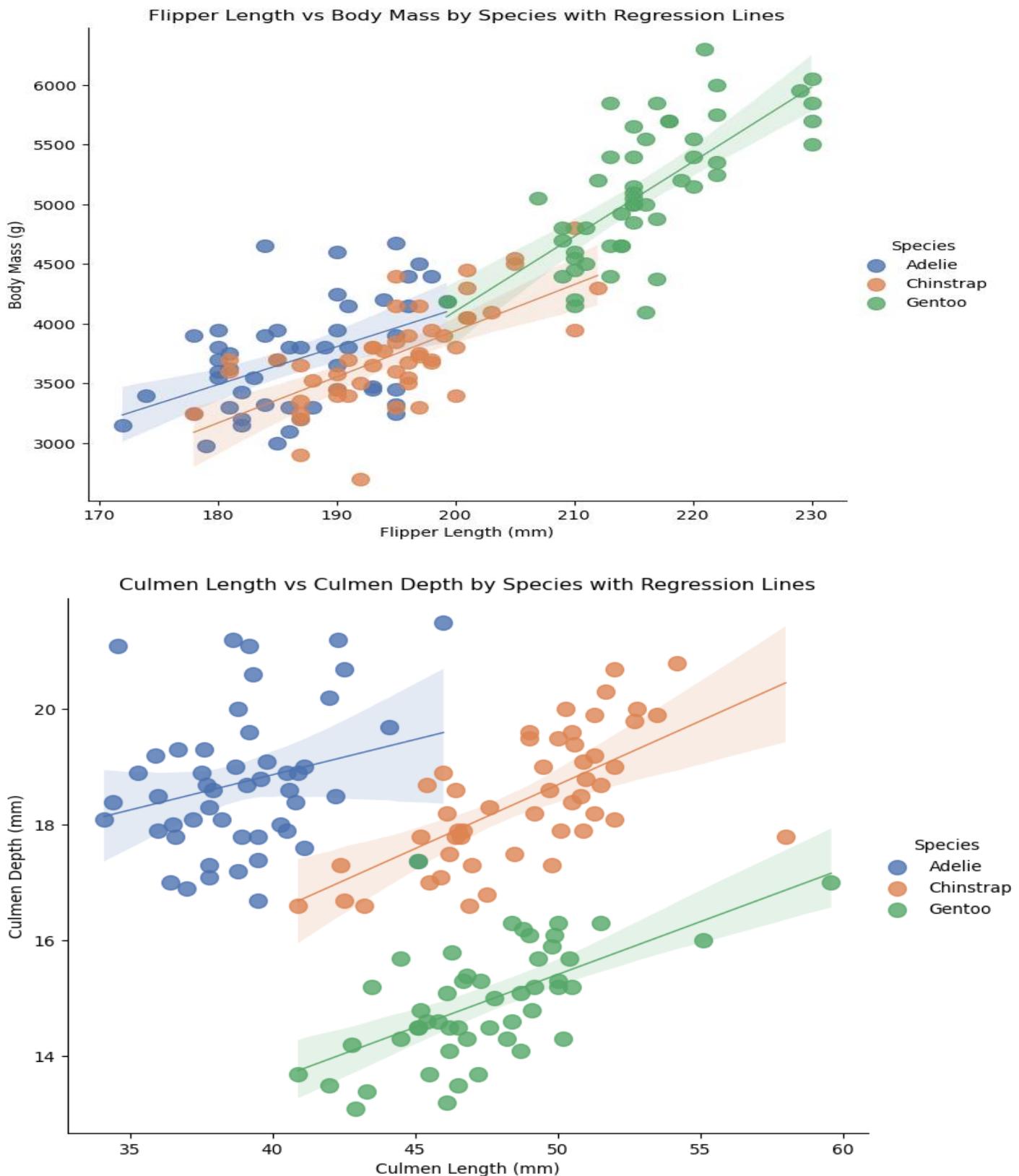
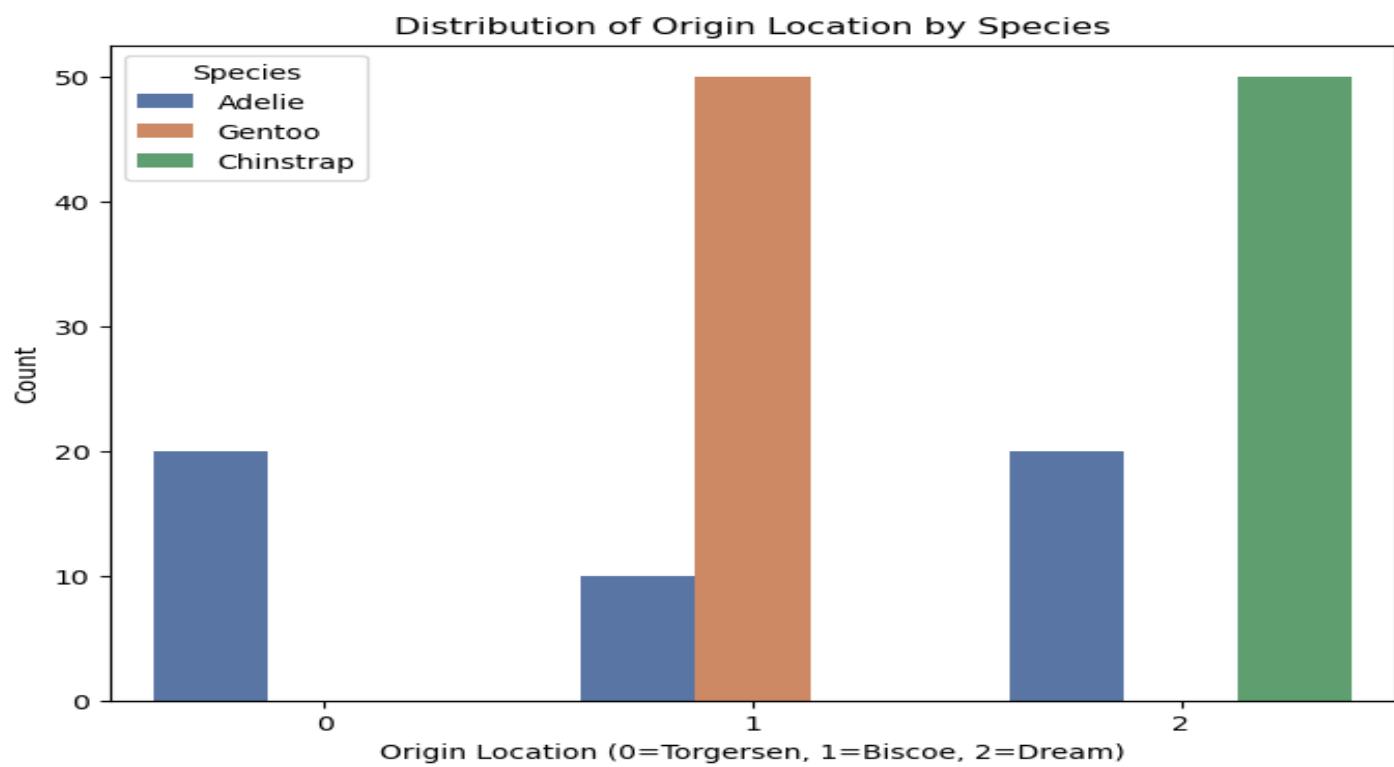


- Very Strong Positive Correlation: FlipperLength and BodyMass have a very strong positive correlation 0.86. Features with strong correlations are generally effective at discriminating between species, but might be redundant if used together.
- Moderate Positive Correlation: CulmenLength shows a moderate positive correlation with FlipperLength 0.56 and BodyMass 0.45.
- Moderate Negative Correlation: CulmenDepth has a moderate negative correlation with FlipperLength -0.60 and BodyMass -0.50.
- Weak Correlation: The correlation between CulmenLength and CulmenDepth is weak -0.15





Adaline Experiments

With eta=0.1, epochs=200, mse_threshold=1e-6 and bias

Analysis Complete! (Adaline: Adelie vs Gentoo)

.....Parameters & Performance.....

Features: OriginLocation and FlipperLength

Max Epochs: 200

Learning Rate (eta): 0.1000

Bias Used: Yes

Final Train MSE Threshold: 1e-06

.....Convergence

Final Train MSE: 0.189949

Test MSE: 0.170155

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

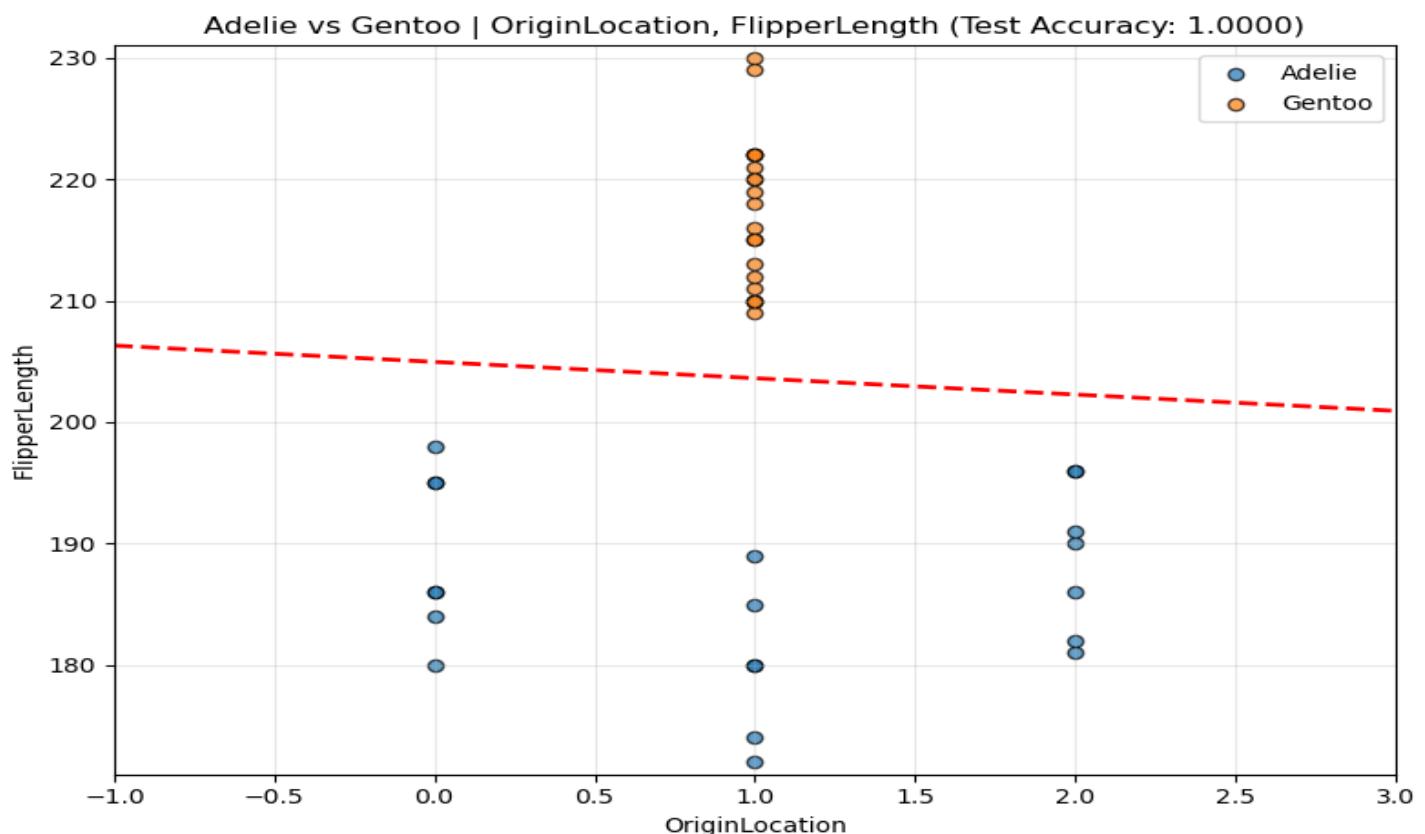
Confusion Matrix (Test Set):

TN (Adelie correctly classified): 20

FP (Adelie misclassified as Gentoo): 0

FN (Gentoo misclassified as Adelie): 0

TP (Gentoo correctly classified): 20



Analysis Complete! (Adaline: Adelie vs Gentoo)

.....Parameters & Performance.....

Features: OriginLocation and BodyMass

Max Epochs: 200

Learning Rate (eta): 0.1000

Bias Used: Yes

Final Train MSE Threshold: 1e-06

.....Convergence

Final Train MSE: 0.393124

Test MSE: 0.298665

..... Test Results (20 samples per class)

Test Accuracy: 92.50%

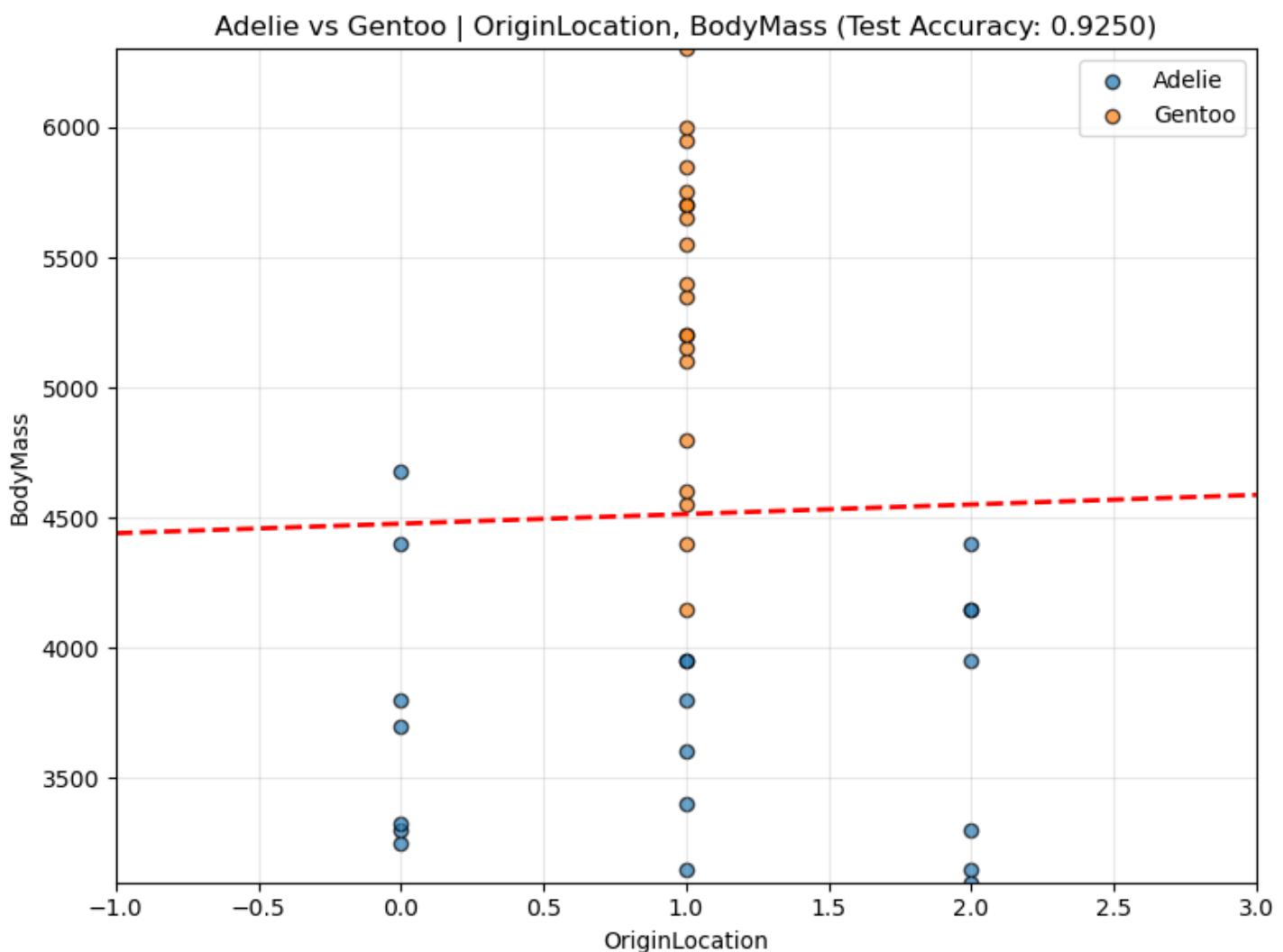
Confusion Matrix (Test Set):

TN (Adelie correctly classified): 19

FP (Adelie misclassified as Gentoo): 1

FN (Gentoo misclassified as Adelie): 2

TP (Gentoo correctly classified): 18



Analysis Complete! (Adaline: Adelie vs Gentoo)

..... Parameters & Performance

Features: CulmenDepth and FlipperLength

Max Epochs: 200

Learning Rate (eta): 0.1000

Bias Used: Yes

Final Train MSE Threshold: 1e-06

..... Convergence

Final Train MSE: 0.082968

Test MSE: 0.041814

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

Confusion Matrix (Test Set):

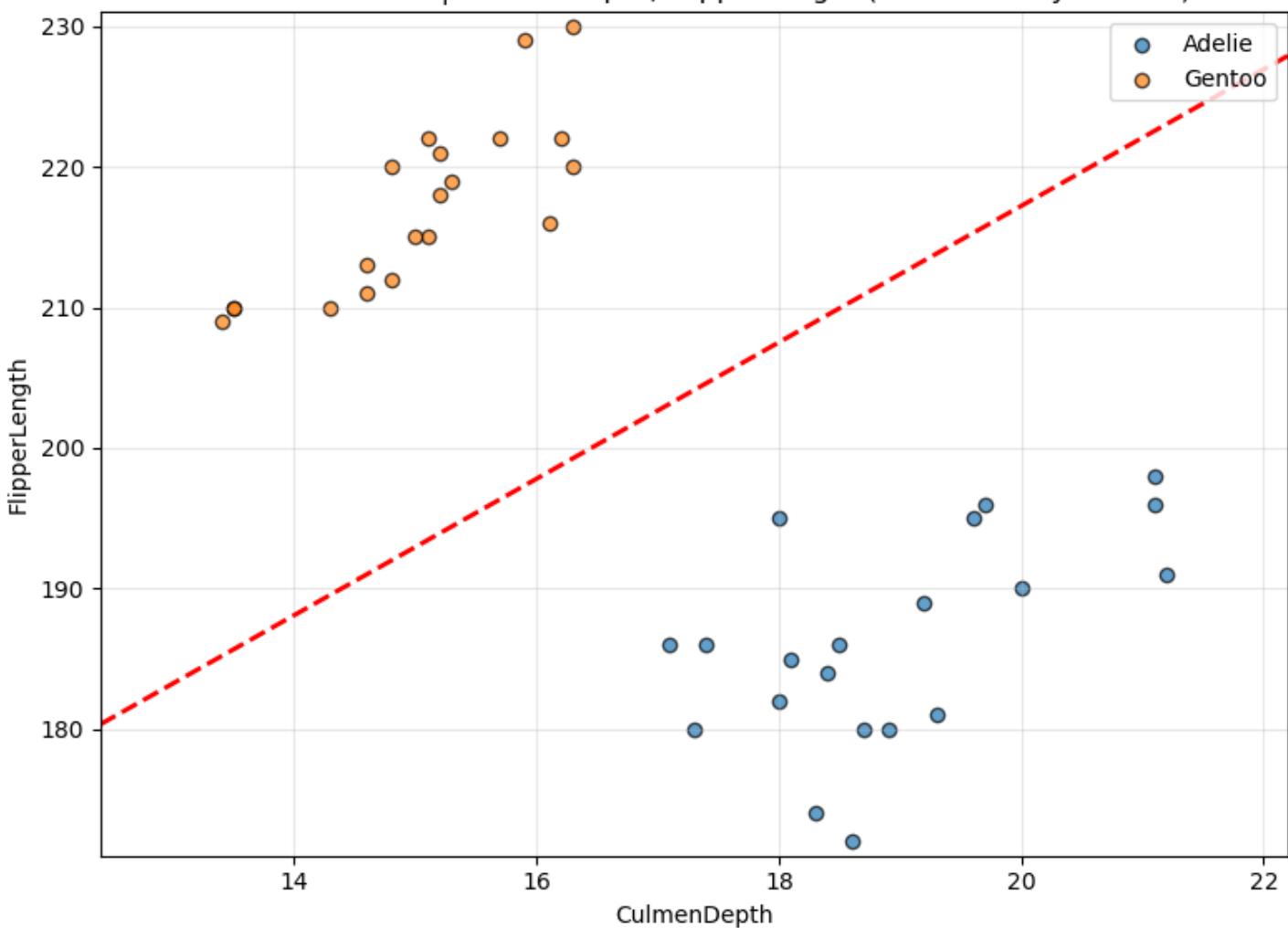
TN (Adelie correctly classified): 20

FP (Adelie misclassified as Gentoo): 0

FN (Gentoo misclassified as Adelie): 0

TP (Gentoo correctly classified): 20

Adelie vs Gentoo | CulmenDepth, FlipperLength (Test Accuracy: 1.0000)



Analysis Complete! (Adaline: Adelie vs Chinstrap)

.....Parameters & Performance.....

Features: CulmenDepth and FlipperLength

Max Epochs: 200

Learning Rate (eta): 0.1000

Bias Used: Yes

Final Train MSE Threshold: 1e-06

.....Convergence

Final Train MSE: 0.648732

Test MSE: 0.643648

..... Test Results (20 samples per class)

Test Accuracy: 75.00%

Confusion Matrix (Test Set):

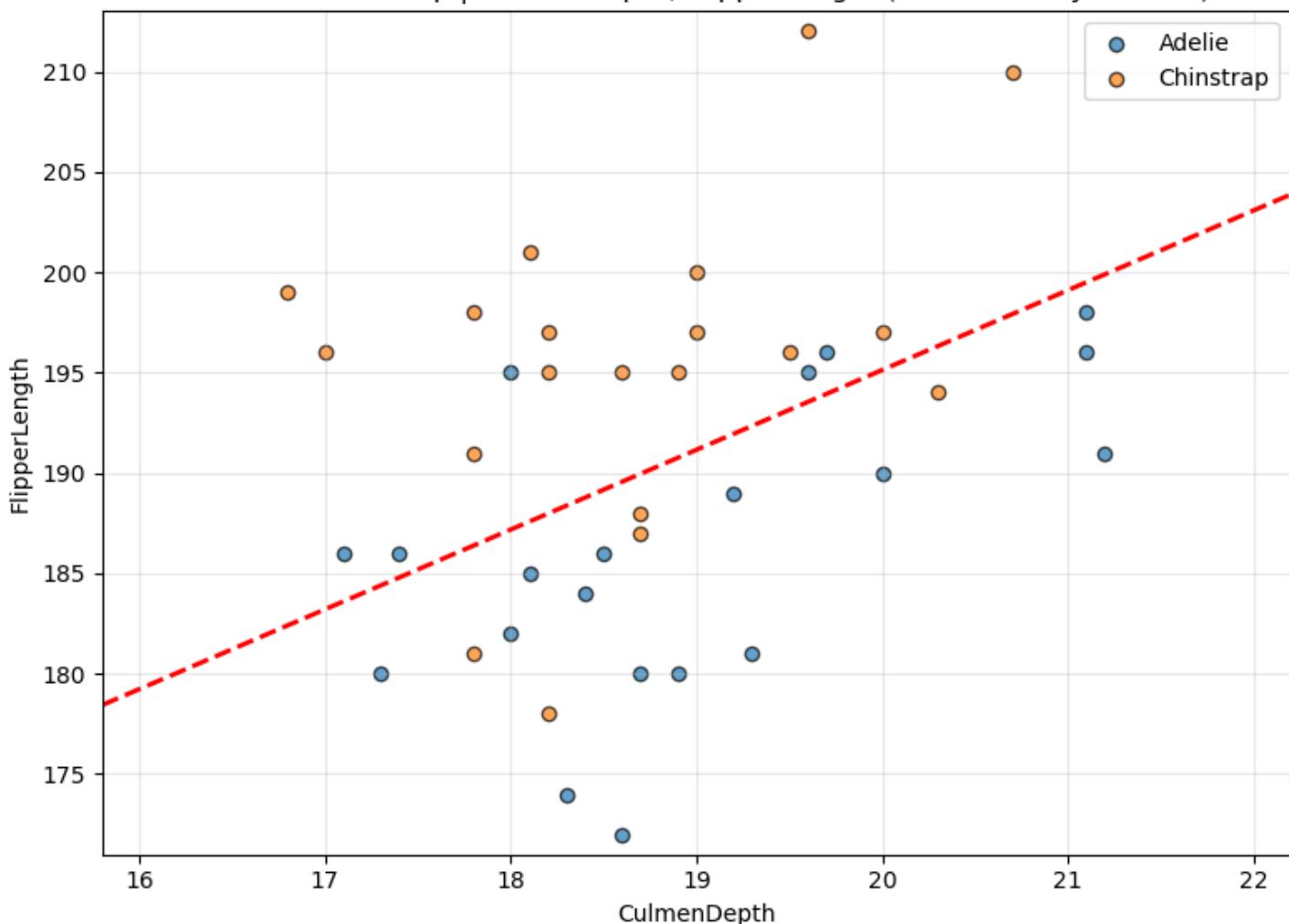
TN (Adelie correctly classified): 15

FP (Adelie misclassified as Chinstrap): 5

FN (Chinstrap misclassified as Adelie): 5

TP (Chinstrap correctly classified): 15

Adelie vs Chinstrap | CulmenDepth, FlipperLength (Test Accuracy: 0.7500)



Analysis Complete! (Adaline: Adelie vs Chinstrap)

.....**Parameters & Performance**.....

Features: BodyMass and FlipperLength

Max Epochs: 200

Learning Rate (eta): 0.1000

Bias Used: Yes

Final Train MSE Threshold: 1e-06

.....**Convergence**.....

Final Train MSE: 0.744344

Test MSE: 0.722161

.....**Test Results (20 samples per class)**.....

Test Accuracy: 72.50%

Confusion Matrix (Test Set):

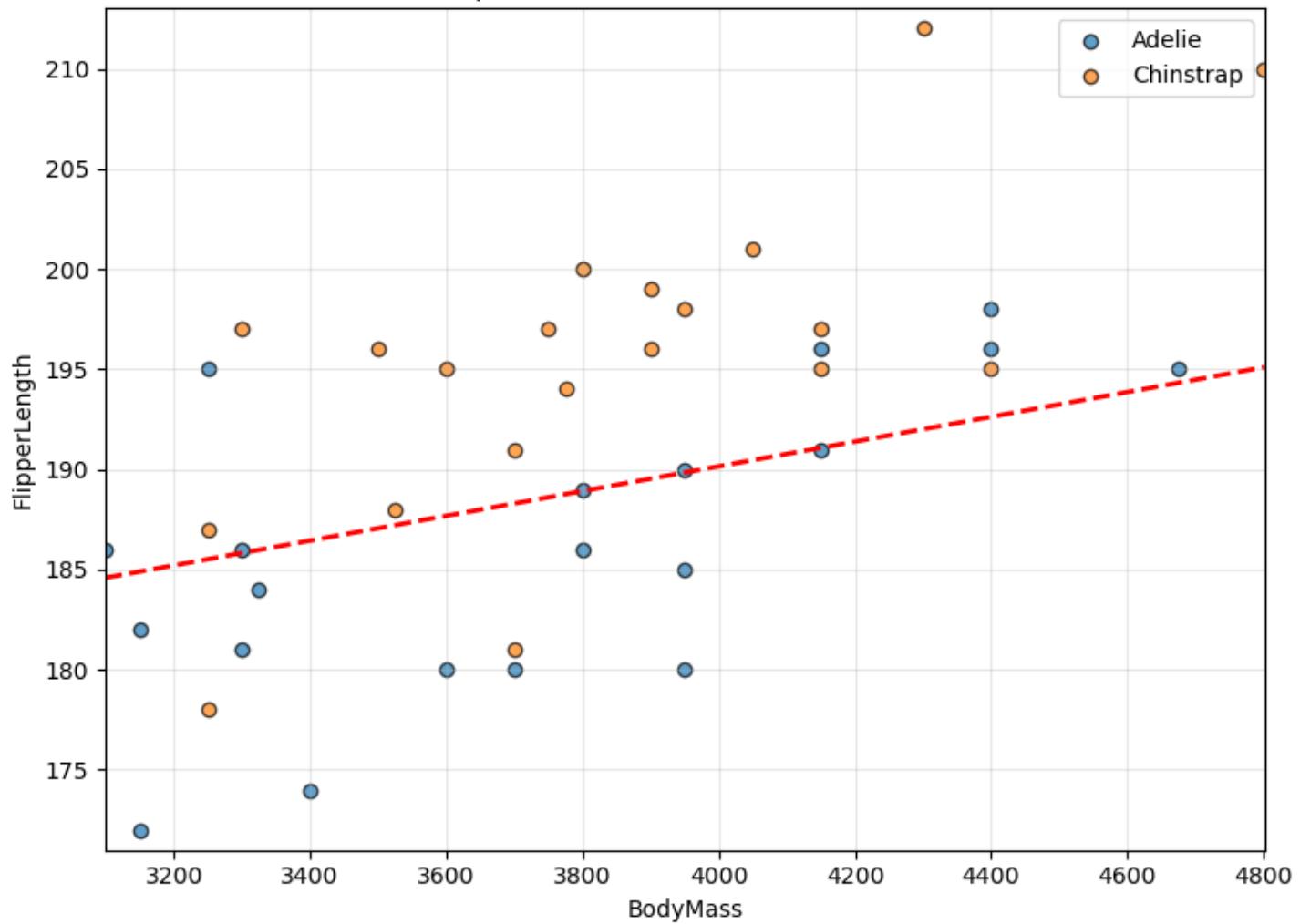
TN (Adelie correctly classified): 11

FP (Adelie misclassified as Chinstrap): 9

FN (Chinstrap misclassified as Adelie): 2

TP (Chinstrap correctly classified): 18

Adelie vs Chinstrap | BodyMass, FlipperLength (Test Accuracy: 0.7250)



Analysis Complete! (Adaline: Gentoo vs Chinstrap)

.....Parameters & Performance.....

Features: BodyMass and CulmenDepth

Max Epochs: 200

Learning Rate (eta): 0.1000

Bias Used: Yes

Final Train MSE Threshold: 1e-06

.....Convergence

Final Train MSE: 0.091124

Test MSE: 0.096820

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

Confusion Matrix (Test Set):

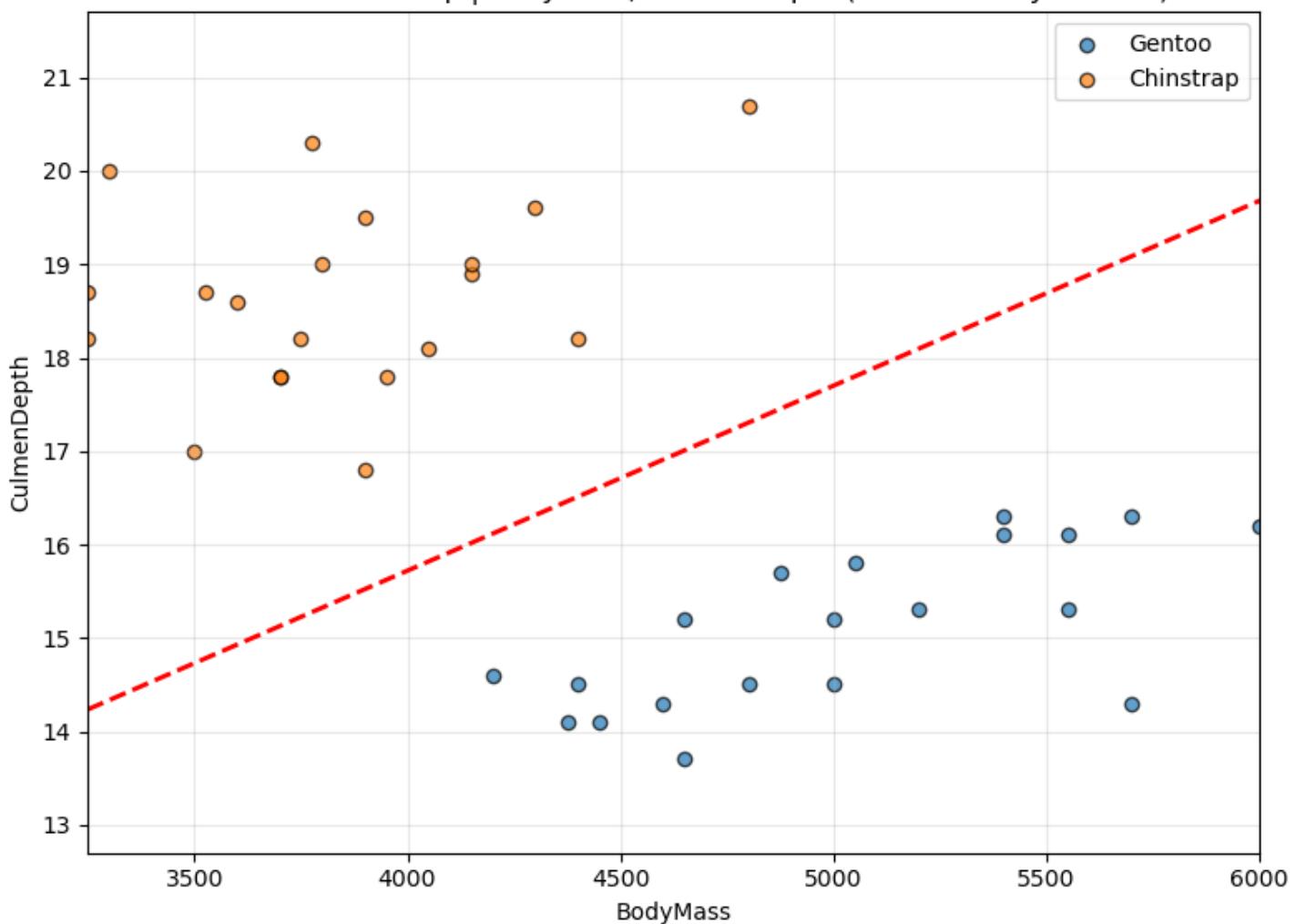
TN (Gentoo correctly classified): 20

FP (Gentoo misclassified as Chinstrap): 0

FN (Chinstrap misclassified as Gentoo): 0

TP (Chinstrap correctly classified): 20

Gentoo vs Chinstrap | BodyMass, CulmenDepth (Test Accuracy: 1.0000)



Run	Classes Features	Test Acc.	Analysis of Class Discrimination & Feature Effectiveness
1	Adelie vs Gentoo OriginLocation, FlipperLength	100%	Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved. Separability: The classes are perfectly linearly separable.
2	Adelie vs Gentoo OriginLocation, BodyMass	92.50%	Discrimination Quality: Moderate-Good. Accuracy is high, but 3 samples were misclassified (FP=1, FN=2). Separability: The classes are mostly linearly separable, but the features cause slight overlap.
3	Adelie vs Gentoo CulmenDepth, FlipperLength	100%	Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved. Separability: The classes are perfectly linearly separable.
4	Adelie vs Chinstrap CulmenDepth, FlipperLength	75.00%	Discrimination Quality: Poor. Accuracy is low, with 10 samples misclassified (FP=5, FN=5). Separability: The classes are not linearly separable; there is significant overlap.
5	Adelie vs Chinstrap BodyMass, FlipperLength	72.50%	Discrimination Quality: Very Poor. This is the lowest accuracy, with 11 misclassifications (FP=9, FN=2). Separability: The classes are not linearly separable; the highly correlated features provide poor distinction for this pair.
6	Gentoo vs Chinstrap BodyMass, CulmenDepth	100%	Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved. Separability: The classes are perfectly linearly separable.

With eta=0.01, epochs=300, mse_threshold=1e-4 and without bias

Analysis Complete! (Adaline: Adelie vs Gentoo)

.....Parameters & Performance.....

Features: OriginLocation and FlipperLength

Max Epochs: 300

Learning Rate (eta): 0.0100

Bias Used: No

Final Train MSE Threshold: 0.0001

.....Convergence

Final Train MSE: 0.155666

Test MSE: 0.172655

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

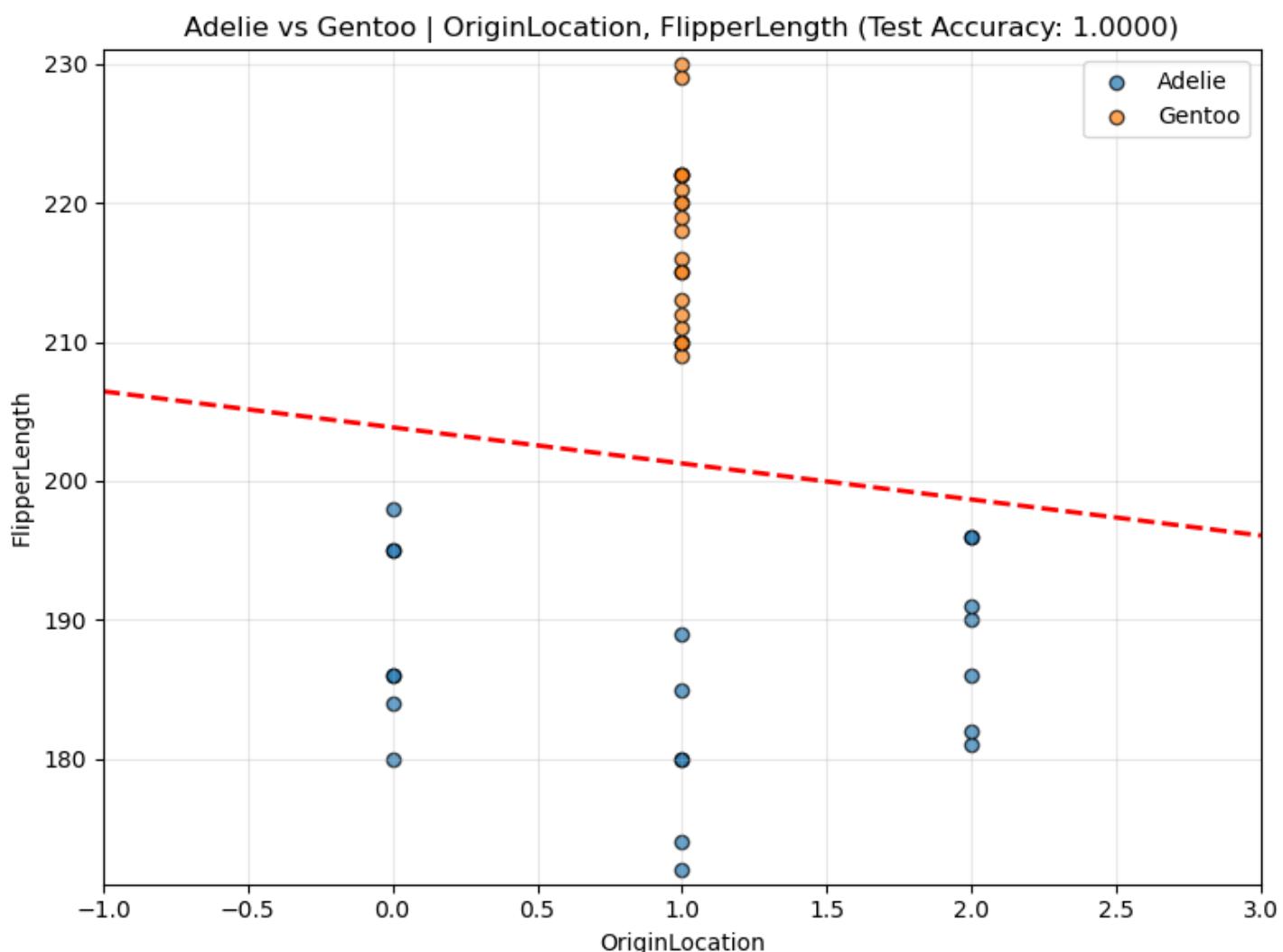
Confusion Matrix (Test Set):

TN (Adelie correctly classified): 20

FP (Adelie misclassified as Gentoo): 0

FN (Gentoo misclassified as Adelie): 0

TP (Gentoo correctly classified): 20



Analysis Complete! (Adaline: Adelie vs Gentoo)

.....**Parameters & Performance**.....

Features: OriginLocation and BodyMass

Max Epochs: 300

Learning Rate (eta): 0.0100

Bias Used: No

Final Train MSE Threshold: 0.0001

.....**Convergence**

Final Train MSE: 0.354970

Test MSE: 0.347554

.....**Test Results (20 samples per class)**

Test Accuracy: 92.50%

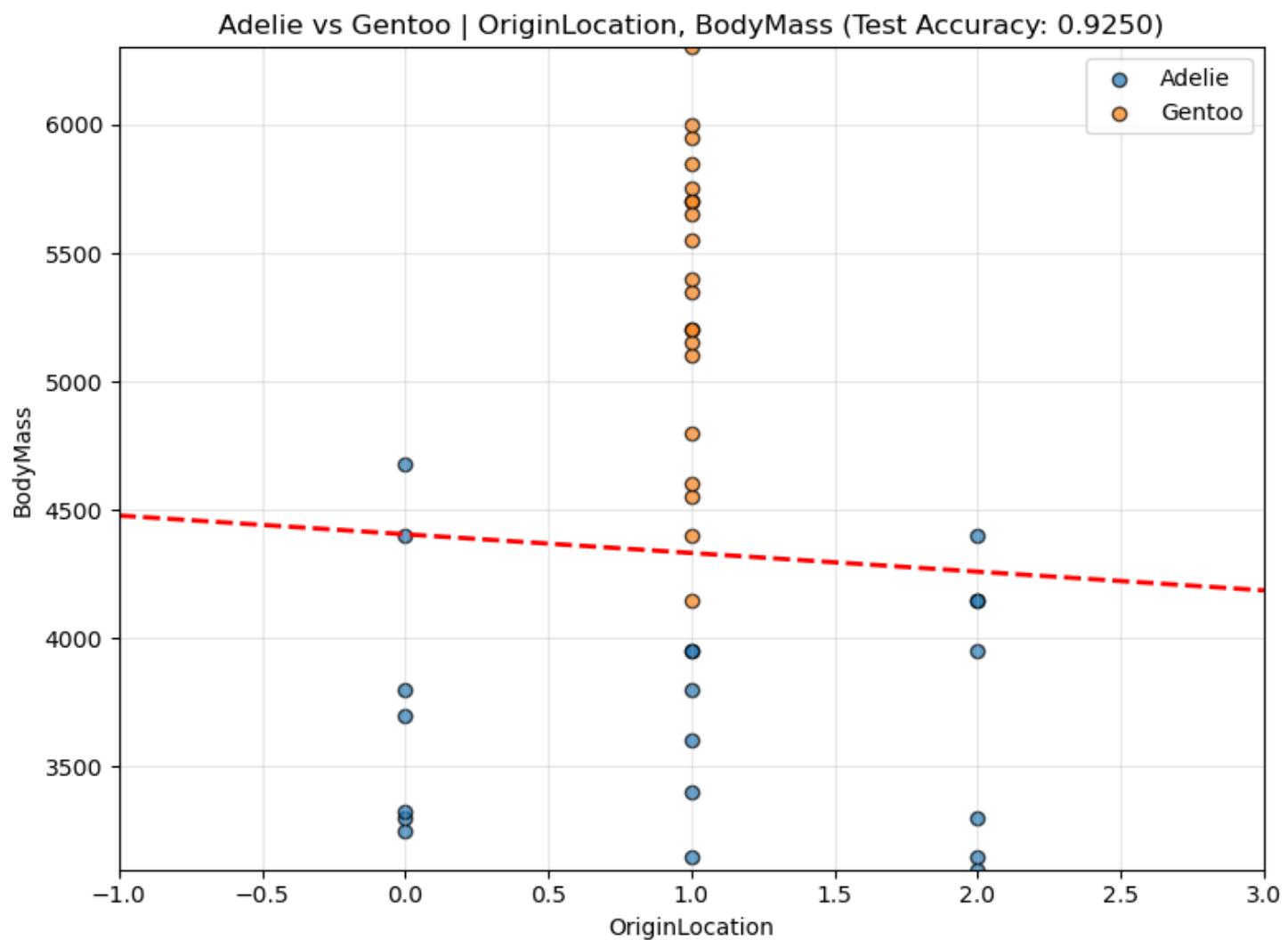
Confusion Matrix (Test Set):

TN (Adelie correctly classified): 18

FP (Adelie misclassified as Gentoo): 2

FN (Gentoo misclassified as Adelie): 1

TP (Gentoo correctly classified): 19



Analysis Complete! (Adaline: Adelie vs Gentoo)

.....Parameters & Performance.....

Features: CulmenDepth and FlipperLength

Max Epochs: 300

Learning Rate (eta): 0.0100

Bias Used: No

Final Train MSE Threshold: 0.0001

.....Convergence

Final Train MSE: 0.081599

Test MSE: 0.042822

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

Confusion Matrix (Test Set):

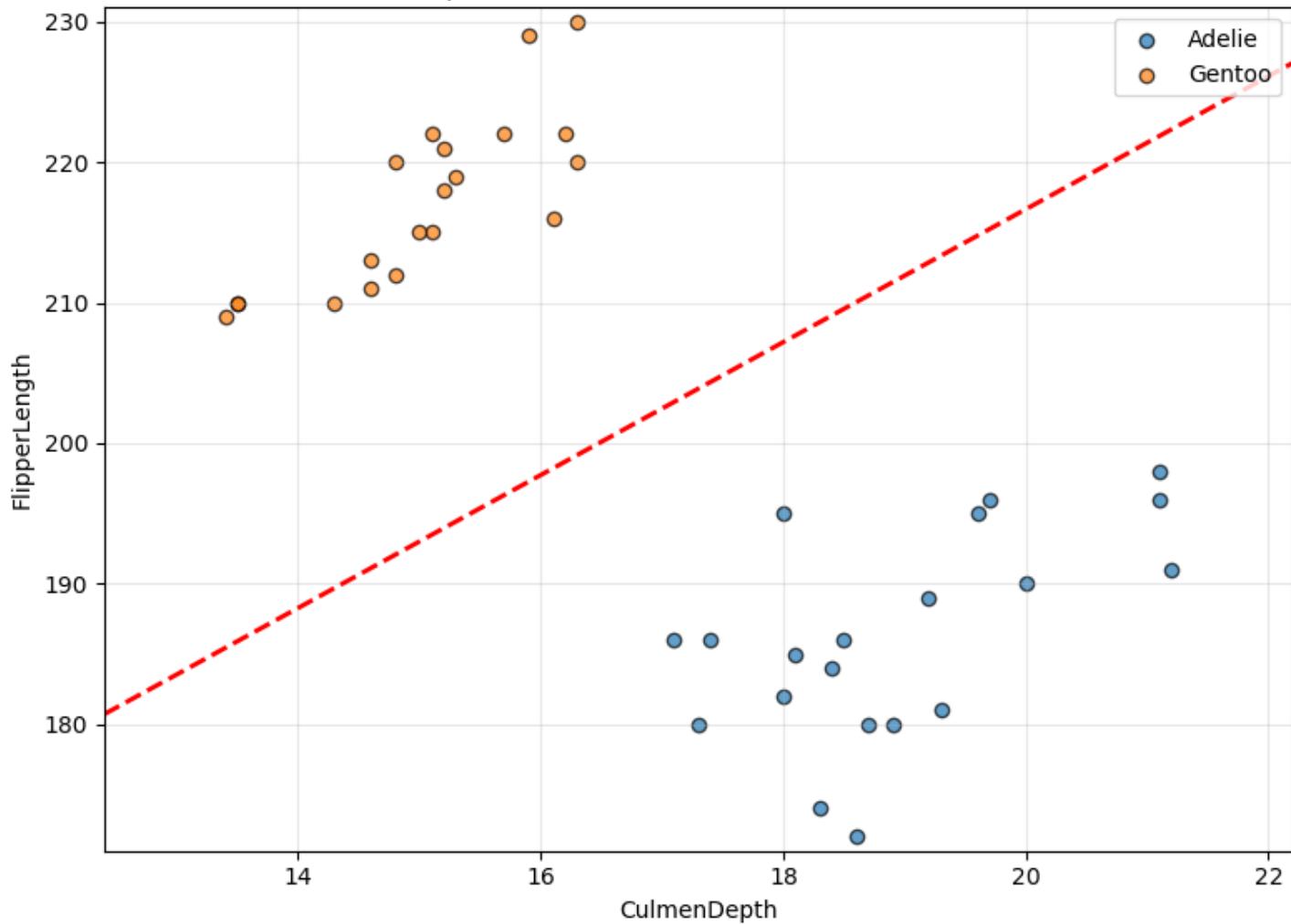
TN (Adelie correctly classified): 20

FP (Adelie misclassified as Gentoo): 0

FN (Gentoo misclassified as Adelie): 0

TP (Gentoo correctly classified): 20

Adelie vs Gentoo | CulmenDepth, FlipperLength (Test Accuracy: 1.0000)



Analysis Complete! (Adaline: Adelie vs Chinstrap)

.....Parameters & Performance.....

Features: CulmenDepth and FlipperLength

Max Epochs: 300

Learning Rate (eta): 0.0100

Bias Used: No

Final Train MSE Threshold: 0.0001

.....Convergence

Final Train MSE: 0.621640

Test MSE: 0.673941

..... Test Results (20 samples per class)

Test Accuracy: 80.00%

Confusion Matrix (Test Set):

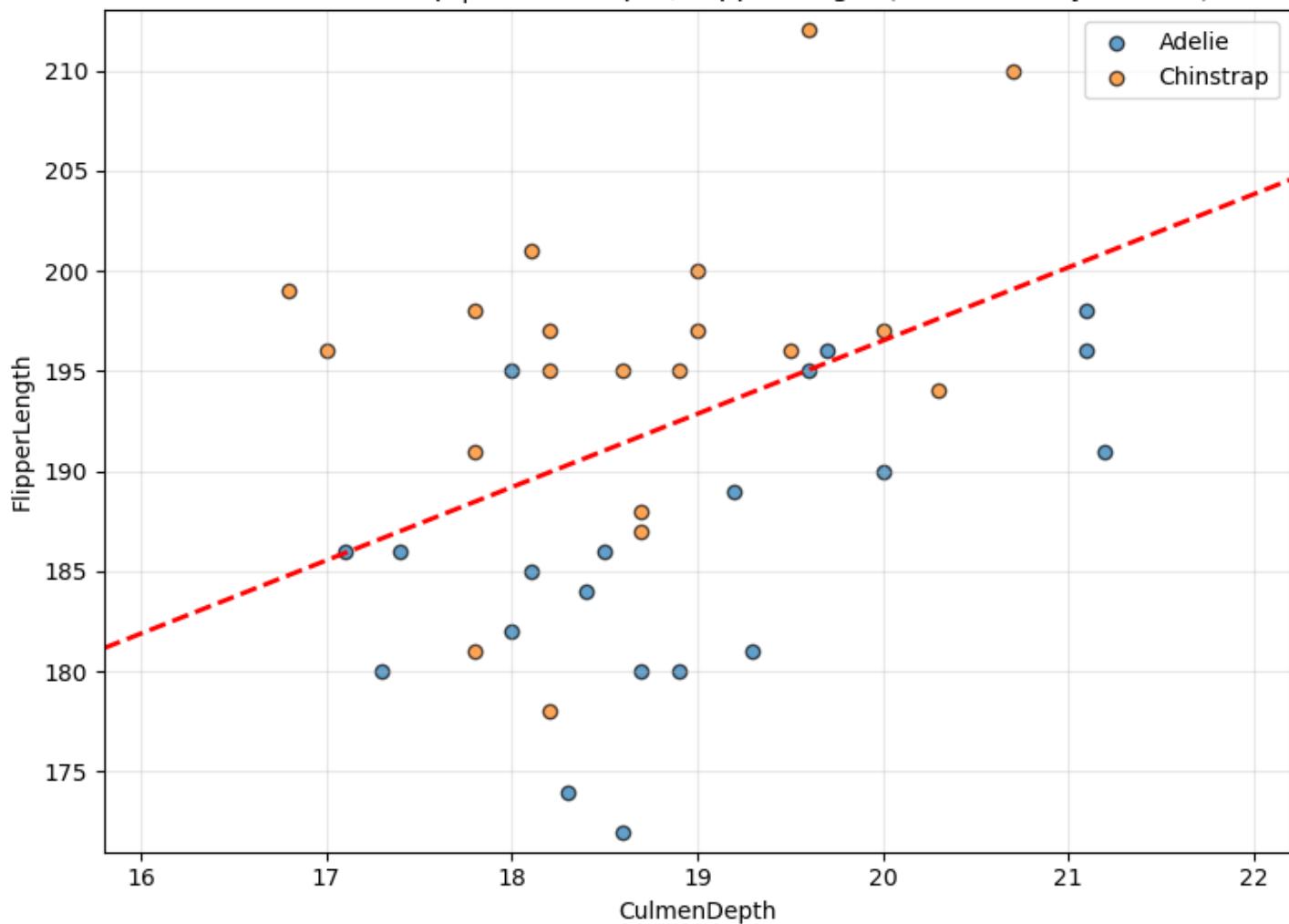
TN (Adelie correctly classified): 17

FP (Adelie misclassified as Chinstrap): 3

FN (Chinstrap misclassified as Adelie): 5

TP (Chinstrap correctly classified): 15

Adelie vs Chinstrap | CulmenDepth, FlipperLength (Test Accuracy: 0.8000)



Analysis Complete! (Adaline: Adelie vs Chinstrap)

.....Parameters & Performance.....

Features: BodyMass and FlipperLength

Max Epochs: 300

Learning Rate (eta): 0.0100

Bias Used: No

Final Train MSE Threshold: 0.0001

.....Convergence

Final Train MSE: 0.683617

Test MSE: 0.679698

..... Test Results (20 samples per class)

Test Accuracy: 77.50%

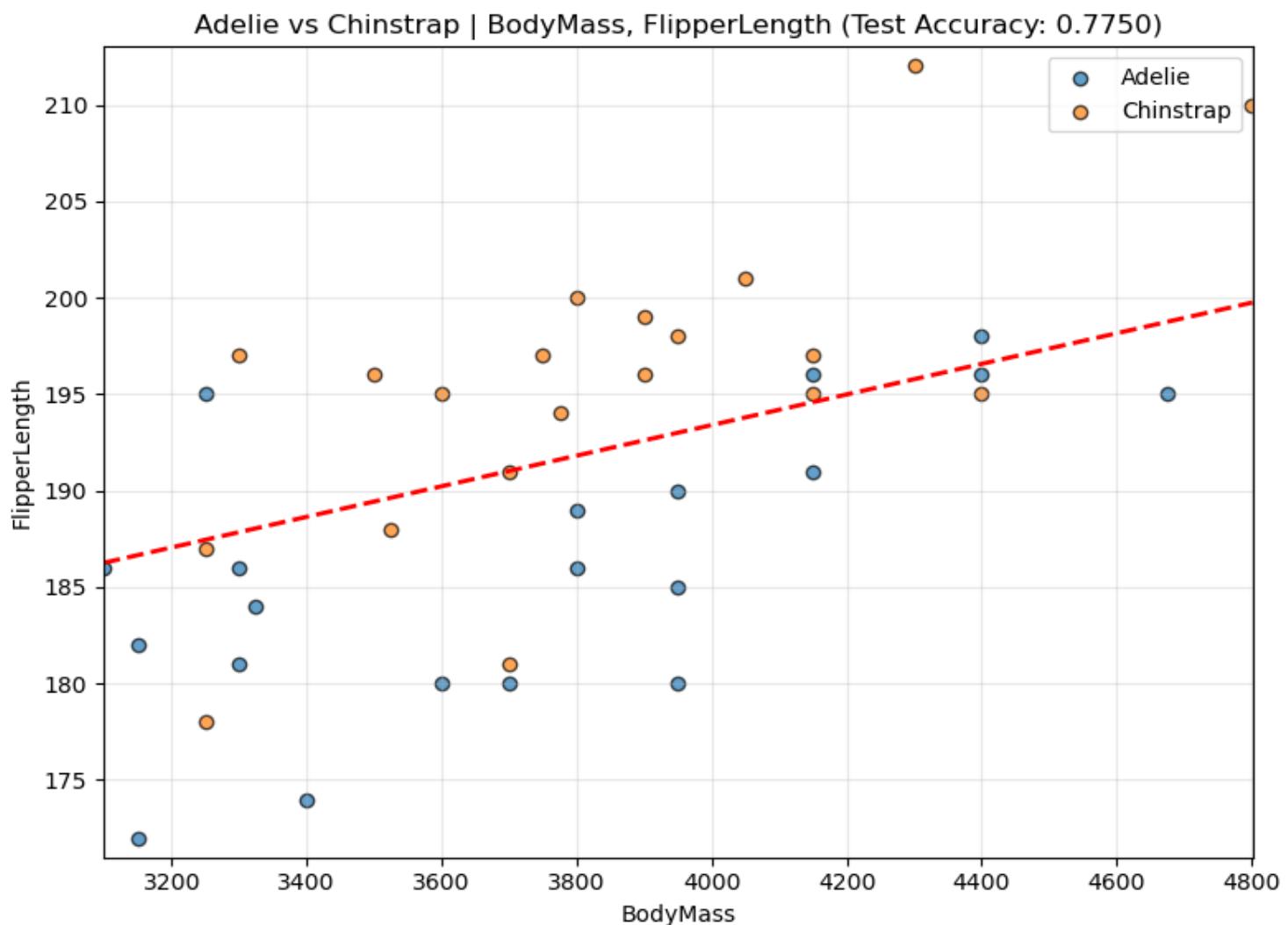
Confusion Matrix (Test Set):

TN (Adelie correctly classified): 17

FP (Adelie misclassified as Chinstrap): 3

FN (Chinstrap misclassified as Adelie): 6

TP (Chinstrap correctly classified): 14



Analysis Complete! (Adaline: Gentoo vs Chinstrap)

.....Parameters & Performance.....

Features: CulmenDepth and BodyMass

Max Epochs: 300

Learning Rate (eta): 0.0100

Bias Used: No

Final Train MSE Threshold: 0.0001

.....Convergence

Final Train MSE: 0.081348

Test MSE: 0.100943

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

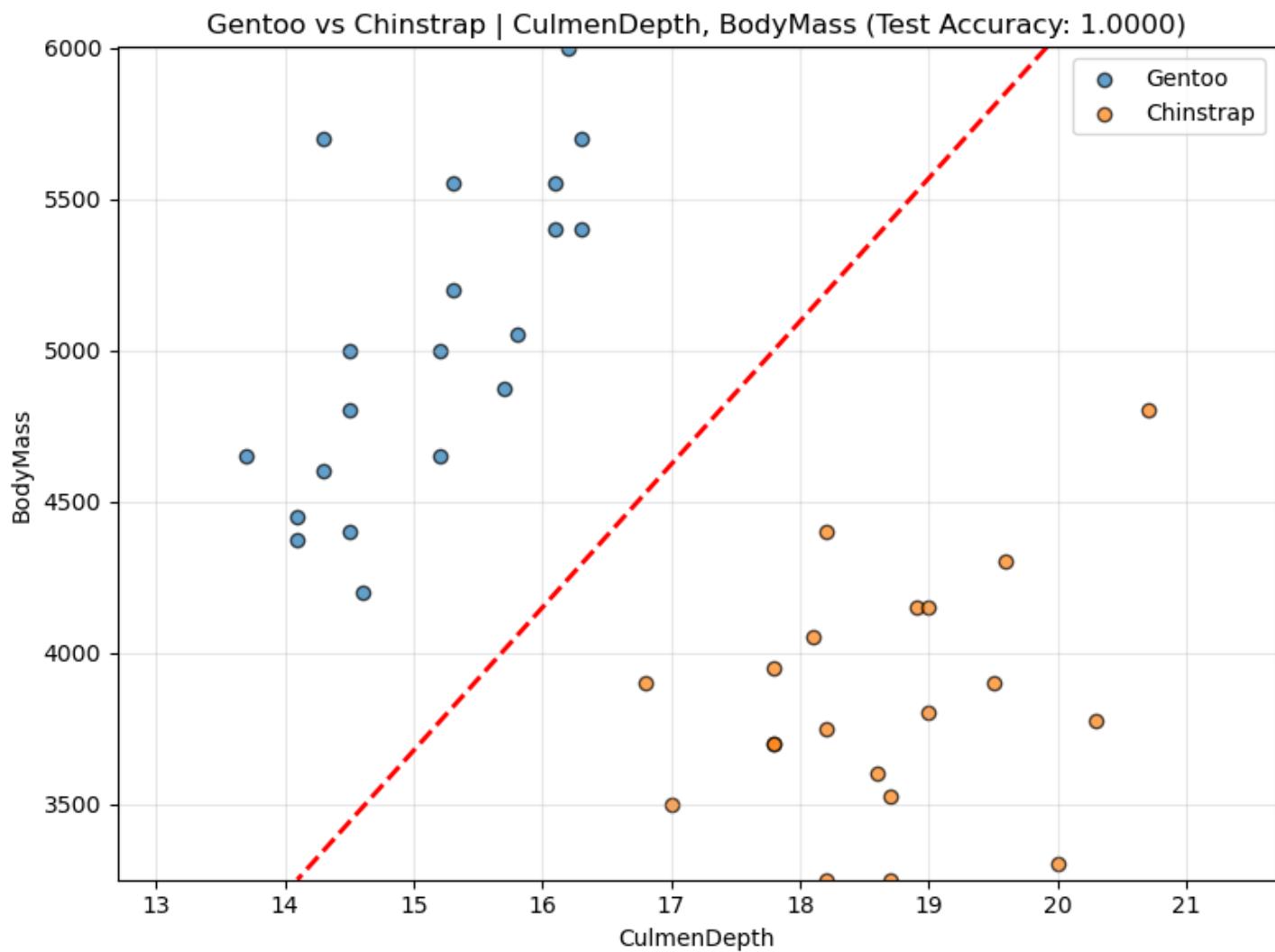
Confusion Matrix (Test Set):

TN (Gentoo correctly classified): 20

FP (Gentoo misclassified as Chinstrap): 0

FN (Chinstrap misclassified as Gentoo): 0

TP (Chinstrap correctly classified): 20



Run	Classes Features	Test Acc	Analysis of Class Discrimination & Feature Effectiveness
7	Adelie vs Gentoo OriginLocation, FlipperLength	100%	Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved. Separability: The classes are perfectly linearly separable.
8	Adelie vs Gentoo OriginLocation, BodyMass	92.50%	Discrimination Quality: Moderate-Good. Accuracy is high, but 3 samples were misclassified (FP=2, FN=1). Separability: The classes are mostly linearly separable, showing consistent results with the previous parameter set.
9	Adelie vs Gentoo CulmenDepth, FlipperLength	100%	Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved. Separability: The classes are perfectly linearly separable.
10	Adelie vs Chinstrap CulmenDepth, FlipperLength	80.00%	Discrimination Quality: Poor. Accuracy is low, with 8 samples misclassified (FP=3, FN=5). Separability: The classes are not linearly separable, although performance improved slightly from Run 4.
11	Adelie vs Chinstrap BodyMass, FlipperLength	77.50%	Discrimination Quality: Poor. Accuracy is low, with 9 misclassifications (FP=3, FN=6). Separability: The classes are not linearly separable; this pair is consistently difficult.
12	Gentoo vs Chinstrap CulmenDepth, BodyMass	100%	Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved. Separability: The classes are perfectly linearly separable.

Best Combination: ('Adelie', 'Gentoo', 'CulmenDepth', 'FlipperLength')

Perceptron

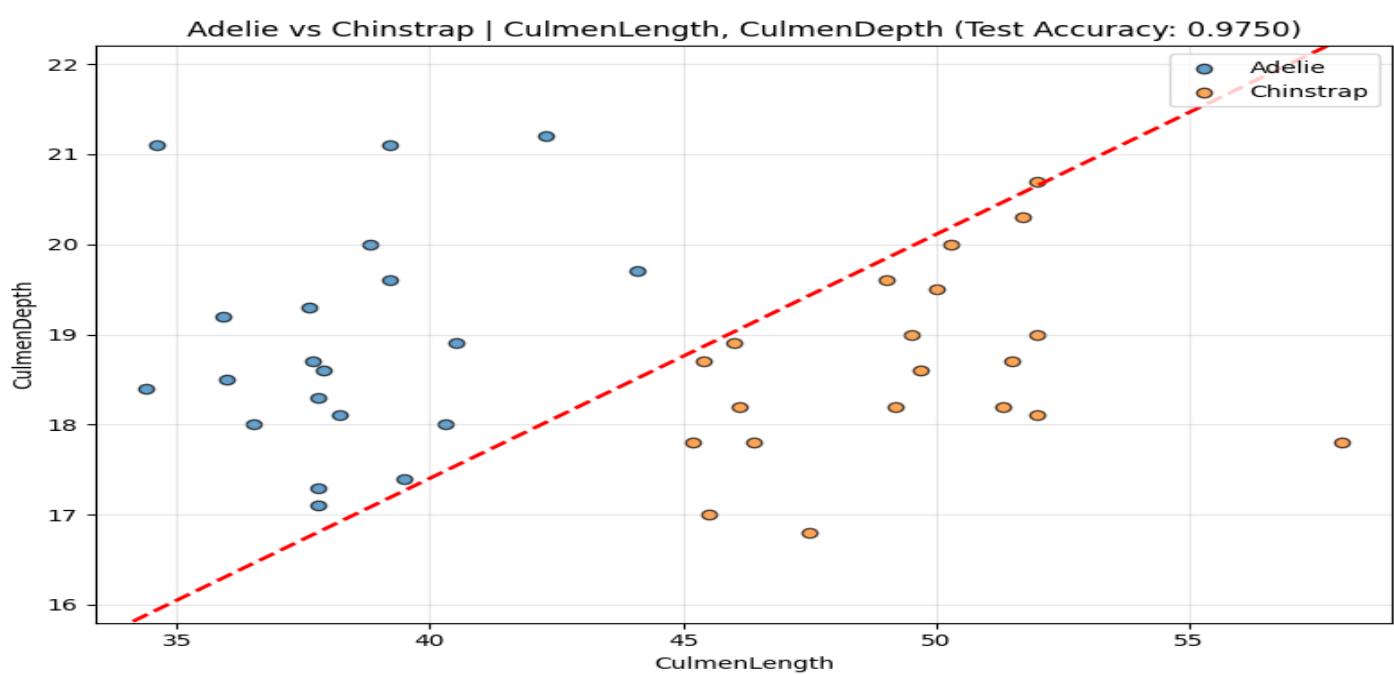
```
Analysis Complete! (Perceptron: Adelie vs Chinstrap)
.....Parameters & Performance.....
Features: CulmenLength and CulmenDepth
Max Epochs: 200
Learning Rate (eta): 0.1000
Bias Used: Yes
Misclassified Threshold: N/A

.....Convergence .....
Convergence Epoch: N/A
Final Misclassified: 4

..... Test Results (20 samples per class) .....
Test Accuracy: 97.50%

Confusion Matrix (Test Set):
TN (Adelie correctly classified): 20
FP (Adelie misclassified as Chinstrap): 0
FN (Chinstrap misclassified as Adelie): 1
TP (Chinstrap correctly classified): 19
```

Figure 1



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Good. The combination achieves high accuracy 97.50%, confirming that these two morphological features are strong discriminators between Adelie and Chinstrap penguins.

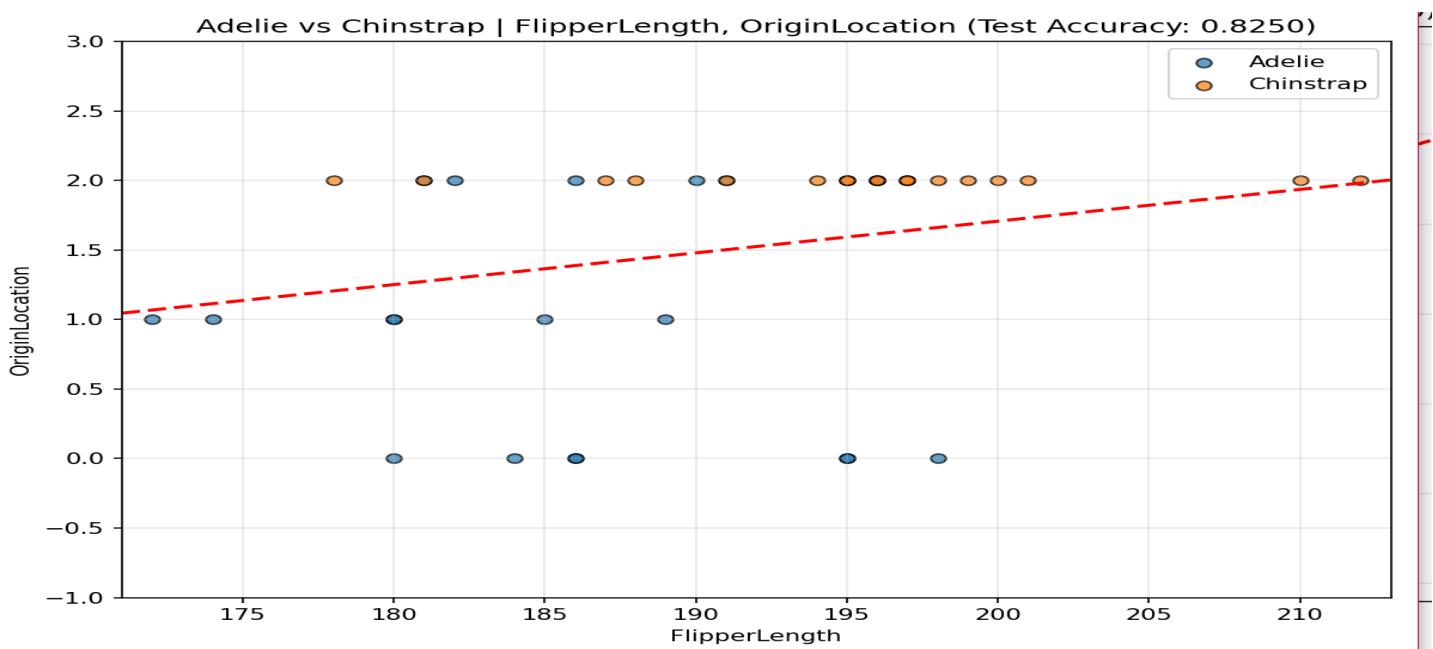
Separability: The classes are nearly linearly separable. The Perceptron found a boundary that correctly classified all but one Chinstrap sample on the test set FN=1.

Analysis Complete! (Perceptron: Adelie vs Chinstrap)

 Parameters & Performance.....
 Features: FlipperLength and OriginLocation
 Max Epochs: 500
 Learning Rate (eta): 0.2000
 Bias Used: No
 Misclassified Threshold: N/A

 Convergence
 Convergence Epoch: N/A
 Final Misclassified: 11

 Test Results (20 samples per class)
 Test Accuracy: 82.50%
 Confusion Matrix (Test Set):
 TN (Adelie correctly classified): 13
 FP (Adelie misclassified as Chinstrap): 7
 FN (Chinstrap misclassified as Adelie): 0
 TP (Chinstrap correctly classified): 20



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Poor/Medium. The accuracy is 82.50%, which is significantly lower than the other combinations, indicating weaker linear separability.

Separability: The classes show substantial overlap, particularly at OriginLocation1 OriginLocation 2, where samples from both species are mixed. The boundary fails to effectively separate the groups, resulting in 7 false positives (Adelie misclassified as Chinstrap).

Analysis Complete! (Perceptron: Chinstrap vs Gentoo)

.....Parameters & Performance.....

Features: BodyMass and FlipperLength

Max Epochs: 1000

Learning Rate (eta): 0.5000

Bias Used: Yes

Misclassified Threshold: N/A

.....Convergence

Convergence Epoch: N/A

Final Misclassified: 8

..... Test Results (20 samples per class)

Test Accuracy: 97.50%

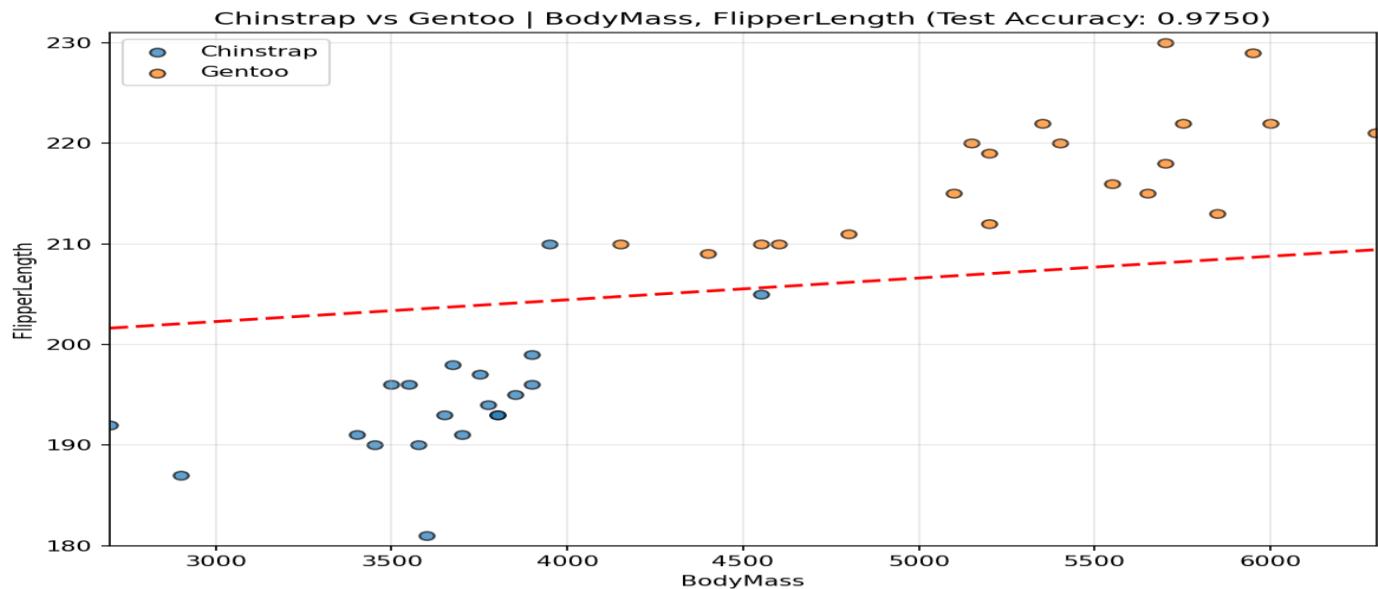
Confusion Matrix (Test Set):

TN (Chinstrap correctly classified): 19

FP (Chinstrap misclassified as Gentoo): 1

FN (Gentoo misclassified as Chinstrap): 0

TP (Gentoo correctly classified): 20



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Good. The 97.50% accuracy indicates strong performance.

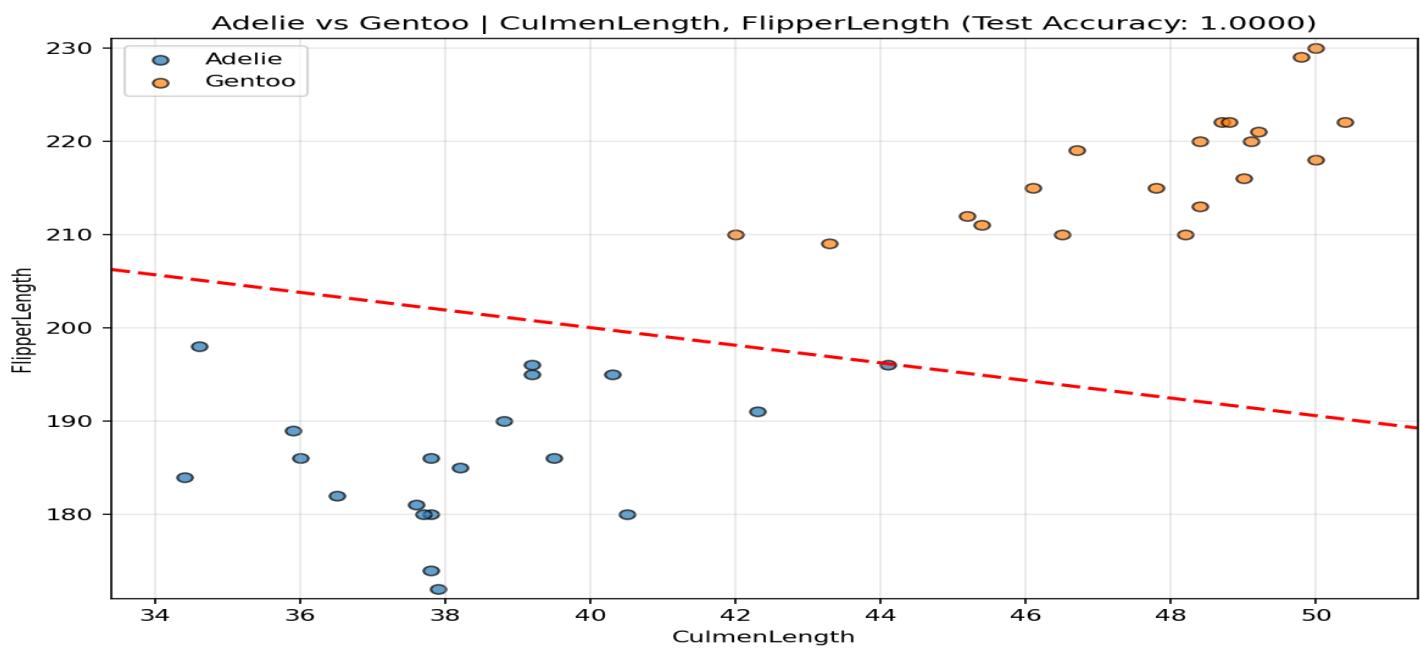
Separability: The two species are almost perfectly linearly separable. The boundary successfully isolates the two clusters, resulting in only one false positive (Chinstrap misclassified as Gentoo, FP=1)

Analysis Complete! (Perceptron: Adelie vs Gentoo)
Parameters & Performance.....
 Features: CulmenLength and FlipperLength
 Max Epochs: 500
 Learning Rate (eta): 0.7000
 Bias Used: Yes
 Misclassified Threshold: N/A

Convergence,
 Convergence Epoch: N/A
 Final Misclassified: 2

 Test Results (20 samples per class),
 Test Accuracy: 100.00%

 Confusion Matrix (Test Set):
 TN (Adelie correctly classified): 20
 FP (Adelie misclassified as Gentoo): 0
 FN (Gentoo misclassified as Adelie): 0
 TP (Gentoo correctly classified): 20



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved on the test set.

Separability: The classes are **perfectly linearly separable** with respect to these two features. Although the Perceptron did not converge to zero misclassified on the training set Final Misclassified=2, the learned boundary generalized perfectly to the test set, achieving 0 false positives and 0 false negatives.

```

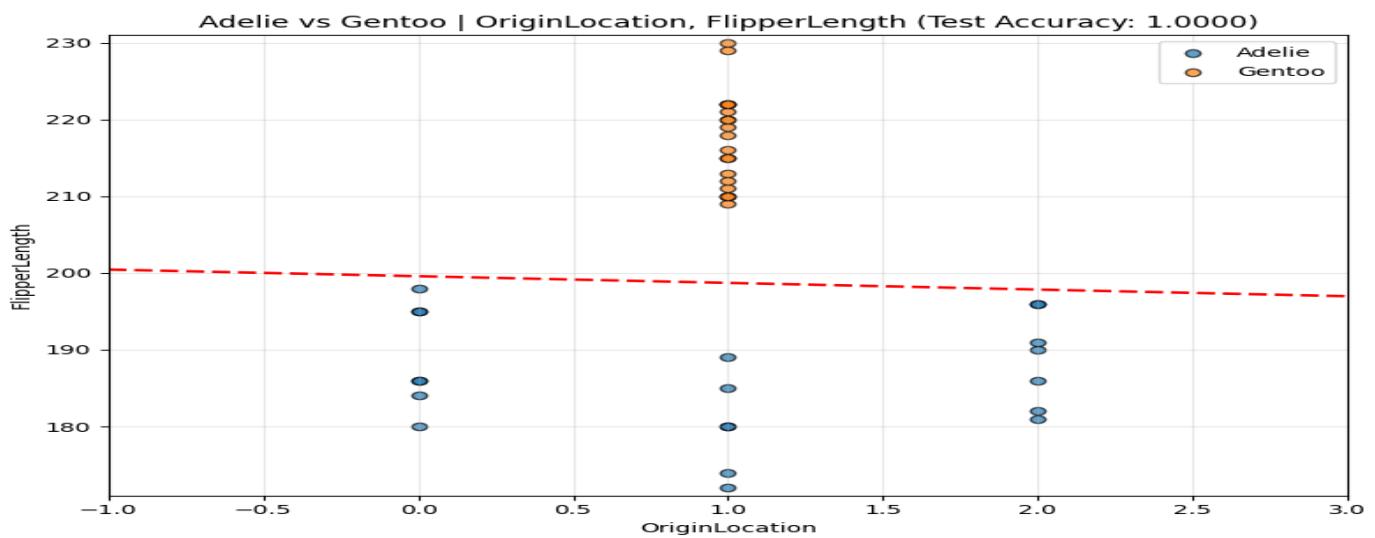
Analysis Complete! (Perceptron: Adelie vs Gentoo)
.....Parameters & Performance.....
Features: OriginLocation and FlipperLength
Max Epochs: 50
Learning Rate (eta): 0.0010
Bias Used: Yes
Misclassified Threshold: N/A

.....Convergence .....
Convergence Epoch: 3
Final Misclassified: 0

..... Test Results (20 samples per class) -----
Test Accuracy: 100.00%

Confusion Matrix (Test Set):
TN (Adelie correctly classified): 20
FP (Adelie misclassified as Gentoo): 0
FN (Gentoo misclassified as Adelie): 0
TP (Gentoo correctly classified): 20

```



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Excellent. Perfect 100.00% accuracy and full convergence textFinal Misclassified=0Convergence Epoch=3.

Separability: The classes are perfectly linearly separable. The Perceptron converged quickly, indicating the separation is robust. The boundary is drawn horizontally at a FlipperLength value that splits the Adelie and Gentoo clusters at OriginLocation=1 and ignores the Adelie points at OriginLocation=0 and OriginLocation=2 because Gentoo is absent there.

Analysis Complete! (Perceptron: Adelie vs Chinstrap)

Parameters & Performance.....

Features: BodyMass and FlipperLength

Max Epochs: 50

Learning Rate (eta): 0.0100

Bias Used: Yes

Misclassified Threshold: N/A

.....Convergence

Convergence Epoch: N/A

Final Misclassified: 22

..... Test Results (20 samples per class)

Test Accuracy: 77.50%

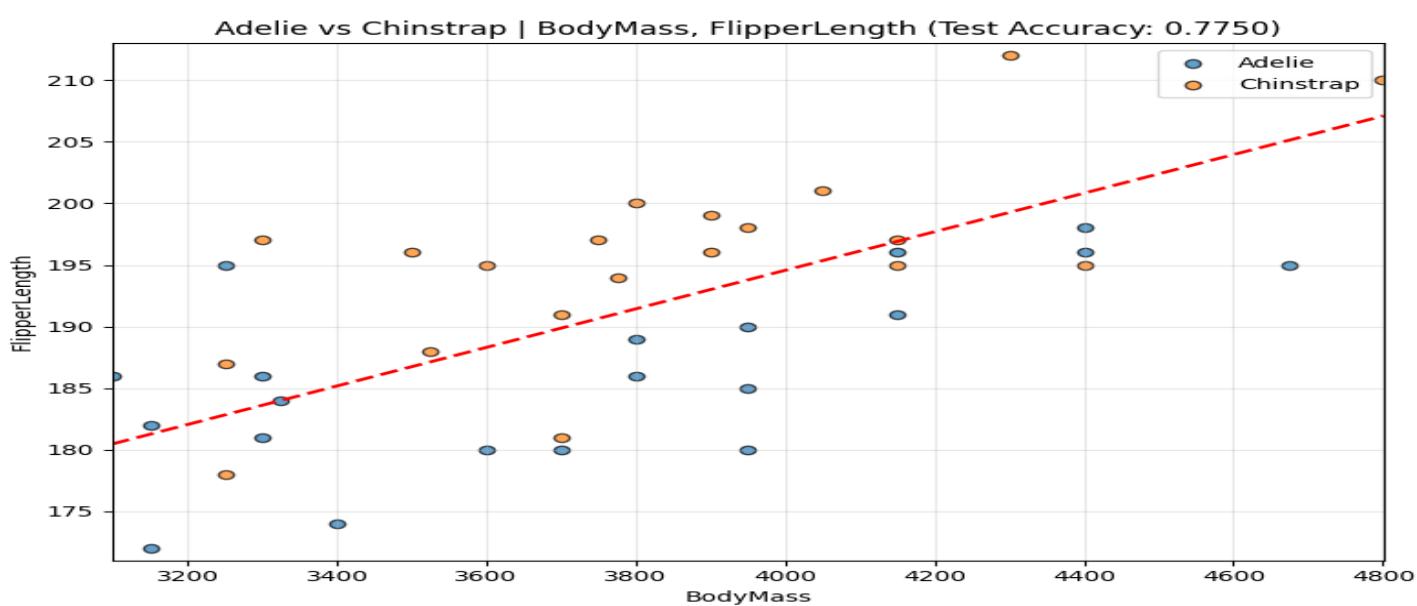
Confusion Matrix (Test Set):

TN (Adelie correctly classified): 15

FP (Adelie misclassified as Chinstrap): 5

FN (Chinstrap misclassified as Adelie): 4

TP (Chinstrap correctly classified): 16



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Poor. The accuracy of 77.50% is the lowest observed, and the high Final Misclassified=22 confirms the Perceptron struggled to find a good solution.

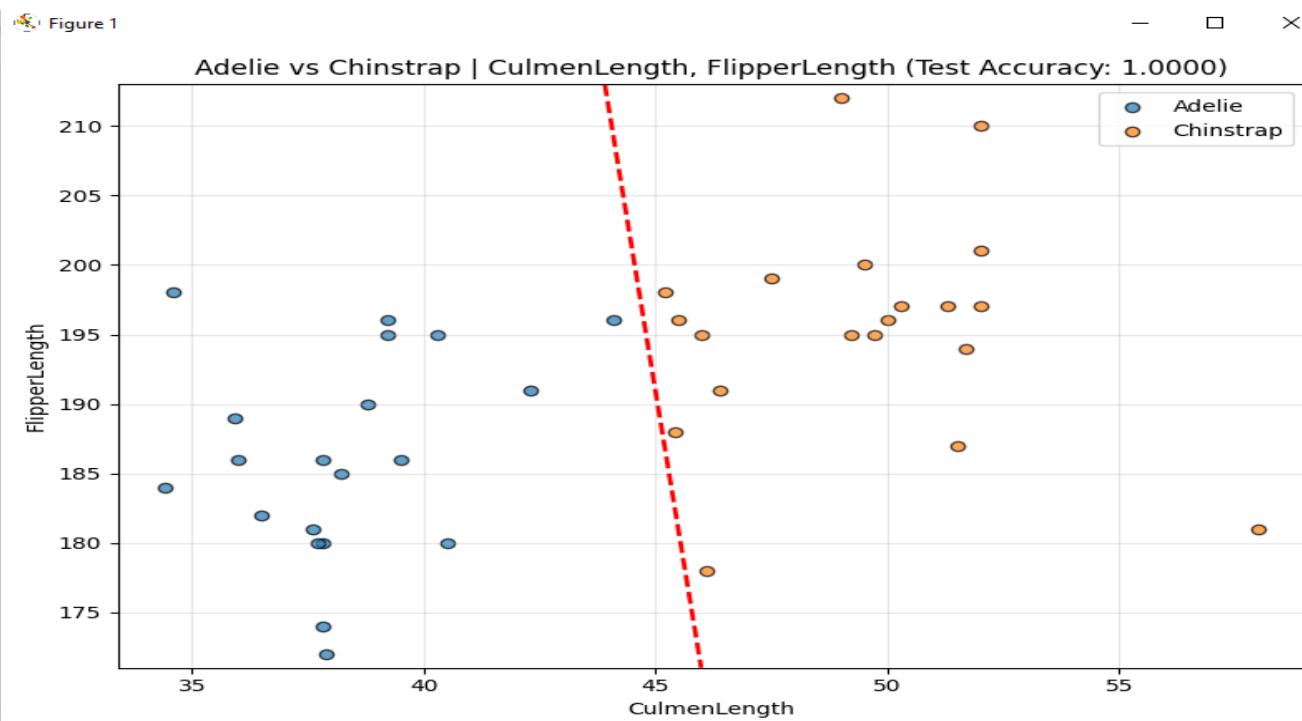
Separability: The classes are **not linearly separable** boundary settled in a position that failed to properly isolate the clusters, leading to 5 false positives and 4 false negatives.

Analysis Complete! (Perceptron: Adelie vs Chinstrap)

 Parameters & Performance.....
 Features: CulmenLength and FlipperLength
 Max Epochs: 50
 Learning Rate (eta): 0.0100
 Bias Used: Yes
 Misclassified Threshold: N/A

 Convergence,
 Convergence Epoch: N/A
 Final Misclassified: 10

 Test Results (20 samples per class),
 Test Accuracy: 100.00%
 Confusion Matrix (Test Set):
 TN (Adelie correctly classified): 20
 FP (Adelie misclassified as Chinstrap): 0
 FN (Chinstrap misclassified as Adelie): 0
 TP (Chinstrap correctly classified): 20



Analysis of Class Discrimination & Feature Effectiveness:

Discrimination Quality: Excellent. A perfect 100.00% accuracy was achieved, and the Perceptron converged very quickly Convergence Epoch=2.

Separability: The classes are perfectly linearly separable

Analysis Complete! (Perceptron: Gentoo vs Chinstrap)

.....Parameters & Performance.....

Features: CulmenLength and OriginLocation

Max Epochs: 50

Learning Rate (eta): 0.0100

Bias Used: Yes

Misclassified Threshold: N/A

.....Convergence

Convergence Epoch: 2

Final Misclassified: 0

..... Test Results (20 samples per class)

Test Accuracy: 100.00%

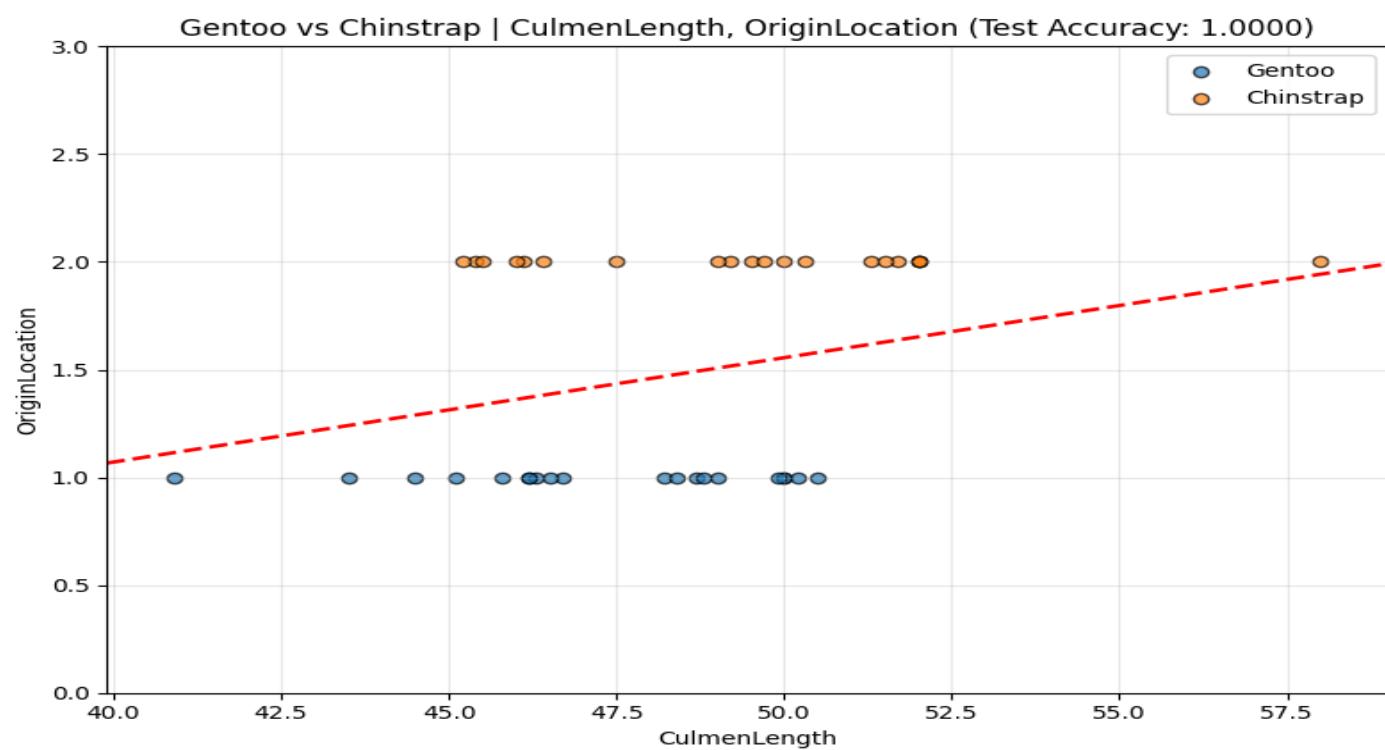
Confusion Matrix (Test Set):

TN (Gentoo correctly classified): 20

FP (Gentoo misclassified as Chinstrap): 0

FN (Chinstrap misclassified as Gentoo): 0

TP (Chinstrap correctly classified): 20



Features achieved highest accuracy:

Adelie VS Chinstrap

1. Culmen length & Flipper length (Acc:100%)
2. Culmen length & Culmen depth (Acc: 0.97)

Chinstrap VS Gentoo

1. Original location & Culmen length (Acc:100%)
2. Body mass & Flipper length (Acc: 0.97)

Adelie VS Gentoo

1. Culmen length & Flipper length (Acc:100%)
2. Original location & Flipper length (Acc:100%)