In [17]:

```
import random
import torch
from torch import nn
import torchvision
from pathlib import Path
import os
from PIL import Image
import matplotlib.pyplot as plt
import numpy as np
from torch.utils.data import DataLoader, Dataset
from torchvision import datasets, transforms
from torchvision import models
import torch.optim as optim
from torch.optim import lr_scheduler

class TinyVGG(nn.Module):
    """Model architecture copying TinyVGG from CNN explainer"""

    def __init__(self, input_shape: int,
                 hidden_units: int,
                 output_shape: int) -> None:
        super().__init__()
        self.conv_block_1 = nn.Sequential(
            nn.Conv2d(in_channels=input_shape,
                      out_channels=hidden_units,
                      kernel_size=3,
                      stride=1,
                      padding=0),
            nn.ReLU(),
            nn.Conv2d(in_channels=hidden_units,
                      out_channels=hidden_units,
                      kernel_size=3,
                      stride=1,
                      padding=0),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2,
                         stride=2)
        )
        self.conv_block_2 = nn.Sequential(
            nn.Conv2d(in_channels=hidden_units,
                      out_channels=hidden_units,
                      kernel_size=3,
                      stride=1,
                      padding=0),
            nn.ReLU(),
            nn.Conv2d(in_channels=hidden_units,
                      out_channels=hidden_units,
                      kernel_size=3,
                      stride=1,
                      padding=0),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2,
                         stride=2)
        )
        self.classifier = nn.Sequential(
            nn.Flatten(),
            nn.Linear(in_features=hidden_units * 53 * 53, out_features=output_shape)
        )

    def forward(self, x):
        x = self.conv_block_1(x)
        x = self.conv_block_2(x)
        x = self.classifier(x)
        return x

def walk_through_dir(dir_path):
    """Walks through dir_path returining its contents. """
```

```
    for dir_path, dirnames, filenames in os.walk(dir_path):
        print(f"There are {len(dirnames)} directories and {len(filenames)} images in {di
r_path}")


def train_step(model: torch.nn.Module,
               dataloader: torch.utils.data.DataLoader,
               loss_fn: torch.nn.Module,
               optimizer: torch.optim.Optimizer):
    model.train()
    train_loss, train_acc = 0, 0

    for (X, y) in dataloader:

        X = X.to(device)
        y= y.to(device)

        y_pred = model(X)

        loss = loss_fn(y_pred, y)
        train_loss += loss.item()

        optimizer.zero_grad()

        loss.backward()

        optimizer.step()

        y_pred_class = torch.argmax(torch.softmax(y_pred, dim=1), dim=1)
        train_acc += (y_pred_class==y).sum().item()/len(y_pred)

    train_loss /= len(dataloader)
    train_acc /= len(dataloader)

    return train_loss, train_acc

def test_step(model: torch.nn.Module,
              dataloader: torch.utils.data.DataLoader,
              loss_fn: torch.nn.Module):
    model.eval()

    test_loss, test_acc = 0, 0

    with torch.inference_mode():
        for (X, y) in dataloader:
            X = X.to(device)
            y= y.to(device)
            y_pred = model(X)

            loss = loss_fn(y_pred, y)

            test_loss += loss.item()

            y_pred_class = torch.argmax(torch.softmax(y_pred, dim=1), dim=1)
            test_acc += (y_pred_class == y).sum().item() / len(y_pred)

        test_loss /= len(dataloader)
        test_acc /= len(dataloader)

    return test_loss, test_acc

#
MODEL_PATH = Path("models")
MODEL_PATH.mkdir(parents=True,
                 exist_ok=True)

MODEL_NAME = "01_vgg16_model.pth"

MODEL_SAVE_PATH = MODEL_PATH / MODEL_NAME

#Setting up device agnostic code
device = "cuda" if torch.cuda.is_available() else "cpu"
```

```
#Getting all paths
data_path = Path("/kaggle/input/100-bird-species/")
test_path = data_path / "test"
train_path = data_path / "train"
valid_path = data_path / "valid"

print(test_path, train_path, valid_path)

#walk_through_dir(train_path)


image_path_list = list(data_path.glob("*/*/*.jpg"))

random_image_path = random.choice(image_path_list)
print(random_image_path)
random_class_name = random_image_path.parent.stem
print(random_class_name)

img = Image.open(random_image_path)
img_as_array = np.asarray(img)

print(img_as_array.shape)


transforms = {"train": transforms.Compose([#transforms.TrivialAugmentWide(num_magnitude_
bins=2),
                                           transforms.Resize(size=(224, 224)),
                                           transforms.ToTensor()]),
              "test": transforms.Compose([transforms.Resize(size=(224, 224)),
                                          transforms.ToTensor()]),
              "valid": transforms.Compose([transforms.Resize(size=(224, 224)),
                                           transforms.ToTensor()])}

train_data = datasets.ImageFolder(root=train_path,
                                  transform=transforms["train"],
                                  target_transform=None)

test_data = datasets.ImageFolder(root=test_path,
                                  transform=transforms["test"],
                                  target_transform=None)

valid_data = datasets.ImageFolder(root=valid_path,
                                  transform=transforms["valid"],
                                  target_transform=None)


class_names = train_data.classes
class_dict = train_data.class_to_idx


print(train_data.classes)

print(len(train_data), len(test_data), len(valid_data))

img, label = train_data[0][0], train_data[0][1]

print(img.shape, label)

BATCH_SIZE = 32

train_dataloader = DataLoader(dataset=train_data,
                              batch_size=BATCH_SIZE,
                              shuffle=True)

test_dataloader = DataLoader(dataset=test_data,
                              batch_size=BATCH_SIZE,
                              shuffle=False)

valid_dataloader = DataLoader(dataset=valid_data,
                              batch_size=BATCH_SIZE,
                              shuffle=False)
```

```
print(next(iter(train_dataloader))[0].shape)

model_0 = TinyVGG(input_shape=3,
                  hidden_units=10,
                  output_shape=len(class_names))

model_1 = models.efficientnet_b0(weights=models.EfficientNet_B0_Weights.IMAGENET1K_V1)
#num_features = model_1.fc.in_features
#model_1.fc = nn.Linear(num_features, len(class_names))
model_1.classifier[1] = nn.Linear(in_features=1280, out_features=len(class_names))
#model_1.load_state_dict(torch.load(f=MODEL_SAVE_PATH))
model_1 = model_1.to(device)

#train_dataloader, test_dataloader = train_dataloader.to(device), test_dataloader.to(devi
ce)

loss_fn = nn.CrossEntropyLoss()
optimizer = optim.SGD(model_1.parameters(), lr=0.003, momentum=0.9)
exp_lr = lr_scheduler.StepLR(optimizer, step_size=7, gamma=0.1)
#loaded_model = models.resnet18(weights=models.ResNet18_Weights.IMAGENET1K_V1)
#loaded_model.fc = nn.Linear(num_features, len(class_names))
#loaded_model.load_state_dict(torch.load(f=MODEL_SAVE_PATH))

EPOCHS = 10

best_acc = 0.0
train_losses = []
train_accs = []
test_losses = []
test_accs = []
#test_loss = test_step(model=loaded_model,
#                      dataloader=test_dataloader,
#                      loss_fn=loss_fn)


for epoch in range(EPOCHS):
    train_loss, train_acc = train_step(model=model_1,
               dataloader=train_dataloader,
               loss_fn=loss_fn,
               optimizer=optimizer)
    test_loss, test_acc = test_step(model=model_1,
              dataloader=test_dataloader,
              loss_fn=loss_fn)
        # Store metrics for visualization
    train_losses.append(train_loss)
    train_accs.append(train_acc)
    test_losses.append(test_loss)
    test_accs.append(test_acc)

    # Optional: Print progress for each epoch
    print(f"Epoch: {epoch+1}/{EPOCHS} | ", end="")
    print(f"Train Loss: {train_loss:.4f} | Train Acc: {train_acc:.4f} | ", end="")
    print(f"Test Loss: {test_loss:.4f} | Test Acc: {test_acc:.4f}")

    # Save the best model based on test accuracy
    if test_acc > best_acc:
        best_acc = test_acc
        torch.save(model_1.state_dict(), MODEL_SAVE_PATH)
```

```
/kaggle/input/100-bird-species/test /kaggle/input/100-bird-species/train /kaggle/input/10
0-bird-species/valid
/kaggle/input/100-bird-species/train/CRESTED OROPENDOLA/002.jpg
CRESTED OROPENDOLA
(224, 224, 3)
['ABBOTTS BABBLER', 'ABBOTTS BOOBY', 'ABYSSINIAN GROUND HORNBILL', 'AFRICAN CROWNED CRANE
', 'AFRICAN EMERALD CUCKOO', 'AFRICAN FIREFINCH', 'AFRICAN OYSTER CATCHER', 'AFRICAN PIED
HORNBILL', 'AFRICAN PYGMY GOOSE', 'ALBATROSS', 'ALBERTS TOWHEE', 'ALEXANDRINE PARAKEET',
'ALPINE CHOUGH', 'ALTAMIRA YELLOWTHROAT', 'AMERICAN AVOCET', 'AMERICAN BITTERN', 'AMERICA
N COOT', 'AMERICAN DIPPER', 'AMERICAN FLAMINGO', 'AMERICAN GOLDFINCH', 'AMERICAN KESTREL'
, 'AMERICAN PIPIT', 'AMERICAN REDSTART', 'AMERICAN ROBIN', 'AMERICAN WIGEON', 'AMETHYST W
OODSTAR', 'ANDEAN GOOSE', 'ANDEAN LAPWING', 'ANDEAN SISKIN', 'ANHINGA', 'ANIANIAU', 'ANNA
```

S HUMMINGBIRD', 'ANTBIRD', 'ANTILLEAN EUPHONIA', 'APAPANE', 'APOSTLEBIRD', 'ARARIPE MANAK
IN', 'ASHY STORM PETREL', 'ASHY THRUSHBIRD', 'ASIAN CRESTED IBIS', 'ASIAN DOLLARD BIRD',
'ASIAN GREEN BEE EATER', 'ASIAN OPENBILL STORK', 'AUCKLAND SHAQ', 'AUSTRAL CANASTERO', 'A
USTRALASIAN FIGBIRD', 'AVADAVAT', 'AZARAS SPINETAIL', 'AZURE BREASTED PITTA', 'AZURE JAY'
, 'AZURE TANAGER', 'AZURE TIT', 'BAIKAL TEAL', 'BALD EAGLE', 'BALD IBIS', 'BALI STARLING'
, 'BALTIMORE ORIOLE', 'BANANAQUIT', 'BAND TAILED GUAN', 'BANDED BROADBILL', 'BANDED PITA'
, 'BANDED STILT', 'BAR-TAILED GODWIT', 'BARN OWL', 'BARN SWALLOW', 'BARRED PUFFBIRD', 'BA
RROWS GOLDENEYE', 'BAY-BREASTED WARBLER', 'BEARDED BARBET', 'BEARDED BELLBIRD', 'BEARDED
REEDLING', 'BELTED KINGFISHER', 'BIRD OF PARADISE', 'BLACK AND YELLOW BROADBILL', 'BLACK
BAZA', 'BLACK BREASTED PUFFBIRD', 'BLACK COCKATO', 'BLACK FACED SPOONBILL', 'BLACK FRANCO
LIN', 'BLACK HEADED CAIQUE', 'BLACK NECKED STILT', 'BLACK SKIMMER', 'BLACK SWAN', 'BLACK
TAIL CRAKE', 'BLACK THROATED BUSHTIT', 'BLACK THROATED HUET', 'BLACK THROATED WARBLER', '
BLACK VENTED SHEARWATER', 'BLACK VULTURE', 'BLACK-CAPPED CHICKADEE', 'BLACK-NECKED GREBE'
, 'BLACK-THROATED SPARROW', 'BLACKBURNIAM WARBLER', 'BLONDE CRESTED WOODPECKER', 'BLOOD P
HEASANT', 'BLUE COAU', 'BLUE DACNIS', 'BLUE GRAY GNATCATCHER', 'BLUE GROSBEAK', 'BLUE GRO
USE', 'BLUE HERON', 'BLUE MALKOHA', 'BLUE THROATED PIPING GUAN', 'BLUE THROATED TOUCANET'
, 'BOBOLINK', 'BORNEAN BRISTLEHEAD', 'BORNEAN LEAFBIRD', 'BORNEAN PHEASANT', 'BRANDT CORM
ARANT', 'BREWERS BLACKBIRD', 'BROWN CREPPER', 'BROWN HEADED COWBIRD', 'BROWN NOODY', 'BRO
WN THRASHER', 'BUFFLEHEAD', 'BULWERS PHEASANT', 'BURCHELLS COURSER', 'BUSH TURKEY', 'CAAT
INGA CACHOLOTE', 'CABOTS TRAGOPAN', 'CACTUS WREN', 'CALIFORNIA CONDOR', 'CALIFORNIA GULL'
, 'CALIFORNIA QUAIL', 'CAMPO FLICKER', 'CANARY', 'CANVASBACK', 'CAPE GLOSSY STARLING', 'C
APE LONGCLAW', 'CAPE MAY WARBLER', 'CAPE ROCK THRUSH', 'CAPPED HERON', 'CAPUCHINBIRD', 'C
ARMINE BEE-EATER', 'CASPIAN TERN', 'CASSOWARY', 'CEDAR WAXWING', 'CERULEAN WARBLER', 'CHA
RA DE COLLAR', 'CHATTERING LORY', 'CHESTNET BELLIED EUPHONIA', 'CHESTNUT WINGED CUCKOO',
'CHINESE BAMBOO PARTRIDGE', 'CHINESE POND HERON', 'CHIPPING SPARROW', 'CHUCAO TAPACULO',
'CHUKAR PARTRIDGE', 'CINNAMON ATTILA', 'CINNAMON FLYCATCHER', 'CINNAMON TEAL', 'CLARKS GR
EBE', 'CLARKS NUTCRACKER', 'COCK OF THE ROCK', 'COCKATOO', 'COLLARED ARACARI', 'COLLARED
CRESCENTCHEST', 'COMMON FIRECREST', 'COMMON GRACKLE', 'COMMON HOUSE MARTIN', 'COMMON IORA
', 'COMMON LOON', 'COMMON POORWILL', 'COMMON STARLING', 'COPPERSMITH BARBET', 'COPPERY TA
ILED COUCAL', 'CRAB PLOVER', 'CRANE HAWK', 'CREAM COLORED WOODPECKER', 'CRESTED AUKLET',
'CRESTED CARACARA', 'CRESTED COUA', 'CRESTED FIREBACK', 'CRESTED KINGFISHER', 'CRESTED NU
THATCH', 'CRESTED OROPENDOLA', 'CRESTED SERPENT EAGLE', 'CRESTED SHRIKETIT', 'CRESTED WOO
D PARTRIDGE', 'CRIMSON CHAT', 'CRIMSON SUNBIRD', 'CROW', 'CUBAN TODY', 'CUBAN TROGON', 'C
URL CRESTED ARACURI', 'D-ARNAUDS BARBET', 'DALMATIAN PELICAN', 'DARJEELING WOODPECKER', '
DARK EYED JUNCO', 'DAURIAN REDSTART', 'DEMOISELLE CRANE', 'DOUBLE BARRED FINCH', 'DOUBLE
BRESTED CORMARANT', 'DOUBLE EYED FIG PARROT', 'DOWNY WOODPECKER', 'DUNLIN', 'DUSKY LORY',
'DUSKY ROBIN', 'EARED PITA', 'EASTERN BLUEBIRD', 'EASTERN BLUEBONNET', 'EASTERN GOLDEN WE
AVER', 'EASTERN MEADOWLARK', 'EASTERN ROSELLA', 'EASTERN TOWEE', 'EASTERN WIP POOR WILL',
'EASTERN YELLOW ROBIN', 'ECUADORIAN HILLSTAR', 'EGYPTIAN GOOSE', 'ELEGANT TROGON', 'ELLIO
TS PHEASANT', 'EMERALD TANAGER', 'EMPEROR PENGUIN', 'EMU', 'ENGGANO MYNA', 'EURASIAN BUL
LFINCH', 'EURASIAN GOLDEN ORIOLE', 'EURASIAN MAGPIE', 'EUROPEAN GOLDFINCH', 'EUROPEAN TUR
TLE DOVE', 'EVENING GROSBEAK', 'FAIRY BLUEBIRD', 'FAIRY PENGUIN', 'FAIRY TERN', 'FAN TAIL
ED WIDOW', 'FASCIATED WREN', 'FIERY MINIVET', 'FIORDLAND PENGUIN', 'FIRE TAILLED MYZORNIS
', 'FLAME BOWERBIRD', 'FLAME TANAGER', 'FOREST WAGTAIL', 'FRIGATE', 'FRILL BACK PIGEON',
'GAMBELS QUAIL', 'GANG GANG COCKATOO', 'GILA WOODPECKER', 'GILDED FLICKER', 'GLOSSY IBIS'
, 'GO AWAY BIRD', 'GOLD WING WARBLER', 'GOLDEN BOWER BIRD', 'GOLDEN CHEEKED WARBLER', 'GO
LDEN CHLOROPHONIA', 'GOLDEN EAGLE', 'GOLDEN PARAKEET', 'GOLDEN PHEASANT', 'GOLDEN PIPIT',
'GOULDIAN FINCH', 'GRANDALA', 'GRAY CATBIRD', 'GRAY KINGBIRD', 'GRAY PARTRIDGE', 'GREAT A
RGUS', 'GREAT GRAY OWL', 'GREAT JACAMAR', 'GREAT KISKADEE', 'GREAT POTOO', 'GREAT TINAMOU
', 'GREAT XENOPS', 'GREATER PEWEE', 'GREATER PRAIRIE CHICKEN', 'GREATOR SAGE GROUSE', 'GR
EEN BROADBILL', 'GREEN JAY', 'GREEN MAGPIE', 'GREEN WINGED DOVE', 'GREY CUCKOOSHRIKE', 'G
REY HEADED CHACHALACA', 'GREY HEADED FISH EAGLE', 'GREY PLOVER', 'GROVED BILLED ANI', 'GU
INEA TURACO', 'GUINEAFOWL', 'GURNEYS PITTA', 'GYRFALCON', 'HAMERKOP', 'HARLEQUIN DUCK', '
HARLEQUIN QUAIL', 'HARPY EAGLE', 'HAWAIIAN GOOSE', 'HAWFINCH', 'HELMET VANGA', 'HEPATIC T
ANAGER', 'HIMALAYAN BLUETAIL', 'HIMALAYAN MONAL', 'HOATZIN', 'HOODED MERGANSER', 'HOOPOES
', 'HORNED GUAN', 'HORNED LARK', 'HORNED SUNGEM', 'HOUSE FINCH', 'HOUSE SPARROW', 'HYACIN
TH MACAW', 'IBERIAN MAGPIE', 'IBISBILL', 'IMPERIAL SHAQ', 'INCA TERN', 'INDIAN BUSTARD',
'INDIAN PITTA', 'INDIAN ROLLER', 'INDIAN VULTURE', 'INDIGO BUNTING', 'INDIGO FLYCATCHER',
'INLAND DOTTEREL', 'IVORY BILLED ARACARI', 'IVORY GULL', 'IWI', 'JABIRU', 'JACK SNIPE', '
JACOBIN PIGEON', 'JANDAYA PARAKEET', 'JAPANESE ROBIN', 'JAVA SPARROW', 'JOCOTOCO ANTPITTA
', 'KAGU', 'KAKAPO', 'KILLDEAR', 'KING EIDER', 'KING VULTURE', 'KIWI', 'KNOB BILLED DUCK'
, 'KOOKABURRA', 'LARK BUNTING', 'LAUGHING GULL', 'LAZULI BUNTING', 'LESSER ADJUTANT', 'LI
LAC ROLLER', 'LIMPKIN', 'LITTLE AUK', 'LOGGERHEAD SHRIKE', 'LONG-EARED OWL', 'LOONEY BIRD
S', 'LUCIFER HUMMINGBIRD', 'MAGPIE GOOSE', 'MALABAR HORNBILL', 'MALACHITE KINGFISHER', 'M
ALAGASY WHITE EYE', 'MALEO', 'MALLARD DUCK', 'MANDRIN DUCK', 'MANGROVE CUCKOO', 'MARABOU
STORK', 'MASKED BOBWHITE', 'MASKED BOOBY', 'MASKED LAPWING', 'MCKAYS BUNTING', 'MERLIN',
'MIKADO PHEASANT', 'MILITARY MACAW', 'MOURNING DOVE', 'MYNA', 'NICOBAR PIGEON', 'NOISY F
RIARBIRD', 'NORTHERN BEARDLESS TYRANNULET', 'NORTHERN CARDINAL', 'NORTHERN FLICKER', 'NOR
THERN FULMAR', 'NORTHERN GANNET', 'NORTHERN GOSHAWK', 'NORTHERN JACANA', 'NORTHERN MOCKIN
GBIRD', 'NORTHERN PARULA', 'NORTHERN RED BISHOP', 'NORTHERN SHOVELER', 'OCELLATED TURKEY'
, 'OILBIRD', 'OKINAWA RAIL', 'ORANGE BREASTED TROGON', 'ORANGE BRESTED BUNTING', 'ORIENTA
L BAY OWL', 'ORNATE HAWK EAGLE', 'OSPREY', 'OSTRICH', 'OVENBIRD', 'OYSTER CATCHER', 'PAIN

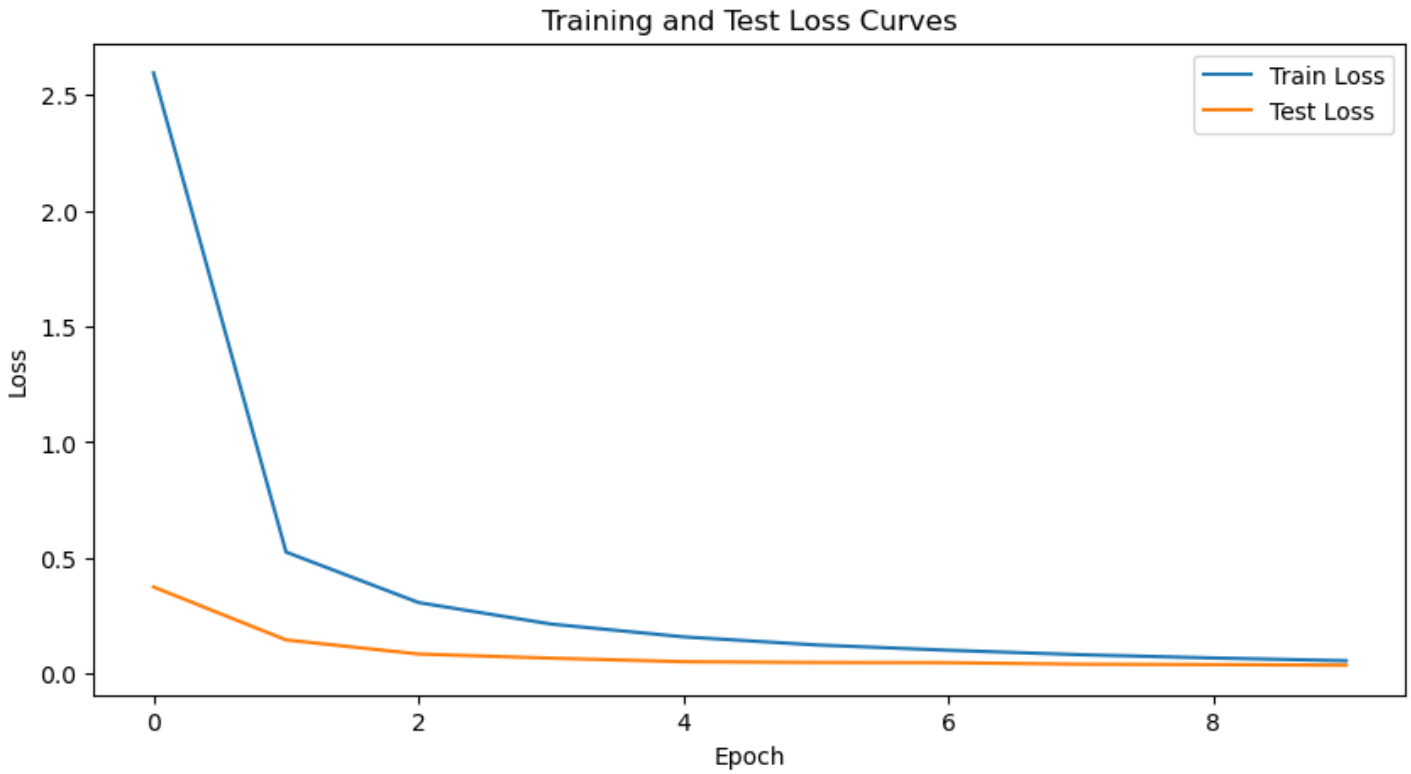
```
TED BUNTING', 'PALILA', 'PALM NUT VULTURE', 'PARADISE TANAGER', 'PARAKETT  AUKLET', 'PARU
S MAJOR', 'PATAGONIAN SIERRA FINCH', 'PEACOCK', 'PEREGRINE FALCON', 'PHAINOPEPLA', 'PHILI
PPINE EAGLE', 'PINK ROBIN', 'PLUSH CRESTED JAY', 'POMARINE JAEGER', 'PUFFIN', 'PUNA TEAL'
, 'PURPLE FINCH', 'PURPLE GALLINULE', 'PURPLE MARTIN', 'PURPLE SWAMPHEN', 'PYGMY KINGFISH
ER', 'PYRRHULOXIA', 'QUETZAL', 'RAINBOW LORIKEET', 'RAZORBILL', 'RED BEARDED BEE EATER',
'RED BELLIED PITTA', 'RED BILLED TROPICBIRD', 'RED BROWED FINCH', 'RED CROSSBILL', 'RED F
ACED CORMORANT', 'RED FACED WARBLER', 'RED FODY', 'RED HEADED DUCK', 'RED HEADED WOODPECK
ER', 'RED KNOT', 'RED LEGGED HONEYCREEPER', 'RED NAPED TROGON', 'RED SHOULDERED HAWK', 'R
ED TAILED HAWK', 'RED TAILED THRUSH', 'RED WINGED BLACKBIRD', 'RED WISKERED BULBUL', 'REG
ENT BOWERBIRD', 'RING-NECKED PHEASANT', 'ROADRUNNER', 'ROCK DOVE', 'ROSE BREASTED COCKATO
O', 'ROSE BREASTED GROSBEAK', 'ROSEATE SPOONBILL', 'ROSY FACED LOVEBIRD', 'ROUGH LEG BUZZ
ARD', 'ROYAL FLYCATCHER', 'RUBY CROWNED KINGLET', 'RUBY THROATED HUMMINGBIRD', 'RUDDY SHE
LDUCK', 'RUDY KINGFISHER', 'RUFOUS KINGFISHER', 'RUFOUS TREPE', 'RUFUOS MOTMOT', 'SAMATRA
N THRUSH', 'SAND MARTIN', 'SANDHILL CRANE', 'SATYR TRAGOPAN', 'SAYS PHOEBE', 'SCARLET CRO
WNED FRUIT DOVE', 'SCARLET FACED LIOCICHLA', 'SCARLET IBIS', 'SCARLET MACAW', 'SCARLET TA
NAGER', 'SHOEBILL', 'SHORT BILLED DOWITCHER', 'SMITHS LONGSPUR', 'SNOW GOOSE', 'SNOW PART
RIDGE', 'SNOWY EGRET', 'SNOWY OWL', 'SNOWY PLOVER', 'SNOWY SHEATHBILL', 'SORA', 'SPANGLED
COTINGA', 'SPLENDID WREN', 'SPOON BILED SANDPIPER', 'SPOTTED CATBIRD', 'SPOTTED WHISTLING
DUCK', 'SQUACCO HERON', 'SRI LANKA BLUE MAGPIE', 'STEAMER DUCK', 'STORK BILLED KINGFISHER
', 'STRIATED CARACARA', 'STRIPED OWL', 'STRIPPED MANAKIN', 'STRIPPED SWALLOW', 'SUNBITTER
N', 'SUPERB STARLING', 'SURF SCOTER', 'SWINHOES PHEASANT', 'TAILORBIRD', 'TAIWAN MAGPIE',
'TAKAHE', 'TASMANIAN HEN', 'TAWNY FROGMOUTH', 'TEAL DUCK', 'TIT MOUSE', 'TOUCHAN', 'TOWNS
ENDS WARBLER', 'TREE SWALLOW', 'TRICOLORED BLACKBIRD', 'TROPICAL KINGBIRD', 'TRUMPTER SWA
N', 'TURKEY VULTURE', 'TURQUOISE MOTMOT', 'UMBRELLA BIRD', 'VARIED THRUSH', 'VEERY', 'VEN
EZUELIAN TROUPIAL', 'VERDIN', 'VERMILION FLYCATHER', 'VICTORIA CROWNED PIGEON', 'VIOLET B
ACKED STARLING', 'VIOLET CUCKOO', 'VIOLET GREEN SWALLOW', 'VIOLET TURACO', 'VISAYAN HORNB
ILL', 'VULTURINE GUINEAFOWL', 'WALL CREAPER', 'WATTLED CURASSOW', 'WATTLED LAPWING', 'WHI
MBREL', 'WHITE BREASTED WATERHEN', 'WHITE BROWED CRAKE', 'WHITE CHEEKED TURACO', 'WHITE C
RESTED HORNBILL', 'WHITE EARED HUMMINGBIRD', 'WHITE NECKED RAVEN', 'WHITE TAILED TROPIC',
'WHITE THROATED BEE EATER', 'WILD TURKEY', 'WILLOW PTARMIGAN', 'WILSONS BIRD OF PARADISE'
, 'WOOD DUCK', 'WOOD THRUSH', 'WOODLAND KINGFISHER', 'WRENTIT', 'YELLOW BELLIED FLOWERPEC
KER', 'YELLOW BREASTED CHAT', 'YELLOW CACIQUE', 'YELLOW HEADED BLACKBIRD', 'ZEBRA DOVE']
84635 2625 2625
torch.Size([3, 224, 224]) 0
torch.Size([32, 3, 224, 224])
Epoch: 1/10 | Train Loss: 2.5959 | Train Acc: 0.5710 | Test Loss: 0.3743 | Test Acc: 0.93
71
Epoch: 2/10 | Train Loss: 0.5251 | Train Acc: 0.8937 | Test Loss: 0.1454 | Test Acc: 0.97
89
Epoch: 3/10 | Train Loss: 0.3069 | Train Acc: 0.9343 | Test Loss: 0.0845 | Test Acc: 0.98
42
Epoch: 4/10 | Train Loss: 0.2140 | Train Acc: 0.9542 | Test Loss: 0.0665 | Test Acc: 0.98
87
Epoch: 5/10 | Train Loss: 0.1586 | Train Acc: 0.9663 | Test Loss: 0.0513 | Test Acc: 0.98
98
Epoch: 6/10 | Train Loss: 0.1238 | Train Acc: 0.9739 | Test Loss: 0.0479 | Test Acc: 0.99
06
Epoch: 7/10 | Train Loss: 0.1007 | Train Acc: 0.9795 | Test Loss: 0.0470 | Test Acc: 0.99
13
Epoch: 8/10 | Train Loss: 0.0814 | Train Acc: 0.9837 | Test Loss: 0.0405 | Test Acc: 0.99
13
Epoch: 9/10 | Train Loss: 0.0673 | Train Acc: 0.9869 | Test Loss: 0.0387 | Test Acc: 0.99
10
Epoch: 10/10 | Train Loss: 0.0555 | Train Acc: 0.9896 | Test Loss: 0.0361 | Test Acc: 0.9
910
```

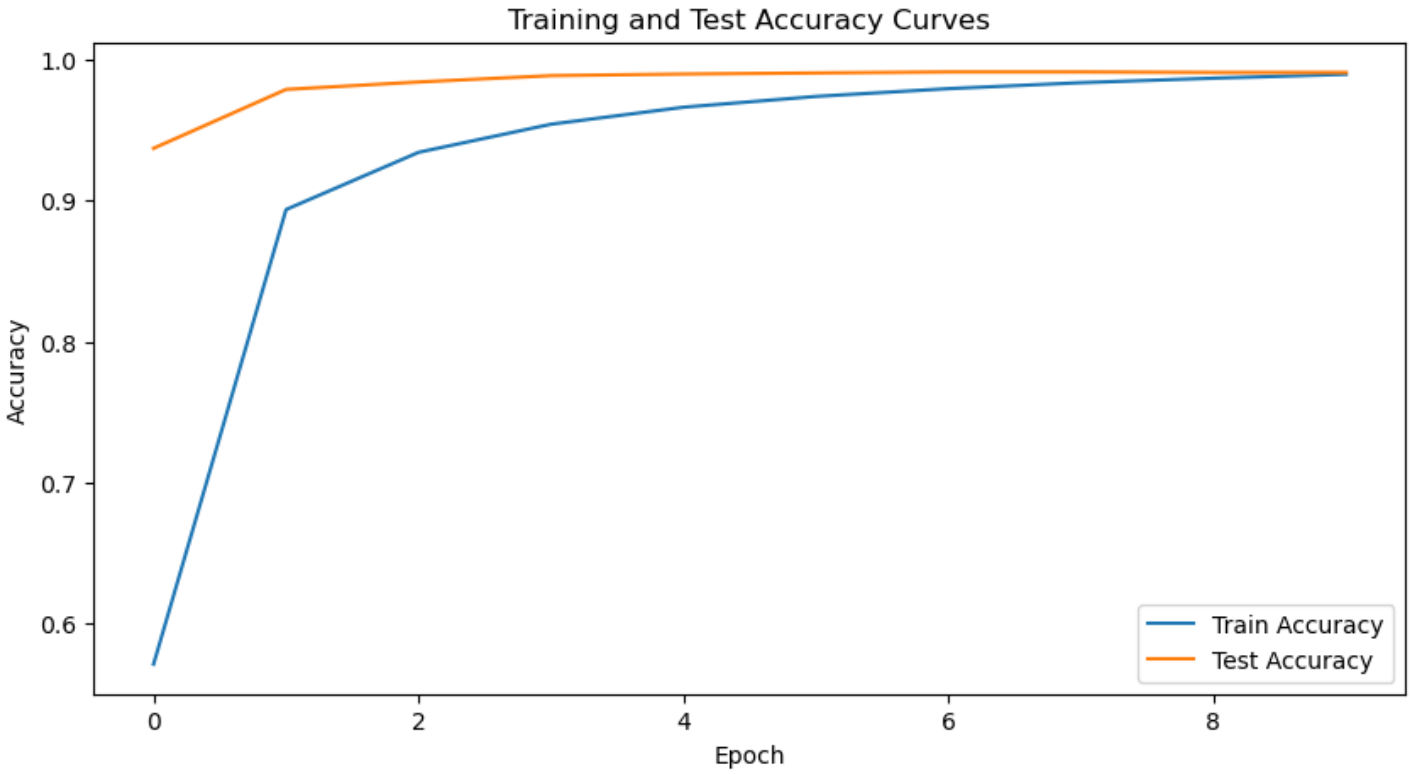
In [18]:

```
# 1. Loss Curves
plt.figure(figsize=(10, 5))
plt.plot(train_losses, label="Train Loss")
plt.plot(test_losses, label="Test Loss")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Training and Test Loss Curves")
plt.legend()
plt.show()

# 2. Accuracy Curves
plt.figure(figsize=(10, 5))
plt.plot(train_accs, label="Train Accuracy")
plt.plot(test_accs, label="Test Accuracy")
```

```
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Training and Test Accuracy Curves")
plt.legend()
plt.show()
```





In [19]:

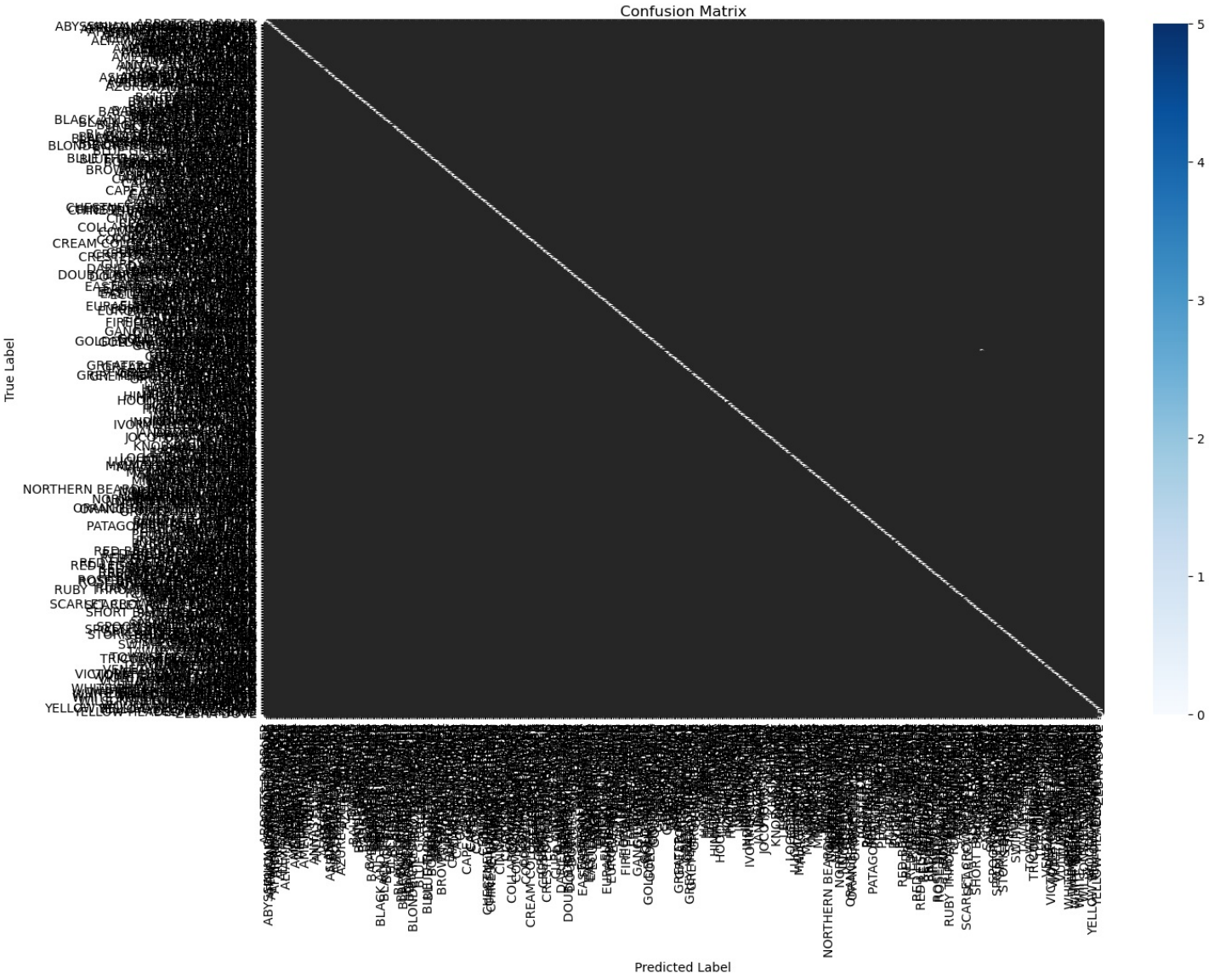
```
from sklearn.metrics import confusion_matrix
import seaborn as sns

# Get predictions for the test data
y_pred = []
y_true = []
with torch.no_grad():
    for (X, y) in test_dataloader:
        X = X.to(device)
        logits = model_1(X)
        pred = torch.argmax(logits, dim=1)
```

```
        y_pred.extend(pred.cpu().numpy())
        y_true.extend(y.cpu().numpy())

# Calculate confusion matrix
cm = confusion_matrix(y_true, y_pred)

# Plot using seaborn
plt.figure(figsize=(15, 10))  # Adjust size as needed
sns.heatmap(cm, annot=True, fmt="d", cmap="Blues", xticklabels=class_names, yticklabels=
class_names)
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.title("Confusion Matrix")
plt.show()
```



In [20]:

```
from sklearn.metrics import classification_report

# Generate classification report
report = classification_report(y_true, y_pred, target_names=class_names)
print(report)
```

```
                              precision    recall  f1-score   support

                ABBOTTS BABBLER       1.00      1.00      1.00         5
                  ABBOTTS BOOBY       1.00      1.00      1.00         5
   ABYSSINIAN GROUND HORNBILL       1.00      1.00      1.00         5
        AFRICAN CROWNED CRANE       1.00      1.00      1.00         5
      AFRICAN EMERALD CUCKOO       1.00      1.00      1.00         5
           AFRICAN FIREFINCH       1.00      1.00      1.00         5
      AFRICAN OYSTER CATCHER       1.00      1.00      1.00         5
       AFRICAN PIED HORNBILL       1.00      1.00      1.00         5
          AFRICAN PYGMY GOOSE       1.00      1.00      1.00         5
```

AFRICAN FIGHT GOOSE	1.00	1.00	1.00	5
ALBATROSS	1.00	1.00	1.00	5
ALBERTS TOWHEE	1.00	1.00	1.00	5
ALEXANDRINE PARAKEET	1.00	1.00	1.00	5
ALPINE CHOUGH	0.83	1.00	0.91	5
ALTAMIRA YELLOWTHROAT	1.00	1.00	1.00	5
AMERICAN AVOCET	1.00	1.00	1.00	5
AMERICAN BITTERN	1.00	1.00	1.00	5
AMERICAN COOT	1.00	1.00	1.00	5
AMERICAN DIPPER	1.00	1.00	1.00	5
AMERICAN FLAMINGO	1.00	1.00	1.00	5
AMERICAN GOLDFINCH	1.00	1.00	1.00	5
AMERICAN KESTREL	1.00	1.00	1.00	5
AMERICAN PIPIT	0.83	1.00	0.91	5
AMERICAN REDSTART	1.00	1.00	1.00	5
AMERICAN ROBIN	1.00	1.00	1.00	5
AMERICAN WIGEON	0.83	1.00	0.91	5
AMETHYST WOODSTAR	0.83	1.00	0.91	5
ANDEAN GOOSE	1.00	1.00	1.00	5
ANDEAN LAPWING	1.00	1.00	1.00	5
ANDEAN SISKIN	1.00	1.00	1.00	5
ANHINGA	1.00	1.00	1.00	5
ANIANIAU	1.00	0.80	0.89	5
ANNAS HUMMINGBIRD	1.00	1.00	1.00	5
ANTBIRD	1.00	1.00	1.00	5
ANTILLEAN EUPHONIA	1.00	1.00	1.00	5
APAPANE	1.00	1.00	1.00	5
APOSTLEBIRD	1.00	1.00	1.00	5
ARARIPE MANAKIN	1.00	1.00	1.00	5
ASHY STORM PETREL	1.00	0.80	0.89	5
ASHY THRUSHBIRD	0.83	1.00	0.91	5
ASIAN CRESTED IBIS	1.00	1.00	1.00	5
ASIAN DOLLARD BIRD	1.00	1.00	1.00	5
ASIAN GREEN BEE EATER	1.00	1.00	1.00	5
ASIAN OPENBILL STORK	1.00	1.00	1.00	5
AUCKLAND SHAQ	1.00	1.00	1.00	5
AUSTRAL CANASTERO	1.00	0.60	0.75	5
AUSTRALASIAN FIGBIRD	1.00	1.00	1.00	5
AVADAVAT	1.00	1.00	1.00	5
AZARAS SPINETAIL	0.83	1.00	0.91	5
AZURE BREASTED PITTA	1.00	1.00	1.00	5
AZURE JAY	1.00	1.00	1.00	5
AZURE TANAGER	1.00	1.00	1.00	5
AZURE TIT	1.00	1.00	1.00	5
BAIKAL TEAL	0.83	1.00	0.91	5
BALD EAGLE	1.00	1.00	1.00	5
BALD IBIS	1.00	1.00	1.00	5
BALI STARLING	1.00	1.00	1.00	5
BALTIMORE ORIOLE	1.00	1.00	1.00	5
BANANAQUIT	1.00	1.00	1.00	5
BAND TAILED GUAN	1.00	1.00	1.00	5
BANDED BROADBILL	1.00	1.00	1.00	5
BANDED PITA	1.00	1.00	1.00	5
BANDED STILT	0.83	1.00	0.91	5
BAR-TAILED GODWIT	1.00	1.00	1.00	5
BARN OWL	1.00	1.00	1.00	5
BARN SWALLOW	1.00	1.00	1.00	5
BARRED PUFFBIRD	1.00	1.00	1.00	5
BARROWS GOLDENEYE	1.00	1.00	1.00	5
BAY-BREASTED WARBLER	1.00	1.00	1.00	5
BEARDED BARBET	1.00	1.00	1.00	5
BEARDED BELLBIRD	1.00	1.00	1.00	5
BEARDED REEDLING	1.00	1.00	1.00	5
BELTED KINGFISHER	1.00	1.00	1.00	5
BIRD OF PARADISE	1.00	1.00	1.00	5
BLACK AND YELLOW BROADBILL	1.00	1.00	1.00	5
BLACK BAZA	1.00	1.00	1.00	5
BLACK BREASTED PUFFBIRD	1.00	1.00	1.00	5
BLACK COCKATO	1.00	1.00	1.00	5
BLACK FACED SPOONBILL	1.00	1.00	1.00	5
BLACK FRANCOLIN	1.00	1.00	1.00	5
BLACK HEADED CAIQUE	1.00	1.00	1.00	5
BLACK NECKED STILT	1.00	0.80	0.89	5

BLACK NECKED STILT	1.00	0.00	0.00	5
BLACK SKIMMER	1.00	1.00	1.00	5
BLACK SWAN	1.00	1.00	1.00	5
BLACK TAIL CRAKE	1.00	1.00	1.00	5
BLACK THROATED BUSHTIT	1.00	1.00	1.00	5
BLACK THROATED HUET	1.00	1.00	1.00	5
BLACK THROATED WARBLER	1.00	1.00	1.00	5
BLACK VENTED SHEARWATER	1.00	1.00	1.00	5
BLACK VULTURE	1.00	1.00	1.00	5
BLACK-CAPPED CHICKADEE	1.00	1.00	1.00	5
BLACK-NECKED GREBE	1.00	1.00	1.00	5
BLACK-THROATED SPARROW	1.00	1.00	1.00	5
BLACKBURNIAM WARBLER	1.00	1.00	1.00	5
BLONDE CRESTED WOODPECKER	1.00	1.00	1.00	5
BLOOD PHEASANT	1.00	1.00	1.00	5
BLUE COAU	1.00	1.00	1.00	5
BLUE DACNIS	1.00	1.00	1.00	5
BLUE GRAY GNATCATCHER	1.00	1.00	1.00	5
BLUE GROSBEAK	1.00	1.00	1.00	5
BLUE GROUSE	1.00	1.00	1.00	5
BLUE HERON	1.00	1.00	1.00	5
BLUE MALKOHA	1.00	1.00	1.00	5
BLUE THROATED PIPING GUAN	1.00	1.00	1.00	5
BLUE THROATED TOUCANET	1.00	1.00	1.00	5
BOBOLINK	1.00	1.00	1.00	5
BORNEAN BRISTLEHEAD	1.00	1.00	1.00	5
BORNEAN LEAFBIRD	1.00	1.00	1.00	5
BORNEAN PHEASANT	1.00	1.00	1.00	5
BRANDT CORMARANT	1.00	1.00	1.00	5
BREWERS BLACKBIRD	1.00	1.00	1.00	5
BROWN CREPPER	1.00	1.00	1.00	5
BROWN HEADED COWBIRD	1.00	1.00	1.00	5
BROWN NOODY	1.00	1.00	1.00	5
BROWN THRASHER	1.00	1.00	1.00	5
BUFFLEHEAD	1.00	1.00	1.00	5
BULWERS PHEASANT	1.00	1.00	1.00	5
BURCHELLS COURSER	1.00	1.00	1.00	5
BUSH TURKEY	1.00	1.00	1.00	5
CAATINGA CACHOLOTE	1.00	1.00	1.00	5
CABOTS TRAGOPAN	0.83	1.00	0.91	5
CACTUS WREN	1.00	1.00	1.00	5
CALIFORNIA CONDOR	1.00	1.00	1.00	5
CALIFORNIA GULL	1.00	1.00	1.00	5
CALIFORNIA QUAIL	1.00	1.00	1.00	5
CAMPO FLICKER	1.00	1.00	1.00	5
CANARY	1.00	1.00	1.00	5
CANVASBACK	1.00	1.00	1.00	5
CAPE GLOSSY STARLING	1.00	1.00	1.00	5
CAPE LONGCLAW	1.00	1.00	1.00	5
CAPE MAY WARBLER	1.00	1.00	1.00	5
CAPE ROCK THRUSH	1.00	1.00	1.00	5
CAPPED HERON	1.00	1.00	1.00	5
CAPUCHINBIRD	1.00	1.00	1.00	5
CARMINE BEE-EATER	1.00	1.00	1.00	5
CASPIAN TERN	1.00	1.00	1.00	5
CASSOWARY	1.00	1.00	1.00	5
CEDAR WAXWING	1.00	1.00	1.00	5
CERULEAN WARBLER	1.00	1.00	1.00	5
CHARA DE COLLAR	1.00	1.00	1.00	5
CHATTERING LORY	1.00	1.00	1.00	5
CHESTNET BELLIED EUPHONIA	1.00	1.00	1.00	5
CHESTNUT WINGED CUCKOO	1.00	1.00	1.00	5
CHINESE BAMBOO PARTRIDGE	1.00	1.00	1.00	5
CHINESE POND HERON	1.00	1.00	1.00	5
CHIPPING SPARROW	1.00	1.00	1.00	5
CHUCAO TAPACULO	1.00	1.00	1.00	5
CHUKAR PARTRIDGE	1.00	1.00	1.00	5
CINNAMON ATTILA	1.00	1.00	1.00	5
CINNAMON FLYCATCHER	1.00	1.00	1.00	5
CINNAMON TEAL	1.00	1.00	1.00	5
CLARKS GREBE	1.00	1.00	1.00	5
CLARKS NUTCRACKER	1.00	1.00	1.00	5
COCK OF THE ROCK	1.00	1.00	1.00	5

COCK OF THE ROCK	1.00	1.00	1.00	5
COCKATOO	1.00	1.00	1.00	5
COLLARED ARACARI	1.00	1.00	1.00	5
COLLARED CRESCENTCHEST	1.00	1.00	1.00	5
COMMON FIRECREST	1.00	1.00	1.00	5
COMMON GRACKLE	1.00	1.00	1.00	5
COMMON HOUSE MARTIN	1.00	1.00	1.00	5
COMMON IORA	1.00	1.00	1.00	5
COMMON LOON	1.00	1.00	1.00	5
COMMON POORWILL	1.00	1.00	1.00	5
COMMON STARLING	1.00	1.00	1.00	5
COPPERSMITH BARBET	1.00	1.00	1.00	5
COPPERY TAILED COUCAL	1.00	1.00	1.00	5
CRAB PLOVER	1.00	1.00	1.00	5
CRANE HAWK	1.00	1.00	1.00	5
CREAM COLORED WOODPECKER	1.00	1.00	1.00	5
CRESTED AUKLET	1.00	1.00	1.00	5
CRESTED CARACARA	1.00	1.00	1.00	5
CRESTED COUA	1.00	1.00	1.00	5
CRESTED FIREBACK	1.00	1.00	1.00	5
CRESTED KINGFISHER	1.00	1.00	1.00	5
CRESTED NUTHATCH	1.00	1.00	1.00	5
CRESTED OROPENDOLA	1.00	1.00	1.00	5
CRESTED SERPENT EAGLE	1.00	1.00	1.00	5
CRESTED SHRIKETIT	1.00	1.00	1.00	5
CRESTED WOOD PARTRIDGE	1.00	1.00	1.00	5
CRIMSON CHAT	1.00	1.00	1.00	5
CRIMSON SUNBIRD	1.00	1.00	1.00	5
CROW	1.00	1.00	1.00	5
CUBAN TODY	1.00	1.00	1.00	5
CUBAN TROGON	1.00	1.00	1.00	5
CURL CRESTED ARACURI	1.00	1.00	1.00	5
D-ARNAUDS BARBET	1.00	1.00	1.00	5
DALMATIAN PELICAN	1.00	1.00	1.00	5
DARJEELING WOODPECKER	1.00	1.00	1.00	5
DARK EYED JUNCO	1.00	1.00	1.00	5
DAURIAN REDSTART	1.00	1.00	1.00	5
DEMOISELLE CRANE	1.00	1.00	1.00	5
DOUBLE BARRED FINCH	1.00	1.00	1.00	5
DOUBLE BRESTED CORMARANT	1.00	1.00	1.00	5
DOUBLE EYED FIG PARROT	1.00	1.00	1.00	5
DOWNY WOODPECKER	1.00	1.00	1.00	5
DUNLIN	1.00	1.00	1.00	5
DUSKY LORY	1.00	1.00	1.00	5
DUSKY ROBIN	1.00	1.00	1.00	5
EARED PITA	1.00	1.00	1.00	5
EASTERN BLUEBIRD	1.00	1.00	1.00	5
EASTERN BLUEBONNET	1.00	1.00	1.00	5
EASTERN GOLDEN WEAVER	1.00	1.00	1.00	5
EASTERN MEADOWLARK	1.00	1.00	1.00	5
EASTERN ROSELLA	1.00	1.00	1.00	5
EASTERN TOWEE	1.00	1.00	1.00	5
EASTERN WIP POOR WILL	1.00	1.00	1.00	5
EASTERN YELLOW ROBIN	1.00	1.00	1.00	5
ECUADORIAN HILLSTAR	1.00	1.00	1.00	5
EGYPTIAN GOOSE	1.00	1.00	1.00	5
ELEGANT TROGON	1.00	1.00	1.00	5
ELLIOTS PHEASANT	1.00	1.00	1.00	5
EMERALD TANAGER	1.00	1.00	1.00	5
EMPEROR PENGUIN	1.00	1.00	1.00	5
EMU	1.00	1.00	1.00	5
ENGGANO MYNA	1.00	1.00	1.00	5
EURASIAN BULLFINCH	1.00	1.00	1.00	5
EURASIAN GOLDEN ORIOLE	1.00	1.00	1.00	5
EURASIAN MAGPIE	1.00	1.00	1.00	5
EUROPEAN GOLDFINCH	1.00	1.00	1.00	5
EUROPEAN TURTLE DOVE	1.00	1.00	1.00	5
EVENING GROSBEAK	1.00	1.00	1.00	5
FAIRY BLUEBIRD	1.00	1.00	1.00	5
FAIRY PENGUIN	1.00	1.00	1.00	5
FAIRY TERN	1.00	1.00	1.00	5
FAN TAILED WIDOW	1.00	1.00	1.00	5
FASCIATED WREN	1.00	1.00	1.00	5

FIERY MINIVET	1.00	1.00	1.00	5
FIORDLAND PENGUIN	1.00	1.00	1.00	5
FIRE TAILLED MYZORNIS	1.00	1.00	1.00	5
FLAME BOWERBIRD	1.00	1.00	1.00	5
FLAME TANAGER	1.00	1.00	1.00	5
FOREST WAGTAIL	1.00	1.00	1.00	5
FRIGATE	1.00	1.00	1.00	5
FRILL BACK PIGEON	1.00	1.00	1.00	5
GAMBELS QUAIL	1.00	1.00	1.00	5
GANG GANG COCKATOO	1.00	1.00	1.00	5
GILA WOODPECKER	1.00	1.00	1.00	5
GILDED FLICKER	1.00	1.00	1.00	5
GLOSSY IBIS	1.00	1.00	1.00	5
GO AWAY BIRD	0.83	1.00	0.91	5
GOLD WING WARBLER	1.00	1.00	1.00	5
GOLDEN BOWER BIRD	1.00	1.00	1.00	5
GOLDEN CHEEKED WARBLER	1.00	1.00	1.00	5
GOLDEN CHLOROPHONIA	1.00	1.00	1.00	5
GOLDEN EAGLE	1.00	1.00	1.00	5
GOLDEN PARAKEET	1.00	1.00	1.00	5
GOLDEN PHEASANT	1.00	1.00	1.00	5
GOLDEN PIPIT	1.00	1.00	1.00	5
GOULDIAN FINCH	1.00	1.00	1.00	5
GRANDALA	1.00	1.00	1.00	5
GRAY CATBIRD	1.00	1.00	1.00	5
GRAY KINGBIRD	1.00	1.00	1.00	5
GRAY PARTRIDGE	1.00	0.40	0.57	5
GREAT ARGUS	1.00	1.00	1.00	5
GREAT GRAY OWL	1.00	1.00	1.00	5
GREAT JACAMAR	1.00	1.00	1.00	5
GREAT KISKADEE	1.00	1.00	1.00	5
GREAT POTOO	1.00	1.00	1.00	5
GREAT TINAMOU	1.00	1.00	1.00	5
GREAT XENOPS	0.83	1.00	0.91	5
GREATER PEWEE	1.00	1.00	1.00	5
GREATER PRAIRIE CHICKEN	1.00	1.00	1.00	5
GREATOR SAGE GROUSE	1.00	1.00	1.00	5
GREEN BROADBILL	1.00	1.00	1.00	5
GREEN JAY	1.00	1.00	1.00	5
GREEN MAGPIE	1.00	1.00	1.00	5
GREEN WINGED DOVE	1.00	1.00	1.00	5
GREY CUCKOOSHRIKE	0.83	1.00	0.91	5
GREY HEADED CHACHALACA	1.00	1.00	1.00	5
GREY HEADED FISH EAGLE	1.00	0.80	0.89	5
GREY PLOVER	1.00	1.00	1.00	5
GROVED BILLED ANI	0.83	1.00	0.91	5
GUINEA TURACO	0.83	1.00	0.91	5
GUINEAFOWL	1.00	1.00	1.00	5
GURNEYS PITTA	1.00	1.00	1.00	5
GYRFALCON	1.00	1.00	1.00	5
HAMERKOP	1.00	1.00	1.00	5
HARLEQUIN DUCK	1.00	1.00	1.00	5
HARLEQUIN QUAIL	1.00	1.00	1.00	5
HARPY EAGLE	1.00	1.00	1.00	5
HAWAIIAN GOOSE	1.00	1.00	1.00	5
HAWFINCH	1.00	1.00	1.00	5
HELMET VANGA	1.00	1.00	1.00	5
HEPATIC TANAGER	1.00	1.00	1.00	5
HIMALAYAN BLUETAIL	1.00	1.00	1.00	5
HIMALAYAN MONAL	1.00	1.00	1.00	5
HOATZIN	1.00	1.00	1.00	5
HOODED MERGANSER	1.00	1.00	1.00	5
HOOPOES	1.00	1.00	1.00	5
HORNED GUAN	1.00	1.00	1.00	5
HORNED LARK	1.00	1.00	1.00	5
HORNED SUNGEM	1.00	1.00	1.00	5
HOUSE FINCH	1.00	0.80	0.89	5
HOUSE SPARROW	1.00	1.00	1.00	5
HYACINTH MACAW	1.00	1.00	1.00	5
IBERIAN MAGPIE	1.00	1.00	1.00	5
IBISBILL	1.00	1.00	1.00	5
IMPERIAL SHAQ	1.00	1.00	1.00	5

IMPERIAL SHAQ	1.00	1.00	1.00	5
INCA TERN	1.00	1.00	1.00	5
INDIAN BUSTARD	1.00	1.00	1.00	5
INDIAN PITTA	1.00	1.00	1.00	5
INDIAN ROLLER	1.00	1.00	1.00	5
INDIAN VULTURE	1.00	1.00	1.00	5
INDIGO BUNTING	1.00	1.00	1.00	5
INDIGO FLYCATCHER	1.00	1.00	1.00	5
INLAND DOTTEREL	1.00	1.00	1.00	5
IVORY BILLED ARACARI	1.00	1.00	1.00	5
IVORY GULL	1.00	1.00	1.00	5
IWI	1.00	1.00	1.00	5
JABIRU	1.00	1.00	1.00	5
JACK SNIPE	1.00	1.00	1.00	5
JACOBIN PIGEON	1.00	1.00	1.00	5
JANDAYA PARAKEET	1.00	1.00	1.00	5
JAPANESE ROBIN	1.00	1.00	1.00	5
JAVA SPARROW	1.00	1.00	1.00	5
JOCOTOCO ANTPITTA	1.00	1.00	1.00	5
KAGU	1.00	1.00	1.00	5
KAKAPO	1.00	1.00	1.00	5
KILLDEAR	1.00	1.00	1.00	5
KING EIDER	1.00	1.00	1.00	5
KING VULTURE	1.00	1.00	1.00	5
KIWI	1.00	1.00	1.00	5
KNOB BILLED DUCK	1.00	1.00	1.00	5
KOOKABURRA	1.00	1.00	1.00	5
LARK BUNTING	1.00	1.00	1.00	5
LAUGHING GULL	1.00	1.00	1.00	5
LAZULI BUNTING	1.00	1.00	1.00	5
LESSER ADJUTANT	1.00	1.00	1.00	5
LILAC ROLLER	1.00	1.00	1.00	5
LIMPKIN	1.00	1.00	1.00	5
LITTLE AUK	1.00	1.00	1.00	5
LOGGERHEAD SHRIKE	1.00	0.80	0.89	5
LONG-EARED OWL	1.00	1.00	1.00	5
LOONEY BIRDS	1.00	1.00	1.00	5
LUCIFER HUMMINGBIRD	1.00	1.00	1.00	5
MAGPIE GOOSE	1.00	1.00	1.00	5
MALABAR HORNBILL	1.00	1.00	1.00	5
MALACHITE KINGFISHER	1.00	1.00	1.00	5
MALAGASY WHITE EYE	1.00	1.00	1.00	5
MALEO	1.00	1.00	1.00	5
MALLARD DUCK	1.00	1.00	1.00	5
MANDRIN DUCK	1.00	1.00	1.00	5
MANGROVE CUCKOO	1.00	0.80	0.89	5
MARABOU STORK	1.00	1.00	1.00	5
MASKED BOBWHITE	1.00	1.00	1.00	5
MASKED BOOBY	1.00	1.00	1.00	5
MASKED LAPWING	1.00	1.00	1.00	5
MCKAYS BUNTING	1.00	1.00	1.00	5
MERLIN	1.00	1.00	1.00	5
MIKADO PHEASANT	1.00	1.00	1.00	5
MILITARY MACAW	1.00	1.00	1.00	5
MOURNING DOVE	1.00	1.00	1.00	5
MYNA	1.00	1.00	1.00	5
NICOBAR PIGEON	1.00	1.00	1.00	5
NOISY FRIARBIRD	1.00	1.00	1.00	5
NORTHERN BEARDLESS TYRANNULET	1.00	1.00	1.00	5
NORTHERN CARDINAL	1.00	1.00	1.00	5
NORTHERN FLICKER	1.00	1.00	1.00	5
NORTHERN FULMAR	0.83	1.00	0.91	5
NORTHERN GANNET	1.00	1.00	1.00	5
NORTHERN GOSHAWK	1.00	1.00	1.00	5
NORTHERN JACANA	1.00	1.00	1.00	5
NORTHERN MOCKINGBIRD	1.00	1.00	1.00	5
NORTHERN PARULA	1.00	1.00	1.00	5
NORTHERN RED BISHOP	1.00	1.00	1.00	5
NORTHERN SHOVELER	1.00	1.00	1.00	5
OCELLATED TURKEY	1.00	1.00	1.00	5
OILBIRD	1.00	1.00	1.00	5
OKINAWA RAIL	1.00	1.00	1.00	5
ORANGE BREASTED TROGON	1.00	0.80	0.89	5

ORANGE BRESTED BUNTING	1.00	1.00	1.00	5
ORIENTAL BAY OWL	1.00	1.00	1.00	5
ORNATE HAWK EAGLE	1.00	1.00	1.00	5
OSPREY	1.00	1.00	1.00	5
OSTRICH	1.00	1.00	1.00	5
OVENBIRD	1.00	1.00	1.00	5
OYSTER CATCHER	1.00	1.00	1.00	5
PAINTED BUNTING	1.00	1.00	1.00	5
PALILA	0.83	1.00	0.91	5
PALM NUT VULTURE	0.83	1.00	0.91	5
PARADISE TANAGER	1.00	1.00	1.00	5
PARAKETT AUKLET	1.00	1.00	1.00	5
PARUS MAJOR	1.00	1.00	1.00	5
PATAGONIAN SIERRA FINCH	1.00	1.00	1.00	5
PEACOCK	1.00	1.00	1.00	5
PEREGRINE FALCON	1.00	1.00	1.00	5
PHAINOPEPLA	1.00	1.00	1.00	5
PHILIPPINE EAGLE	1.00	1.00	1.00	5
PINK ROBIN	1.00	1.00	1.00	5
PLUSH CRESTED JAY	1.00	1.00	1.00	5
POMARINE JAEGER	1.00	1.00	1.00	5
PUFFIN	1.00	1.00	1.00	5
PUNA TEAL	1.00	1.00	1.00	5
PURPLE FINCH	0.83	1.00	0.91	5
PURPLE GALLINULE	1.00	1.00	1.00	5
PURPLE MARTIN	1.00	1.00	1.00	5
PURPLE SWAMPHEN	1.00	1.00	1.00	5
PYGMY KINGFISHER	1.00	0.80	0.89	5
PYRRHULOXIA	1.00	1.00	1.00	5
QUETZAL	1.00	1.00	1.00	5
RAINBOW LORIKEET	1.00	1.00	1.00	5
RAZORBILL	1.00	1.00	1.00	5
RED BEARDED BEE EATER	1.00	1.00	1.00	5
RED BELLIED PITTA	1.00	1.00	1.00	5
RED BILLED TROPICBIRD	0.83	1.00	0.91	5
RED BROWED FINCH	1.00	1.00	1.00	5
RED CROSSBILL	1.00	1.00	1.00	5
RED FACED CORMORANT	1.00	1.00	1.00	5
RED FACED WARBLER	1.00	1.00	1.00	5
RED FODY	1.00	1.00	1.00	5
RED HEADED DUCK	1.00	1.00	1.00	5
RED HEADED WOODPECKER	1.00	1.00	1.00	5
RED KNOT	1.00	1.00	1.00	5
RED LEGGED HONEYCREEPER	1.00	1.00	1.00	5
RED NAPED TROGON	0.83	1.00	0.91	5
RED SHOULDERED HAWK	1.00	1.00	1.00	5
RED TAILED HAWK	1.00	1.00	1.00	5
RED TAILED THRUSH	1.00	1.00	1.00	5
RED WINGED BLACKBIRD	1.00	1.00	1.00	5
RED WISKERED BULBUL	1.00	1.00	1.00	5
REGENT BOWERBIRD	1.00	1.00	1.00	5
RING-NECKED PHEASANT	1.00	1.00	1.00	5
ROADRUNNER	1.00	1.00	1.00	5
ROCK DOVE	1.00	1.00	1.00	5
ROSE BREASTED COCKATOO	1.00	1.00	1.00	5
ROSE BREASTED GROSBEAK	1.00	1.00	1.00	5
ROSEATE SPOONBILL	1.00	1.00	1.00	5
ROSY FACED LOVEBIRD	1.00	1.00	1.00	5
ROUGH LEG BUZZARD	1.00	1.00	1.00	5
ROYAL FLYCATCHER	1.00	1.00	1.00	5
RUBY CROWNED KINGLET	1.00	1.00	1.00	5
RUBY THROATED HUMMINGBIRD	1.00	0.80	0.89	5
RUDDY SHELDUCK	1.00	1.00	1.00	5
RUDY KINGFISHER	1.00	1.00	1.00	5
RUFOUS KINGFISHER	0.83	1.00	0.91	5
RUFOUS TREPE	1.00	1.00	1.00	5
RUFUOS MOTMOT	1.00	1.00	1.00	5
SAMATRAN THRUSH	1.00	1.00	1.00	5
SAND MARTIN	1.00	1.00	1.00	5
SANDHILL CRANE	1.00	1.00	1.00	5
SATYR TRAGOPAN	1.00	0.80	0.89	5
SAYS PHOEBE	1.00	0.60	0.75	5

SCARLET CROWNED FRUIT DOVE	1.00	1.00	1.00	5
SCARLET FACED LIOCICHLA	1.00	1.00	1.00	5
SCARLET IBIS	1.00	1.00	1.00	5
SCARLET MACAW	1.00	1.00	1.00	5
SCARLET TANAGER	1.00	1.00	1.00	5
SHOEBILL	1.00	1.00	1.00	5
SHORT BILLED DOWITCHER	1.00	1.00	1.00	5
SMITHS LONGSPUR	1.00	1.00	1.00	5
SNOW GOOSE	1.00	1.00	1.00	5
SNOW PARTRIDGE	0.62	1.00	0.77	5
SNOWY EGRET	1.00	1.00	1.00	5
SNOWY OWL	1.00	1.00	1.00	5
SNOWY PLOVER	1.00	1.00	1.00	5
SNOWY SHEATHBILL	1.00	1.00	1.00	5
SORA	1.00	1.00	1.00	5
SPANGLED COTINGA	1.00	1.00	1.00	5
SPLENDID WREN	1.00	1.00	1.00	5
SPOON BILED SANDPIPER	1.00	1.00	1.00	5
SPOTTED CATBIRD	1.00	1.00	1.00	5
SPOTTED WHISTLING DUCK	1.00	0.80	0.89	5
SQUACCO HERON	1.00	1.00	1.00	5
SRI LANKA BLUE MAGPIE	1.00	1.00	1.00	5
STEAMER DUCK	1.00	1.00	1.00	5
STORK BILLED KINGFISHER	1.00	1.00	1.00	5
STRIATED CARACARA	1.00	0.60	0.75	5
STRIPED OWL	1.00	1.00	1.00	5
STRIPPED MANAKIN	1.00	1.00	1.00	5
STRIPPED SWALLOW	1.00	1.00	1.00	5
SUNBITTERN	1.00	1.00	1.00	5
SUPERB STARLING	1.00	1.00	1.00	5
SURF SCOTER	1.00	1.00	1.00	5
SWINHOES PHEASANT	1.00	1.00	1.00	5
TAILORBIRD	1.00	1.00	1.00	5
TAIWAN MAGPIE	1.00	1.00	1.00	5
TAKAHE	1.00	1.00	1.00	5
TASMANIAN HEN	1.00	1.00	1.00	5
TAWNY FROGMOUTH	1.00	1.00	1.00	5
TEAL DUCK	1.00	0.80	0.89	5
TIT MOUSE	1.00	1.00	1.00	5
TOUCHAN	1.00	1.00	1.00	5
TOWNSENDS WARBLER	1.00	1.00	1.00	5
TREE SWALLOW	1.00	1.00	1.00	5
TRICOLORED BLACKBIRD	1.00	1.00	1.00	5
TROPICAL KINGBIRD	1.00	1.00	1.00	5
TRUMPTER SWAN	1.00	1.00	1.00	5
TURKEY VULTURE	1.00	1.00	1.00	5
TURQUOISE MOTMOT	1.00	1.00	1.00	5
UMBRELLA BIRD	1.00	1.00	1.00	5
VARIED THRUSH	1.00	1.00	1.00	5
VEERY	1.00	0.80	0.89	5
VENEZUELIAN TROUPIAL	1.00	1.00	1.00	5
VERDIN	1.00	1.00	1.00	5
VERMILION FLYCATHER	1.00	1.00	1.00	5
VICTORIA CROWNED PIGEON	1.00	1.00	1.00	5
VIOLET BACKED STARLING	1.00	1.00	1.00	5
VIOLET CUCKOO	1.00	1.00	1.00	5
VIOLET GREEN SWALLOW	1.00	1.00	1.00	5
VIOLET TURACO	1.00	1.00	1.00	5
VISAYAN HORNBILL	1.00	1.00	1.00	5
VULTURINE GUINEAFOWL	1.00	1.00	1.00	5
WALL CREAPER	1.00	1.00	1.00	5
WATTLED CURASSOW	1.00	1.00	1.00	5
WATTLED LAPWING	1.00	1.00	1.00	5
WHIMBREL	1.00	1.00	1.00	5
WHITE BREASTED WATERHEN	1.00	1.00	1.00	5
WHITE BROWED CRAKE	1.00	1.00	1.00	5
WHITE CHEEKED TURACO	1.00	0.80	0.89	5
WHITE CRESTED HORNBILL	1.00	1.00	1.00	5
WHITE EARED HUMMINGBIRD	1.00	1.00	1.00	5
WHITE NECKED RAVEN	1.00	1.00	1.00	5
WHITE TAILED TROPIC	1.00	1.00	1.00	5
WHITE THROATED BEE EATER	1.00	1.00	1.00	5

WILD TURKEY	1.00	1.00	1.00	5
WILLOW PTARMIGAN	1.00	1.00	1.00	5
WILSONS BIRD OF PARADISE	1.00	1.00	1.00	5
WOOD DUCK	1.00	1.00	1.00	5
WOOD THRUSH	1.00	1.00	1.00	5
WOODLAND KINGFISHER	1.00	1.00	1.00	5
WRENTIT	1.00	1.00	1.00	5
YELLOW BELLIED FLOWERPECKER	1.00	1.00	1.00	5
YELLOW BREASTED CHAT	1.00	1.00	1.00	5
YELLOW CACIQUE	1.00	1.00	1.00	5
YELLOW HEADED BLACKBIRD	1.00	1.00	1.00	5
ZEBRA DOVE	1.00	1.00	1.00	5
accuracy			0.99	2625
macro avg	0.99	0.99	0.99	2625
weighted avg	0.99	0.99	0.99	2625

In [22]:

```
pip install grad-cam
```

```
Collecting grad-cam
  Downloading grad-cam-1.5.2.tar.gz (7.8 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7.8/7.8 MB 50.7 MB/s eta 0:00:0000:0100:01
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
  Preparing metadata (pyproject.toml) ... done
Requirement already satisfied: numpy in /opt/conda/lib/python3.10/site-packages (from gra
d-cam) (1.23.5)
Requirement already satisfied: Pillow in /opt/conda/lib/python3.10/site-packages (from gr
ad-cam) (9.5.0)
Requirement already satisfied: torch>=1.7.1 in /opt/conda/lib/python3.10/site-packages (f
rom grad-cam) (2.0.0)
Requirement already satisfied: torchvision>=0.8.2 in /opt/conda/lib/python3.10/site-packa
ges (from grad-cam) (0.15.1)
Collecting ttach (from grad-cam)
  Downloading ttach-0.0.3-py3-none-any.whl (9.8 kB)
Requirement already satisfied: tqdm in /opt/conda/lib/python3.10/site-packages (from grad
-cam) (4.64.1)
Requirement already satisfied: opencv-python in /opt/conda/lib/python3.10/site-packages (
from grad-cam) (4.5.4.60)
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.10/site-packages (fro
m grad-cam) (3.6.3)
Requirement already satisfied: scikit-learn in /opt/conda/lib/python3.10/site-packages (f
rom grad-cam) (1.2.2)
Requirement already satisfied: filelock in /opt/conda/lib/python3.10/site-packages (from
torch>=1.7.1->grad-cam) (3.12.0)
Requirement already satisfied: typing-extensions in /opt/conda/lib/python3.10/site-packag
es (from torch>=1.7.1->grad-cam) (4.5.0)
Requirement already satisfied: sympy in /opt/conda/lib/python3.10/site-packages (from tor
ch>=1.7.1->grad-cam) (1.12)
Requirement already satisfied: networkx in /opt/conda/lib/python3.10/site-packages (from
torch>=1.7.1->grad-cam) (3.1)
Requirement already satisfied: jinja2 in /opt/conda/lib/python3.10/site-packages (from to
rch>=1.7.1->grad-cam) (3.1.2)
Requirement already satisfied: requests in /opt/conda/lib/python3.10/site-packages (from
torchvision>=0.8.2->grad-cam) (2.28.2)
Requirement already satisfied: contourpy>=1.0.1 in /opt/conda/lib/python3.10/site-package
s (from matplotlib->grad-cam) (1.0.7)
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.10/site-packages (f
rom matplotlib->grad-cam) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in /opt/conda/lib/python3.10/site-packag
es (from matplotlib->grad-cam) (4.39.3)
Requirement already satisfied: kiwisolver>=1.0.1 in /opt/conda/lib/python3.10/site-packag
es (from matplotlib->grad-cam) (1.4.4)
Requirement already satisfied: packaging>=20.0 in /opt/conda/lib/python3.10/site-packages
(from matplotlib->grad-cam) (21.3)
Requirement already satisfied: pyparsing>=2.2.1 in /opt/conda/lib/python3.10/site-package
s (from matplotlib->grad-cam) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in /opt/conda/lib/python3.10/site-pac
kages (from matplotlib->grad-cam) (2.8.2)
```

```
Requirement already satisfied: scipy>=1.3.2 in /opt/conda/lib/python3.10/site-packages (f
rom scikit-learn->grad-cam) (1.10.1)
Requirement already satisfied: joblib>=1.1.1 in /opt/conda/lib/python3.10/site-packages (
from scikit-learn->grad-cam) (1.2.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /opt/conda/lib/python3.10/site-pac
kages (from scikit-learn->grad-cam) (3.1.0)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.10/site-packages (from
python-dateutil>=2.7->matplotlib->grad-cam) (1.16.0)
Requirement already satisfied: MarkupSafe>=2.0 in /opt/conda/lib/python3.10/site-packages
(from jinja2->torch>=1.7.1->grad-cam) (2.1.2)
Requirement already satisfied: charset-normalizer<4,>=2 in /opt/conda/lib/python3.10/site
-packages (from requests->torchvision>=0.8.2->grad-cam) (2.1.1)
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/lib/python3.10/site-packages (f
rom requests->torchvision>=0.8.2->grad-cam) (3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.10/site-pa
ckages (from requests->torchvision>=0.8.2->grad-cam) (1.26.15)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.10/site-packa
ges (from requests->torchvision>=0.8.2->grad-cam) (2023.5.7)
Requirement already satisfied: mpmath>=0.19 in /opt/conda/lib/python3.10/site-packages (f
rom sympy->torch>=1.7.1->grad-cam) (1.3.0)
Building wheels for collected packages: grad-cam
  Building wheel for grad-cam (pyproject.toml) ... done
  Created wheel for grad-cam: filename=grad_cam-1.5.2-py3-none-any.whl size=38335 sha256=
ba9adf4c2825379c10bfa883ab4eb187cfae9e2b83a09e38dbf3814d0188b945
  Stored in directory: /root/.cache/pip/wheels/b4/68/bb/d10381e86dc0de1c9354bce3d86bffcd2
47305058c40ce2e55
Successfully built grad-cam
Installing collected packages: ttach, grad-cam
Successfully installed grad-cam-1.5.2 ttach-0.0.3
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting
behaviour with the system package manager. It is recommended to use a virtual environment
instead: https://pip.pypa.io/warnings/venv
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:

```python
# Essential Libraries
import torch
import torch.nn as nn
import torchvision
from torchvision import models, transforms
from torch.utils.data import DataLoader, Dataset
from pathlib import Path
import os
import random

# Visualization Libraries
from PIL import Image
import matplotlib.pyplot as plt
import seaborn as sns  # For nicer plots
from IPython.display import HTML, display  # For image display in notebook

# Numerical Libraries
import numpy as np
import pandas as pd

# Optimization and Scheduling
import torch.optim as optim
from torch.optim import lr_scheduler

# Model Explanation Libraries
import captum  # Or another visualization library like tf-explain (if using TensorFlow)
from captum.attr import (
    GradientShap,
    DeepLift,
    IntegratedGradients,
    Occlusion
)

# Additional Utilities (if needed)
from tqdm.notebook import tqdm  # Progress bars
```

```
from sklearn.metrics import confusion_matrix, classification_report
```

In [26]:

```
print(f"Best Test Accuracy: {best_acc:.4f}")
```

```
Best Test Accuracy: 0.9913
```

In [ ]:

```
import torch
print(torch.cuda.is_available())
```