

Livestock depredation by large carnivores in the Indian trans-Himalaya: conflict perceptions and conservation prospects

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Summary

Livestock depredation by the snow leopard, *Uncia uncia*, and the wolf, *Canis lupus*, has resulted in a human-wildlife conflict that hinders the conservation of these globally-threatened species throughout their range. This paper analyses the alleged economic loss due to livestock depredation by these carnivores, and the retaliatory responses of an agro-pastoral community around Kibber Wildlife Sanctuary in the Indian trans-Himalaya. The three villages studied (80 households) attributed a total of 189 livestock deaths (18% of the livestock holding) over a period of 18 months to wild predators, and this would amount to a loss per household equivalent to half the average annual per capita income. The financial compensation received by the villagers from the Government amounted to 3% of the perceived annual loss. Recent intensification of the conflict seems related to a 37.7% increase in livestock holding in the last decade. Villagers have been killing the wolf, though apparently not the snow leopard. A self-financed compensation scheme, and modification of existing livestock pens are suggested as area-specific short-term measures to reduce the conflict. The need to address the problem of increasing livestock holding in the long run is emphasized.

Keywords: livestock, snow leopard, *Uncia uncia*, wolf, *Canis lupus*, conflict, Himalaya

Introduction

The intimate interspersed of people in protected areas often results in conflicts between humans and wildlife (Rodgers 1989). Most wildlife protected areas in India support various forms of land use, such as agriculture, livestock grazing, and collection of minor forest produce. Livestock grazing is especially widespread, and livestock holdings form an important component of the local pastoral and agricultural economy. Kothari *et al.* (1989) report livestock grazing in as many as 73% wildlife sanctuaries and 39% national parks in India (of the 101 and 14 protected areas surveyed respectively in those categories), with livestock densities up to 1500 per

km². Not surprisingly, livestock often greatly outnumber wild ungulates within many protected areas. Such a disproportionate presence of wild and domestic ungulates results in killing of livestock by wild predators, and thereby a conflict of interests between local communities and wildlife managers.

Human-wildlife conflicts are acute when the species involved is highly imperilled while its presence in an area poses a serious threat to human welfare (Saberwal *et al.* 1994). Such is the conflict between wild carnivores and pastoralists in trans-Himalaya, one of the most fragile, and yet the least represented, of all the biogeographic zones in the Indian protected area network (Rodgers & Panwar 1988). The trans-Himalaya biogeographic zone harbours at least 12 mammal and bird species listed in Schedule I of the Indian Wildlife (Protection) Act, 1972 (Anon. 1992). Among these, the snow leopard, *Uncia uncia*, is globally threatened, and is categorized as endangered (in danger of extinction) by the IUCN (1990). The Tibetan wolf, *Canis lupus chanku*, represents another globally-threatened species, categorized as vulnerable (IUCN 1990). Both these species are in conflict with humans in most parts of their range, specifically due to the damage they cause to livestock (Schaller 1977; Fox *et al.* 1988; Mallon 1988; Oli *et al.* 1994; Meriggi & Lovari 1996; Nowell & Jackson 1996).

The purpose of this paper is to examine the conflict between these wild predators and agro-pastoralists around Kibber Wildlife Sanctuary, which is an area of acute conflict in the Spiti Region of the north Indian state of Himachal Pradesh, and to propose measures that might be taken to reduce the conflict. The paper first establishes the economic loss to local communities due to the perceived wild-carnivore predation on livestock, and then qualitatively describes the retaliatory persecution of the carnivores.

Methods

Study area

Kibber Wildlife Sanctuary (32°5' to 32°30' N and 78°1' to 78°32' E) was established in the Spiti Region (Lahaul & Spiti District) of the Indian state of Himachal Pradesh in 1992 for conservation of trans-Himalayan wildlife. The sanctuary occupies an area of 1400 km² in the river Spiti's catchment. Bordered by Ladakh on the north and Tibet on the east, it is a mountainous cold desert, where altitudes range between c. 3600 m and 6700 m above mean sea level. Temperatures range between -30°C and 3°C in winter, and between 1°C and 28°C in summer (Rana 1994). The vegetation of this area

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has been broadly classified as dry alpine steppe (Champion & Seth 1968).

Large mammalian fauna of the area includes bharal, *Pseudois nayaur*, relatively few ibex, *Capra ibex*, and their predators, namely the snow leopard and the Tibetan wolf. Other fauna includes the red fox, *Vulpes vulpes*, pale weasel, *Mustela altaica*, stone marten, *Martes foina*, and the Himalayan mouse hare, *Ochotona* sp. During the course of this study, 45 species of birds were identified, including several species typical of this alpine habitat, such as chukar, *Alectoris chukar*, and Tibetan snowcock, *Tetraogallus tibetanus* (C. Mishra, unpublished data 1996).

Thirteen villages are located along the boundary of the sanctuary, supporting a total human population of 1985, according to the 1991 census. The main occupations of the inhabitants are agriculture and livestock rearing. Most agriculture-related activities are restricted to the short growing season (from May to September). The main crops cultivated are barley, *Hordeum vulgare*, and green peas, *Pisum sativum*. Livestock includes goats and sheep, cattle, 'dzomo' (a female hybrid of cattle and yak), and yaks. Donkeys are the beasts of burden, while horses, apart from being used for religious ceremonies, are mainly raised for trade. All these animals graze in the sanctuary.

Sources and data

Secondary data from the 1991 census of the human population for all the 13 villages bordering the sanctuary were collected from archival records (unpublished) maintained at the Office of the Additional Deputy Commissioner, Desert Development Project at Kaza in Spiti. Of these, the largest village, namely Kibber, was selected for the study: Kibber village accounted for 16% of the human population of the 13 villages. Two small nearby villages, Gete and Tashigang, were later included in the study to raise the coverage to 19%. I also searched the archival records for data on human population and livestock holding of the sample villages in the past. The exponential growth curve equation was used to calculate human and livestock population growth rates.

At least one member from each household in the three villages was interviewed. Interviewees were asked whether they had lost any livestock in the previous one and a half years (1995 and January to July 1996) to wild predators. They were also asked if they had applied for and received financial compensation from the Office of the Director, Pin Valley National Park at Kaza, which functions as the local wildlife department for Spiti. The species, age, and sex of livestock reportedly killed by wild predators were recorded. Interviewees were asked about the composition of their present livestock holdings. To estimate the current average market value of different classes of livestock species by age and sex, a butcher (Kibber village), two horse traders (one from Kibber and another from a nearby village called Chichim), and two other people (Kibber), who were

frequently involved in trading livestock, were interviewed. This market value refers to the average amount of money required to buy an animal of a particular species. Financial compensation rates were obtained from the Office of the Director, Pin Valley National Park.

The focus of this particular study was the perceived livestock loss to the wild predators, and therefore the cases of mistaken, but unintentional, attribution of livestock deaths to wild predators were included. However, it is important to keep in mind that the proportion of such mistaken cases could have been substantial, even greater than the genuine cases of depredation. Precautions were taken against intentional exaggeration. All the information provided by the respondents from Kibber was cross-checked using the knowledge of two local villagers who served as my field-assistants. This could not be done for the other two villages. The survey was conducted after I spent about three months in the area in 1996, during which time the villagers had realized that I had no immediate say in policy making or implementation of any wildlife-management programme, including financial compensation.

Chi-square goodness of fit was employed to test whether the reported frequency of predation on different livestock species deviated significantly from the expected frequency (Zar 1984).

Results

The 80 households of the three study villages, namely Kibber, Gete, and Tashigang, owned 1054 heads of livestock in August 1996 when this survey was conducted (Table 1). Most of the households owned goats/sheep (95%) and at least one cow or dzomo (89%). Fewer had donkeys (79%) and yaks (65%), while only 55% of the households owned horses. A total of 189 livestock deaths (18% of the livestock holding) over a period of 1.5 years preceding the survey was attributed by the villagers to wild predators. This amounted to 1.6 livestock heads/family/year and an annual loss of 12% of the livestock holding.

Market values of livestock varied by species, age and sex (Tables 2 and 3). Using data in Tables 2 and 3, the alleged economic loss due to wild predators amounted to US \$15 418, which translated into US \$128 per family per year (1 US\$ ≈ 31.4 Indian rupees, 1994–95).

Of the 131 reported cases in 1995, villagers had applied for monetary compensation in 54 cases and received compensation for 28 cases (amounting to US\$ 307). Considering an average perceived annual loss of US\$ 10 279, the compensation for 1995 amounted to 3% of the perceived annual loss. It must be noted here that 'perceived loss' also includes those deaths for which the villagers may not have been certain about the cause.

Perceived kills of goats and sheep (combined) and horses accounted for 42.1% and 37.4% of the economic loss, respectively. In terms of the proportion of livestock heads, yaks (16.4%) followed goats and sheep (60.3%) (Table 1).

Table 1 Livestock population, alleged kills by wild predators, and the percentage economic loss in three villages adjoining Kibber Wildlife Sanctuary, Indian trans-Himalaya.

Variable	Yak	Horse	Cow/ dzomo	Donkey	Goats/sheep
Livestock population	139	75	126	125	589
Alleged kills	31	26	0	18	114
Ratio of alleged kills to relative abundance	1.24	1.94	0	0.79	1.07
% economic loss	15.4	37.4	0	5.1	42.1

Table 2 Market value (US\$) of goats and sheep by age and sex around Kibber Wildlife Sanctuary, Indian trans-Himalaya.

Age	Goat:		Sheep:	
	Male	Female	Male	Female
4 months	8.0	6.4	15.9	12.7
6 months	15.9	12.7	31.8	25.4
12 months	31.8	25.4	57.3	44.6
18 months	51.0	31.8	63.7	60.5
≥24 months	63.5	57.3	63.5	60.5

Among all livestock species, only horses were reported to be killed significantly more in proportion to their relative abundance ($\chi^2 = 37.32$, $df = 4$, $p \leq 0.01$). Except for cows and dzomo, which were not preyed on, all the remaining species were reportedly killed with a frequency proportional to their relative abundance (Table 1).

Between 1971 and 1996, the three study villages underwent a 6.5% increase in human population (from 353 to 376), an average annual growth rate of 0.25%. The period between 1971 and 1987 saw a 52.2% (from 115 to 175) increase in the livestock population of Gete and Tashigang (growth rate = 2.6%). Livestock data for Kibber village for the year 1971 were not available. Between 1987 and 1996, the livestock population in all the three villages increased by 37.7% (growth rate = 3.5%).

Retaliatory measures of the villagers

Spiti in general, and the villages around Kibber Wildlife Sanctuary in particular, have been areas of high conflict between agro-pastoralists and wild predators. Although the locals are Buddhist, wolves are killed; the villagers locate wolf dens and capture the pups. The pups are then paraded live around the neighbouring villages, where people reward the captors with money. The litter is then destroyed, often using dynamite. According to locals, wolf litters were destroyed around the study villages almost every year in the 1980s. The wolf has reportedly not littered in this part of the sanctuary for the last four to five years, and has rarely been sighted. Almost all the livestock kills reported in this paper were attributed to the snow leopard.

Local information revealed that a litter was destroyed in 1996 near Hikkim, one of the 13 villages bordering the sanctuary. Locals also brought a live litter of four wolf cubs (captured near a distant Spiti village called Losar) to the Office of the Director, Pin Valley National Park, during the course of the study (C. Mishra, personal observation 1996).

According to the locals, there was only one case where an adult snow leopard was killed after it was accidentally trapped inside an indoor pen in Kibber village four or five years ago. Except for this incident, the snow leopards are apparently only occasionally persecuted, by driving them off livestock kills.

Discussion

The conflict

Conflicts between humans and wildlife in India are escalating due to increasing human population, loss of natural habitats, and, in some regions, increasing wildlife populations as a result of successful conservation programmes (Rodgers 1989; Saberwal *et al.* 1994). In Kibber Wildlife Sanctuary, though the killing of livestock by wild carnivores is not a recent phenomenon, the number of kills has increased in the last five years, both according to local people, and the Government officials at the Office of the Director, Pin Valley National Park. This period coincides with the declaration of the area as a wildlife sanctuary in 1992. However, the escalated conflict has little to do with increased protection to wild carnivores. This is evident from the continued persecution of the wolf in the area. Human population in the study villages has also remained almost constant over the last 25 years. The increased conflict seems related to the drastic increase in livestock population in the last decade, which has accompanied a change from subsistence to commercial agriculture and animal husbandry (Mishra 1997). Shifts in carnivore diets in response to changes in relative abundance of prey species have been documented (Kitchner 1991; Chellam 1993). Livestock, due to their reduced escape abilities compared to wild herbivores, become especially vulnerable to predation (Nowell & Jackson 1996).

Actual rate of predation on livestock in Kibber is not available. This is important but not easy to establish, since the losses attributed to wild predators are usually exaggerated, either deliberately, or due to an inability to ascertain the cause of death (Kruuk 1980; Hoogesteijn *et al.* 1993; Mizutani 1993; Oli *et al.* 1994). High predation levels on livestock by snow leopard and wolf have been reported from other parts of their range (Schaller 1977; Fox *et al.* 1988; Mallon 1988; Oli *et al.* 1994; Nowell & Jackson 1996). In Kibber too, livestock seems to constitute important prey for the snow leopard. Although robust estimates of wild ungulate populations are not available, I counted about 60 bharal, an important prey of the snow leopard (Jackson 1991;

Table 3 Market value (US\$) of different livestock species by age and sex around Kibber Wildlife Sanctuary, Indian trans-Himalaya.* Male horses usually sold off by this age. ** The price of female horses starts declining with age ≥ 6 years.

Age	Yak	Horse:		Dzomo	Cattle:		Donkey:	
		Male	Female		Male	Female	Male	Female
6 months	31.8	0.0	0.0	0.0	0.0	0.0	9.6	4.8
1 year	63.6	127.4	95.5	41.4	15.9	31.8	9.6	4.8
2 years	95.5	254.8	159.2	82.8	57.3	63.7	25.5	8.0
3 years	127.4	382.2	302.5	95.5	63.7	79.6	44.6	25.5
4 years	175.2	477.7	350.3	127.4	63.7	95.5	63.7	25.5
5 years	207.0	573.2	382.2	127.4	63.7	95.5	63.7	25.5
6 years	222.9	573.2*	382.2**	127.4	63.7	95.5	63.7	25.5
≥ 7 years	238.9	–	–	127.4	63.7	95.5	63.7	25.5

Chundawat 1994), within the ecological unit (*c.* 20–30 km²) that encompasses the pastures of the three study villages. Field surveys indicated that during the spring-summer season when this study was carried out, the bharal abundance did not exceed 100 individuals, which is one-tenth of the livestock abundance in the area.

Oli *et al.* (1994) assessed the impact of perceived snow leopard predation on livestock in the Manang district of Nepal, and found that the loss per household represented a quarter of the average annual per capita Nepalese income. In the present study, the perceived loss to wild predators per household and per individual was almost twice as great as in the Nepalese study, amounting to 52% and 11%, respectively, of the annual per capita income of Himachal Pradesh (US\$ 248) for 1994–95 (World Bank 1996). The loss was only marginally reduced after incorporating the amount received as financial compensation (50% per household and 10.6% per individual of the average annual per capita income).

For reasons discussed earlier, the levels of livestock depredation and the consequent economic loss presented in this paper surely exceed the actual loss due to wild predators. There is little doubt, however, that a serious conflict exists between the wild predators and the agro-pastoralists. Even during the course of four months spent in the field, seven goats/sheep and a horse belonging to the study villages, were reportedly killed by wild predators, and another horse injured. The identity of the predator was mostly unavailable, with the exception of the horse which was killed by snow leopard; this was indicated by canine puncture marks on the throat and pug-marks nearby. In any case, the tendency of people to attribute, often unintentionally, most cases of livestock death to the wild predators, accentuates the conflict. This is because when peoples' tolerance towards the wild predators is in question, it is the loss they perceive, rather than the actual loss, which can lead them to retaliate.

Reducing the conflict

Contemporary management strategies to minimize livestock depredation by wild carnivores involve elimination of specific animals causing damage, improved anti-predator and general

livestock management, and compensation for livestock lost to predators (Nowell & Jackson 1996). In India, Schedule I species (Anon. 1992) such as the Tibetan wolf and the snow leopard cannot be destroyed by law for reasons such as livestock depredation (Sawarkar 1986). Oli *et al.* (1994) outline specific management strategies to reduce the snow leopard–pastoralist conflict, and emphasize the need for financial compensation schemes. Such a scheme does exist within the wildlife department (Office of the Director, Pin Valley National Park) in Spiti. However, in 1995, people applied for compensation for only about 41% of the perceived livestock predation cases. Low compensation rates (6–20% of market value), bureaucratic apathy, and the time and costs involved in securing compensations, apparently discouraged people from applying for such schemes. It is clear that the compensation scheme, as it exists now, can do little to reduce the human–wildlife conflict in this area. Such disinterest in existing Government financial schemes, for similar reasons, has been reported from elsewhere in India (Saberwal *et al.* 1994).

Preliminary discussions with the local people indicated a willingness of most families to contribute an equivalent of US\$ 1 (4.8% of the average monthly per capita income) per month if a self-financed compensation scheme is developed in the area. If such a scheme could be developed by the local wildlife department along with non-governmental organizations, by setting up a committee of the village community to manage the funds and decide the compensation rates, it would surely be an improvement on the existing scheme. Such a fund would need to be strengthened with corpus grants (where the capital remains untouched and only interest is spent) from national and international conservation agencies.

In summer, the livestock are penned adjacent to houses at night. These pens are small enclosures (up to 10 m \times 20 m) with *c.* 1.5 m high walls and no ceiling. Snow leopard occasionally raid these pens. The kills inside villages, for obvious psychological reasons, cause greater resentment among the locals. In some houses in Gete, one of the study villages, people have covered their pens with chain-link fences, which according to them have substantially cut down instances of kills inside the village. Providing chain-link fences to the locals would be a small but important step in

reducing the conflict. For this, I estimated a one-time investment of about US\$ 75 per family. This cost could be met either by the state, conservation agencies, the village community fund mentioned above, or a combination of these.

It is important to note that such management schemes can provide only a short-term remedy. The conflict in the long run is likely to intensify unless the problem of growing stock sizes is addressed. Persecution by humans in response to livestock depredation in historical times has eliminated several carnivores, including the tiger, *Panthera tigris*, lion, *Panthera leo*, and puma, *Felis concolor*, from large parts of their former range (Nowell & Jackson 1996). In Kibber, the wolf has faced the brunt of the agro-pastoralists' retaliation. This is despite the belief that most livestock kills are at present made by snow leopard. The persecution of wolf is possibly related to the relative ease in locating dens and capturing litters. So far there seems to have been no attempt to eliminate the snow leopard. Such cases, however, have been reported for trans-Himalayan Buddhist communities elsewhere (Fox & Chundawat 1988). With losses equivalent to half the average annual per capita income for every household at stake, it is highly probable that unless urgent extenuatory management measures are undertaken in Kibber Wildlife Sanctuary, active elimination of snow leopard would be resorted to in the near future.

Yet existing herding practices are partly responsible for the conflict. For instance, yaks and horses are free-ranging at least in summer, which makes them vulnerable to predation. Clearly, research efforts need to focus on how herding practices could be improved, monitoring the abundance of prey species, establishing actual livestock losses to wild predators, and assessing the ecological impacts of the expanding livestock holdings.

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References

- Anon. (1992) *The Wildlife (Protection) Act, 1972*. Dehradun, India: Natraj Publishers: 138 pp.
- Champion, H.G. & Seth, S.K. (1968) *A Revised Survey of the Forest Types of India*. Delhi, India: Manager of Publications: 404 pp.
- Chellam, R. (1993) Ecology of the Asiatic lion (*Panthera leo persica*). Ph.D. dissertation, Saurashtra University, Rajkot, India: 170 pp.
- Chundawat, R.S. (1994) Ecological studies of snow leopard and its associate prey species in Hemis High Altitude National Park, Ladakh. Ph.D. Dissertation, University of Rajasthan, Jaipur, India: 167 pp.
- Fox, J.L. & Chundawat, R.S. (1988) Observations of snow leopard stalking, killing, and feeding behaviour. *Mammalia* 52: 137–40.
- Fox, J.L., Sinha, S.P., Chundawat, R.S. & Das, P.K. (1988) A field survey of snow leopard in northwestern India. In: *Proceedings of the Fifth International Snow Leopard Symposium*, ed. H. Freeman, pp. 9–111. Bellevue, Washington, USA and Dehradun, India: International Snow Leopard Trust, and Wildlife Institute of India.
- IUCN (1990) *Red List of Threatened Animals*. Gland, Switzerland: IUCN: 192 pp.
- Hoogesteijn, R., Hoogesteijn, A. & Mondolfi, E. (1993) Jaguar predation vs conservation: cattle mortality by felines on three ranches in Venezuelan llanos. In: *Mammals as Predators*, ed. N. Dunstone & M.L. Gorman, pp. 391–406. Symposia of the Zoological Society of London, Number 65. Oxford, UK: Clarendon Press: 485 pp.
- Jackson, R. (1991) Snow leopards. In: *Great Cats: Majestic Creatures of the Wild*, ed. J. Seidensticker & S. Lumpkin, pp. 124–9. Pennsylvania, USA: Rodale Press Inc.: 240 pp.
- Kitchner, A. (1991) *The Natural History of the Wild Cats*. London, UK: Christopher Helm, A. & C. Black: 280 pp.
- Kothari, A., Pande, P., Singh, S. & Variava, D. (1989) *Management of National Parks and Wildlife Sanctuaries in India: a Status Report*. New Delhi, India: Indian Institute of Public Administration: 298 pp.
- Kruuk, H. (1980) The effects of large carnivores on livestock and animal husbandry in Marsabit District, Kenya. Integrated Project in Arid Lands (IPAL). IPAL Technical Report E-4 (ITE Project 675). Banchory, UK: Institute of Terrestrial Ecology for United Nations Environment Programme – Man and the Biosphere Programme: 52 pp.
- Mallon, D.P. (1988) A further report on the snow leopard in Ladakh. In: *Proceedings of the Fifth International Snow Leopard Symposium*, ed. H. Freeman, pp. 89–97. Bellevue, Washington, USA: International Snow Leopard Trust and Wildlife Institute of India.
- Meriggi, A. & Lovari, S. (1996) A review of wolf predation in southern Europe: does the wolf prefer wild prey to livestock? *Journal of Applied Ecology* 33: 1561–71
- Mishra, C. (1997) Livestock grazing and wildlife conservation in the Indian Trans-Himalaya: a preliminary survey. Unpublished report for the Wildlife Conservation Society, Bronx, NY, USA. Mysore, India: Centre for Ecological Research and Conservation: 22 pp.
- Mizutani, F. (1993) Home range of leopards and their impact on livestock in Kenyan ranches. In: *Mammals as Predators*, ed. N. Dunstone and M.L. Gorman, pp. 425–39. Symposia of the Zoological Society of London 65. Oxford, UK: Clarendon Press.
- Nowell, K. & Jackson, P., ed. (1996) *Status and Conservation Action Plan: Wild Cats*. Gland, Switzerland: IUCN/SSC Cat Specialist Group, IUCN: 382 pp.
- Oli, M.K., Taylor, I.R. & Rogers, M.E. (1994) Snow leopard *Panthera uncia* predation of livestock: an assessment of local perceptions in the Annapurna conservation area, Nepal. *Biological Conservation* 68: 63–8

- Rana, B.S. (1994) Management plan of Kibber Wildlife Sanctuary. Unpublished report, Department of Forest Farming and Conservation, Wildlife Wing, Himachal Pradesh: 81 pp.
- Rodgers, W.A. (1989) Policy issues in wildlife conservation. *Indian Journal of Public Administration* 35: 461–8.
- Rodgers, W.A. & Panwar, H.S. (1988) *Planning a Protected Area Network in India. Volume I – the Report*. Dehradun, India: Wildlife Institute of India: 341 pp.
- Saberwal, V.K., Gibbs, J.P. Chellam, R. & Johnsingh, A.J.T. (1994) Lion-human conflict in Gir forest, India. *Conservation Biology* 8(2): 501–7.
- Sawarkar, V.B. (1986) Animal damage: predation on domestic livestock by large carnivores. *The Indian Forester* 112: 858–66.
- Schaller, G.B. (1977) *Mountain Monarchs: Wild Sheep and Goats of the Himalaya*. Chicago, IL, USA: University of Chicago Press: 425 pp.
- World Bank (1996) *India: Country Economic Memorandum*. World Bank Report 158882-IN, World Bank, Washington, DC, USA.
- Zar, J.H. (1984) *Biostatistical Analysis*. Second edition. Englewood Cliffs, NJ, USA: Prentice-Hall: 718 pp.