications retrieved in the period from 2005 to 2009

Table 1. Most frequently cited papers on “paratuberculosis” (published from 1995 to 2009), analysed in January 2010

- 496 Kobayashi KS, Chamaillard M, Ogura Y, Henegariu O, Inohara N, Nunez G, Flavell RA (2005): **Nod2-dependent regulation of innate and adaptive immunity in the intestinal tract.** *Science* 307, 731–734.
- 399 Loftus EV (2004): **Clinical epidemiology of inflammatory bowel disease: Incidence, prevalence, and environmental influences.** *Gastroenterology* 126, 1504–1517.
- 259 Sartor RB (1995): **Current Concepts of the Etiology and Pathogenesis of Ulcerative-Colitis and Crohns-Disease.** *Gastroenterology Clinics of North America* 24, 475–507.
- 191 Naser SA, Ghobrial G, Romero C, Valentine JF (2004): **Culture of Mycobacterium avium subspecies paratuberculosis from the blood of patients with Crohn’s disease.** *Lancet* 364, 1039–1044.
- 180 Ott SL, Wells SJ, Wagner BA (1999): **Herd-level economic losses associated with Johne’s disease on US dairy operations.** *Preventive Veterinary Medicine* 40, 179–192.
- 175 Clarke CJ (1997): **The pathology and pathogenesis of paratuberculosis in ruminants and other species.** *Journal of Comparative Pathology* 116, 217–261.
- 174 Harris NB, Barletta RG (2001): **Mycobacterium avium subsp paratuberculosis in veterinary medicine.** *Clinical Microbiology Reviews* 14, 489–512.
- 161 Sartor RB (2006): **Mechanisms of disease: pathogenesis of Crohn’s disease and ulcerative colitis.** *Nature Clinical Practice Gastroenterology & Hepatology* 3, 390–407.
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- 139 Greiner M, Gardner IA (2000): **Epidemiologic issues in the validation of veterinary diagnostic tests.** *Preventive Veterinary Medicine* 45, 3–22.
- 131 Whitlock RH, Wells SJ, Sweeney RW, Van Tiem J (2000): **ELISA and fecal culture for paratuberculosis (Johne’s disease): sensitivity and specificity of each method.** *Veterinary Microbiology* 77, 387–398.
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- 124 Grant IR, Ball HJ, Neill SD, Rowe MT (1996): **Inactivation of Mycobacterium paratuberculosis in cows’ milk at pasteurization temperatures.** *Applied and Environmental Microbiology* 62, 631–636.
- 120 Whitlock RH, Buergelt C (1996): **Preclinical and clinical manifestations of paratuberculosis (including pathology).** *Veterinary Clinics of North America-Food Animal Practice* 12, 345–356.
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Table 1 continued

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- 111 Sartor RB (2008): **Microbial influences in inflammatory bowel diseases.** *Gastroenterology* 134, 577–594.
- 109 Li LL, Bannantine JP, Zhang Q, Amonsin A, May BJ, Alt D, Banerji N, Kanjilal S, Kapur V (2005): **The complete genome sequence of Mycobacterium avium subspecies paratuberculosis.** *Proceedings of the National Academy of Sciences of the United States of America* 102, 12344–12349.
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- 102 Collins MT (1996): **Diagnosis of paratuberculosis.** *Veterinary Clinics of North America-Food Animal Practice* 12, 357–371.
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- 102 Whittington RJ, Marsh I, McAllister S, Turner MJ, Marshall DJ, Fraser CA (1999): **Evaluation of modified BACTEC 12B radiometric medium and solid media for culture of Mycobacterium avium subsp. paratuberculosis from sheep.** *Journal of Clinical Microbiology* 37, 1077–1083.
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- 093 Cousins DV, Whittington R, Marsh I, Masters A, Evans RJ, Kluver P (1999): **Mycobacteria distinct from Mycobacterium avium subsp paratuberculosis isolated from the faeces of ruminants possess IS900-like sequences detectable by IS900 polymerase chain reaction: implications for diagnosis.** *Molecular and Cellular Probes* 13, 431–442.
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Table 1 continued

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- 085 Stabel JR (1998): **Symposium: Biosecurity and disease – Johne's disease: A hidden threat.** Journal of Dairy Science 81, 283–288.
- 085 Whittington RJ, Marsh I, Turner MJ, McAllister S, Choy E, Eamens GJ, Marshall DJ, Ottaway S (1998): **Rapid detection of Mycobacterium paratuberculosis in clinical samples from ruminants and in spiked environmental samples by modified BACTEC 12B radiometric culture and direct confirmation by IS900 PCR.** Journal of Clinical Microbiology 36, 701–707.
- 085 Dubey JP, Schares G, Ortega-Mora LM (2007): **Epidemiology and control of neosporosis and Neospora caninum.** Clinical Microbiology Reviews 20, 323–367.
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- 080 Naser SA, Schwartz D, Shafran I (2000): **Isolation of Mycobacterium avium subsp paratuberculosis from breast milk of Crohn's disease patients.** American Journal of Gastroenterology 95, 1094–1095.
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Table 2. Journals which published twenty or more papers on “paratuberculosis” from 1995 to 2009

Source	405 ^a	2305 ^b	Number of records among most cited	Percent	IF 2008
Veterinary Microbiology	1	140	1	6.1	2.370
Preventive Veterinary Medicine	2	92	3	4.0	1.506
Journal of Clinical Microbiology	3–4	84	5	3.6	3.945
Journal of Dairy Science	3–4	84	2	3.6	2.486
Australian Veterinary Journal	5	66		2.8	0.801
Veterinary Immunology and Immunopathology	6	62		2.6	1.907
Journal of Veterinary Diagnostic Investigation	7	59	2	2.5	1.403
Veterinary Record	8	58		2.4	1.240
Applied and Environmental Microbiology	9	55	4	2.3	3.801
Infection and Immunity	10	50		2.1	3.987
Gastroenterology	11	37	4	1.6	12.591
Veterinarni Medicina	12	34		1.4	0.659
Clinical and Vaccine Immunology	13	33	1	1.4	2.237
Journal of Animal Science	14	30		1.3	2.123
American Journal of Veterinary Research	15–16	29	1	1.2	1.280
Inflammatory Bowel Diseases	15–16	29		1.2	2.000
Journal of Microbiological Methods	17	28	1	1.2	4.975
Journal of Wildlife Diseases	18	26		1.1	1.330
Cattle Practice	19	23		1.0	0.102
Acta Veterinaria Scandinavica	20–22	22		0.9	0.899
Journal of the American Veterinary Medical Association	20–22	22	1	0.9	1.773
Molecular and Cellular Probes	20–22	22	2	0.9	2.196
Canadian Veterinary Journal – Revue Veterinaire Canadienne	23–24	21		0.9	0.855
JAVMA – Journal of the American Veterinary Medical Association	23–24	21		0.9	1.773
Veterinary Clinics of North America-Food Animal Practice	25	20	3	0.8	0.537

percent = number of records in relation to total number of publications

IF = impact factor 2008 (Journal Citation Reports, Thomson Reuters Web of Knowledge)

^anumber of sources

^bnumber of publications

Table 3. Publications on “paratuberculosis” from 1995 to 2009; the authors, institutions and countries involved

	1995–1999	2000–2004	2005–2009	1995–2009
Publications	390	737	1178	2305
Authors	1075	1789	3110	5149
Institutions	331	558	973	1465
Countries	38	49	66	75

Table 4. Authors who published 10 and more papers on “paratuberculosis” from 1995 to 2009, in comparison to the number of publications published in the periods 1995–1999 and 2000–2004

		2005–2009	2000–2004	1995–1999
	Authors	1178 ^a 3110 ^b	737 ^a 1789 ^b	390 ^a 1075 ^b
1	Bannantine JP	39	12	2
2–3	Collins MT	36	27	15
2–3	Pavlik I	36	27	7
4	Stabel JR	35	29	16
5	Whittington RJ	31	26	5
6–8	Nielsen SS	23	13	
6–8	Singh SV	23	4	2
6–8	Wells SJ	23	11	2
9–14	Kapur V	22	9	2
9–14	Singh AV	22		
9–14	Singh PK	22		
9–14	Sohal JS	22		
9–14	Waters WR	22	8	
9–14	Whitlock RH	22	13	4
15–16	Gardner IA	20	6	
15–16	Palmer MV	20	8	
17–19	Bartos M	17	10	1
17–19	Behr MA	17	1	
17–19	Manning EJB	17	8	
20	Sreevatsan S	16	5	
21–23	Juste RA	15	2	
21–23	Paustian ML	15	2	
21–23	Shin SJ	15	4	
24–25	Roussel AJ	13		
24–25	Sechi LA	13	4	
26–34	Alvarez J	12		
26–34	De Juan L	12	2	
26–34	Grant IR	12	14	5
26–34	Kohler H	12	2	
26–34	Moravkova M	12		
26–34	Schukken YH	12	5	
26–34	Sevilla I	12		
26–34	Weiss DJ	12	4	
26–34	Zanetti S	12	3	
35–41	[Anon]	11	17	10
35–41	Evanson OA	11	4	
35–41	Fosgate GT	11		
35–41	Griffin JFT	11		
35–41	Rowe MT	11	12	6
35–41	Souza CD	11		
35–41	Stevenson K	11	15	6
42–50	Ahmed N	10		
42–50	Aranaz A	10		
42–50	Davis WC	10	3	
42–50	Dominguez L	10	1	
42–50	Ellingson JLE	10	1	1
42–50	Garrido JM	10	3	
42–50	Naser SA	10	14	6
42–50	Toft N	10		
42–50	Vanleeuwen JA	10	6	

Highlighted authors have published less than 10 papers in the previous five-year periods; ^anumber of papers published in the respective period; ^bnumber of authors publishing in the respective period

Table 5. Institutions which produced 10 or more publications on “paratuberculosis” from 2005 to 2009, in comparison to the number of publications published in the periods 1995–1999 and 2000–2004

		2005–2009	2000–2004	1995–1999
		1178 ^a	737 ^a	390 ^a
	Institutions	973 ^b	558 ^b	331 ^b
1	University of Minnesota	68	25	4
2	US Department of Agriculture ARS	65	29	18
3	University of Wisconsin	63	33	17
4	University of Sydney	42	17	1
5	Veterinary Research Institute	37	27	8
6	University of California Davis	33	14	2
7–8	Cornell University	32	17	7
7–8	Iowa State University	32	10	5
9	Texas A&M University	26	6	3
10	University of Pennsylvania	24	16	7
11	Michigan State University	22	11	5
12	US Department of Agriculture	21	14	7
13	University of Otago	20	2	3
14–16	Central Institute for Research on Goats	19	4	2
14–16	McGill University	19	1	
14–16	University of Guelph	19	11	5
17–18	University of Copenhagen	17	2	1
17–18	University of Florida	17	8	3
19–20	Queens University Belfast	16	17	8
19–20	University Prince Edward Island	16	8	
21	Colorado State University	15	13	3
22–25	Animal Research Service	14	7	2
22–25	University of Sassari	14	5	
22–25	University of Utrecht	14	8	3
22–25	Washington State University	14	6	2
26–29	Montreal General Hospital	13	2	
26–29	Moredun Research Institute	13	7	9
26–29	National Veterinary Institute	13	29	3
26–29	Purdue University	13	4	1
30–32	Indian Veterinary Research Institute	12	9	
30–32	University College Dublin	12	2	
30–32	University of Tennessee	12		
33–39	Complutense University of Madrid	11	3	1
33–39	Norwegian School of Veterinary Science	11	14	
33–39	Oregon State University	11	6	1
33–39	Pennsylvania State University	11	4	1
33–39	University of Central Florida	11	17	9
33–39	University of Giessen	11		3
33–39	University of Saskatchewan	11	4	1
40–41	Pasteur Institute	10	3	7
40–41	University of Georgia	10	6	5

Highlighted institutions have published less than 10 papers in the previous five-year periods

^anumber of papers published in the respective period

^bnumber of institutions publishing in the respective period

Table 6. Countries which produced 10 or more publications on “paratuberculosis” from 2005 to 2009, in comparison to the number of publications published in the periods 1995–1999 and 2000–2004

		2005–2009	2000–2004	1995–1999
		1178 ^a	737 ^a	390 ^a
	Country	66 ^b	49 ^b	38 ^b
1	USA	460	254	129
2	Australia	91	75	21
3	Canada	84	34	14
4	England	71	47	36
5–6	India	60	14	9
5–6	Spain	60	15	12
7	Germany	59	42	22
8	Scotland	44	29	30
9	The Netherlands	43	39	18
10	New Zealand	41	19	20
11	Czech Republic	38	29	8
12–13	Denmark	37	30	7
12–13	France	37	15	19
14	Italy	31	15	9
15	North Ireland	25	22	9
16	Ireland	23	16	1
17	Belgium	22	8	9
18–19	Greece	20	8	
18–19	Japan	20	11	11
20	Norway	19	31	2
21	Brazil	18	3	3
22	Switzerland	16	6	6
23	South Korea	15	2	4

Highlighted countries have published less than 10 papers in the previous five-year periods; ^anumber of papers published in the respective period; ^bnumber of countries publishing in the respective period

Table 7. Most frequently acknowledged funding agencies supporting paratuberculosis research (papers published from 2005 to 2009)

Funding agency	Number of grants
European Commission	15
USDA Agricultural Research Service	14
Ministry of Agriculture of the Czech Republic	11
Meat and Livestock Australia	8
National Institutes of Health	8
Johne’s Disease Integrated Program	4
Animal Formula Fund	3
Canadian Institutes for Health Research	3
Deutsche Forschungsgemeinschaft	3
University of Sydney Australia	3
Wellcome Trust	3

Note: The authors should avoid variations in acknowledgments to the funding agencies, because the results of analysis are therefore not credible. Examples from this analysis follow:

European Commission: European Union; EC

USDA Agricultural Research Service: USDA APHIS VS; APHIS; United States Department of Agriculture; USDA NRI; Usda’s Agricultural Research Service

National Institutes of Health: NIH

Johne’s Disease Integrated Program: Johne’s Disease Integrated Program JDIP

with mycobacteria (Kazda et al. 2009), and the oft-mentioned public health risk (Eltholth et al. 2009; Carbonnel et al. 2009) are compelling reasons for directing even more attention to paratuberculosis research and control programs for the improvement of animal health and protection of consumers. Data are available which indicate that both the incidence of paratuberculosis in ruminants and Crohn's disease in humans is increasing. Trends in publications on Crohn's disease and the growing body of literature on the relationship between paratuberculosis and Crohn's disease are the result of studies supporting a link between *Mycobacterium avium* subsp. *paratuberculosis* and Crohn's disease, a notion entertained for several decades now.

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Received: 2010–01–21

Accepted after corrections: 2010–02–28

Corresponding Author:

Professor Karel Hruska, Veterinary Research Institute, Hudcova 70, 621 00 Brno, Czech Republic
Tel. +420 533 332 014, E-mail: hruska@vri.cz