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Production and reproduction performance of Gangatiri cattle in middle Gangetic plains of Bihar

P C CHANDRAN[1], A DEY[2], REENA KAMAL[3], PANKAJ KUMAR[4] and DEO KARAN[5]

ICAR Research Complex for Eastern Region, Patna, Bihar 800 014 India

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ABSTRACT

The characteristics, production and reproduction performance of Gangatiri cattle was investigated by visiting 142 farmer families in 37 villages under Buxar and Itahri blocks of Buxar district of Bihar. The study revealed that the coat colour of Gangatiri cattle were milky white and light grey, and the face was long and narrow. The estimated body weight of cattle in the breeding tract were 83.02±0.20, 132.06±0.71, 172.24±0.31, 326.45±0.70 and 261.63±0.26 kg, at various stages, viz. calves less than one year, 1–3 year males, 1–3 year females, adult males and adult females, respectively. The body length and height at withers of Gangatiri cattle were nearly equal to each other whereas the chest girth was prominent in all stages of age. The mean lactation length, peak yield, age at first calving, service period and dry period were 230.24±7.44 days, 4.52±0.31 kg, 56.63±0.63 months, 129.45±3.63 days and 169.26±10.18 days under farmers' management. Among the kinds of different farming systems adopted by the farmers, the practice of agriculture along with rearing of Gangatiri cattle was prominent followed by other farming systems in the breeding tract. Regression of different dependent variables such as number of cattle, quantity of concentrate fed and the occurrence of diseases on the income generated from Gangatiri cattle (independent variable) were 2.66, 4.15 and –5.91, respectively.

Key words: Characterization, Gangatiri, Indigenous, Production, Regression

Agricultural economy in India depends invariably on animal husbandry for its stability with different species of livestock playing varying roles. Cattle and buffaloes are the part of income generators in many households and the income from these species acts as a buffer for the household economy. However, organized rearing of cattle and buffaloes is sporadic in the country as small scale production system with the management involving more of traditional knowledge rather than the scientific principles is more prevalent. Besides, large scale haphazard execution of artificial insemination has so far resulted in increase in the number of crossbred cattle but the genetic gain achieved in term of increase in milk production has almost reached the selection limit. With the focus being back on conservation and development of native animals, it would be ideal to characterize, select and breed indigenous cattle towards higher milk productivity. Though the task may be very much demanding in the prevailing situation of sparse and scattered resources, it is still possible to gather breed-wise pool of indigenous cattle for further improvement. Identification of indigenous populations and distinguishing their performance are the primary assignments before undertaking the job of breeding them for further improvement. With these importance, it was decided to study the characteristics and performance of one of the indigenous populations of Bihar, Gangatiri breed and the role of the cattle in the farming systems practiced by the farmers in the breeding tract.

Present address: [1]Scientist (vetchandran@gmail.com), [2]Principal Scientist (amitavdey_icar@yahoo.co.in), [3,4]Scientist (dr.reenakamal@yahoo.com, pankajvet@gmail.com), Division of Livestock and Fishery Management. [5]Technical Officer (deokaran_s@rediffmail.com), Krishi Vigyan Kedra, Buxar, Bihar.

MATERIALS AND METHODS

Characteristics and performance of Gangatiri cattle under farmers' management system were studied by visiting 37 villages in Buxar and Itahri blocks of Buxar district from January 2017 to December 2017. The characterization of the breed was carried out based on the guidelines suggested in Breed Descriptors for Cattle and Buffaloes (FAO 1986). Information pertaining to land utilizationand livestock populations in the breeding tract were collected from Directorate of Statistics and Evaluation, and Directorate Economics & Statistics, Govt. of Bihar, respectively. Weather information was compiled from the data obtained from ICAR Research Complex for Eastern Region, Patna for the year from 1960 to 2008. A total of 142 farmer families rearing Gangatiri cattle were interacted for collecting data on cattle management interventions. Further, a total of 368 Gangatiri cattle of different age groups were subjected into morphometric evaluation as a part of phenotypic characterization. Age of the cattle was decided

by dentition and the information from the farmers. The body weight characteristics of Gangatiri cattle was estimated using Shaeffer's formula for different age groups. Production and reproduction characteristics of the cattle were assessed based on observation and the information from the farmers. Prevalence of various farming systems in the breeding tract with Gangatiri as one of the component was also studied. Regression of dependent variables such as number of cattle, quantity of concentrates fed and occurrence of diseases on the independent variable, viz. income generated by the farmers from Gangatiri cattle was studied using standard statistical procedures as suggested by Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Environmental factors in the breeding tract: Gangatiri breed of cattle are medium sized dual purpose cattle which are reared in the bordering districts of Bihar and eastern Uttar Pradesh and are mainly reared for draught and milk purpose. The breeding tract of this cattle falls under Bihar agro climatic zone IIIB, which is a southwest alluvial plain of the state and adjacent to southern bank of river Ganges. Bachaur cattle, one of the recognized cattle breed of Bihar, distributed in Sitamarhi, Darbanga, Sheohar and Madhubani districts of Bihar (Chandran *et al.* 2014b) could be considered as geographically most closely reared cattle breed to Gangatiri cattle. Though both are reared in the terrain of middle Gangetic plains, Bachaur is a draught cattle whereas the Gangatiri is a dual purpose in nature.

The general climate of the region is hot and humid. The average maximum and minimum temperature and the rainfall data collected from ICAR Research Complex for Eastern Region, which is located close to the breeding tract (Table 1). The maximum temperature recorded was as high as 47.0°C as against the minimum temperature of 1.9°C. The tract received maximum rainfall during Southwest monsoon from June to September with the annual rainfall ranged from 618.5 to 1734.4 mm in the last 49 years. Though water recedes generally after rainfall in the breeding tract, certain regions especially in Rohtas district, experience severe flood during the rainy season vowing to low land and seepage of water from river.

Land utilization pattern: Land utilization pattern in the breeding tract of Gangatiri cattle in Bihar was studied for 26 years from 1987 to 2013 and the summary is given in Table 2. The study revealed that the proportion of cultivable waste land and the land under permanent pastures and grazing, which are the major nourishing factors, have reduced by 16.1% and 63.5%, respectively. There are no other major changes in the land utilization except that the land under trees and groves has witnessed constant rise over the years. In the absence of breed-wise census in the breeding tract, the authors could not make any authentic estimate on Gangatiri population statistics except assuming that the population of Gangatiri might have shrunken over the years due to its scattered presence and the shrinkage of adequate grazing land.

Livestock population dynamics: Growth of livestock population in the breeding tract of Bihar was studied from livestock census 2003 to 2012 (Table 3). The study revealed that the proportion of different species of livestock population in Gangatiri breeding tract to the total livestock

Table 1. Summary of meteorological data of the breeding tract

Weather particulars	From 1960 to 2008 (49 years)	From 1994 to 2008 (15 years)
Average maximum temperature	38.5°C	37.7°C
Maximum temperature range	10.0°C–47.0°C	10.0°C–43.9°C
Average minimum temperature	19.3°C	19.8°C
Minimum temperature range	1.9°C–32.2°C	4°C–31.8°C
Average annual rainfall	1136.8 mm	1168.1 mm
Annual rainfall range	618.5–1734.4 mm	704.4–1734.4 mm

Table 2. Changes in land utilization over a period of time in Gangatiri breeding tract

Land divisions	1987–92	1992–97	1997–02	2002–07	2007–12	2012–13	% shift
Geographical area	1137507	1137507	1137507	1137507	1137507	1137507	0
Forest area	179762	179762	179762	179762	179762	179762	0
Barren uncultivable area	45424	45484	45424	45377	45001	44969	–1.002
Land put to non-agricultural use	121092	124837	128126	130428	133230	135146	11.606
Cultivable waste land	5021	8706	4247	3722	4153	4215	–16.05
Permanent pastures and grazing land	880	606	400	357	331	321	–63.52
Land under trees and groves	1965	3107	4951	5952	6296	6422	226.89
Current fallow	12164	13009	11091	9941	5098	3979	–67.29
Other fallows	53788	51199	32831	28483	42890	34215	–36.39
Total uncultivable land	420094	426711	406832	404022	416761	409029	–2.634
Net sown area	717413	710796	730675	733485	720746	728478	1.5424

Table 3. Livestock population dynamics in the breeding tract of Gangatiri cattle

Livestock species	Bovine			Sheep			Goat			Pig		
Year	2003	2007	2012	2003	2007	2012	2003	2007	2012	2003	2007	2012
Population in Gangatiri breeding tract*	1.72	1.79	1.62	0.12	0.10	0.10	0.50	0.41	0.45	0.04	0.04	0.05
Population in Bihar state*	16.24	19.10	17.78	0.35	0.22	0.24	9.61	10.17	14.70	0.63	0.63	0.55
Proportion of population in Gangatiri tract to Total Bihar	10.61	9.38	9.11	35.22	45.63	41.77	5.24	4.02	3.09	6.85	6.54	8.97
Livestock density per square kilometer	15146.71	15746.70	14235.35	1072.19	875.41	882.43	4427.74	3594.41	3995.32	377.45	363.45	433.59

*In million. *Source:* (Directorate of Economics and Statistics, 2012); (Directorate of Economics and Statistics, 2014)

population of the state were 9.70, 40.87, 4.12 and 7.45 for bovines, sheep, goats and pigs, respectively. This indicates that the farmers in the breeding tract prefers to rear sheep and cattle in comparison to other species of livestock. Further, the population density of more than 15000 bovine and 4000 goats per square km. found in study is also the phenomenon in major parts of Gangetic plains and Gangatiri cattle tract is no exception to it. When compared the density of Gangatiri cattle in the breeding tract with the density of livestock population in different countries, density in this locality is much higher. Hence, this is the right time to strike a balance in maintaining a livestock population between the number essential to improve the livelihood status of farmers and the number necessary to minimize greenhouse gas production.

Housing: The study revealed that the 92% of Gangatiri farmers in the breeding tract provided housing to their cattle. Among the houses, 64% were *pucca* houses whereas the remaining were *kachcha* houses built with thatched roof with the support of bamboo sticks in most of the cases. Even though the sheds were *pucca* in many places, provision for water and slopes for drainage were invariably absent. Floor in the shed had undulating surface with stagnation of water mixed with urine in many places. Feed manger, though provided, did not have proper dimensions. The intention of rearing Gangatiri cattle with minimum capital might be one of the reasons for the disorderly conditions of cattle sheds.

Breeding: Study revealed that 31% of Gangatiri cows were mated with bulls of the same breed through natural service. The remaining cows were artificially inseminated with the semen of exotic germplasm with the intention of improving the milk production. Unavailability of Gangatiri semen in the breeding tract was due to lack of animal breeding infrastructure in the breeding tract and the delay in policy implementation. On all accounts, the absence of semen of Gangatiri germplasm in the tract leads to genetic dilution posing the danger of diminishing the population size. In addition, there were no breed registration societies in the breeding tract for taking up either rearing of genetically potent Gangatiri bulls or establishing infrastructure for collection and storage of semen doses. The situation reveals that the sense of maintaining the genetic integrity of Gangatiri cattle is invariably absent among the farmers rearing Gangatiri cattle. Genetic upgradation of Gangatiri cattle and creation of strong extension mechanism to make farmers realize the importance of the cattle may encourage the farmers to shift the focus towards this indigenous cattle.

Feeding: System of feeding and feeding pattern varied widely in the breeding tract. A total of 54.6% farmers in the surveyed breeding tract adopted intensive system of feeding practices where as 45.4% farmers followed extensive rearing of Gangatiri cattle. Under intensive feeding practices, the cattle were maintained on dry fodders including paddy and wheat straw to a greater extent, and green fodders such as sorghum, berseem and oat to a smaller extent. Concentrate feeds such as grain, bran and cakes were provided to lactating animals under intensive and extensive management systems. Mixing of feed ingredients was a common feeding practice adopted by majority of the farmers (90.5%) in Gangatiri breeding tract.

Morphological features of Gangatiri cattle: The study reported two coat colours of Gangatiri cattle in milky white (Fig. 1) and light grey (Fig. 2) with the former genetic group comprised 73% while the remaining were the latter genetic group. The head was medium in size and the face was long and narrow. The ears were invariably erect. Horns were generally black in colour, grew lateral, upwards and then inwards. Muzzle and eyelashes were black in colour. Cows had medium sized hump whereas bulls and bullocks had large sized one (Fig. 3). Body was long and cylindrical with the straight back. Tail was thin with black switch and extended beyond knee joint. Udder was medium sized with visible milk vein in some cases. Based on the characteristics, it could be seen that these cattle phenotypically resemble closer to Bachaur cattle of Bihar.

Study revealed that the average herd size of Gangatiri cattle was 4.8 which included 2.1 cows, 0.8 bullocks and 1.9 calves. A total of 43% of surveyed herds had only one

Figs 1–3. **1**. Gangatiri cow (white variety), **2**. Gangatiri cow (grey variety), **3**. Gangatiri bull.

animal with the rest having more than one. The findings on herd size of Gangatiri cattle revealed that the breed was mostly reared in small scale extensive system with strong interaction with other agricultural components. However, Sharma *et al.* (2012) reported relatively larger herd size of 2 to 30 animals in Shahabadi (Gangatiri) herd in the breeding tract, which may be due to varying study area owing to substantially larger breeding tract of Gangatiri breed.

Morphometry and body weight: The morphological characteristics of male and female Gangatiri cattle belonging to various age groups are given in Table 4. Results showed that the body length and height at withers of Gangatiri cattle were almost equal to each other whereas the chest girth was prominent at all stages. The height, body length and girth increased by 37, 39 and 52%, respectively, from one year stage to adult stage. Females were heavier than males during one to three years of age and this might be due to the varying level of feeding among different sexes by the farmers. However, during the adult stage, males were found to be heavier than their female counterparts for all morphometric traits. Sharma *et al.* (2012) reported the body length, chest girth and height at withers of Shahabadi cattle (Gangatiri) to be 123.80±0.39 cm, 155.96±0.58 cm and 122.40±0.58 cm, respectively, which are almost similar to the findings of the present study.

Face in Gangatiri cattle was relatively longer (42.78 cm) whereas the horns were medium in size with 19.80 cm. Tail was very long with 85.43 cm in length which extended up to switch. However, still longer face (47.48±0.15 cm) and shorter horn (6.43±0.21 cm) and tail (72.98±0.29 cm) were reported in Bachaur cattle, an another breed found in Bihar (Chandran *et al.* 2014a).

The body weight of Gangatiri cattle in the breeding tract were estimated to be 83.02±0.20 kg, 132.06±0.71 kg, 172.24±0.31 kg, 326.45±0.70 kg and 261.63±0.26 kg, for calves less than one year, 1–3 year males, 1–3 year females, adult males and adult females, respectively. The estimated body weight show that the Gangatiri cattle are medium sized and within the range of body weight of most of the cattle breeds of India.

Production and reproduction: The production and reproduction traits of Gangatiri cattle found in the breeding tract are summarized in Table 5. The production characteristics of Gangatiri cattle observed from the study indicates that these cows were capable of substantial milk production. Peak yield of the cattle ranged from 2 to 9 l of milk with an average being 4.52 l/day. The breed showed great variations in production characteristics which could efficiently be utilized in the selection and breeding programs. Singh *et al.* (2016) reported that the average lactation length and the average dry period of Gangatiri cattle were 187.80±14 days and 176.60±14.7 days, respectively, in which duration of dry period corroborates

Table 4. Morphometry of Gangatiri cattle belonging to different age groups

Attribute	Adult female (>3 years)	Adult male (>3 years)	Growing females (1–3 years)	Growing males (1–3 years)	Calves (< 1 year old)
Height at withers (cm)	122.93±0.35 (136) {3.29}	136.64±1.71 (14) {4.70}	109.94±0.74 (78) {5.98}	101.78±2.11 (23) {9.96}	90.53±0.69 (117) {8.29}
Body length (cm)	120.71±0.38 (136) {3.64}	125.21±1.67 (14) {4.98}	107.15±0.65 (78) {5.36}	100.22±1.69 (23) {8.10}	86.99±0.49 (117) {6.03}
Chest girth (cm)	152.84±0.60 (136) {4.55}	168.00±1.54 (14) {3.43}	131.41±0.81 (78) {5.45}	119.13±1.90 (23) {7.65}	101.28±0.50 (117) {5.38}
Face length (cm)	42.03±0.17 (136) {4.70}	50.07±0.61 (14) {4.53}	37.22±0.29 (78) {6.84}	39.39±0.62 (23) {7.61}	30.57±0.30 (117) {10.50}
Ear length (cm)	29.15±0.16 (136) {6.02}	29.79±0.66 (14) {8.24}	24.90±0.27 (78) {9.55}	26.91±0.44 (23) {7.84}	20.74±0.26 (117) {13.38}
Horn length (cm)	19.21±0.53 (136) {32.30}	25.50±1.61 (14) {23.57}	4.82±0.37 (78) {68.58}	5.91±0.67 (23) {54.66}	2.14±0.13 (117) {64.13}
Tail length (cm)	85.04±1.18 (136) {16.15}	89.21±1.60 (14) {6.71}	73.29±1.09 (78) {13.09}	73.09±1.84 (23) {12.07}	54.85±0.91 (117) {17.94}

Table 5. Production and reproduction characteristics of Gangatiri cattle

Traits	Mean	Range
Lactation length (Days)	230.24±7.44 (42)	167 to 315
Peak yield (Lit.)	4.52±0.31 (42)	02 to 09
Age at sexual maturity in males (years)	3.07±0.10 (14)	2.5 to 3.5
Age at sexual maturity in females (years)	3.97±0.04 (72)	3.5 to 4.5
Age at 1st calving (months)	56.63±0.63 (48)	51 to 63
Service period (Days)	129.45±3.63 (44)	92 to 170
Dry period (Days)	169.26±10.18 (42)	90 to 270
Lifetime number of calvings	6.45±0.71 (11)	3 to 10

Table 6. Kinds of farming system adopted by the farmers of Gangatiri cattle

Kinds of farming systems	Number
Gangatiri cattle + Agriculture	47 (33.1)
Gangatiri cattle + Agriculture + Buffalo	22 (15.5)
Gangatiri cattle + Agriculture + Buffalo + Goat	14 (9.9)
Gangatiri cattle + Agriculture + Buffalo + Goat + Poultry	8 (5.6)
Gangatiri cattle + Agriculture + Goat + Poultry	15 (10.6)
Gangatiri cattle + Agriculture + Goat	15 (10.6)
Gangatiri cattle + Buffalo	17 (12.0)
Gangatiri cattle + Goat	4 (2.8)

Figures in the parentheses are percentages.

with the present study.

Though possessing substantial production characteristics, the breed attained late sexual maturity with an average of 3.07 years for males and 3.97 years for females. Service period in Gangatiri cattle ranged from 92 to 170 days with an average being 129.45 days. Dry period was quite extensive which indicates that calf a year was not a regular phenomenon in majority of the animals. Singh *et al.* (2008) reported the age at first calving of Hallikar cattle ranged from 2.5 to 4 years with a mean of 3.02±0.07 years which is lesser than the age at first calving found in the present study. Pundir*et al.* (2013) found the lactation length, dry period and service period of Uttara cattle to be 275 days, 147 days and 124 days, respectively, which agree more or less with the findings of the present study. Marginal differences in the reproductive performances might be due to variations in genotype, environment or genotype environment interactions. However, detailed study is required to analyze the reproductive health of Gangatiri cattle and to diagnose disorders prevailing in the tract.

Gangatiri in farming system: The breeding tract of Gangatiri cattle is vastly agrarian and is fed by river Ganges on both sides. Different types of farming systems adopted by the farmers in the breeding tract of Gangatiri cattle (Table 6). Cultivated crops in the breeding tract included rice, maize, sorghum, wheat, lentil and different vegetables and other horticulture crops. The tract was also thickly populated with different species of livestock including cattle, buffalo, sheep and goats to a greater extent and pigs to a smaller extent. However, most of the farmers possessing Gangatiri cattle had agriculture as a primary component with cattle as a secondary component of occupation. Agriculture in the tract was low capital intensive and was completely dependent on Gangatiri cattle for soil rejuvenation in most of the places. Study on different farming systems involving Gangatiri cattle and the cost benefit analyses of each system may help understand efficiency of different farming systems in the breeding tract. The results also corroborates with the findings of Erenstein*et al.* (2007) who reported the Eastern Indo-Gangetic Plains (which comprises of the state of Bihar) supports rural livelihoods mainly with rice-cattle farming systems.

Regression coefficients: Study on regression of different dependent variables on the income generated from Gangatiri cattle is presented in Table 7. Number of cattle and the quantity of concentrate fed by the farmers had positive effect whereas the occurrence of diseases had negative regression on the income generated by Gangatiri farmers. Saxena *et al.* (2017) found positive regression coefficients of 0.42 and 0.16 for the regression of crossbred milk yield and buffalo to cattle ratio on the income from livestock.

It is concluded that Gangatiri is a potent population in the middle Gangetic plains and the cattle is being maintained in the low input system. It is highly essential that the population needs more attention from the policy makers by selecting superior males for breeding purposes and making the semen available to the Gangatiri farmers. This would pave the way for the improvement of Gangatiri cattle vis-à-vis enhancement of livelihood status of Gangatiri farmers. Alternatively, assisting Gangatiri farmers to establish self-sustainable breed societies may also cause

Table 7. Regression coefficients of different dependent variables on income from Gangatiri cattle

Independent variables	Number of cattle		Quantity of concentrates fed		Occurrence of diseases	
	Regression coefficient	Standard error	Regression coefficient	Standard error	Regression coefficient	Standard error
Small farmers	1.76	0.42	3.83	0.25	–5.42	0.23
Medium farmers	3.13	0.58	4.67	0.45	–6.49	0.33
Large farmers	2.76	0.98	4.30	2.13	–6.54	0.85
Pooled	2.66	0.34	4.15	0.21	–5.91	0.18

the effect of breed improvement.

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REFERENCES

Chandran P C, Dey A, Barari S K, Reena Kamal, Bhatt B P and Prasad R E. 2014a. Characteristics and performance of Bachaur cattle in the Gangetic plains of North Bihar. *Indian Journal of Animal Sciences* **84**(8): 872–75.

Chandran P C, Dey A, Barari S K, Reena Kamal, Dayal S and Chakrabarti A. 2014b. Socio-economic status of farmers rearing Bachaur cattle in its habitat under middle Gangetic plains. *Indian Journal of Animal Sciences* **84**(12): 1300–03.

Directorate of Economics and Statistics 2012. Bihar Statistical Handbook. Department of Planning and Development. Govt. of Bihar, Patna.

Directorate of Economics and Statistics 2014. Bihar Statistical Handbook. Department of Planning and Development. Govt. of Bihar, Patna.

Erenstein O, Thorpe W, Singh J and Varma A. 2007. Crop-livestock interactions and livelihoods in the Indo-Gangetic Plains, India: A regional synthesis. CIMMYT, ILRI and RWCCG Block, NASC Complex, DPS Marg, Pusa Campus, New Delhi.

FAO. 1986. Animal Genetic Resources Data Banks. 2. Descriptor list for cattle, buffalo, pigs, sheep and goats. *FAO Animal Production and Health Paper* **59**: 12–33.

Pundir R K, Singh P K, Neelkant, Sharma D, Singh C V and Prakash B. 2013. Uttara-A new cattle germplasm from Uttarakhand hills. *Indian Journal of Animal Sciences* **83**(1): 51–58.

Saxenaa R, Singha N P, Choudharya B B, Balaji SJ, Paulb R K, Ahujaa U, Joshia D, Kumara R and Khana M A. 2017. Can Livestock Sector be the Game Changer in Enhancing the Farmer's Income? Reinvesting Thrust with Special Focuson Dairy Sector. *Agricultural Economics Research Review* **30**: 59–76.

Sharma R, Pandey A K, Singh P K, Maitra A, Mukesh M, Singh S R and Singh B. 2012. Characterization of Shahabadi cattle of Bihar-Phenotypic and molecular approaches. *Indian Journal of Animal Sciences* **82**(3): 318–22.

Singh P K, Pundir R K, Ahlawat S P S, Kumar S N, Govindaiah M G and Asija K. 2008. Phenotypic characterization and performance evaluation of Hallikar cattle in its native tract. *Indian Journal of Animal Sciences* **78**(2): 211–14.

Singh P K, Sankhala G, Singh A and Prasad K. 2016. Sustainability of Gangatiri cattle rearing. *Indian Journal of Animal Sciences* **86**(8): 936–39.

Snedecor G W and Cochran W G. 1989. Statistical Methods. 8thEdn. Iowa State University Press.