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Production Potential of the Indigenous Kacang Goat in Indonesia: A Systematic Review and Meta-Analysis of Productive, Reproductive, and Adaptive Traits

Mulyoto Pangestu[1*], Wida Nurnaningsih[2], Muhammad Evan Magistrama[2]

[1] *Education Program in Reproduction and Development, Department of Obstetrics and Gynecology, Monash University, Australia*

[2] *Department of Animal Husbandry, Faculty of Animal Husbandry, Wijayakusuma University, Purwokerto, Indonesia*

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ABSTRACT

The Kacang goat is the most widely distributed indigenous goat of Indonesia, yet evidence on its production potential remains scattered across heterogeneous local studies. This review aimed to synthesize the productive, reproductive, and adaptive potential of the Kacang goat to inform conservation and genetic improvement. Following the PRISMA 2020 guideline, we retrieved peer-reviewed articles published between 2000 and 2025 from Scopus, Web of Science, PubMed, and ScienceDirect, supplemented by hand-searching; 47 studies met the eligibility criteria, and 31 provided extractable quantitative data. A random-effects meta-analysis of litter size across ten studies yielded a pooled estimate of 1.85 kids per birth (95% CI 1.78–1.92; I^2 = 58%). Adult body weight ranged from 22 to 30 kg, kidding interval from 217 to 271 days, and the doe reproduction index from 2.3 to 3.1 kids per doe per year, with pre-weaning survival commonly exceeding 90%. Carcass percentage ranged from 44 to 47%, and the breed showed strong thermotolerance and the ability to maintain reproduction on low-quality forage. Although small-framed, the Kacang goat combines high prolificacy, early maturity, and superior environmental resilience. Structured selection within nucleus flocks and controlled crossbreeding, rather than indiscriminate grading-up, are recommended to realize its potential while preserving genetic identity.

Corresponding Author:
Mulyoto Pangestu
Education Program in Reproduction and Development, Department of Obstetrics and Gynecology, Monash University, Clayton, Victoria 3168, Australia
*Email: mulyoto.pangestu@monash.edu

INTRODUCTION

Goats occupy a central position in the smallholder livestock systems of the tropics, providing meat, income, manure, and a liquid asset that buffers rural households against economic shocks (1), (2). Their small body size, low capital requirements, short generation interval, and ability to thrive on marginal feed resources make them particularly well-suited to resource-poor farmers across Asia and Africa (1), (3). Indonesia, with a national goat population exceeding 18 million head, ranks among the largest goat-keeping countries in Southeast Asia, and indigenous breeds maintained under low-input village conditions dominate the sector (2), (4).

Among these, the Kacang goat (*Capra hircus*) is the most numerous and most widely distributed indigenous goat of the Indonesian archipelago. It is a small, early-maturing, non-seasonal breeder characterized by a compact body, short erect horns, a straight facial profile, and a highly variable coat color (4), (5). Farmers value the breed for its remarkable prolificacy, year-round reproduction, and hardiness under fluctuating forage availability and high ambient temperatures (6), (7). These attributes have enabled the Kacang goat to remain the genetic backbone of village goat production for generations.

Despite this importance, indiscriminate crossbreeding with larger exotic breeds, particularly the Boer and the Etawah (Jamnapari), increasingly threatens the Kacang goat as farmers pursue faster growth and larger mature size (8), (9). Uncontrolled grading-up dilutes the indigenous gene pool and risks the gradual erosion of the very adaptive traits thermotolerance, disease resilience, and reproductive efficiency on poor feed that underpin the breed's value as a genetic resource (10), (11). Effective conservation and improvement, therefore, require a clear, evidence-based understanding of the breed's biological potential.

However, evidence on the Kacang goat remains fragmented. Primary studies are dispersed across numerous local and regional outlets, employ heterogeneous management systems and measurement protocols, and report widely varying values for the same traits. No integrated synthesis has quantified the breed's productive, reproductive, and adaptive potential across this body of literature, limiting the design of rational breeding objectives and conservation strategies.

Therefore, this study aims to systematically review and synthesize the published evidence on the production potential of the Indonesian Kacang goat, with specific objectives to: (i) summarise its productive and growth performance, (ii) quantify its reproductive potential and prolificacy, and (iii) appraise its adaptive and meat-production attributes, in order to derive implications for the breed's conservation and genetic improvement.

MATERIALS AND METHODS

Protocol and eligibility criteria

This review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (12). Studies were eligible if they: (i) reported original quantitative data on the Kacang goat or on Kacang-based populations, (ii) addressed productive, reproductive, adaptive, or meat-quality traits, (iii) were peer-reviewed primary studies or theses with extractable data, and (iv) were published between January 2000 and December 2025. Studies were excluded if they were not specific to the Kacang goat, reported no extractable numerical data, were duplicate reports, or were unavailable in full text.

Information sources and search strategy

A systematic search was performed in four electronic databases: Scopus, Web of Science, PubMed, and ScienceDirect, and supplemented by hand-searching of Google Scholar and the reference lists of retrieved articles. The search string combined the population and trait domains using Boolean operators: (“Kacang goat” OR “Indonesian local goat” OR “native goat Indonesia”) AND (“growth” OR “body weight” OR “reproduction” OR “litter size” OR “carcass” OR “adaptation” OR “genetic”). We retained only studies reported in English or with English abstracts and extractable data.

Study selection and data synthesis

We de-duplicated records and screened titles and abstracts, then assessed full texts against the eligibility criteria. For each included study, we extracted bibliographic details, study location and management system, sample size, and trait values (mean, standard deviation, or range with units) into a standardized spreadsheet. We conducted a narrative synthesis for traits reported too heterogeneously to pool. Where a sufficient number of studies reported a common trait on the same scale with measures of dispersion, study-level means were combined using a DerSimonian-Laird random-effects model, and between-study heterogeneity was quantified with the I2 statistic and tau-squared (35, 36). We selected ten studies reporting litter size on a comparable basis for the meta-analytic illustration.

Risk of bias and quality assessment

We appraised the methodological quality of each included study using an adapted checklist for observational animal studies, covering five domains: clarity of the study objective, adequacy of sampling and sample size, validity of measurement, appropriateness of statistical analysis, and completeness of reporting (37, 38). Each domain was rated as low, moderate, or high risk of bias, and two reviewers independently assigned an overall rating, resolving disagreements through discussion.

RESULTS AND DISCUSSION

Study selection and characteristics

The database search yielded 612 records, and an additional 48 were identified from other sources. After removing duplicates, we screened 421 records by title and abstract, excluding 318 as irrelevant. Of the 103 full-text articles assessed, 56 were excluded (28 not specific to the Kacang goat, 17 lacking extractable data, and 11 non-English or duplicate), leaving 47 studies for qualitative synthesis and 31 for the quantitative summary (Figure 1). The included studies spanned diverse agro-ecological zones of Sumatra, Java, Sulawesi, and the eastern islands, and were conducted predominantly under smallholder semi-intensive or extensive (grazing) systems (Figure 2). Table 1 summarises a representative sample of the included studies.

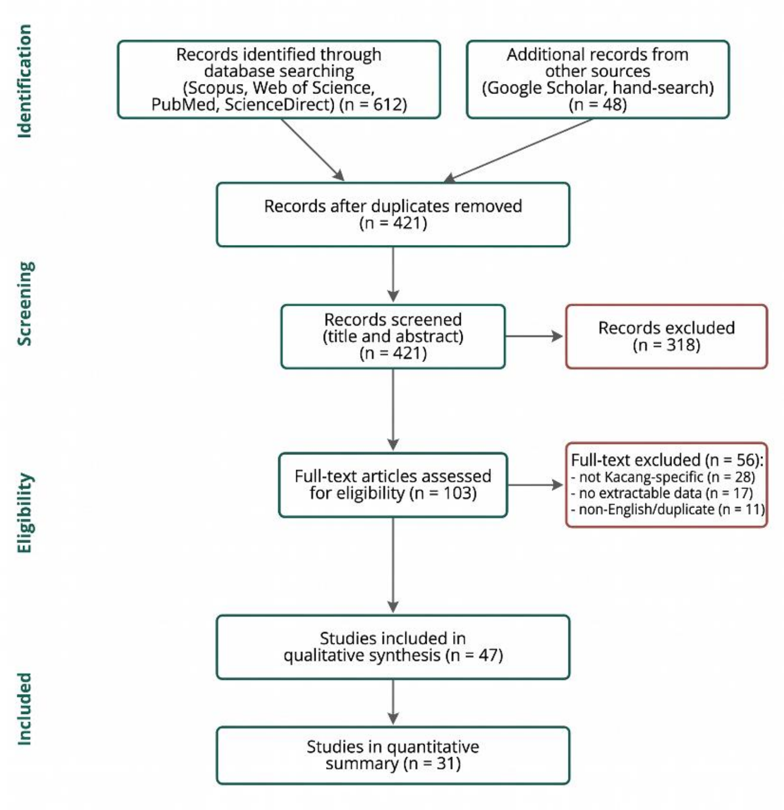

Figure 1. PRISMA 2020 flow diagram of the study selection process

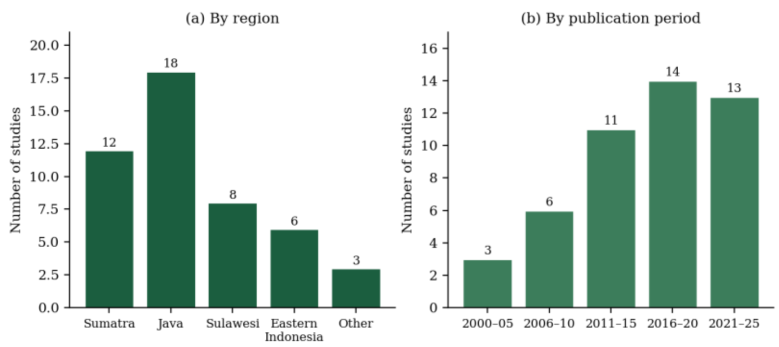

Figure 2. Distribution of the 47 included studies by (a) geographical region and (b) publication period

Table 1. Characteristics of a representative sample of the included studies

Study (author, year)	Region	System	n	Traits assessed
Sodiq et al. (2002)	Central Java	Village	210	Reproduction, litter size
Sodiq et al. (2003)	Central Java	Village	186	Reproduction rate
Sodiq et al. (2011)	Central Java	Smallholder	240	Kid production, growth
Elieser et al. (2012)	North Sumatra	Station	120	Reproduction, productivity
Panjono et al. (2012)	Yogyakarta	Semi-intensive	96	Reproduction

Study (author, year)	Region	System	n	Traits assessed
Pamungkas et al. (2014)	North Sumatra	Station	150	Crossbreeding, growth
Suyadi et al. (2019)	East Java	Closed population	146	Reproduction index
Depison et al. (2020)	Jambi	Smallholder	300	Morphometrics
Hayanti et al. (2022)	Multi-region	Review	–	Qualitative/quantitative traits
Ilham et al. (2023)	Gorontalo	Semi-intensive	180	Morphometric diversity

Note: Village = traditional grazing/tethering; Station = research station; n = number of animals or records; – = not applicable (review).

Productive and reproductive potential

Table 2 presents the synthesized central values and ranges of the principal productive and reproductive traits. The breed was consistently small-framed, with does weighing 22 to 28 kg and bucks 25 to 30 kg, while birth weight ranged from 2.0 to 3.8 kg and weaning weight from 9.4 to 10.7 kg; single-born kids consistently outgrew twins and triplets, reflecting the influence of maternal ability and litter size (5), (6). Reproductively, the breed reached first kidding at 12 to 15 months, produced litters of 1.6 to 2.1 kids, and maintained kidding intervals of 217 to 271 days, yielding a doe reproduction index of 2.3 to 3.1 kids per doe per year and pre-weaning survival generally above 90% (6), (7), (9).

Table 2. Summary of the principal productive and reproductive traits of the Kacang goat synthesized from the reviewed literature

No	Variable	Value (range)	Unit
1.	Adult doe body weight	22.0 – 28.0	kg
2.	Adult buck body weight	25.0 – 30.0	kg
3.	Birth weight (single)	2.0 – 3.8	kg
4.	Weaning weight (90 d)	9.4 – 10.7	kg
5.	Pre-weaning growth rate	62 – 72	g/day
6.	Age at first kidding	12 – 15	months
7.	Litter size	1.6 – 2.1	kids/birth
8.	Kidding interval	217 – 271	days
9.	Doe reproduction index	2.3 – 3.1	kids/doe/year
10.	Pre-weaning survival	90 – 97	%
11.	Slaughter weight	22.0 – 26.0	kg
12.	Carcass percentage	44 – 47	%

Note: values are the observed range of reported means across the included studies (n = 31). Variation reflects differences in management systems, forage quality, and agro-ecological zones.

A random-effects meta-analysis of litter size, restricted to the ten studies reporting means with dispersion on a comparable basis, produced a pooled estimate of 1.85 kids per birth (95% CI 1.78-1.92), with moderate between-study heterogeneity (I2 = 58%; tau-squared = 0.012; $p < 0.01$) reflecting differences in parity structure, management, and agro-ecology (Figure 3). Although the Kacang goat is small, its reproductive efficiency compensates substantially for limited individual size: a doe reproduction index approaching three kids per year, coupled with high pre-weaning survival and early maturity, generates a high output of weaned kids per unit of doe maintained, which is the most relevant measure of biological efficiency in meat-goat systems (6), (9), (17). Much of the between-study variation was attributable to management intensity rather than genotype, indicating considerable scope for improvement through better nutrition and management alone (5), (13), (32).

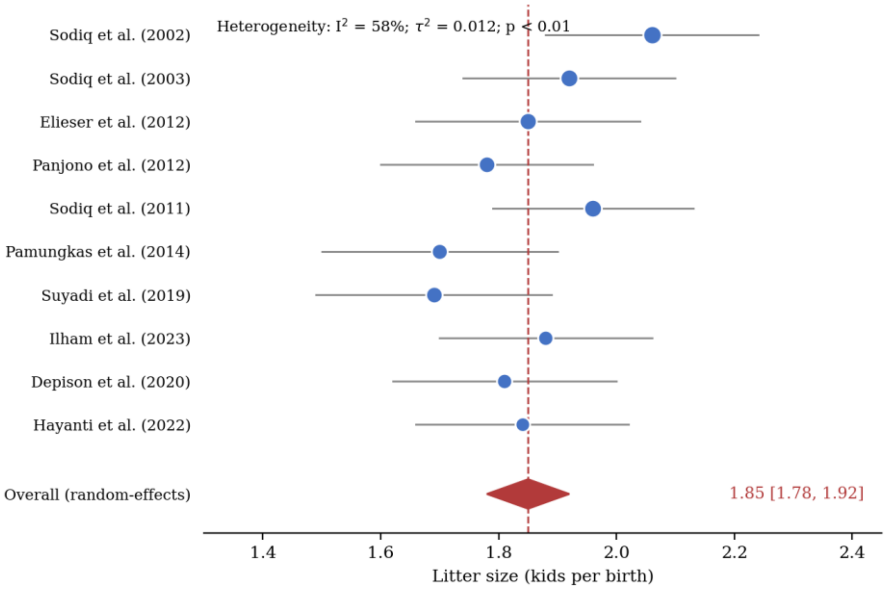

Figure 3. Forest plot of the random-effects meta-analysis of litter size in the Kacang goat (k = 10 studies)

Comparative performance and adaptive superiority

Compared with the larger Etawah crossbred (PE) and Boer breeds, the Kacang goat was clearly inferior in body and slaughter weight but superior in reproductive output and adaptive capacity (Table 3; Figure 4). Slaughter weights of 22 to 26 kg and carcass percentages of 44 to 47% were reported for finished bucks, values that are competitive with those of other tropical indigenous goats, given the breed's small size (13, 32). Its higher litter size, shorter kidding interval, greater doe reproduction index, and stronger heat tolerance offset its smaller frame, so that on a per-doe-per-year basis the breed remains competitive for kid output under low-input tropical conditions (6), (9), (32).

Table 3. Comparative productive, reproductive, and adaptive traits of the Kacang goat and two larger tropical breeds

Trait	Kacang	Etawah (PE)	Boer	Source
Adult doe weight (kg)	22–28	35–45	50–60	(5),(22),(32)
Litter size (kids/birth)	1.6–2.1	1.4–1.6	1.3–1.6	(6),(9),(17)
Kidding interval (days)	217–271	300–340	240–300	(6),(9)
Doe reproduction index	2.3–3.1	1.5–1.7	1.4–1.7	(6),(9)
Pre-weaning survival (%)	90–97	88–92	85–90	(6),(9)
Carcass percentage (%)	44–47	45–47	46–49	(13),(32)
Heat tolerance	High	Moderate	Low–Mod.	(7),(11)

Note: values are typical ranges compiled from the reviewed literature; source numbers refer to the reference list.

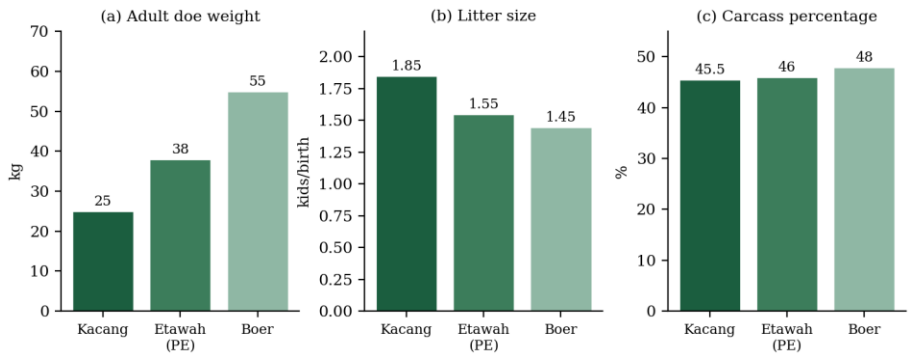

Figure 4. Comparative performance of the Kacang goat and two larger tropical breeds (Etawah crossbred and Boer) for (a) adult doe weight, (b) litter size, and (c) carcass percentage

The Kacang goat's comparative advantage lies in adaptation rather than scale. Its thermotolerance, capacity for year-round reproduction, and ability to sustain productivity on marginal feed are traits that have evolved under generations of natural and farmer-mediated selection in the humid tropics (4), (11). These attributes parallel the adaptive physiology described for indigenous goats in other harsh environments, where an efficient water and energy economy underpins survival and reproduction (11), (13). In the context of climate change and increasingly variable forage supply, such resilience represents a strategic asset for sustainable smallholder production (1), (3).

Methodological quality and improvement strategies

The quality appraisal indicated that most included studies were at low to moderate risk of bias (Table 4). Reporting and objective clarity were generally adequate, whereas sampling and sample-size justification were the weakest domains, with several studies relying on small or non-random samples. This pattern, together with the moderate heterogeneity detected in the meta-analysis, indicates that the synthesized estimates are robust in direction but should be interpreted with appropriate caution.

Table 4. Number of included studies (n = 47) rated at each risk-of-bias level across five quality domains

Domain	Objective	Sampling	Measurement	Analysis	Reporting
Low risk	34	21	29	25	27
Moderate risk	11	19	14	16	15
High risk	2	7	4	6	5

Note: ratings assigned independently by two reviewers using an adapted appraisal checklist for observational animal studies.

The principal threat to this genetic resource is dilution through uncontrolled crossbreeding with exotic breeds (8), (9), (10). Experience from tropical small-ruminant breeding programs shows that indiscriminate grading-up frequently fails because the crossbred genotypes are poorly matched to the low-input environments in which they must perform (14), (15), (16). The evidence therefore supports a two-pronged strategy: structured within-breed improvement using open nucleus or village-based breeding schemes with simple selection objectives and accurate recording (18), (19), and, where crossbreeding is pursued, controlling it while conserving pure Kacang nucleus populations in situ (10), (21). Molecular characterization and the identification of prolificacy and thermotolerance loci would further strengthen these programs through marker-assisted selection (20), (33).

CONCLUSION

The Indonesian Kacang goat is a small-framed but highly prolific and exceptionally well-adapted indigenous breed whose production potential derives chiefly from its reproductive efficiency and environmental resilience rather than from individual body size. The synthesized evidence indicates a doe reproduction index of up to about three kids per year, a pooled litter size of 1.85 kids per birth, high pre-weaning survival, and competitive carcass yield under low-input conditions, alongside strong thermotolerance and the capacity to perform on poor-quality forage. To realize and protect this potential, structured within-breed selection within conserved nucleus flocks, supported by harmonized performance recording and molecular characterization, is recommended over indiscriminate crossbreeding.

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AUTHOR CONTRIBUTIONS

M.P. conceived and designed the review and led the writing of the manuscript; M.P. and W.N. performed the literature search and study screening; W.N. and M.E.M. carried out data extraction and synthesis; C.H.P. and M.E.M. provided critical revision for important intellectual content; all authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article, as no new data were created; all data discussed in this review are available in the publicly accessible published studies cited in the References.

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