tries Also, the lack of protection to intellectual property has led to blatant copying of processes with impunity, and hence failure to nurture research skills. Multinationals operating in India are also hesitant to bring newer technologies because of these reasons.

In spite of the tax concessions, Indian industries have so far not shared the burden of the R&D expenditure. Poor R&D management and short-term goals have led them to spend less on R&D.

Although this paper covers only the chemical literature, a similar picture may emerge if a corresponding study is carried out on R&D in other branches of science. The watch-dogs of Indian R&D, namely, the Department of Science and Technology and the Department of Scientific and Industrial Research should be carrying out regular studies on the performance of Indian R&D, *vis-à-vis* the international scene, to help the science planners and managers to give better focus to the efforts of the scientific community.

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Decline of blackbuck (*Antilope cervicapra*) in an insular nature reserve: The Guindy National Park, Madras

T. R. Shankar Raman, R. K. G. Menon and R. Sukumar

Based on the equilibrium theory of island biogeography[1], conservation biologists have predicted that insularization of nature reserves would lead to extinction of several species occurring within the reserves[2–4]. Some species are more likely to go extinct than others for a variety of reasons[5]. A classic example of such extinction in insular habitats is that of many bird species on Barro Colorado, which became an island in 1910 during the creation of the Panama Canal[6]. It is generally believed that small, insular reserves will need active management if specific conservation objectives have to be met.

Along with Selvakumar[7], we (RKGM and RS) have been making general ecological observations in Guindy National Park (GNP), Madras, since 1974. A more systematic study was begun in 1991. During this period the park has shrunk in size and enclosed by a wall, the vegetation has undergone qualitative changes, while the population of blackbuck (*Antilope cervicapra*), an endangered antelope endemic to the Indian sub-continent, has declined considerably. While the detailed results of our observations are being reported elsewhere[8], here we highlight briefly the need to take urgent management action if the species is to be saved from its precarious position in the park.

Once covering an area of about 500 ha of one of the last remnants of the tropical dry evergreen forest of the Coromandel coast[9] (now reclassified as the *Albizia amara* Boiv. Community[10]), the GNP was established as a Reserve Forest in 1910. It now occupies an area of only 270 ha, walled off since the late 1980s from the adjacent Raj Bhavan and Indian Institute of Technology (IIT) campus. At least 350 species of flowering plants are found here (C. Livingstone pers. commun. and RS pers. observ.) in addition to about 150 species of birds[11] (V. Santharam, pers. comm.) and several species of lower plants, invertebrates, fishes, amphibians, reptiles and mammals. The park has been regarded in the past as one of the native strongholds of blackbuck, although it is also popular for its sizeable population of chital or spotted deer (*Axis axis*) which was introduced into the park[12] probably less than 50 years ago.

Trends in blackbuck and chital populations

Our studies of the blackbuck and chital populations here during the 1970s were based on total counts[7] and sample counts using belt transects[13, 14] for estimating population sizes, keeping records of population structure (age and sex class of animals) and, in the case of blackbuck, territoriality in males During 1991–92 we used the statistically more robust line transect sampling[15] to obtain estimates of population density and size, in addition to information on population structure, habitat use and territoriality[8]. Classification of animals was based on Schaller[16], Mungall[17] and Selvakumar[7].

During 1975–80, censuses conducted under the auspices of the Forest Department using volunteers and naturalists (including two of us, RKGM and RS) gave an average population of 295 blackbuck (unpublished records) for the combined GNP and Raj Bhavan areas In 1979, a 'total count' gave a figure of 260 blackbuck[7] which can be considered as a minimum number as some animals would have been missed due to poor visibility in denser vegetation. Sample counts during 1981–82 by Menon[14] gave an average figure of 333 blackbuck for this area, which may have been a slight overestimate[13]. These observations indicate that at least 250 blackbuck were present in GNP and Raj Bhavan during 1975–82.

In contrast, the line transect estimate during 1991–92 was 22.9 (±4.1, 95% Confidence Interval) blackbuck/km^2 in

GNP or a population of 85 (±15; 95% CI) animals in GNP and Raj Bhavan. Clearly, the blackbuck population has declined by about 75% since 1975–82. There have also been other obvious demographic changes reinforcing our view of a declining population. The proportion of sub-adult males in the total population was 23 5% during 1979 (ref. 7) but only 4% during 1991–92 indicating poor recruitment. The proportion of sub-adults and fawns of both sexes declined from 13.2% in 1991 to 6.3% in 1992.

The chital population, on the other hand, has remained relatively stable or even increased over this period. An estimate[7] in 1979 gave a minimum of 360 animals for GNP and Raj Bhavan, while sample counts by Menon (1982) during 1981–82 gave an average density of 200 individuals/km^2 or a total population of 540 animals for GNP. By comparison, our line transect estimates gave mean densities of 185.4/km^2 (±29.3, 95% CI) during 1991 and 239.2/km^2 (±37.2, 95% CI) during 1992 in GNP, an increase which is statistically significant ($z = 2.22$, $p < 0.05$)

Causes for decline of blackbuck

We believe it is useful to explore some causes for the decline of the endangered blackbuck in spite of some of these being indirect or speculative for the present.

Changes in grassland habitat and territorial grounds

The blackbuck is primarily a species of open grassland habitat[17, 18]. One such major habitat at GNP is the Polo Field[7] in which daily counts indicated the presence of 60–80 blackbuck, along with 10–20 males, of which 5 regularly held territories, during 1977–79 (RKGM, unpublished data). Since that period, the field was overrun by weedy plants (such as *Prosopis juliflora, Cassia tora, C occidentalis, Croton bonplandianus* and *Sida cordifolia*) and tree saplings of *Cassia fistula* and *Borassus flabellifer*. During 1991–92 a maximum of only 29 blackbuck was seen on the Polo Field Similarly, in 1991 only 2 territorial males were observed in this field. Such changes also occurred in other grassland areas. The deterioration of the grassland habitat combined with the fact that non-territorial males rarely reproduce[19] may have contributed to a decline in the fertility of the population. Similar changes occurred in other grassland areas.

Other vegetational changes

In the understorey, shrubs such as *Clausena dentata* and *Glycosmis mauritiana* are now denser and grown about 1–2 m taller than during the 1970s (RS, personal observations). One possible reason for this is a change in nutrient cycling caused by the influx into the park of 35 tons (dry weight) of biomass every year or a total of 525 tons (nearly 200 tons/km^2) over a 15-year period, provided as fodder for deer by the Forest Department. Concurrently, wood poaching has declined considerably after the park was walled off.

Competition from chital

Blackbuck very rarely feed on the grass provided. However, the provision of artificial fodder has resulted in lowering fawn mortality rates in chital as seen from a comparison during 1991 (when no fodder was provided) and 1992 (when fodder was given). This combined with a better adaptability of the introduced chital[12] may be exerting considerable competitive pressure (for both space and food) on the blackbuck. Chital herds of 50–100 individuals have been observed to crowd into the Polo Field during the wet season and physically disrupt feeding of blackbuck herds and territorial behaviour of male blackbuck, a phenomenon not seen during the 1970s.

Reduction in genetic viability of blackbuck population

Although very speculative at this stage, the decline in blackbuck population due initially to ecological reasons could have accentuated through a reduction in the genetic viability of the population. Both the small population size and breeding by only a few males (the adult sex ratio is about 1 male to 5 females) would result in a small genetically effective population size (we estimate this to be only 26 during 1991–92). This is much below the minimum believed necessary to counter inbreeding depression even in the short-term[20].

Management recommendations

In order to maintain a stable and viable population of blackbuck in the park we suggest the following management action.

(a) Allow natural mortality of chital by stopping or phasing out artificial feeding and the shooting of dogs. Some chital may also have to be removed to zoos or other places.
(b) Maintain the grasslands such as the Polo Field as open areas for blackbuck. *Acacia auriculiformis* has to be removed from open areas where it has been planted Other invasive exotics such as the cactus *Cereus peruviana* and *Antigonon leptopus* can be cleared from the scrub jungle they are invading
(c) Sub-adult male blackbuck from the adjoining IIT campus (once contiguous with GNP) may be introduced into GNP. At a later stage blackbuck from other areas can also be introduced (after appropriate screening) in order to widen the genetic base and prevent inbreeding
(d) The ecology of the park should be closely monitored.

Our long-term observations suggest that active and 'adaptive' management of small, insular reserves such as GNP, rather than a *laissez faire* approach, may be needed to prevent extinctions of vulnerable species.

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Learning lessons from Israel

We are living at a momentous time in human history. Not only is knowledge advancing at an unprecedented pace, but sworn enemies have learnt to live together as brothers – the Germans and the French, the whites and blacks in South Africa, the Israelis and the Palestinians who entered into an agreement for mutual recognition on September 13, 1993. Recently I was in Israel for five days – five of the most educative and rewarding days of my life.

Nations and civilizations have perished through affluence; but no nation, no civilization, has died of adversity. Nations, like individuals, evolve through suffering; and are provided to do their best by hardship and distress. The holocaust killed six million Jews – more than the entire present population of Israel.

In 1948 Israel was a barren desert, as a large part still is – and the inhabitants endured for years the trials and tribulations arising from acute scarcity of water. But with hard work and highly developed technology, the Israelis have made the arid wasteland now blossom like a garden. They have become past masters in the modern techniques of irrigation of recycling sewage water, refurbishing pipelines, desalinating and transporting large quantities of water, and expanding practical research in potential water sources. They are producing vegetables and fruits which are sold to the less industrious peoples who inhabit the far more fertile countries of Europe. Israel estimates that in two decades the population of the Middle East will double, and the demand for water in the region will increase by approximately one billion cubic meters per year. Israel is well geared to meet the challenge. The 'Rio Declaration', ratified by the United Nations Conference on Environment and Development in June 1992, called for a global partnership of governments and nations for the common cause of protecting the environment. Israel has already started living up to the Declaration. As a nation, it has reached a stage of evolution which holds significant lessons for India.

Admirably equipped

President Mitterand said, 'In future a nation's power will depend less on its financial wealth than on its grey matter'. By this test, Israel is admirably equipped to enter the 21st century. The tiny country is studded with eight universities for higher learning, and has achieved hundred per cent literacy (barring some recent immigrants).

Israel is to India what quality is to quantity. The territory of Israel extends to 27,817 sq. km. – less than one hundredth of India's 3.3 million sq. km; while its population is only 5.3 million (less than half the population of Bombay), against our 900 million. But its exports for last year totalled $23 billion, against India's $22 billion.

Israel is a truly egalitarian society, while India continues to proclaim itself to be, and even largely conducts itself as a socialist state. The Kibbutz is a laudable institution unique to Israel. The members of a Kibbutz own and enjoy their property jointly and each person gets what he needs from the common property and income of the Kibbutz. There are only 125,000 members in the 270 Kibbutzim which are in operation today. They represent a very small percentage of Israel's population, but they are responsible for 35 per cent of the agricultural produce and eight per cent of the manufactured articles. Communism, which is based on the same ideology, has failed hopelessly because it coerces and tyrannizes people into accepting common ownership. By con-

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