In [ ]:
```
import numpy as np
import os
import matplotlib.pyplot as plt
import tensorflow as tf
from tqdm import tqdm
from tensorflow.keras.applications.resnet50 import ResNet50, preprocess_input
from tensorflow.keras.preprocessing.image import load_img, img_to_array
from sklearn.cluster import KMeans
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from sklearn.preprocessing import LabelEncoder
```

In [ ]:
```
# Load model
model = ResNet50(weights='imagenet', include_top=False)
model.summary()
```

```
Model: "resnet50"
__________________________________________________________________________________________________
 Layer (type)                Output Shape                 Param #   Connected to
==================================================================================================
 input_1 (InputLayer)        [(None, None, None, 3)]      0         []

 conv1_pad (ZeroPadding2D)   (None, None, None, 3)        0         ['input_1[0]
[0]']

 conv1_conv (Conv2D)         (None, None, None, 64)       9472      ['conv1_pad
[0][0]']

 conv1_bn (BatchNormalizati  (None, None, None, 64)       256       ['conv1_conv
[0][0]']
 on)

 conv1_relu (Activation)     (None, None, None, 64)       0         ['conv1_bn[0]
[0]']

 pool1_pad (ZeroPadding2D)   (None, None, None, 64)       0         ['conv1_relu
[0][0]']

 pool1_pool (MaxPooling2D)   (None, None, None, 64)       0         ['pool1_pad
[0][0]']

 conv2_block1_1_conv (Conv2  (None, None, None, 64)       4160      ['pool1_pool
[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, None, None, 64)       0         ['conv2_block
1_1_bn[0][0]']
 ation)

__________________________________________________________________________________________________
 Layer (type)                Output Shape                 Param #   Connected to
==================================================================================================
 input_1 (InputLayer)        [(None, None, None, 3)]      0         []

 conv1_pad (ZeroPadding2D)   (None, None, None, 3)        0         ['input_1[0]
[0]']

 conv1_conv (Conv2D)         (None, None, None, 64)       9472      ['conv1_pad
[0][0]']

 conv1_bn (BatchNormalizati  (None, None, None, 64)       256       ['conv1_conv
[0][0]']
 on)

 conv1_relu (Activation)     (None, None, None, 64)       0         ['conv1_bn[0]
[0]']

 pool1_pad (ZeroPadding2D)   (None, None, None, 64)       0         ['conv1_relu
```

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[0][0]']

 pool1_pool (MaxPooling2D)   (None, None, None, 64)       0         ['pool1_pad
[0][0]']

 conv2_block1_1_conv (Conv2  (None, None, None, 64)       4160      ['pool1_pool
[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, None, None, 64)       0         ['conv2_block
1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, None, None, 64)       36928     ['conv2_block
1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, None, None, 64)       0         ['conv2_block
1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, None, None, 256)      16640     ['pool1_pool
[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, None, None, 256)      16640     ['conv2_block
1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, None, None, 256)      1024      ['conv2_block
1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, None, None, 256)      1024      ['conv2_block
1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, None, None, 256)      0         ['conv2_block
1_0_bn[0][0]',
                                                                     'conv2_block
1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, None, None, 256)      0         ['conv2_block
1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, None, None, 64)       16448     ['conv2_block
1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
2_1_conv[0][0]']
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 rmalization)

 conv2_block2_1_relu (Activ  (None, None, None, 64)       0         ['conv2_block
2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, None, None, 64)       36928     ['conv2_block
2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, None, None, 64)       0         ['conv2_block
2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, None, None, 256)      16640     ['conv2_block
2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, None, None, 256)      1024      ['conv2_block
2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, None, None, 256)      0         ['conv2_block
1_out[0][0]',
                                                                     'conv2_block
2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, None, None, 256)      0         ['conv2_block
2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, None, None, 64)       16448     ['conv2_block
2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, None, None, 64)       0         ['conv2_block
3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, None, None, 64)       36928     ['conv2_block
3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, None, None, 64)       256       ['conv2_block
3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, None, None, 64)       0         ['conv2_block
3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, None, None, 256)      16640     ['conv2_block
```

```
3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, None, None, 256)      1024      ['conv2_block
3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, None, None, 256)      0         ['conv2_block
2_out[0][0]',
                                                                     'conv2_block
3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, None, None, 256)      0         ['conv2_block
3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, None, None, 128)      32896     ['conv2_block
3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, None, None, 128)      0         ['conv3_block
1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, None, None, 128)      147584    ['conv3_block
1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, None, None, 128)      0         ['conv3_block
1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, None, None, 512)      131584    ['conv2_block
3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, None, None, 512)      66048     ['conv3_block
1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, None, None, 512)      2048      ['conv3_block
1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, None, None, 512)      2048      ['conv3_block
1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, None, None, 512)      0         ['conv3_block
1_0_bn[0][0]',
                                                                     'conv3_block
1_3_bn[0][0]']
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 conv3_block1_out (Activati  (None, None, None, 512)      0         ['conv3_block
1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, None, None, 128)      65664     ['conv3_block
1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, None, None, 128)      0         ['conv3_block
2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, None, None, 128)      147584    ['conv3_block
2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, None, None, 128)      0         ['conv3_block
2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, None, None, 512)      66048     ['conv3_block
2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, None, None, 512)      2048      ['conv3_block
2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, None, None, 512)      0         ['conv3_block
1_out[0][0]',
                                                                     'conv3_block
2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, None, None, 512)      0         ['conv3_block
2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, None, None, 128)      65664     ['conv3_block
2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, None, None, 128)      0         ['conv3_block
3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, None, None, 128)      147584    ['conv3_block
3_1_relu[0][0]']
```

```
 D)

 conv3_block3_2_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, None, None, 128)      0         ['conv3_block
3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, None, None, 512)      66048     ['conv3_block
3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, None, None, 512)      2048      ['conv3_block
3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, None, None, 512)      0         ['conv3_block
2_out[0][0]',
                                                                     'conv3_block
3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, None, None, 512)      0         ['conv3_block
3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, None, None, 128)      65664     ['conv3_block
3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, None, None, 128)      0         ['conv3_block
4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, None, None, 128)      147584    ['conv3_block
4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, None, None, 128)      512       ['conv3_block
4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, None, None, 128)      0         ['conv3_block
4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, None, None, 512)      66048     ['conv3_block
4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, None, None, 512)      2048      ['conv3_block
4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, None, None, 512)      0         ['conv3_block
```

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3_out[0][0]',
                                                                 'conv3_block
4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, None, None, 512)      0         ['conv3_block
4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, None, None, 256)      131328    ['conv3_block
4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, None, None, 256)      0         ['conv4_block
1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, None, None, 256)      590080    ['conv4_block
1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, None, None, 256)      0         ['conv4_block
1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, None, None, 1024)     525312    ['conv3_block
4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, None, None, 1024)     263168    ['conv4_block
1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, None, None, 1024)     0         ['conv4_block
1_0_bn[0][0]',
                                                                  'conv4_block
1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, None, None, 1024)     0         ['conv4_block
1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, None, None, 256)      262400    ['conv4_block
1_out[0][0]']
 D)
```

```
 conv4_block2_1_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, None, None, 256)      0         ['conv4_block
2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, None, None, 256)      590080    ['conv4_block
2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, None, None, 256)      0         ['conv4_block
2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, None, None, 1024)     263168    ['conv4_block
2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, None, None, 1024)     0         ['conv4_block
1_out[0][0]',
                                                                     'conv4_block
2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, None, None, 1024)     0         ['conv4_block
2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, None, None, 256)      262400    ['conv4_block
2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, None, None, 256)      0         ['conv4_block
3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, None, None, 256)      590080    ['conv4_block
3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, None, None, 256)      0         ['conv4_block
3_2_bn[0][0]']
```

```
 ation)

 conv4_block3_3_conv (Conv2  (None, None, None, 1024)     263168    ['conv4_block
3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, None, None, 1024)     0         ['conv4_block
2_out[0][0]',
                                                                     'conv4_block
3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, None, None, 1024)     0         ['conv4_block
3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, None, None, 256)      262400    ['conv4_block
3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, None, None, 256)      0         ['conv4_block
4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, None, None, 256)      590080    ['conv4_block
4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, None, None, 256)      0         ['conv4_block
4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, None, None, 1024)     263168    ['conv4_block
4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, None, None, 1024)     0         ['conv4_block
3_out[0][0]',
                                                                     'conv4_block
4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, None, None, 1024)     0         ['conv4_block
4_add[0][0]']
 on)
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 conv4_block5_1_conv (Conv2  (None, None, None, 256)      262400    ['conv4_block
4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, None, None, 256)      0         ['conv4_block
5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, None, None, 256)      590080    ['conv4_block
5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, None, None, 256)      0         ['conv4_block
5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, None, None, 1024)     263168    ['conv4_block
5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, None, None, 1024)     0         ['conv4_block
4_out[0][0]',
                                                                     'conv4_block
5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, None, None, 1024)     0         ['conv4_block
5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, None, None, 256)      262400    ['conv4_block
5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, None, None, 256)      0         ['conv4_block
6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, None, None, 256)      590080    ['conv4_block
6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, None, None, 256)      1024      ['conv4_block
6_2_conv[0][0]']
 rmalization)
```

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 conv4_block6_2_relu (Activ  (None, None, None, 256)      0         ['conv4_block
6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, None, None, 1024)     263168    ['conv4_block
6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, None, None, 1024)     4096      ['conv4_block
6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, None, None, 1024)     0         ['conv4_block
5_out[0][0]',
                                                                     'conv4_block
6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, None, None, 1024)     0         ['conv4_block
6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, None, None, 512)      524800    ['conv4_block
6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, None, None, 512)      2048      ['conv5_block
1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, None, None, 512)      0         ['conv5_block
1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, None, None, 512)      2359808   ['conv5_block
1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, None, None, 512)      2048      ['conv5_block
1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, None, None, 512)      0         ['conv5_block
1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, None, None, 2048)     2099200   ['conv4_block
6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, None, None, 2048)     1050624   ['conv5_block
1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, None, None, 2048)     8192      ['conv5_block
1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, None, None, 2048)     8192      ['conv5_block
1_3_conv[0][0]']
```

```
 rmalization)

 conv5_block1_add (Add)      (None, None, None, 2048)     0         ['conv5_block
1_0_bn[0][0]',
                                                                     'conv5_block
1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, None, None, 2048)     0         ['conv5_block
1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, None, None, 512)      1049088   ['conv5_block
1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, None, None, 512)      2048      ['conv5_block
2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, None, None, 512)      0         ['conv5_block
2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, None, None, 512)      2359808   ['conv5_block
2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, None, None, 512)      2048      ['conv5_block
2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, None, None, 512)      0         ['conv5_block
2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, None, None, 2048)     1050624   ['conv5_block
2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, None, None, 2048)     8192      ['conv5_block
2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, None, None, 2048)     0         ['conv5_block
1_out[0][0]',
                                                                     'conv5_block
2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, None, None, 2048)     0         ['conv5_block
2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, None, None, 512)      1049088   ['conv5_block
2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, None, None, 512)      2048      ['conv5_block
3_1_conv[0][0]']
 rmalization)
```

```
 conv5_block3_1_relu (Activ  (None, None, None, 512)      0         ['conv5_block
3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, None, None, 512)      2359808   ['conv5_block
3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, None, None, 512)      2048      ['conv5_block
3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, None, None, 512)      0         ['conv5_block
3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, None, None, 2048)     1050624   ['conv5_block
3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, None, None, 2048)     8192      ['conv5_block
3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, None, None, 2048)     0         ['conv5_block
2_out[0][0]',
                                                                     'conv5_block
3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, None, None, 2048)     0         ['conv5_block
3_add[0][0]']
 on)

==================================================================================
=================
Total params: 23587712 (89.98 MB)
Trainable params: 23534592 (89.78 MB)
Non-trainable params: 53120 (207.50 KB)
_________________________________________________________________________________
_________________
```

In [ ]:

```python
# função de extração das features das imagens
def extract_features(image_paths, model):
    features_list = []
    for img_path in tqdm(image_paths):
        img = load_img(img_path, target_size=(224, 224))
        img_array = img_to_array(img)
        img_array = np.expand_dims(img_array, axis=0)
        img_array = preprocess_input(img_array)
        features = model.predict(img_array, verbose=0)
        features_list.append(features.flatten())
    return np.array(features_list)

# Images paths
data_dir = '../Data/Raw'
data_subdir = [os.path.join(data_dir, subdir) for subdir in os.listdir(data_dir)
image_paths = [os.path.join(subdir, filename) for subdir in data_subdir for file

# Exxtract features using ResNet-50
features = extract_features(image_paths, model)
```

```
# CLustering with KMeans (K=10)
kmeans = KMeans(n_clusters=10, n_init='auto', random_state=42)
predicted_labels = kmeans.fit_predict(features)
```

```
  0%|          | 0/5000 [00:00<?, ?it/s]100%|██████████| 5000/5000 [21:52<00:00,
3.81it/s]
```

In [ ]:
```
# Função para mostrar imagens
def show_cluster_images(image_paths, labels, cluster_id):
    cluster_indices = np.where(labels == cluster_id)[0]
    sample_indices = np.random.choice(cluster_indices, 5, replace=False)
    plt.figure(figsize=(14, 5))
    for i, idx in enumerate(sample_indices):
        plt.subplot(1, 5, i+1)
        img = load_img(image_paths[idx], target_size=(224, 224))
        plt.imshow(img)
        plt.axis('off')
    plt.show()

# Mostrar imagens para cada cluster
for cluster_id in range(10):
    print(f"Cluster {cluster_id}:")
    show_cluster_images(image_paths, predicted_labels, cluster_id)
```

```
Cluster 0:
```

```
Cluster 1:
```

```
Cluster 2:
```

```
Cluster 3:
```

```
Cluster 4:
```

Cluster 5:

Cluster 6:

Cluster 7:

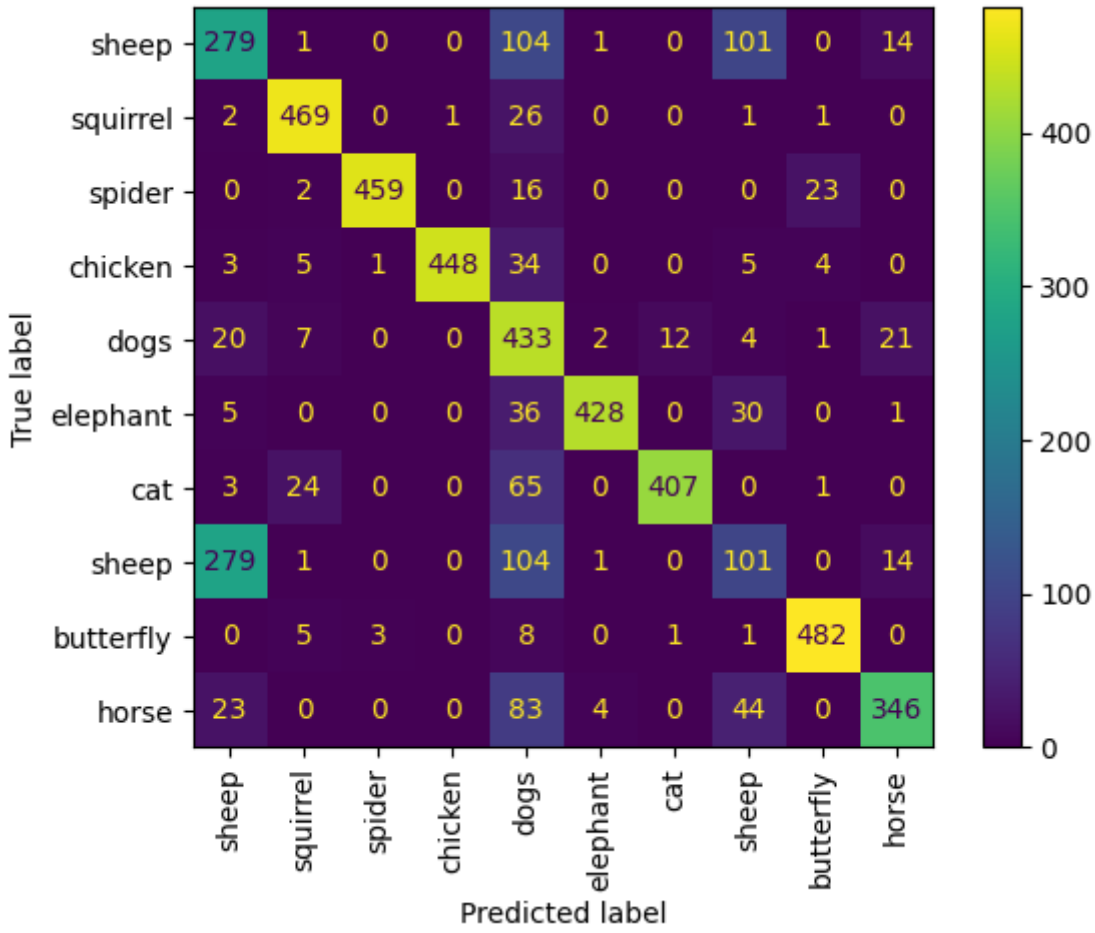
Cluster 8:

Cluster 9:

In [ ]:
```
# Labels verdadeiros
true_labels = [os.path.basename(os.path.dirname(img_path)) for img_path in image

# Conversão labels para números
label_encoder = LabelEncoder()
true_labels_encoded = label_encoder.fit_transform(true_labels)
class_names = np.array(label_encoder.classes_)

confusion = confusion_matrix(true_labels_encoded, predicted_labels)

# organização da matriz de confusão
order = np.argmax(confusion, axis=0)
confusion = confusion[order]
class_names = class_names[order]
```

```
# Plot
ConfusionMatrixDisplay(confusion, display_labels=class_names).plot()
plt.xticks(rotation=90)

# Acurácia
accuracy = np.trace(confusion) / np.sum(confusion)
print(f'Accuracy: {accuracy * 100 :.2f}%')
```

```
Accuracy: 77.04%
```



De acordo com a acurácia obtida tivemos um erro de quase 25% dos dados. Embora muitos clusters tiveram uma boa definição, alguns deles (ovelha, vaca, cavalo) tiveram problemas na clusterização.