

D.D. Kosambi

Ramakrishna Ramaswamy
Editor

D.D. Kosambi

Selected Works in Mathematics and Statistics

 Springer

Editor

Ramakrishna Ramaswamy
School of Physical Sciences
Jawaharlal Nehru University
New Delhi
India

ISBN 978-81-322-3674-0 ISBN 978-81-322-3676-4 (eBook)
DOI 10.1007/978-81-322-3676-4

Library of Congress Control Number: 2016953284

© Springer (India) Pvt. Ltd. 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer (India) Pvt. Ltd.

The registered company address is: 7th Floor, Vijaya Building, 17 Barakhamba Road, New Delhi 110 001, India

Preface

Damodar Dharmananda Kosambi¹ was a man of many parts: *phi beta kappa* scholar and Harvard graduate, mathematics professor, historian, archaeologist, epigraphist, polyglot, numismatist, Sanskritist, Indologist, and Marxist: the list of his identities and his personæ is a long and varied one. Over a period of a little over 35 years, Kosambi built a reputation as a major (if somewhat maverick) thinker of modern India, and this reputation has largely remained intact over the years. Widely regarded as one of the founding figures of contemporary Indian historiography, Kosambi quantified numismatics and used statistical inference to inform the study of Indian history [1]. His contributions to Indology and the study of prehistory have been fundamental, and his translations of the poetry of *Bhartrhari* [2] are considered definitive.

As it happens, while the historian, Indologist, and numismatist Kosambi has been written about and his articles and papers in those areas have been published in collections [3] and celebrated, much less has been done with regard to his contributions to mathematics and statistics. This is surprising for at least two reasons. Kosambi was first and last a mathematician in that his first independent paper and his last-known academic contribution were both in mathematics. Indeed, mathematics was the one constant and consistent preoccupation of his professional life: he says as much in the epilogue to his posthumously published autobiographical essay [4]. DDK's first paper² [DDK1] was written when he, then 22 years of age, was temporarily at the Banaras Hindu University in 1930, and his final work, a monograph on prime numbers [5], was submitted to publishers very shortly before his death at the age of 59, in 1966. It can be argued that his major contributions in other areas were moulded by his knowledge and style of mathematics—whether the

¹For convenience, I will henceforth use just the surname Kosambi or the initials DDK. Other abbreviations used frequently are American Mathematical Society (AMS), Mathematical Reviews (MR), International Mathematical Union (IMU), Journal of the Indian Society of Agricultural Statistics (JISAS), Riemann hypothesis (RH), and Tata Institute of Fundamental Research (TIFR).

²These papers of DDK are numbered 1 through 67 and are distinguished from the other references by the initials preceding the paper number. See the bibliography on pages xv–xix.

creation of numismatics as a form of historiography through the extensive statistical analysis of large hoards of coins or his deduction of the probable location of the Karasambhale caves [6] through a combination of estimation and logic.

Most scholars who have been influenced by the historical writings of Kosambi are acquainted with a lesser extent with the nature and range of his mathematical contributions [7]. This is mainly a domain issue: as a field, mathematics and history are perceived as separated by a major cultural divide, and there is a general (and reasonable) feeling that the mathematics would be too difficult to understand by any but a trained mathematician. Ironically, Kosambi had in his lifetime experienced the same reaction from the other side—his scientist colleagues at the TIFR had also not appreciated the nature and the extent of his contributions to Indology and the study of Indian history.

Kosambi's intellectual legacy needs to be considered in its totality; the mathematics is integral to his thinking and analysis and cannot be seen as separate from the work in numismatics or, for that matter, history. DDK wrote about 65 papers that were of a mathematical or statistical nature [7]. Some articles were pedagogic expositions rather than original contributions, and some were multidisciplinary in the sense that they integrated linguistics or numismatics along with the mathematics or statistics. Two were the same work in two languages, Chinese [DDK56] and English [DDK59]. In addition, there were original contributions in German [DDK7] and French [DDK5, DDK20, DDK21, DDK42, DDK45], and one of his papers had been translated into Japanese [DDK22]. He wrote at least two mathematical monographs, but regrettably, these never appeared in print, and the manuscripts of both of them are lost. Towards the end of his life, he published two articles [DDK60, DDK64] in the *Journal of the Indian Society of Agricultural Statistics* that tangentially implied that he had a proof of the Riemann hypothesis. These articles contained an incomplete and flawed approach to this very fundamental mathematical problem; the damage that they caused to his reputation as a serious mathematician was irreparable and irreversible.

Details of Kosambi's professional life are well known and bear only a limited retelling [8]. On completing his BA (*summa cum laude*) at Harvard, Kosambi had, for a complex combination of reasons, to return to India in 1929. He took up a position at the Banaras Hindu University teaching mathematics and gave (optional) German classes on the side [6]. Although he started doing some research in mathematics at BHU, he was soon persuaded to move to Aligarh Muslim University to join a department of mathematics headed by the French mathematician André Weil. It was here that Kosambi first earned a place in the history of mathematics. His paper, *On a generalization of the second theorem of Bourbaki* [DDK2], was written at the provocation of Weil, as “a parodic note passed off as a serious contribution to a provincial journal” [9], the *Bulletin of the Academy of Sciences, U. P.* [10]. The incident remains somewhat mysterious; according to Weil, Kosambi was having problems with a colleague, and he (Weil) suggested this prank, to name a theorem after a fictitious Russian author. Whether or not this paper deflated the recalcitrant colleague's ego is not clear, but nevertheless, this paper

of Kosambi marks the first occurrence of the name of *Bourbaki* in the published literature [11].

Kosambi lasted 2 years in Aligarh before moving back to Pune, to Fergusson College where he stayed until 1945. In this time, he first built up a reputation as a serious mathematician, serious enough that he was elected to the Indian Academy of Sciences by C.V. Raman in 1935 who also probably nominated him for the Ramanujan Medal of the Madras University in 1934. He had started a study of the area he termed “path–geometry” [12] that was to occupy him for several decades subsequently. *A note on the trial of Socrates* appeared in the magazine of Fergusson College in 1939, marking his initial professional foray outside mathematics. In 1940, this was followed by *The emergence of national characteristics among three Indo-European people* [13] in the Annals of the Bhandarkar Oriental Research Institute. By this time, he had also begun his careful analysis of the weights of ancient coins—the first publication on this topic also dates to 1940—and marks the start of his use of quantitative methods in historical analysis.

The years of World War II saw DDK at his creative best. Between 1939 and 1944, he published 35 articles including two papers he wrote in 1943–1944 which brought him considerable renown. One that appeared in the Journal of the Indian Mathematical Society, *Statistics in function space* [DDK36], is a method for decomposing an arbitrary signal into its significant components, a technique termed the principal value decomposition. Today, this is known as the Karhunen–Loève expansion, although both Karhunen and Loève did their work only later, in 1947 and 1948, respectively. It is regrettable that Kosambi’s work was not followed up either by him or by others (although it was reviewed in Mathematical Reviews). The second contribution is in his 1944 paper in the Annals of Eugenics [DDK37]. This work in genetics, on what is termed the map distance, quantifies the genetic similarity in terms of the recombination frequency of linked genes. At the time when DDK did the work, his knowledge of genetics was probably minimal, and the structure of DNA was itself largely unknown. Nevertheless, Kosambi provided an interesting and useful method to estimate the map distances from recombination values and this work continues to be used and cited even to this day.

In 1945, DDK left Fergusson College to move to the newly established Tata Institute of Fundamental Research (TIFR) in Bombay following an invitation from the founding director, Homi J. Bhabha, to help establish a School of Mathematics. This remained his address for the next 16 years, although his increasingly meandering intellectual interests, his personal politics, his mathematical obsessions, and his personal angularities all combined to make his tenure at the TIFR a fraught one.

The relationship between Bhabha and Kosambi started off on a cordial note. Bhabha was responsible for having DDK elected president of the Mathematics Section of the Indian Science Congress that was held in Delhi in early 1947 where he gave his presidential address on “Possible applications of the functional calculus” [DDK44], a summary of his ideas on function spaces and the proper orthogonal decomposition [14]. Bhabha also helped arrange a year’s visit to the USA for DDK. He gave a course of lectures on tensor analysis at the University of Chicago

and also spent time at the Institute for Advanced Studies in Princeton as well as Harvard and MIT in Cambridge.

As his interests in historical analysis increased in the 1950s, DDK's mathematics inevitably slowed down. He travelled to the Soviet Union and China during this period and wrote on a variety of social issues. All these activities were at variance with the TIFR ethos; Bhabha, who was attempting to build a first-class research establishment in nuclear science and mathematics, had little time to indulge DDK in these pursuits. Towards the end of the 1950s, Kosambi started working on the Riemann hypothesis. He published two papers offering a proof of this problem, in the *Indian Journal of Agricultural Statistics* [DDK60, DDK64]. The motivation for his foray into this work remains unknown since his approach, a probabilistic one, does not evolve out of his earlier work. At any rate, his choice of the journal and the scale of his claim (since the Riemann hypothesis remains unproven today) exposed him to ridicule, both professionally and in person. Mathematicians who knew Kosambi speak of this phase of his life with a distinct air of embarrassment.

The relationship with Bhabha soured, and DDK's contract with the TIFR was not renewed after 1962, making Kosambi one of the very few people to have effectively been fired by the Tata Institute of Fundamental Research. Between 1962 and 1964, DDK was without a formal position although he published papers both in and outside mathematics. Peculiarly, he wrote four of these under the pseudonym S. Ducray [DDK62, DDK63, DDK65, and DDK66]. In 1964, he was appointed a CSIR emeritus professor attached to the Maharashtra Vidyanvardhini in Pune, a position he held until his death in 1966.

There remain important gaps in writings by or on DDK that need to be filled in the order that an accurate picture of the evolution of his intellectual framework can be drawn. His extensive correspondence with Professor and Mrs. R.J. Conklin between 1930 and 1948, friends of him from his undergraduate years at Harvard, is only partly available. The TIFR correspondence is on record, and the details of the relationship with Bhabha that started out so cordially and ended in so much acrimony that DDK could not bring himself to be generous even after Bhabha died are again well enough known but incompletely analysed. A series of letters exchanged between Divyabhanusinh Chavda and DDK in his final and very bitter years remain essentially unknown. Some of these gaps are being addressed, most recently in *Unsettling the Past*, a collection of essays by and on Kosambi [15].

The present volume brings together the complete bibliography of the mathematics papers of DDK, along with other essays on and by Kosambi. This preface gives a general background, summarizing an earlier essay that was published in the *Economic and Political Weekly* [8]. Part I of this book contains an introductory essay, *A Scholar in his Time*, which analyses the mathematical development of Kosambi and attempts to situate his contributions in context. This is a reproduction of [16] with small modifications and is followed by selected essays by DDK that help give a perspective on the many strands of thought that he integrated into his work. The autobiographical *Adventures into the Unknown* [4] has appeared in part in several collections as *Steps in Science* [17], but the essay, *On Statistics*, is not widely known. In the war years, when Kosambi was teaching at Fergusson College

in Poona in his most intellectually fertile period, he made several interesting mathematical contributions that were in part responsible for his being invited in 1945 to the newly formed Tata Institute of Fundamental Research in Bombay, to help its director, Homi J. Bhabha, to nucleate the School of Mathematics. Also around that time, he received a small grant from the Tata Trust, and the report that he submitted to them and which is reprinted here reveals a side of him that is not evident in his publications. He worked on a diverse set of problems more or less simultaneously, was meticulous in his accounts, and was frugal as well.

Reprinted in Part II are some of the most significant papers written by Kosambi between 1930 and 1964, in particular, those that contributed to his reputation as well as those that were responsible for its loss. The selection of papers and the essays that are reprinted in this book are each accompanied by an introductory paragraph. Part III contains a listing of DDK's papers in languages other than English. Three of these, in German, French, and Chinese, respectively, are reprinted. The articles that are *not* reproduced here are available at the repository of the Indian Academy of Sciences, Bangalore. Along with the personal papers of Kosambi that are now available in the Nehru Memorial Museum and Library, these various resources can only help complete the mosaic of a complex and very gifted scholar.

New Delhi, India
June 2016

Ramakrishna Ramaswamy

Note to the Reader

This volume includes both published papers in mathematics and statistics, as well as essays and commentaries. The footnotes and citations in each of these come in several styles.

- DDK's papers are listed on pages xv–xix. They are cited as [DDK1], [DDK2], etc. throughout the book.
- For biographical information, I have relied to a great extent on Chintamani Deshmukh's *Damodar Dharmanand Kosambi: Jivan ani Karya* (The life and Work of D.D. Kosambi), Mumbai: Granthali, 1993. This was first published in Marathi and subsequently translated into English by Suman Oak, and several versions are freely available online. This is referred to as [DDK-JK] where cited in the commentaries to the papers.
- For each of DDK's published papers that has been reprinted here, the references and footnotes appear within the article. Attempts have been made to remain faithful to the originals.
- References cited in the Preface are listed on the following pages. References in the essays and commentaries in Part I are collectively listed on pages 41–45.

References

1. DDK's books on history are (a) *An Introduction to the Study of Indian History* (Popular Book Depot, Bombay, 1956), (b) *Myth and Reality: Studies in the Formation of Indian Culture* (Popular Prakashail, Bombay, 1962) and (c) *The Culture and Civilisation of Ancient India in Historical Outline* (Routledge & Kegan Paul, London, 1965).
2. DDK edited the following three books on the poetry of Bhartrhari: (a) *The Sataktrayam of Bhartrhari with the Comm. of Ramarsi*, ed. by D.D. Kosambi, K.V. Krishnamoorthi Sharma (Anandasrama Sanskrit Series, No.127, Poona, 1945), (b) *The Southern Archetype of Epigrams Ascribed to Bhartrhari* (Bharatiya Vidya Series 9, Bombay, 1946) and (c) *The Epigrams Attributed to Bhartrhari* (Singhi Jain Series 23, Bombay, 1948).
3. *The Oxford India Kosambi*, ed. by B.D. Chattopadhyaya (Oxford University Press, New Delhi, 2009); *Combined Methods in Indology & Other Writings: Collected Essays*, D.D. Kosambi, Compiled, edited and introduced by Brajadulal Chattopadhyaya (Oxford University Press, New Delhi, 2005); D.D. Kosambi, *Indian Numismatics* (Orient Longman, Hyderabad, 1981); D.D. Kosambi, *Exasperating Essays* (Peoples Publishing House, New Delhi, 1957).
4. D.D. Kosambi, 'Adventure into the Unknown', in *Current Trends in Indian Philosophy*, ed. by K. Satchidananda Murty, K. Ramakrishna Rao (Asia Publishing House, Bombay, 1972).
5. D.D. Kosambi, *Prime Numbers*. The manuscript of this book, that was apparently mailed to his publishers shortly before DDK's death in June 1966, has not been traced.
6. C. Deshmukh, *Damodar Dharmnanand Kosambi: Jivan ani Karya* (The life and Work of D.D. Kosambi). (Granthali, Mumbai, 1993). First published in Marathi and subsequently translated into English by Suman Oak; this book is cited as [DDK-JK].
7. The bibliography that now appears on pages xv–xix of this volume is a listing of the complete set of the papers of DDK that are of a mathematical nature. The list has been compiled in part from incomplete sources in the biography by Chintamani Deshmukh [6] as well as Web listings. In addition to the papers listed, many of his essays relate to scientific issues, but these are not included here.
8. R. Ramaswamy, Integrating Mathematics and History: The scholarship of D.D. Kosambi. *Econ. Polit. Wkly.* **47**, 58–62 (2012). Reproduced in [15].
9. A. Weil, *The apprenticeship of a mathematician* (Birkhäuser, Basel, 1992).
10. In the paper [DDK2], Kosambi thanks Weil for making him aware of the "important work" of this Bourbaki. The French group eventually chose the initial N (Nicolas) for Bourbaki rather than the D given by Kosambi.
11. M. Mashaal, *Bourbaki: A Secret Society of Mathematicians*, (American Mathematical Society, Providence, 2006).
12. Starting with [DDK3], Kosambi developed the idea in a number of papers, including [DDK5, DDK6, DDK8] and [DDK18] and so on. In the 1950s, he was on the editorial board of the Japanese journal, *Tensor* (New Series) wherein he published [DDK55], possibly his final paper on the topic.
13. The emergence of national characteristics among three Indo-European People. *Ann. Bhandarkar Orient. Res. Inst.* **20**, 195–206 (1940).
14. In [DDK45], Section 8, Kosambi gives the following examples of where the functional calculus techniques would apply. If average temperature curves are available for any range or period, is it possible to say whether two samples from two different places differ materially? Or do two skulls found by the archaeologist or anthropometrician in two different places differ significantly? The need for a mathematical technique to decide questions of this form is suggestive of how his interests in one area inspired work in the other.
15. M. Kosambi (ed.), *Unsettling the Past: Unknown Aspects and Scholarly Assessments of D.D. Kosambi* (Permanent Black, New Delhi, 2012).

16. R. Ramaswamy, A scholar in his time: Contemporary views of Kosambi the mathematician. Occasional Paper of the Nehru Memorial Museum and Library, Perspectives in Indian Development, New Series **45** (2014).
17. Steps in Science, in *Science and Human Progress: Essays in Honour of Late Prof. D.D. Kosambi, Scientist, Indologist, and Humanist* (Popular Prakashan, Mumbai, 1974).

Acknowledgements

A conversation with Romila Thapar at the Jawaharlal Nehru University a decade or so ago made me aware that the mathematical side of DDK was still largely inaccessible to social scientists. Given the scale of his contributions to historical research and in particular his introduction of quantitative methods into historical analysis, it seemed worthwhile to undertake to collect his contributions in mathematics and statistics in one place, much like what had been done for his historical writing. Putting together a complete bibliography took a little more time than I had anticipated, largely due to the fact that some of the journals that Kosambi published in were not digitized (and some still are not). Nevertheless, with a little help from friends who helped me get the more obscure articles, this was done by 2013.

An invitation from the Nehru Memorial Museum and Library to speak on Kosambi's mathematical contributions gave me the opportunity to put together the material for the essay *A Scholar in his Time* that is the basis of Chap. 1 of this book. DDK's essays that are reprinted as Chaps. 2 and 3 have been published earlier but are still incompletely known and especially in a volume of this sort are worth recalling. I would like to thank the NCRA Library and the TIFR Archives for access to digital versions of DDK's papers. I would also like to thank the Indian Academy of Sciences, the Current Science Association, the Indian Association for the Cultivation of Science, the National Academy of Sciences, India, John Wiley and Sons, the American Mathematical Association, the Indian Mathematical Society, and the Indian Society of Agricultural Statistics for permission to reprint DDK's articles from their journals.

A number of people have helped along the way, and it is my pleasure to thank them all. I have greatly benefited from conversations and/or correspondence with Michael Berry, Divyabhanusinh Chavda, Indira Chowdhury, Shrikrishna G. Dani, Louise Morse, Aban Mukherji, Rajaram Nityananda, Andrew Odlyzko, Oindrila Raychaudhuri, Toshio Yamazaki, and, particularly, Romila Thapar. The mathematical articles were retyped in LaTeX by Mr. Srinivas of the University of Hyderabad in order to make the text more uniform, and Cicilia Edwin of the Indian Academy of Sciences, Bangalore, assisted with the proofreading. Time has not been

kind, not only to DDK's mathematics but also to the various journals in which he published: some of the articles are barely legible and quite difficult to read in the original.

In large part, this book was a joint enterprise with Meera Kosambi who offered considerable help, encouragement, and suggestions in the 5 years during which I grew to know her well. Her death in February 2015 was a great loss, and in her absence, this project feels oddly incomplete. In retrospect though, it seems she knew her time was limited; in her last years, she was anxious to consolidate the intellectual legacies of her grandfather and father in books she wrote and edited.

My family has been greatly supportive over the years, indulging my various preoccupations and obsessions with patience and with grace. My wife Charusita passed away earlier this year, and it is a great personal sadness that she did not live to see this book in its final form. I know she felt that the effort invested in this project was worth the while, and I hope that my children, Krithi and Rohan, will feel the same way.

New Delhi, India
June 2016

Ramakrishna Ramaswamy

D.D. Kosambi's Mathematical and Scientific Publications

Given below is a chronology of D.D. Kosambi's articles in different areas of mathematics, statistics, and science. In addition, he wrote two monographs, neither of which were eventually published. The first, a book on *Path Geometry*, was to have been published in the *Annals of Mathematics Studies*, a series edited by Marston Morse at the Institute for Advanced Studies, Princeton. The manuscript sent to Morse and a copy that was given to Homi Bhabha could not be traced. In 2010, when Louise J. (Mrs. Marston) Morse was nearly 100 years old, the Morse Archives were searched one last time. However, it was not possible to locate this manuscript or any reference to it. Shortly before his death, Kosambi mailed the manuscript of another book on *Prime Numbers* to his publishers, Routledge & Kegan Paul. Unfortunately, this was also lost.

The papers that were reviewed in *Mathematical Reviews* are indicated, along with the corresponding MR number and the name of the reviewer where applicable. Some of these "reviews" merely record the publication of the paper and do not offer a serious commentary on the work. The titles of papers that have been reprinted in this collection are in boldface.

1. **Precessions of an elliptical orbit,**
Indian Journal of Physics **5**, 359–64 (1930)
2. **On a generalization of the second theorem of Bourbaki,**
Bulletin of the Academy of Sciences, U. P. **1**, 145–47 (1931)
3. *Modern differential geometries,*
Indian Journal of Physics **7**, 159–64 (1932)
4. *On differential equations with the group property,*
Journal of the Indian Mathematical Society **19**, 215–19 (1932)
5. *Geometrie differentielle et calcul des variations,*
Rendiconti della Reale Accademia Nazionale dei Lincei **16**, 410–15 (1932)
6. *On the existence of a metric and the inverse variational problem,*
Bulletin of the Academy of Sciences, U. P. **2**, 17–28 (1932)
7. **Affin-geometrische Grundlagen der Einheitlichen Feldtheorie,**
Sitzungsberichten der Preussische Akademie der Wissenschaften,
Physikalisch-mathematische Klasse **28**, 342–45 (1932)

8. **Parallelism and path-spaces**,
 Mathematische Zeitschrift **37**, 608–18 (1933)
 Review: MR1545422.
 The above paper was followed by an extract from the correspondence between É. Cartan and DDK.
Observations sur le memoire precedent: *Extrait d'une lettre à M. D. D. Kosambi.*,
 Mathematische Zeitschrift **37**, 619–22 (1933)
 Review: MR1545423. The review attributes authorship of the paper to both Cartan and Kosambi
9. *The problem of differential invariants*,
 Journal of the Indian Mathematical Society **20**, 185–88 (1933)
10. *The classification of integers*,
 Journal of the University of Bombay **2**, 18–20 (1933)
11. *Collineations in path-space*,
 Journal of the Indian Mathematical Society **1**, 68–72 (1934)
12. *Continuous groups and two theorems of Euler*,
 The Mathematics Student **2**, 94–100 (1934)
13. *The maximum modulus theorem*,
 Journal of the University of Bombay **3**, 11–12 (1934)
14. *Homogeneous metrics*,
 Proceedings of the Indian Academy of Sciences **1**, 952–54 (1935)
15. *An affine calculus of variations*,
 Proceedings of the Indian Academy of Sciences **2**, 333–35 (1935)
16. *Systems of differential equations of the second order*,
 Quarterly Journal of Mathematics (Oxford) **6**, 1–12 (1935)
17. *Differential geometry of the Laplace equation*,
 Journal of the Indian Mathematical Society **2**, 141–43 (1936)
18. *Path-spaces of higher order*,
 Quarterly Journal of Mathematics (Oxford) **7**, 97–104 (1936)
19. *Path-spaces of higher order*,
 Quarterly Journal of Mathematics (Oxford) **7**, 97–104 (1936)
20. *Les metriques homogenes dans les espaces cosmogoniques*,
 Comptes Rendus **206**, 1086–88 (1938)
21. **Les espaces des paths generalises qu'on peut associer avec un espace de Finsler**,
 Comptes Rendus **206**, 1538–41 (1938)
22. **The tensor analysis of partial differential equations**,
 Journal of the Indian Mathematical Society **3**, 249–53 (1939)
 Review: MR0001882 (1, 313f) Reviewer: E. W. Titt.
 A Japanese translation of this paper appeared in Tensor, **2**, 36–39 (1939)
 Review: MR0001075 (1,176c) Reviewer: A. Kawaguchi.
23. **A statistical study of the weights of the old Indian punch-marked coins**,
 Current Science **9**, 312–14 (1940)

24. *On the weights of old Indian punch-marked coins*,
Current Science **9**, 410–11 (1940)
25. *Path-equations admitting the Lorentz group*,
Journal of the London Mathematical Society **15**, 86–91 (1940)
Review: MR0002258 (2, 21f) Reviewer: J. L. Vanderslice.
26. *The concept of isotropy in generalized path-spaces*,
Journal of the Indian Mathematical Society **4**, 80–88 (1940)
Review: MR0003125 (2,166g) Reviewer: J. L. Vanderslice.
27. *A note on frequency distribution in series*,
The Mathematics Student **8**, 151–55 (1940)
Review: MR0005390 (3,147h).
28. **A bivariate extension of Fisher's Z-test**,
Current Science **10**, 191–92 (1941)
Review: MR0005589 (3,175h) Reviewer: A. Wald.
29. *Correlation and time series*,
Current Science **10**, 372–74 (1941)
Review: MR0005590 (3,175i) Reviewer: A. Wald.
30. *Path-equations admitting the Lorentz group-II*,
Journal of the Indian Mathematical Society **5**, 62–72 (1941)
Review: MR0005713 (3,192g) Reviewer: J. L. Vanderslice.
31. *On the origin and development of silver coinage in India*,
Current Science **10**, 395–400 (1941)
32. *On the zeros and closure of orthogonal functions*,
Journal of the Indian Mathematical Society **6**, 16–24 (1942)
Review: MR0006770 (4, 39d) Reviewer: E. S. Pondiczery.
33. **The effect of circulation upon the weight of metallic currency**,
Current Science **11**, 227–31 (1942)
34. **A test of significance for multiple observations**,
Current Science **11**, 271–74 (1942)
Review: MR0007235 (4,107b) Reviewer: A. Wald.
35. **On valid tests of linguistic hypotheses**,
New Indian Antiquary **5**, 21–24 (1942)
Review: MR0007247 (4,109a) Reviewer: A. Wald.
36. **Statistics in function space**,
Journal of the Indian Mathematical Society **7**, 76–88 (1943)
Review: MR0009816 (5, 207c) Reviewer: J. L. Doob.
37. **The estimation of map distance from recombination values**,
Annals of Eugenics **12**, 172–75 (1944)
38. *Direct derivation of Balmer spectra*,
Current Science **13**, 71–72 (1944)
39. **The geometric method in mathematical statistics**,
American Mathematical Monthly **51**, 382–89 (1944)
Review: MR0010937 (6, 91c) Reviewer: R. L. Anderson.

40. *Parallelism in the tensor analysis of partial differential equations*,
Bulletin of the American Mathematical Society **51**, 293–96 (1945)
Review: MR0011793 (6, 217e) Reviewer: J. L. Vanderslice.
41. **The law of large numbers**,
The Mathematics Student **14**, 14–19 (1946)
Review: MR0023471 (9, 360i) Reviewer: W. Feller.
42. *Sur la différentiation covariante*,
Comptes Rendus **222**, 211–13 (1946)
Review: MR0015274 (7, 396b) Reviewer: J. L. Vanderslice.
43. *An extension of the least-squares method for statistical estimation*,
Annals of Eugenics **18**, 257–61 (1947)
Review: MR0021290 (9, 49d) Reviewer: J. Wolfowitz.
44. **Possible Applications of the Functional Calculus**,
Proceedings of the 34th Indian Science Congress. Part II: Presidential
Addresses, 1–13 (1947)
45. *Les invariants différentiels d'un tenseur covariant a deux indices*,
Comptes Rendus **225**, 790–92 (1947)
Review: MR0022433 (9, 207b) Reviewer: N. Coburn.
46. *Systems of partial differential equations of the second order*,
Quarterly Journal of Mathematics (Oxford) **19**, 204–19 (1948)
Review: MR0028514 (10, 458d) Reviewer: M. Janet.
47. *Characteristic properties of series distributions*,
Proceedings of the National Institute of Science of India **15**, 109–13 (1949)
Review: MR0030731 (11, 42h) Reviewer: J. L. Doob.
48. **Lie rings in path-space**,
Proceedings of the National Academy of Sciences (USA) **35**, 389–94 (1949)
Review: MR0030807 (11, 56a) Reviewer: O. Varga.
49. *The differential invariants of a two-index tensor*,
Bulletin of the American Mathematical Society **55**, 90–94 (1949)
Review: MR0028653 (10, 480b) Reviewer: V. Hlavatý.
50. *Series expansions of continuous groups*,
Quarterly Journal of Mathematics (Oxford, 2) **2**, 244–57 (1951)
Review: MR0045732 (13, 624b) Reviewer: M. S. Knebelman.
51. (with S. Raghavachari) *Seasonal variations in the Indian birth-rate*,
Annals of Eugenics **16**, 165–92 (1951)
Review: MR0046135 (13, 691b) Reviewer: R. P. Boas, Jr.
52. *Path-spaces admitting collineations*,
Quarterly Journal of Mathematics (Oxford, 2) **3**, 1–11 (1952)
Review: MR0047387 (13, 870d) Reviewer: O. Varga.
53. *Path-geometry and continuous groups*,
Quarterly Journal of Mathematics (Oxford, 2) **3**, 307–20 (1952)
Review: MR0051562 (14, 498g) Reviewer: A. Nijenhuis.
54. (with S. Raghavachari) *Seasonal variations in the Indian death-rate*,
Annals of Human Genetics **19**, 100–19 (1954)

55. *The metric in path-space*,
Tensor (New Series) **3**, 67–74 (1954)
Review: MR0061869 (15, 898a) Reviewer: J. A. Schouten.
56. **The method of least-squares**, (in Chinese)
Advancement in Mathematics **3**, 485–491 (1957)
Review: MR0100960 (20 #7385).
57. *Classical Tauberian theorems*,
Journal of the Indian Society of Agricultural Statistics **10**, 141–49 (1958)
Review: MR0118997 (22 #9766) Reviewer: J. Korevaar.
58. (with U. V. R. Rao) *The efficiency of randomization by card-shuffling*,
Journal of the Royal Statistics Society **121**, 223–33 (1958)
59. **The method of least-squares**,
Journal of the Indian Society of Agricultural Statistics **11**, 49–57 (1959)
Review: MR0114265 (22 #5089) Reviewer: R. G. Laha.
60. **An application of stochastic convergence**,
Journal of the Indian Society of Agricultural Statistics **11**, 58–72 (1959)
Review: MR0122792 (23 #A126) Reviewer: W. J. LeVeque.
61. **The sampling distribution of primes**,
Proceedings of the National Academy of Sciences (USA) **49**, 20–23 (1963)
Review: MR0146168 (26 #3690) Reviewer: J. B. Kelly.
62. (as S. Ducray) *A note on prime numbers*,
Journal of the University of Bombay **31**, 1–4 (1962)
63. (as S. Ducray) *Normal Sequences*,
Journal of the University of Bombay **32**, 49–53 (1963)
Review: MR0197433 (33 #5598) Reviewer: B. Volkmann.
64. **Statistical methods in number theory**,
Journal of the Indian Society of Agricultural Statistics **16**, 126–35 (1964)
Review: MR0217024 (36 #119) Reviewer: A. Rényi.
65. (as S. Ducray) **Probability and prime numbers**,
Proceedings of the Indian Academy of Sciences **60**, 159–64 (1964)
Review: MR0179148 (31 #3399) Reviewer: J. Kubilius.
66. (as S. Ducray) *The sequence of primes*,
Proceedings of the Indian Academy of Sciences **62**, 145–49 (1965)
67. *Scientific numismatics*,
Scientific American, February 1966, pages 102–11.

Contents

Part I Essays on and by D.D. Kosambi

1	A Scholar in His Time	3
2	Adventure into the Unknown	15
3	On Statistics	27
4	A Report to the JRD Tata Trust	35

Part I References

Part II Select Publications of D.D. Kosambi

5	Precessions of an Elliptical Orbit D.D. Kosambi	49
6	On a Generalization of the Second Theorem of Bourbaki D.D. Kosambi	55
7	Parallelism and Path-Spaces D.D. Kosambi	59
8	Observations sur le mémoire précédent par Élie Cartan	71
9	The Tensor Analysis of Partial Differential Equations	75
10	A Statistical Study of the Weights of Old Indian Punch-Marked Coins D.D. Kosambi	81
11	A Bivariate Extension of Fisher's Z-Test D.D. Kosambi	87
12	The Effect of Circulation Upon the Weight of Metal Currency D.D. Kosambi	93

13	A Test of Significance for Multiple Observations	101
	D.D. Kosambi	
14	On Valid Tests of Linguistic Hypotheses	109
	D.D. Kosambi	
15	Statistics in Function Space	115
	D.D. Kosambi	
16	The Estimation of Map Distances from Recombination Values	125
	D.D. Kosambi	
17	The Geometric Method in Mathematical Statistics	131
	D.D. Kosambi	
18	The Law of Large Numbers	141
	D.D. Kosambi	
19	Possible Applications of the Functional Calculus	149
	D.D. Kosambi	
20	Lie Rings in Path Space	165
	D.D. Kosambi	
21	The Method of Least-Squares	171
	D.D. Kosambi	
22	An Application of Stochastic Convergence	179
	D.D. Kosambi	
23	The Sampling Distribution of Primes	193
	D.D. Kosambi	
24	Statistical Methods in Number Theory	197
	D.D. Kosambi	
25	Probability and Prime Numbers	207
	S. Ducray	

Part III Select Publications of D.D. Kosambi in Other Languages

26	Affin-geometrische Grundlagen der einheitlichen Feldtheorie	215
	von D.D. Kosambi	
27	Les Espaces des Paths Généralisés Qu'on Peut Associer Avec Un Espace de Finsler	221
	Note de M. Damodar Kosambi, présentée par M. Élie Cartan	
28	最小二乘法 The Method of Least Squares	225
	高善必 Kosambi	
	(印度) (India)	

About the Editor

Ramakrishna Ramaswamy is a professor in the School of Physical Sciences as well as in the School of Computational and Integrative Sciences at the Jawaharlal Nehru University, New Delhi. He served as the vice chancellor of the University of Hyderabad during 2011–2015. Professor Ramaswamy's main research interests are in nonlinear science and systems and computational biology. He has been interested in Kosambi's life and works over the past decade and in early 2016 edited a book of essays by D.D. Kosambi, *Adventures into the Unknown* (Three Essays Collective, Gurgaon, 2016).