Helpers in cooperatively breeding small green bee-eater (*Merops orientalis*)

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A three-year study of breeding behaviour in the small green bee-eaters (*Merops orientalis*) conducted in and around Bangalore, revealed that in 40% of the nests studied, a solitary helper assisted the breeding pair in nesting activities. In such nests the duration of the nesting was significantly reduced and the number of chicks fledged per nest was significantly higher. It was also observed that nests with helper were more during the season following poor rainfall than those following good rainfall.

OVER 300 species of birds are known to exhibit co-operative breeding behaviour where an auxiliary (non-breeding adult) typically assists the breeding pair in rearing their young[1]. Such a behaviour has been recorded for at least five species in India (Table 1). Such altruism appears, at first sight, to be paradoxical under the Darwinian theory of natural selection. The most important advance to explain such paradoxical behaviour is the theory of inclusive fitness[2]. The central idea in Hamilton's theory is that fitness comes not only from rearing ones' offspring but may also come from caring for ones' genetic relatives. In other words, altruism is not paradoxical since it is nepotistic, i.e. directed preferentially towards genetic relatives[3].

Table 1. Indian birds exhibiting cooperative breeding

Name	Source	Year
Chestnutheaded bee-eater *Merops leschenaulti*	Pappanna, per. commun.	1990
Small green bee-eater *Merops orientalis*	This report	1992
Jungle babbler *Turdoides stratus*	Gaston, A. J.[9]	1976
	Zacharias, V. J.[10]	1978
White-headed babbler *Turdoides affinis*	Zacharias, V. J. and Mathew, D. N.[10]	1978
	Praveen Karanth, K. and Sridhar, S. unpublished	1990
Pied kingfisher *Ceryle rudis*	Rayer, H. U.[11]	1980
	Sridhar, S. and Karanth K. P. unpublished	1989

The bee-eaters (family Meropidae) are alert and vivacious birds, distributed in tropical Old World. They specialize in catching bees and related hymenopterans. Of the 24 species of bee-eaters in the world, 11 are reported to exhibit seemingly cooperative breeding behaviour[4]. The small green bee-eater, *Merops orientalis*, has eight races, easily the most geographically variable among bee-eaters with slight plumage variation. They are common in open cultivated fields, nest on face of perpendicular banks of canals and ravines, sandy river banks and sandy bunds and gently sloping bare grounds, around cultivated tracks. The nests are in loose colonies, with a distance between any two nests being more than 10 m. The nesting season around Bangalore is February–August, with peak breeding around April–May. Only one helper is seen with a pair, arriving normally after the completion of nest excavation or beginning of incubation and staying with the breeding pair, even after the chicks have fledged.

A total of 24 pairs were observed for three years (1990 – 92) during breeding months (February to August) at GKVK Campus of the University of Agricultural Sciences, in North Bangalore (13° N 77° E, rainfall 890 mm; altitude 930 m). Three nests were observed daily for 2 h (4.00 PM to 6.00 PM) from the period of nest site selection till the chicks fledged, while the other 21 nests were observed twice a week.

Birds visiting the nest were marked using indelible nontoxic dye for identification. To do this we erected mist net in front of the nests under excavation during night. When the birds leave the burrow or approach the burrow the next morning they became harmlessly entangled in the nets. After taking measurement we put the non-toxic dye (Fevicryl fabric paint), different colours for different individuals caught at each nest. Frequency of food provisioning by individuals (parents and helper) in nests with and without helpers was recorded. Data on each stage of the breeding cycle which included duration of nest digging, incubation, feeding the chicks and feeding the fledglings were also recorded. The average duration of each stage of nest cycle was taken for determining the time spent on primary nesting activities (excavation, incubation and feeding). The peak breeding period was determined by finding out the months in which maximum number of active nests were observed compared to previous months.

Nest digging activity in small green bee-eaters, commenced around mid-February and excavation was completed in 15 to 20 days. A lag period of 5 to 10 days was noticed before egg laying and incubation. The period of

Table 2. Comparison of nests with and without helper

Nests	Predated	Nested	No. of days (analysed)	No. of chicks to fledge	No. of chicks hatched	Feeding hatched (freq./h./nest)
Helped	9	0	4	2.25(±1)	6.5(±1)	14.75
Not helped	15	3	5	4.6(±1)	5(±1)	10.50
Mann–Whitney U test to compare nests with and without helper				$P < 0.02$	$P < 0.05$	$P < 0.05$

Values in parentheses indicate SD.

incubation varied between 20 and 25 days. The period of feeding the chicks at nest lasted for about 25 days, subsequently the fledglings started emerging.

Nine out of twenty-four (40%) nests were frequented by one helper each, where the helpers normally arrived after the commencement of incubation and assisted in the nesting activities such as incubation, feeding the breeding female, feeding the chicks (for 6 to 7 weeks). The helpers also vocalized with the breeding pairs and chicks.

It was noticed that in the nests with a helper, the nestlings grew rapidly and all the chicks fledged within (2.25 ± 1) days, whereas in an unhelped nest the chicks were at different stages of development; hence the fledging period (the time period between the first and the last chick emerging out of the nest) was significantly higher (4.6 ± 1 days) (Table 2). On an average, the nests with a helper fledged significantly more number of chicks (6.5 ± 1), compared to nests without helpers (5 ± 1) (Table 2). None of the nests helped were predated while 20% of those without helpers suffered predation, this difference is marginally significant (G-test of independence, $0.1 > P > 0.05$). The frequency of feeding the newly hatched brood at the nests with helper was significantly higher (14.75 h/nest) compared to the rate in unhelped nest (10.5 h/nest) (Table 2).

The nests initiated following poor monsoon (rainfall < 890 mm) were more likely to receive help compared to nests initiated following good rains (rainfall > 890 mm) ($\chi^2 = 7.8$, $df = 1$, $P < 0.001$) (see Table 3).

In one particular instance, the same individual was seen helping the breeding pair at the same site in two consecutive years (1990 and 1991) thus, suggesting natal philopatry in helpers. In this case the helper was seen preferentially feeding a particular chick after it has fledged from the nest.

Helping increases the number of chicks fledged per nest and decreases the days taken by the chicks to fledge. This is possible because of the increased frequency of food received by the chicks in the nests with helpers. Helpers also reduced the probability of a nest being predated. This is accomplished through increased vigilance of the nest by the frequent presence of one of the three adults in these nests.

Table 3. Influence of rainfall on nesting strategy of Bee-eaters

	Poor seasons 1989–90	1990–91	Good season 1991–92	Total
Rainfall (mm)	640	504	1260	
Helped	3	4	2	9
Unhelped	4	3	8	15
Total	7	7	10	24

The question why the 'helper' should help has been addressed in different ways. One of the arguments is that this happens when the auxiliary has a lower probability of being successful as a breeder[5–8]; that is it is constrained to breed due to prohibitive cost of independent reproduction (ecological constraint model[8]). Such a situation occurs during harsh season (breeding season following poor monsoon) when the insect population is predicted to be low, it then pays to increase ones own fitness by helping a closely related, established pair to reproduce. This is supported by the present work; the frequency of helping was high following a poor monsoon than following good monsoon, the helpers are expected to have a lower probability of success if they attempt to breed on their own following a poor monsoon. Though this report demonstrates that nests receiving help have a higher fitness compared to unhelped nest, more data are required to determine whether helping is directed only towards close relatives.

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Paleontographica Indica, Number 1: Studies in Mesozoic Foraminifera and Chronostratigraphy of Western Kutch, Gujarat. Jagadish Pandey and Alok Dave. K. D. Malaviya Institute of Petroleum Exploration, Oil & Natural Gas Commission, Dehra Dun 248 195. 1993. 221 pp.

Over the past three decades, zonation of marine sequences by means of calcareous plankton has resulted in a relatively precise biostratigraphic framework. Similar approaches employing benthic foraminifera have been greatly hampered by unsatisfactory taxonomy, low abundances, high species diversity, relatively long stratigraphic ranges and changing depth distribution patterns through time.

In recent years, there have been a large number of systematic studies of benthic foraminifera mainly on material recovered by the Deep Sea Drilling Project (DSDP) and Ocean Drilling Programme (ODP) which enabled us to gain a better understanding of their taxonomy, biostratigraphy and paleobathymetric distributions.

Detailed biostratigraphic investigations using foraminifera in different sedimentary basins of India have been carried out by the paleontologists of the Oil and Natural Gas Commission. All these years the need was felt to document detailed systematics and stratigraphic ranges of the fauna basin-wise in order to establish stable taxonomy and biostratigraphy. This volume under the title *Paleontographica Indica Number 1*, documenting Mesozoic foraminifera of Western Kutch is a welcome and most timely contribution in this direction. The book is in two parts. The first part contains evolution of stratigraphic concepts, sections documented, zonation, chronostratigraphy and systematics; while the second part dwells on the Jurassic/Cretaceous boundary.

Kutch has been a centre of attraction for paleontologists and stratigraphers since the classical work of Wynne and Fedden (1872–74). Since then the sedimentary sequences of Kutch were extensively studied by the geologists of the ONGC, Geological Survey of India and Universities. As a result, a number of litho-biostratigraphic classifications were proposed. The litho-stratigraphic classification of the Mesozoic of Kutch proposed by Biswas (1971, 1977) following the code, has provided satisfactory answer as far as the rock stratigraphy is concerned. But unfortunately, barring a few workers (Jaikrishna and Pathak, 1991) none of the authors so far have provided a formal description of the proposed biostratigraphic zones and their mappability in terms specified by ISSC (1976) or NASCN (1983). This renders a number of biostratigraphic classifications informal and unsatisfactory. With the publication of the present volume, Pandey and Dave have gone a long way in satisfying the need.

In the introductory chapter the authors have highlighted the inadequacies in stratigraphic nomenclature and terminology currently used in Kutch and emphasized the need for establishing stratotypes/reference sections for the biozones as per the guidelines of ISSC (1976).

The study attempts to systematically establish several stratigraphic sections in different parts of western Kutch and then draw a correlation among these surface and subsurface sections. The effort is especially to visualize the validity of pre-existing Patcham, Chari, Katrol and Umia units *vis-à-vis* the newly attempted stratigraphic correlation. The finding that the Patcham 'Series' *S. S.* of the conventional usage is no younger than Bajocian and its earlier placing in upper Bathonian or Callovian is erroneous, is very significant.

Of equal relevance is the discovery of a Callovian/Oxfordian unconformity in the Jumara Dome, which though hinted in the study of Rajnath (1932), was never physically verified. This again warrants a major separation of Chari and Dhosa Oolites in the rank of stage homotaxial with Callovian and Oxfordian.

Two new chronostratigraphic units, Bannian Stage and Badian Stage corresponding to Aalenian and Bathonian Stage respectively are described with their boundary stratotypes and mappability. It is for the first time the stratotypes have been designated and described in detail for the Mesozoic chronostratigraphic units of Kutch.

Although foraminifera from the Kutch Mesozoic have been recorded and described by Subbotina *et al.* (1960) and later by many workers, a comprehensive foraminiferal zonation has not emerged in Kutch so far corresponding to the global ammonite zones. The present study is a step towards achieving this goal and to fulfil this long-standing deficiency. The attempt of the authors to correlate benthic foraminiferal and ammonite zones with Kutch Mesozoic stages and Magnetostratigraphy to provide an integrated biomagnetochronology is interesting and useful.

An atlas for identification of Mesozoic foraminifera has been desired for some time. With this publication, the authors have fulfilled the need. The book contains 31 plates of scanning electron micrographs and taxonomic descriptions of 85 foraminiferal taxa, including 13 new species. The Epistominids, the most important group of Jurassic benthic foraminifera, have been dealt in detail which provide better understanding of phylogenetic relationship within various taxa of this group. Perhaps, this is the first reference work to furnish a detailed systematic account of the Indian Mesozoic foraminifera and chronostratigraphy.

Part II of the book deals with the upper Jurassic and lower Cretaceous stratigraphy with special reference to the delineation of the Jurassic/Cretaceous boundary in Kutch.

The work is unique in that it integrates both surface and subsurface data to provide a comprehensive scenario of the Kutch basin. The get up of the book is quite impressive but the binding is poor. A subject index would enhance this edition. The apparent lapse is the absence of caption to tables.

Stratigraphers and micropaleontologists in industry, academic and National Laboratories, as well as students, will find the book very useful. KDMIPE should be congratulated on bringing out such a useful publication.

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Biotechnological Applications for Food Security in Developing Countries. H. C. Srivastava. Oxford & IBH Publishing Co. Pvt. Ltd., 66 Janpath, New Delhi 110 001. 1993. Rs. 585. pp. 616.

Biotechnology has been broadly defined as 'any technique that uses living

organisms, or part of organisms, to make or modify products, to improve plants or animals, or to develop micro-organisms for specific uses'. The above definition by the Office of Technology Assessment of the US Congress would include all food production systems—traditionally known as agriculture. However, biotechnology in a restricted definition or what is often referred as the modern biotechnology is based on: recombinant DNA technology, monoclonal antibodies and cell and tissue culture techniques. A yet more restrictive definition of biotechnology is the commercial application of molecular biology. It is the application of molecular biology which is beginning to emerge as a powerful new technology. This biotechnology is likely to influence all aspects of human life in future and holds all the excitement and the potential for new 'products'. Hence, biotechnology is a fashionable word these days and every year many meetings are organized. Most of such meetings in the developing world only project the possibilities. The volume *Biotechnology Applications for Food Security in Developing Countries* covers agriculture, aquaculture, animal sciences, plantations including medicinal plants. The papers included in the volume were presented in a two-day get-together organized by the Non-Aligned Movement (NAM) Science and Technology Centre at New Delhi in December 1991. In addition, invited contributions are also included in the volume.

The General Section (1) includes seven articles on food security, south–south cooperation, an overview of biotechnology and socio-economic development in developing countries and a status report of different countries on crop and animal productivity. This chapter covers 58 pages. Food security is extensively discussed by three authors. Section II on agriculture includes eight articles ranging from molecular biology and biotechnology applications for crop improvement to water conservation for higher crop productivity. Fourteen articles form the third section on plantations of which 10 deal with medicinal plants and four others on topics as diverse as increasing tea productivity, vegetable oil bearing plants of Brazil, aromatic plants and utilization of wastelands to mitigate poverty. Sections IV and V include respectively four and three articles on aquaculture and animal sciences.

The stated objective of bringing out the volume is to serve as a reference book. It certainly meets the objective for laymen, and for specialists when they happen to be in situations with no access to the original information. The volume can also be a good starting point for the new entrants in the field. As is common with the volumes based on get-together or scientific meetings of this kind, the papers cover a very wide range of topics. The reviewer feels that the articles on medicinal plants should have been brought out as a separate volume. They do not really fit in the volume on food security. Many authors have not cared to give the source of their information as no references are cited. Therefore the reader looking for the original information, will have to search other publications.

Though the title includes 'developing countries', the volume certainly lacks the international flavour of NAM, both by the titles as well as the nationality of the authors. They are predominantly from India, followed by Pakistan, three from Venezuela and two from Saudi Arabia. The well-known promises of biotechnology in different areas of agriculture are very well covered but those familiar with the subject will not find many new ideas. A review of the current status and competence built up in different third world countries would have been far more useful to identify the present strengths for building the future. It is interesting to note that some authors still believe in transfer of nitrogen fixing abilities to non-leguminous plants.

The present scenario of south–south cooperation is reviewed by M. N. Qureshy, former Director of NAM S&T Centre. A strong plea is made for '"south" countries to pool their resources together for tackling problems that are beyond the resources of one country'.

To present the food production scenario in the right perspective, mentioning the other viewpoint will not be out of place. It has been repeatedly said that in spite of all the promises of biotechnology to increase food production and thereby food security, at least for the next ten years productivity increases for major crops like wheat, rice, maize and soybean will come from the use of classical methods of crop improvement. Biotechnology tools (R-DNA technique) will not contribute to major productivity increases. Initially, their contribution will be limited to enhancing herbicide, pest and disease resistance of the crops.

Overall, it is a useful and informative compilation of articles, especially for the readers in the Indian subcontinent. Books are getting out of reach for the scientists in India and many other developing countries. At a price of Rs 585 it would be difficult to buy a personal copy but it is certainly recommended for the libraries.

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Prof. R. S. Krishnan, doyen of experimental physics in the country, is having his Sathabishekam (i.e. he has in theory viewed 1008 full moons). We reproduce below a letter that was written to him on this occasion. — *Editor*

A letter to R.S. Krishnan

My dear Prof. Krishnan,

I notice that your *Sathabishekam* is being celebrated on the 18th of September 1993. May I congratulate you on this auspicious occasion and also on the extraordinary life of science you have led. I wish you a further long period of very happy life.

Sometime ago, I had to speak on the growth of physics in India immediately after independence at an Indo-French meeting. It was while preparing the text of this lecture that many important issues came into perspective and I thought this may be a good occasion to mention them to you. In the lecture I said:

'Because of the policies the government had followed just before and immediately after Independence, one might have expected a set-back in the progress of science as the country would have had to wait for the newly trained young scientists who were sent abroad to return and establish schools of science. In the case of Physics and Applied Physics, this simply did not happen. In fact, Physics actually flourished magnificently. Vigorous schools of research in Pure and Applied Physics that too in new fields were set up which produced internationally competitive scientific work. The tradition and momentum built up in physics in the country during the previous three or four decades came into play.'

'The greatest contribution made by Raman to post-Independence physics was not just his science but the students he had trained and who had passed through his laboratories. One can mention the names of many of his students like S. K. Mitra, S. K. Banerjee, K. R. Ramanathan, L. A. Ramdas, K. S. Krishnan, S. Bhagavantham, K. Banerjee, R. S. Krishnan, Vikram Sarabhai, P. Nilakantan, P. R. Pisharoty, Anna Mani, G. N. Ramachandran, S. Chandrasekhar, A. Jayaraman and S. Pancharathnam. Many more could be added to this list.'

About you I said: 'R. S. Krishnan was amongst the most outstanding experimenters of Raman's students. He is well known for the new effects he discovered in colloid optics. His work on the second order Raman Effect is nothing less than brilliant. It was a pity, however, that it became a subject of much controversy; not his experiments but their interpretation. His work on Brillouin scattering in diamond and the work he did with V. Chandrasekharan can only be described as monumental. Apart from renown in his personal science, I think the greatest contribution he made was when he changed the style in which physics was done in India. A clear break from the traditions set-up earlier.'

He had a knack of picking young scientists and encouraging them to start new things and making them work in almost independent groups. He courageously started such activities like dating of rocks, mass spectroscopy, ultrasonics, crystal dynamics and crystal properties, especially photoelasticity, paramagnetic and nuclear magnetic resonance and also X-ray crystallography. Many of these had never before been done in the country. By creating these semi-independent groups, Krishnan was in a sense (perhaps unconsciously) responsible for breaking the 'GEHEIMRAT' system in which the Professor is supreme and all the members of the lab work for him. Unfortunately, this old system still persists at many places in the country.

You chose V. S. Venkatasubramanian (VSV) to work on the dating of rocks. The work you and he did was truly path breaking. The first mass spectrometer was built in the Physics Department under your guidance (and not in Bombay). With VSV and E. S. Raja Gopal, ultrasonic research came of age and elastic constants (of solids also) were determined using the most modern techniques. Your encouragement of Suryan, who was so full of ideas, was truly phenomenal. The first paramagnetic resonance and nuclear magnetic resonance setup was done in the Physics Department. Indeed, modern electronics really entered into physics because of you in your department. The remarkable work of R. Srinivasan, his theoretical and experimental acumen is something you and all of us can be proud of. I think Chidambaram, under your inspiration, became one of the best in India in instrumentation and he produced notable science in many fields.

I remember how you egged me on to finish my doctoral thesis and later persuaded me to change my field of research from magnetooptics and paramagnetic resonance. When G. N. Ramachandran left, you 'picked me' and said that you had decided to put me 'in charge' of X-rays and said 'Try to build a group worthy of this department'. I am personally very thankful to you for this decision of yours. Students who came out of this group attained world renown: Viswamitra, Venkatesan, Vijayan and N. V. Mani (who died young) and also *their* students. I flatter myself in thinking that your experiment in this regard was not too unsuccessful.

You can be truly proud of your personal students V. Chandrasekharan, V. S. Venkatasubramanian, R. Srinivasan, E. S. Raja Gopal and R. Chidambaram for they are as good as any in the world. You can feel immensely proud of and pleased with some of the products of your laboratory who occupy/occupied few of the highest scientific posts like the Chairman of the Atomic Energy Commission, Director of the National Physical Laboratory, Director of the Indian Insititute of Science, etc.

You can look back with pride and with some satisfaction on the contributions you have made to the intellectual wealth of the country by your personal efforts and through those who were associated with you.

With my respectful regards,

S. RAMASESHAN