UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

TABLE OF CONTENTS

LETTER OF LEGITIMACY iii

DECLARATION OF ORIGINALITY iv

PREFACE AND ACKNOWLEDGEMENTS v

TABLE OF CONTENTS vii

LIST OF FIGURES xii

LIST OF TABLES xiv

ATTACHMENTS xvi

ABSTRACT xvii

INTISARI xviii

CHAPTER I INTRODUCTION 1

1.1. Background 1

1.2. Research Questions 5

1.3. Hypotheses 6

1.4. Objective of the Research 7

1.5. Significance of the Research 8

CHAPTER II REVIEW OF THE LITERATURE 9

2.1. Japanese Serow (*Capricornis crispus*) 9

2.1.1. Taxonomy 9

2.1.2. Morphology 9

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

2.1.3. Habitat and Distribution 10

2.1.4. Diet 11

2.2. Sika Deer (*Cervus nippon*) 12

2.2.1. Taxonomy 12

2.2.2. Morphology 12

2.2.3. Habitat and Distribution 14

2.2.4. Diet 15

2.3. Winter Ecology and Habitat Use in Snowy Regions 16

2.4. Interspecific Competition Theory 19

2.5. Species Distribution Modeling 21

2.5.1. Maximum Entropy Modeling (MaxEnt) 22

2.5.2. Environmental Predictors and Ecological Relevance 24

2.5.3. Multicollinearity and Predictor Interpretation 26

2.5.4. Model Evaluation and Interpretation 27

2.6. Spatial Niche Overlap Index: Schoener's D 30

2.7. Regional Context: Shonai and Minamiaizu 33

2.8. State of the art and Research Gap 35

CHAPTER III RESEARCH METHODOLOGY 39

3.1. Study Period and Location of Research 39

3.2. Tools and Materials 41

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

3.3. Data Collection Method 42

3.3.1. Field Data Collection 42

3.3.2. Environmental Data Sources 44

3.3.3. Occurrence Preparation and Data Quality 46

3.4. Data Analysis Methods 47

3.4.1. Spatial Data Preprocessing 48

3.4.2. Assessment of Multicollinearity 52

3.4.3. MaxEnt Habitat Suitability Modeling 54

3.4.4. Model Evaluation and Interpretation 58

3.4.5. Spatial Niche Overlap Analysis 60

CHAPTER IV RESULTS AND DISCUSSION 62

4.1. Field Survey Summary and Occurrence Data 62

4.1.1. Field Survey Summary 62

4.1.2. Raw Occurrence Data Records 63

4.1.3. Effective Occurrence Records Used in MaxEnt 64

4.2. Relationships among Environmental Predictors 65

4.3. MaxEnt Model Performance 68

4.4. Winter Habitat Suitability in Shonai 72

4.4.1. Winter Habitat Suitability of Japanese Serow in Shonai 73

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

4.4.2. Environmental Variables Associated with Japanese Serow Habitat Suitability in Shonai 74

4.4.3. Winter Habitat Suitability of Sika Deer in Shonai 78

4.4.4. Environmental Variables Associated with Sika Deer Habitat Suitability in Shonai 79

4.4.5. Comparison Between Japanese Serow and Sika Deer in Shonai 82

4.5. Winter Habitat Suitability in Minamiaizu 84

4.5.1. Winter Habitat Suitability of Japanese Serow in Minamiaizu 85

4.5.2. Environmental Variables Associated with Japanese Serow Habitat Suitability in Minamiaizu 86

4.5.3. Winter Habitat Suitability of Sika Deer in Minamiaizu 90

4.5.4. Environmental Variables Associated with Sika Deer Habitat Suitability in Minamiaizu 92

4.5.5. Comparison Between Japanese Serow and Sika Deer in Minamiaizu..... 97

4.6. Spatial Niche Overlap Between Japanese Serow and Sika Deer.. 100

4.7. Synthesis in Relation to the Research Hypotheses..... 102

4.8. Ecological Implications and Limitations 104

CHAPTER V CONCLUSIONS AND RECOMMENDATIONS 107

5.1. Conclusions..... 107

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

5.2. Recommendations 108

REFERENCES 111

ATTACHMENTS 119

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

LIST OF FIGURES

Figure 1. Japanese Serow (source: https://animalia.bio/japanese-serow)..... 10

Figure 2. Sika Deer (source: https://animalia.bio/sika-deer) 13

Figure 3. Study Area (Minamiaizu Region) 40

Figure 4. Study Area (Shonai Region)..... 40

Figure 5. Spatial distribution of Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) occurrence records in (a) Shonai and (b) Minamiaizu, Japan.... 64

Figure 6. Receiver Operating Characteristic (ROC) curves summarising five-fold cross-validation for Japanese serow in Shonai 69

Figure 7. Receiver Operating Characteristic (ROC) curves summarising five-fold cross-validation for japanese serow in Minamiaizu..... 70

Figure 8. Receiver Operating Characteristic (ROC) curves summarising five-fold cross-validation for sika deer in Shonai..... 70

Figure 9. Receiver Operating Characteristic (ROC) curves summarising five-fold cross-validation for sika deer in Minamiaizu..... 71

Figure 10. Winter habitat suitability map of Japanese serow in Shonai..... 73

Figure 11. Response curve of Japanese serow to distance to roads in Shonai..... 75

Figure 12. Response curve of Japanese serow to snow depth in Shonai 76

Figure 13. Winter habitat suitability map of sika deer in Shonai 78

Figure 14. Response curve of sika deer to distance to road in Shonai..... 80

Figure 15. Response curve of sika deer to elevation in Shonai 81

Figure 16. Winter habitat suitability map of Japanese serow in Minamiaizu..... 85

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Figure 17. Response curve of Japanese serow to distance to roads in Minamiaizu 87

Figure 18. Response curve of Japanese serow to elevation in Minamiaizu..... 88

Figure 19. Winter habitat suitability map of sika deer in Minamiaizu 90

Figure 20. Response curve of Sika deer to elevation in Minamiaizu 93

Figure 21. Response curve of Sika deer to distance to roads in Minamiaizu 94

Figure 22. Response curve of Sika deer to snow depth in Minamiaizu..... 95

Figure 23. Response curve of Sika deer to land cover in Minamiaizu 96

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

LIST OF TABLES

Table 1. Aspect classification used in MaxEnt models. 48

Table 2. Reclassification of the JAXA land-cover classes for MaxEnt modelling. 50

Table 3. MaxEnt settings used for winter habitat suitability modelling in Shonai and Minamiaizu. 55

Table 4. Summary of winter field survey effort 62

Table 5. Summary of raw occurrence records of winter field surveys 63

Table 6. Input occurrence records and effective species–cell records used by MaxEnt. 65

Table 7. Spearman correlations among the five continuous environmental predictors in Shonai and Minamiaizu. 66

Table 8. Variance inflation factors for the five continuous environmental predictors in Shonai and Minamiaizu. 67

Table 9. MaxEnt model performance 69

Table 10. Percent contribution and permutation importance of environmental variables for the Japanese serow MaxEnt model in Shonai 74

Table 11. Percent contribution and permutation importance of environmental variables for the sika deer MaxEnt model in Shonai 79

Table 12. Percent contribution and permutation importance of environmental variables for the Japanese serow MaxEnt model in Minamiaizu 86

Table 13. Percent contribution and permutation importance of environmental variables for the sika deer MaxEnt model in Minamiaizu 92

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Table 14. Spatial niche overlap (Schoener's D) between Japanese serow and sika deer in Shonai and Minamiaizu 100

Table 15. Descriptive assessment of the research expectations using the final habitat suitability models and spatial overlap estimates. 103

UNIVERSITAS
GADJAH MADA
Winter habitat suitability and spatial niche overlap between Japanese serow (Capricornis crispus) and sika deer (Cervus nippon) in Shonai and Minamiaizu, Japan
Radite Aranda, Dr. rer. Silv. Muhammad Ali Imron, S.Hut., M.Sc. ; Prof. Dr. Hiroto Enari
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

ATTACHMENTS

Attachment 1. Summary of field survey dates in Shonai 119

Attachment 2. Summary of field survey dates in Minamiaizu 120

Attachment 3. Survey preparation before winter field data collection..... 121

Attachment 4. Signs recorded during winter field surveys..... 122

Attachment 5. Summary of waypoint-based occurrence records collected during winter field surveys 124

Attachment 6. Environmental raster layers used for MaxEnt modeling in Shonai..... 156

Attachment 7. Environmental raster layers used for MaxEnt modeling in Minamiaizu 158

Attachment 8. Multicollinearity test results for environmental variables in Shonai and Minamiaizu..... 160

Attachment 9. MaxEnt output summary for Japanese serow in Shonai 161

Attachment 10. MaxEnt output summary for sika deer in Shonai 167

Attachment 11. MaxEnt output summary for Japanese serow in Minamiaizu 173

Attachment 12. MaxEnt output summary for sika deer in Minamiaizu 179

Attachment 13. Schoener's D analysis in R for Shonai 185

Attachment 14. Schoener's D analysis in R for Minamiaizu 190

Attachment 15. Field photographs and survey documentation..... 194